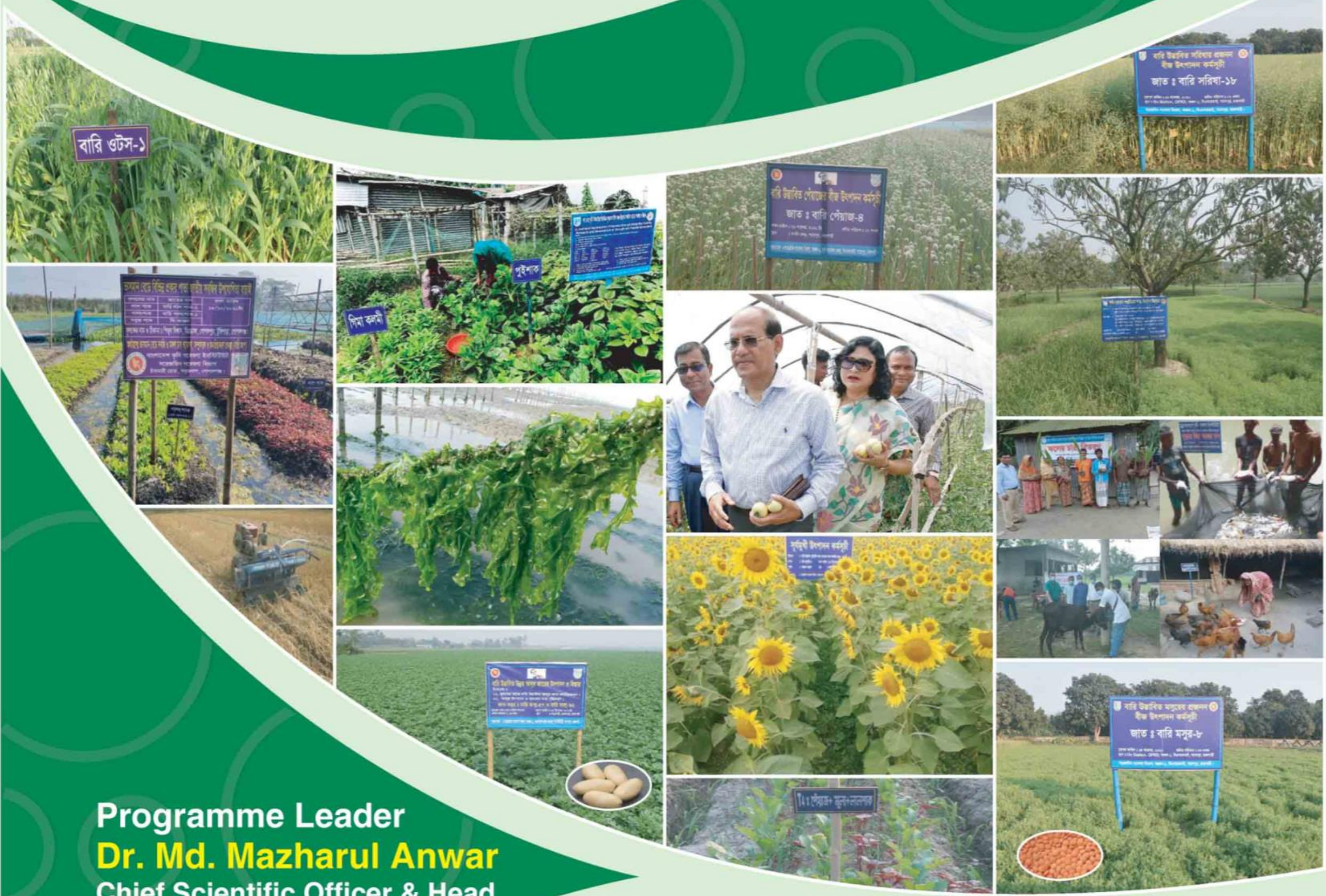
Annual Research Report

2021 -2022



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Bangladesh Agricultural Research Institute
Gazipur-1701

ANNUAL RESEARCH REPORT
2021-22

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ABBREVIATION

BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BCR	Benefit Cost Ratio
BINA	Bangladesh Institute of Nuclear Agriculture
BJRI	Bangladesh Jute Research Institute
BRRI	Bangladesh Rice Research Institute
BSRI	Bangladesh Sugar Crops Research Institute
CP	Cropping Pattern
CV	Coefficient of Variance
DAE	Department of Agriculture Extension
DAS	Days After Sowing
DAT	Days After Transplanting
DMRT	Duncan's Multiple Range Test
FRG	Fertilizer Recommendation Guide
FSRD	Farming System Research and Development
GM	Gross Margin
GO	Government Organization
GR	Gross Return
ha	Hectare
IPNS	Integrated Plant Nutrient System
kg	Kilogram
LSD	Least Significant Difference
MBCR	Marginal Benefit Cost Ratio
MLT	Multilocation Testing
mm	Millimeter
NGO	Non-government Organization
OFRD	On-Farm Research Division
RCBD	Randomized Complete Block Design
REY	Rice Equivalent Yield
SRDI	Soil Resource Development Institute
t	Ton
T.	Transplanted
Tk.	Taka
TVC	Total Variable Cost

Preface

On-Farm Research Division (OFRD) of Bangladesh Agricultural Research Institute (BARI) is going to publish its Annual Research Report based on the research program implemented during 2021-22 through Farming System Research and Development (FSRD) and Multilocation Testing (MLT) sites across the country. The mandate of OFRD is to execute research for the improvement of existing farming systems, testing and validation of on-station technologies under a wide range of agroclimatic situation for the fine tuning of the technologies and development of location specific technologies based on the local problems and needs and transfer of appropriate mature technologies. As per the mandate, major thrust was given on the improvement of existing cropping systems through introduction of modern varieties, crop, and soil fertility management as well as pest and disease management.

Our commitment was given emphasis to address some challenges like improvement of existing cropping system practiced by the farmers with introduction of new crops and varieties and technologies in plainland, coastal, drought, charland, haor, floating and hill ecosystems. For sustainable crop production and soil fertility, it is needed to develop cropping pattern-based fertilizer recommendation and update the fertilizer recommendation guide. Our research thrust is to develop 2 to 4 crop-based cropping pattern for intensification and diversification in the environmental harsh areas, Integrated Plant Nutrient Systems (IPNS), bio-slurry management, bio-fertilizer, organic fertilizer, location specific soil test-based fertilizer recommendation and use of ash, biochar and lime for problematic soil, conservation agriculture base resource saving technologies, agriculture mechanization, subsistence agriculture to climate smart commercial agriculture etc. Adaptation to climate change, climate change and crop modeling, integrated farming, family nutrition, homestead production systems, soil fertility management, cropping systems, four crop-based cropping pattern, floating agriculture, agroforestry-based cropping systems, conservation agriculture, technology transfer of field and horticultural crops, socioeconomic studies and seaweeds production are also included in this report.

On-farm trials on cereals, tuber crops, pulses, oilseeds, spices, seaweed, horticultural crops, and community-based system approach pilot production program were conducted at different MLT and FSRD sites throughout the country in collaboration with NARS institutes, Department of Agricultural Extension (DAE) and development partners. Results of these activities also incorporated in this report. Through the technical support of this division, different activities (training, field days and others) were conducted and organized for farmers, DAE personnel, SSA/SA, and scientists with the financial support of MoA, KGF, NATP (Phase II), CIMMYT, IRRI, ACIAR and FtFBP during 2021-22.

We are expecting this report will be very useful to the researchers, GO, NGOs, extension personnel, grassroot level workers, development partners as well as policy makers.

I expressed my sincere thanks and gratitude to BARI, MoA, CIMMYT, IRRI, ACIAR, FtFBP, KGF, OCP Foundation, NATP (Phase-II), IDA, IFAD, World Bank and BARC for providing financial assistance to conduct different research, training, and Research-Extension linkage activities. I sincerely admire and appreciate my colleagues and SSA/SAs who look after the experiments at different locations. Special thanks to the cooperator farmers for their valuable cooperation and support. Last of all, I acknowledged those who worked hard to accomplish this voluminous report successfully.

Dr. Md. Mazharul Anwar
Chief Scientific Officer & Head

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Executive Summary

On-Farm Research Division (OFRD) is one of the largest divisions and recognized as a window of Bangladesh Agricultural Research Institute (BARI). With the alignment of government policy and development vision and feedback from extension agency, OFRD carried out research and development activities on On-Farm Soil Fertility Management, Improvement of Cropping Systems, Adaptive Trial of Advance Lines and Technologies, Integrated Farming System and Socioeconomic studies at farmers' field of national agricultural hotspots like Rainfed/Drought, Coastal, Charland, Hill, Haor and Plainland ecosystem. One of the important core functions of OFRD is location specific problem-oriented research and technology generation for solving the perceived problems. Research works on soil test based integrated nutrient management with synthetic fertilizer and organic manure at different ecosystem exhibited higher crop yield and improved soil health under different cropping pattern. The effect of organic manure recycling, bio-fertilizer, compound fertilizer and conservation agriculture with crop residue retention on different crops was found better regarding yield and economic return. Significant research effort has been made for the improvement of existing cropping pattern through inclusion of high yielding and short duration new varieties and improved management practices which contributed relatively higher production and farmers' income over famers managed existing cropping at different ecosystem of Bangladesh. Selection of promising BARI developed varieties/lines of oil seed, pulse, vegetables, fruits, tuber and spices crops through On-Farm adaptive trial with active participation of farmers, extension personnel, scientists open greater scope for introduction of BARI varieties to the farmers. OFRD has developed around 10 homestead-based production model with year-round vegetables and quick growing fruits for different ecosystem utilizing all possible production units or niches which exhibited remarkably higher year round fruits, vegetables, spices production and supplementary family nutrition (Vit. A, Vit. C, Protein, Iron, Ca etc.) over traditional farming. Adoption of integrated farming system with crops, livestock, fisheries and agroforestry technologies and off-farm activities created excellent positive impact on existing farming with manifold production and income generation of the farm households. High Barind Tract is represented with extreme hot and erratic rainfall. OFRD has developed technologies with low water requirement crops (Pulse, oil seed), conservation agriculture with minimum tillage and mulching, water management with rainwater stored in mini pond etc. in HBT and made significant contribution in production and income generation. OFRD has accomplished comprehensive research works and generation of viable technologies in coastal ecosystem like adaptation of BARI developed Mungbean, Sunflower and Barley, cultivation of potato, garlic, and wheat with zero tillage, integrated Sorjan based production system with fruits+ vegetables+ fishes being used by the farmers in coastal area. In Charland ecosystem OFRD gained success in adaptation of different crops with climate and soil characteristics. Greater adoption of BARI developed minor cereals like proso millet, pearl millet, sweet gourd, bitter gourd, chilli, cucumber, potato, sweet potato, maize, zero tillage onion, etc. through pilot production program exhibited remarkably higher production and economic return of the Char households. Greater adoption of BARI developed fruits, vegetables

and agroforestry technologies in the hill ecosystem made greater availability of fruits and vegetables round the year for hill people. OFRD has made a lot of diversity in technology generation and wide scale adoption of BARI developed pulse, oil seed, fruits, vegetables, spices, minor cereals etc. in the plain land ecosystem which eventually uplift livelihood of the farmers. Development of agroforestry technologies with fruit trees and high value vegetables, pulse, oil seed and spices crops at different ecosystem demonstrated 2 to 3 times higher system productivity and farmers income as compared to sole fruits cultivation. Adaptation of summer hybrid tomato varieties and community-based pilot production approach has made remarkable impact on increasing summer tomato production countrywide and created greater opportunity for value chain and marketing. This division acts a bridge between BARI and Extension agency through validation of On-Station technologies at farmer's field. The technologies those prove viable through OFRD validation process at farmers' field are eventually handover to DAE for large scale dissemination. However, pilot production program of new BARI varieties across the country has opened greater availability of seeds of high yielding BARI varieties, development of seed entrepreneurship and Village Seed Bank. OFRD follows Farming Systems Research and Development methodology with farmers training, Field days, Focal group discussion and intensive field monitoring for transferring of technologies on improving soil fertility, improvement of cropping system, cropping pattern improvement, integrated farming, pest management, and socioeconomic development of the farmers at different hotspots of the country. OFRD engaged with generation of climate change adaptation technologies maintaining collaboration with NARS institute, DAE, DLS, DoF and international organization like IFAD, ACIAR, CIMMYT, IRRI and others. As a mirror of BARI, OFRD created excellent impact on sustainable crop production, income generation, food and nutrition security of the rural farm families in Bangladesh.

Mature Technologies

Technology 01	:	**Development of alternate cropping pattern Wheat-T. Aus-T. Aman rice in Dinajpur region**		
Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur l70l		
Location of application	:	Dinajpur region with similar soils of AEZ 1 and 3		
Key characteristics of the technology	:	• The newly introduced crop in the farmer's cropping pattern was T. Aus (BRRI dhan48) in Kharif season • A short duration T- Aman rice variety BRRI dhan62 was also introduced for timely sowing of wheat and T. Aus rice • Rice equivalent yield (REY) 14.90 t $ha^{-1}yr^{-1}$ was in the improved cropping pattern whereas in the existing pattern (Wheat-Fallow- T. Aman rice) was recorded 10.32 t $ha^{-1}yr^{-1}$ • Gross margin increased by 25% over existing pattern		
Year of experimentation	:	2016-17and 2017-18		
Production guideline	:			
Crop	:	Wheat	T.Aus	T. Aman rice
Variety	:	BARI Gom-26	BRRI dhan48	BRRI dhan62
Spacing (cm)	:	Broadcast	20 cm × 15 cm	20 cm × 15 cm
Sowing/Transplanting date	:	1st week of December	5-10 May	1st week of August
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	:	100-30-50-20-1-1	75-10-25-9-0.6-0	90-10-35-12-1-0
Fertilizer application method	:	3/2 N and all P, S,K, Zn, B fertilizers should be applied as basal during final land preparation. Rest N a should be applied in 18 DAS .	All P, K, S, Zn, B fertilizers should be applied as basal during final land preparation. N should be applied in 2 equal splits, at 10 and 25 days after Transplanting.	All P, K, S and Zn fertilizers should be applied as basal. N should be applied in 3 equal splits, the 1st one as immediately after seedling establishment, the 2nd one at early tillering stage and 3rd one at 5-7 days before panicle initiation. Last week of October
Date of Harvesting	:	18-25 March	24-30 July	20-27 October
Yield (t ha^{-1})	:	4.6	4.45	3.84
Intercultural Operation		Intercultural operation should be done for necessary support to normal growth of the crops		
Field duration (days)	:	105-110	80	78
Risk involvement in adopting the technology		No risk involvement		
Impact on environment	:	No harmful effects on environment		
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
Expected outcome	:	Total productivity and cropping intensity can be increased		
Socioeconomic aspects	:	Considering the whole pattern		
		Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
		268350	143256	12509
Recommendation	:	Improved cropping pattern Wheat-T.Aus-T. Aman rice was more productive and remunerative and it could be suggested for large scale adoption in medium high land of Dinajpur region with similar soils of AEZ 1 and 3.		

Technology 02	:	**Development of alternate cropping pattern Maize-T. Aus-T. Aman rice in Dinajpur region**
Name of organization	:	Bangladesh Agricultural Research Institute (BARI)
Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur l70l
Location of application	:	Dinajpur region with similar soils of AEZ 1 and 3
Key characteristics of the technology	:	• The newly introduced crop in the farmers cropping pattern was T. Aus (BRRI dhan48) in Kharif season • A short duration T, Aman rice variety BRRI dhan62 was also introduced for timely sowing of Maize and T. Aus. • Rice equivalent yield (REY) 17.34 t $ha^{-1}yr^{-1}$ was in the improved cropping pattern whereas in the existing pattern (Maize-Fallow- T. Aman rice) was recorded 12.98 t $ha^{-1}yr^{-1}$ • Gross margin increased by 27% over existing pattern
Year of experimentation	:	2016-17and 2017-18

Production guideline	:			
Crop	:	Maize	T. Aus rice	T. Aman rice
Variety	:	BARI Hybrid Maize-9	BRRI dhan48	BRRI dhan62
Spacing (cm)	:	Broadcast	20 cm × 15 cm	20 cm × 15 cm
Sowing/Transplanting date	:	20-25 November	7-12 May	15-20 August
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	:	150-42-80-27-3-1	75-12-33-9-0.6-0	80-10-35-12-1-0
Fertilizer application method	:	$^{1}/_{3}$ N and all P, S, K, Zn, B fertilizers should be applied as basal during final land preparation. Rest N should be applied in 18 & 40 DAS .	All P, K, S, Zn, B fertilizers should be applied as basal during final land preparation. N should be applied in 2 equal splits, at 10 and 25 days after Transplanting.	All P, K, S and Zn fertilizers should be applied as basal. N should be applied in 3 equal splits, the 1st one as immediately after seedling establishment, the 2nd one at early tillering stage and 3rd one at 5-7 days before panicle initiation.
Date of Harvesting	:	1-5 May	8-15 August	10-15 November
Yield (t ha^{-1})	:	9.96	4.02	3.90
Intercultural Operation		Intercultural operation should be done for necessary support to normal growth of the crops		
Field duration (days)	:	150	80	80
Risk involvement in adopting the technology		No risk involvement		
Impact on environment	:	No harmful effects on environment		
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
Expected outcome	:	Total productivity and cropping intensity can be increased		
Socioeconomic aspects	:	Considering the whole pattern		

Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
346764	158955	187809

Recommendation	:	Improved cropping pattern Maize-T.Aus-T. Aman rice was more productive and remunerative and it could be suggested for large scale adoption in medium high land of Dinajpur region with similar soils of AEZ 1 and 3.

Technology 03	:	**Effect of Different Planting System of Chilli in the Char Areas of Kishoreganj district**		
Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
Location of application	:	Kishoreganj Sadar and Hossainpur upazilla with similar soils of AEZ-8 & 9		
Key characteristics of the technology	:	• Farmer's get more yield in continuous seed showing double row method than transplanting in double row and broadcasting methods • Continuous sowing in double row method plants gets more space for natural and nutrients sources and inter species competition is low than other treatments • Continuous seed showing in double row method gives the highest yield (7.21 t/ha) which is 12% higher than the transplanting in double row and 28% higher than the broadcasting method • Gross margin increased by 17% over transplanting in double row and 71% over the broadcasting method		
Year of experimentation	:	2017-2020		
Production guideline	:			
Treatments	:	Broadcasting	Continuous sowing in double row	Transplanting in double row
Variety		Nodaria (Local)	Nodaria (Local)	Nodaria (Local)
Spacing (cm)	:	Broadcasting	Continuous sowing	25cm x 20cm
Sowing/Transplanting date	:	09 to 19 October	09 to 19 October	10 to 15 October
Fertilizer dose (N-P-K -B kg ha-1)	:	97-66-100-.85	97-66-100-.85	97-66-100-.85
Fertilizer application method	:	One third K and all P, B were applied as basal at final land preparation. N and rest of the K was applied as top dressed at three equal splits at the time of 25, 50 and 70 DAS.	One third K and all P, B were applied as basal at final land preparation. N and rest of the K was applied as top dressed at three equal splits at the time of 25, 50 and 70 DAS.	One third K and all P, B were applied as basal at final land preparation. N and rest of the K was applied as top dressed at three equal splits at the time of 25, 50 and 70 DAT.
Date of Harvesting	:	10 Feb. to 25 April	16 Feb. to 10 May	14 Feb. to 12 May
Field duration (Days)	:	190	200	188
Yield (t ha^{-1})		6.45	7.21	5.74
Intercultural Operation	:	In chilli cultivation two weeding should be done at 25 and 45 DAS. Three to four irrigation is needed at crop demand for proper flower initiation. Two sprays of vertimac done to control insects and pest.		
Impact on environment	:	No harmful effects on environment		
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
Expected outcome	:	Total productivity can be increased		
Socioeconomic aspects	:	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
		180250	76050	104200
Recommendation	:	Among the three treatments farmers are vary much encouraged to grow chilli with continuous sowing in double row, as intercultural operation and harvesting is easier and yield is high in this method.		

Technology 04	:	**Development of two crops-based Potato-Boro rice-Fallow cropping pattern against Fallow-Boro -Fallow cropping pattern in haor area of Kishoreganj**
Organization	:	Bangladesh Agricultural Research Institute (BARI)
Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701
Location	:	Nikli upazila, Kishoreganj region with similar soils of AEZ-19
Key characteristics of the technology	:	• The newly introduced crop in the farmers cropping pattern was potato (BARI Alu-8) in rabi season • Rice equivalent yield of Potato-Boro-Fallow pattern (21.89 t ha^{-1}) was found 215% higher than the sole boro rice (6.96 t/ha) cultivation • Higher gross margin (Tk. 224510 ha^{-1}) achieved by Potato-Boro-Fallow cropping pattern which was 265% higher than the sole boro rice cultivation • MBCR of Potato-Boro-Fallow cropping pattern was 2.20 which indicated the superiority of potato-based cropping pattern over sole boro rice
Duration	:	2018-2020

Production guideline	:	Potato-Boro rice-Fallow		Fallow-Boro rice-Fallow
Crop		Potato	Boro rice	Boro rice
Variety		BARI Alu-8	BRRI dhan29	BRRI dhan29
Spacing (cm)	:	60cm x 25cm	25cm x15cm	25cm x15cm
Sowing/Transplanting	:	04 to 22 November	19 Jan.-04 February	25 December-10 January
Fertilizer dose (kg/ha) (N-P-K-S-Zn-B)	:	152-42-125-20-04-02	140-18-53-08-03-02	140-18-53-08-03-02
Fertilizer application method		Half N and all PKSZn and B were applied as basal at final land preparation. Rest of N should be applied 30-35 DAS.	One third N and full dose of other fertilizers be applied at final land preparation. Rest one third N should be applied at 20-25 DAT and rest one third N should be applied 5-7 days before panicle initiation.	One third N and full dose of other fertilizers be applied at final land preparation. Rest one third N should be applied at 20-25 DAT and rest one third N should be applied 5-7 days before panicle initiation.
Date of Harvesting		10 January-04 February	22 April-15 May	13-20 April
Field duration (Days)		78-90	94-101	110-117
Yield (t ha^{-1})		24.17	6.62	6.43
Intercultural Operation		In potato cultivation two weeding and two earthing up should be done 15 and 35 DAS. Two to three irrigation is needed at 20 and 45 DAS for proper tuber formation. In case of Rice cultivation two weeding and top dressed of urea should be done and 10 to 15 cm water should be retain in the field.		

Impact on environment	:	No harmful effects on environment
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.
Expected outcome	:	Total productivity and cropping intensity can be increased
Socioeconomic aspects	:	Considering the whole pattern

Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Potato-Boro rice -Fallow	Potato-Boro rice -Fallow	Potato-Boro rice -Fallow
437747	213237	224510

Recommendation	:	Improved cropping pattern Potato-Boro-Fallow was more productive and remunerative, and it could be suggested for large scale production in upper catena of Haor areas.

Technology 05	**:**	**Effect of De-topping on Grain and Fodder Yield of Maize in Haor Areas of Kishoreganj**
Name of organization	:	Bangladesh Agricultural Research Institute (BARI)
Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701
Location of application	:	Nikli upazila, Kishoreganj District with similar soils of AEZ-9
Key characteristics of the technology	:	• The newly introduced forced maturity technique (De-topping of maize after silking) farmer's get more time for Boro and jute cultivation than traditional farmer's practice • De-topping of maize enhance maturity (save around 10 to 15 days) and thus save the crop from early flash flood in the haor areas • Though farmer's practice (without de-topping) give highest yield (10.31 t/ha) but it gets longest life duration (140 days), that creates a big problem with latter Boro rice and Jute cultivation • In addition, de-topping technique give a huge amount of fresh fodder yield (6.04 t/ha), which serves as a good source of food for cattle at lean season • Gross margin (Tk. 98485/ha) and MBCR (2.29) is highest at farmer's practice (No de-topping)
Year of experimentation	:	2018-2020
Production guideline	:	

Treatments	:	De-topping at 25 days after pollination	De-topping at 35 days after pollination	No de-topping
Variety		BARI Hybrid Maize-9	BARI Hybrid Maize-9	BARI Hybrid Maize-9
Spacing (cm)	:	60 cm x 25 cm	60 cm x 25 cm	60 cm x 25 cm
Sowing/Transplanting date	:	24 to 30 October	24 to 30 October	24 to 30 October
Fertilizer dose (N-P-K-S-Z_n -B kg/ ha	:	244-50-110-29-3.6-1.2	244-50-110-29-3.6-1.2	244-50-110-29-3.6-1.2
Fertilizer application method		One-third urea and all others fertilizers were applied as basal during final land preparation. The remaining one-third urea was applied as a top dress at 35 DAS and the rest of urea was applied at 60 DAS. Three irrigations were used	One-third urea and all others fertilizers were applied as basal during final land preparation. The remaining one-third urea was applied as a top dress at 35 DAS and the rest of urea was applied at 60 DAS. Three irrigations were used	One-third urea and all others fertilizers were applied as basal during final land preparation. The remaining one-third urea was applied as a top dress at 35 DAS and the rest of urea was applied at 60 DAS. Three irrigations were used
Date of Harvesting	:	26 Feb. to 06 March	02 to 11 Mach	10 to 25 Mach
Field duration (Days)		126	131	142
Yield (t ha-1)		8.8	9.91	10.31
Intercultural Operation		In maize cultivation two earthing up along with weeding should be done at 25 and 60 DAS. Four irrigation is needed at crop demand for proper kernel development. Two spray of Carate and Virtako was done to control *Spodoptera letura*.		

Impact on environment	:	No harmful effects on environment
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.
Expected outcome	:	Total crop duration is shorter and farmer's can easily cultivate next crop like jute and total productivity and cropping intensity can be increased
Socioeconomic aspects	:	Considering all the treatments

Gross return (Tk. ha^{-1})			Total variable cost (Tk. ha^{-1})			Gross margin (Tk. ha^{-1})		
159453	180026	174460	82695	82695	7975	76758	96858	98485

Technology 06	:	**Development of alternate cropping pattern Sesame–T. Aman rice– Mustard in less flood affected medium highland of Manikganj**
Name of organization	:	Bangladesh Agricultural Research Institute (BARI)
Contract Division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701
Location of application	:	Lees flood affected area of Manikganj region with similar soils of AEZ 7, 8 and 12
Key characteristics of the technology	:	• Local variety of sesame was replaced by high yielding BARI Til-4. T. Aman rice (BRRIdhan-49) was replaced by short duration high yielding T. Aman rice (BRRIdhan-75) and local variety of mustard (Tori-7) was replaced by high yielding variety of mustard (BARI sarisha-14). • Rice equivalent yield (REY) in the improved cropping pattern increased by 31% over the existing cropping pattern. • Farmers were benefitted due to higher gross margin over existing pattern.
Year of experimentation	:	2020-22
Production guideline	:	

Crop	:	Sesame	T. Aman	Mustard
Variety	:	BARI Til-4	BRRIDhan-75	BARI Sarisha-14
Spacing (cm)	:	Broadcast	25 cm x 15 cm	Broadcast
Sowing/transplanting date	:	2nd to 3rd week of March	2nd to 3rd week of July	1st to 3rd week of November
Fertilizer dose (N-P-K-S-Zn-B kg ha)	:	55-30-25-20-1.97-1.70	90-15-35-12-1.49-0.85	104-33-45-20-1.69-1.28
Fertilizer application method	:	Half of urea and all other fertilizers to be applied during final land preparation. The remaining urea to be top dressed at 20-25 days after sowing	One-third of urea and all other fertilizers to be applied during final land preparation. The remaining urea to be top dressed in two equal splits at 15-20 and 35-40 days after sowing.	Half of urea and all other fertilizers to be applied during final land preparation. The remaining urea to be top dressed at 20-25 days after sowing.
Date of harvesting	:	2nd to 3rd week of June	2nd to 3rd week of October	Last week of January to 1st week of February
Yield (t ha1^{-l})	:	1.36	4.52	1.45
Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
Field duration (days)	:	85	89 (excluding seedling age)	88

Risk involvement in adopting the technology	:	No risk involvement
Impact on environment	:	No harmful effects on environment
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.
Expected outcome	:	Total productivity and cropping intensity can be increased
Socioeconomic aspects	:	Considering the whole pattern

Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
329490	161640	167450

Recommendation	:	Improved cropping pattern Sesame (BARI Til-4) – T. Aman rice (BRRI dhan75) – Mustard (BARI Sarisha-14) was more productive, and it could be suggested for large scale adoption in medium high land of Manikganj region with similar soils of AEZ 7, 8 and 12.

Technology 07	:	**Development of alternate cropping pattern Mustard–Boro rice–Fallow in flood affected low-lying area of Manikganj**		
Name of organization	:	Bangladesh Agricultural Research Institute (BARI)		
Contract Division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
Location of application	:	Flood affected low-lying area of Manikganj region with similar soils of AEZ 7, 8 & 12		
Key characteristics of the technology	:	• Local variety of mustard was replaced by high yielding variety of mustard (BARI Sarisha-14) and Boro rice (BRRIdhan-29) was replaced by short duration high yielding Boro rice (BRRIdhan-89). • Rice equivalent yield (REY) in the improved cropping pattern increased by 20% over the existing cropping pattern. • Farmers were benefitted due to higher gross margin over existing pattern.		
Year of experimentation	:	2020-21 and 2021-22		
Production guideline	:			
Crop	:	Mustard	Boro rice	Fallow (flood)
Variety	:	BARI Sarisha-14	BRRI dhan89	-
Spacing (cm)	:	Broadcast	25cm x 15cm	-
Sowing/Transplanting date	:	1st to 2nd week of November	2nd to 3rd week of January	-
Fertilizer dose (N-P-K-S-Zn-B kg ha)	:	55-30-25-20-1.97-1.70	115-18-75-20-2.6-1.27	
Fertilizer application method	:	Half of urea and all other fertilizers to be applied during final land preparation. The remaining urea to be top dressed 20-25 days after sowing.	One-third of urea and all other fertilizers to be applied during final land preparation. The remaining urea to be top dressed in two equal splits at 15-20 and 35-40 days after sowing.	-
Date of harvesting	:	Last week of January to 1st week of February	1st to 2nd week of June	-
Yield (t ha^{-l})	:	1.43	7.37	-
REY (t ha^{-l})			11.68	
Intercultural Operation	:	Intercultural operation should be done for necessary support to normal growth of the crops		
Field duration (days)	:	90	110 (excluding seedling age)	-
Risk involvement in adopting the technology	:	No risk involvement		
Impact on environment	:	No harmful effects on environment		
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet etc.		
Expected outcome	:	Total productivity and cropping intensity can be increased		
Socioeconomic aspects	:	Considering the whole pattern		
	:	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
		315240	195135	120105
Recommendation	:	Improved cropping pattern Mustard (BARI Sarisha-14) – Boro rice (BRRI dhan89) – Fallow was more productive and it could be suggested for large scale adoption in flood affected low-lying areas of Manikganj region with similar soils of AEZ 7, 8 and 12.		

Technology 08	**:**	**Effect of border trees on potato in northern region of Bangladesh**
Name of the Organization	:	Bangladesh Agricultural Research Institute (BARI)
Contract Division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701
Location of application	:	Multilocation testing (MLT) site Gobindaganj, Gaibandha
Key characteristics of the technology		• Under tree surrounded land required more irrigation compared to open field and tree surrounded potato field decreased average 10 t ha^{-1} potato yield compared to open field normal potato. • It has reduced around 30 % potato yield compared to open field. • The impact of tree roots on the water supply available to nearby plants. • Trees primarily in terms of shade (as competitors for sunlight), under the extreme drought conditions trees can become serious competitors for water too.
Year of experimentation		2018-19 to 2020-21
Production guideline		
Crop		Potato
Variety		BARI Alu-25
Spacing (cm)		60 × 25
Sowing/Transplanting date		Last week of Nov.
Fertilizer rate (N-P-K-S-Zn-B-cowdung Kg ha^{-1})		135-30-110-22-2-1-5000
Fertilizer application		Half of N and all P,K,S, Zn, B were applied at final land preparation as basal and rest of N was applied at 30-35 days after planting
Harvesting time		01-05 March
Field duration (days)	:	90-95
Yield (t ha^{-1})		Normal potato field – 30.55 Tree surrounded potato field-20.22
Risk involvement in adopting the technology		No risk involvement
Impact on environment	:	No harmful effects on environment
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet, leaflet, TV or radio talk etc.
Expected outcome		Total productivity can be increased

Socioeconomic aspects :	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Normal potato field	284800	135677	149123
Tree surrounded potato field	190013.3	142297	47716.33

Recommendation	:	Open field crop production may be recommended for the farmers instead of tree surrounded crop production.

Technology 09	:	**Improvement of non-rice-based cropping pattern Potato-Onion/Groundnut in charland**		
Name of the Organization	:	Bangladesh Agricultural Research Institute (BARI)		
Contract Division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701		
Location of application	:	Char Ganai, Kaunia, Rangpur		
Key characteristics of the technology		• Non-rice crops-based cropping pattern Potato (var. BARI Alu-25)-Onion (var. BARI Piaj-1)/Groundnut (var. BARI Chinabadam-9) tested against existing two crops-based cropping pattern Potato (var. BARI Alu-8)-Groundnut (var. Local-Noli)-Fallow at Char Ganai, Kaunia under Rangpur district. • In the improved pattern, BARI Piaj-1 produced as an extra crop where groundnut relayed after about two months of onion planting/sowing. • Potato equivalent yield (PEY) increased 107% in the improved cropping pattern. • Gross margin increased 153% in improved cropping pattern compared to existing pattern.		
Year of experimentation		2020-21		
Production guideline				
Crop		Potato	Onion	Groundnut
Variety		BARI Alu-25	BARI Piaj-1	BARI Chinabadam-9
Spacing (cm)		50 cm x 10 cm	10 cm x 05 cm	20cm x 15 cm
Sowing/Transplanting date		02-05 Nov.	18-29 Jan.	20.-25 Feb. (Relay)
Fertilizer rate (N-P-K-S-Zn-B Kg ha^{-1})		115-30-125-21.58-3.58-1.70	110.6-44-75-19.78-3.58-1.70 + CD 5 t/ha	-
Fertilizer application		Half of N and all P,K,S, Zn, B were applied at final land preparation as basal and rest of N was applied at 30-35 days after planting	All fertilizers were applied as basal.	-
Harvesting time		15-24 Jan.	03-13 April	20-30 Jun.
Field duration (days)	:	78-80	64-77	114-117 (including relay time)
Turnaround time (day)		125	04	-
Yield (t ha^{-1})		25.83	9.84	2.14
Risk involvement in adopting the technology		No risk involvement		
Impact on environment	:	No harmful effects on environment		
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet, leaflet, TV or radio talk etc.		
Expected outcome		Total productivity and profitability can be increased		
Socioeconomic aspects Considering the whole pattern	:	Gross return (Tk. ha^{-1}) 1038600	Total variable cost (Tk. ha^{-1}) 293414	Gross margin (Tk. ha^{-1}) 745186
Recommendation	:	Potato-onion/groundnut is an easy setting cropping pattern. This cropping pattern was more productive and profitable, and it could be suggested for large scale production in char land of Rangpur region under AEZ-3.		

Technology 10	: **Improvement of rice-based cropping pattern Potato-Groundnut-T. Aman**
Name of the Organization	: Bangladesh Agricultural Research Institute (BARI)
Contract Division	: CSO, On-Farm Research Division, BARI, Gazipur 1701
Location of application	: Char Gonai, Kaunia, Rangpur
Key characteristics of the technology	• Potato (var. BARI Alu-25)-Groundnut (var. BARI Chinabadam-9)-T. Aman (BRRI dhan71) tested against existing two crops-based cropping pattern Potato (var. BARI Alu-8)-Groundnut (var. Local-Noli)-Fallow at Char Ganai, Kaunia under Rangpur district. • In the improved pattern, BRRI dhan71 produced as an extra crop. The long gap period between potato to groundnut harvesting can be used successfully by cultivating of T. Aman rice. • Rice equivalent yield (REY) increased 53% in the improved cropping pattern. • Gross margin increased 70% in improved cropping pattern compared to existing pattern.
Year of experimentation	2020-21
Production guideline	

Crop	Potato	Groundnut	T. Aman rice
Variety	BARI Alu-25	BARI Chinabadam-9	BRRI dhan71
Spacing (cm)	50 cm x 10 cm	20 cm x 15 cm	20cm x 15 cm
Sowing/Transplanting date	07-13 Nov.	27-28 Jan to 02 Feb.	19 June to 08 Jul.
Fertilizer rate (N-P-K-S-Zn-B kg ha^{-1})	115-30-125-21.58-3.58-1.70	11.52-32-42.5-53.96-0-1.7	100-12-30-10-1.5-0
Fertilizer application	Half of N and all P,K,S, Zn, B were applied at final land preparation as basal and rest of N was applied at 30-35 days after planting	All fertilizers were applied as basal.	All P,K,S, Zn, B were applied at final land preparation as basal and N was applied at15, 30 and 45 days after planting
Harvesting time	21-28 Jan.	01-26 Jun.	21-24 Sep.
Field duration (days)	: 70-88	116-121	94-97
Turnaround time (days)	17	05	15
Yield (t ha^{-1})	26.03	2.24	4.58

Risk involvement in adopting the technology	No risk involvement
Impact on environment	: No harmful effects on environment
Procedure of transfer	: Block demonstration, farmers training, field day, booklet, leaflet, TV or radio talk etc.
Expected outcome	Total productivity and profitability can be increased

Socioeconomic aspects Considering the whole pattern	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
	771400	271414	499986

Recommendation	: Potato-groundnut-T. Aman is an easy setting cropping pattern. This cropping pattern was more productive and profitable, and it could be suggested for large scale production in char land of Rangpur region under AEZ-3.

Technology 11	:	**A four crop-based cropping pattern: Laishak (mustard green) – Patshak - T. Aus - T. Aman rice suggested for Sylhet region**
Name of the organization	:	Bangladesh Agricultural Research Institute (BARI)
Contact division	:	On-Farm Research Division, BARI, Gazipur 1701
Location of application	:	Surma-kushiyara flood plain under AEZ 20
Key characteristics of the technology	:	• Inclusion of popular vegetable crops after harvesting of T. Aman rice in the existing cropping pattern Fallow-T. Aus-T. Aman rice. • Improved cropping pattern increases rice equivalent yield by 80% over farmers existing pattern. • Improved pattern increases production efficiency and provides higher economic return.
Year of experiment	:	2020-2022

Production guideline

Crop	:	Mustard green	Patshak	T. Aus rice	T. Aman rice
Variety	:	Local	Deshi Patshak-1	BARI dhan48	BARI dhan49
Spacing (cm)	:	30cm x 15 cm	Broadcast	20 cm x 15 cm	25 cm x 15 cm
Sowing/transplanting date	:	12-14 Nov.	3-5 Mar.	22-24 Mar.	21-23 June.
Fertilizer Dose (N-P=K-S-Zn-B kg ha^{-1})	:	210-120-60-40-7-5	40-10-18-10	162-40-60-17-4	158-35-50-22-4
Fertilizer application method	:	Basal and top dressed split application			
Date of harvesting	:	24-27 Feb.	11-13 Apr.	12-14 July	04-06 Nov.
Yield (t ha^{-1})	:				
Leaf		15.57	10.67	-	
Seed		1.14	-	3.82	4.04
Straw		2.47	-	3.89	4.21
REY		20.20	11.13	3.65	4.22
Intercultural operation	:	Weeding was done for rice			
Field duration (days)	:	95-100	35-40	75-80	90-95

Risk involvement in adopting the technology	:	No risk involvement
Impact on environment	:	No harmful effects on environment
Procedure of transfer	:	Block demonstration, farmers training, field day, booklet/leaflet, radio talk, etc.
Expected outcome	:	Economically viable cropping pattern (Mustard green-Patshak-T. Aus-T. Aman rice) will be developed.

Socioeconomic aspects :

Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
907580	300720	606860

Recommendation	:	Mustard green-Patshak-T. Aus-T. Aman rice cropping system is more productive, sustainable and remunerative for medium high land under Eastern Surma Kushiyara Floodplain (AEZ 20). So, farmers of commanding area could follow Mustard green (Local cultivar)-Patshak (Deshi patshak-1)-T. Aus (var. BRRI dhan48)-T. Aman rice (var. BRRI dhan49) cropping pattern for higher productivity and profitability as well as locally popular vegetable (Laishak and patshak) can be a good source of family nutrition.

Technology 12	**:**	**Relay of grass pea (BARI Khesari-3) with T. Aman rice in Tangail**
Name of the organization	:	Bangladesh Agricultural Research Institute
Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701
Location of Application		Tangail region and similar soils of other AEZs
Key characteristics of the technology	:	• Improved variety of grass pea was introduced among the farmers of Char areas of Tangail. • 26 and 41% production and gross margin were increased, respectively compared to the local cultivar. • Production of BARI Khesari-3 has uplifted the socio-economic condition of the farmers' Char areas of Tangail.
Year of the experiment		2021-22
Production guideline	:	
Crop	:	Grass pea (BARI Khesari-3)
Spacing	:	Seeds were broadcasted15-20 days prior to T. Aman harvesting @ 70 kg ha^{-1}
Sowing date	:	First week of November
Harvesting date	:	Third week of March
Fertilizer dose (N kg ha^{-1})	:	10 kg ha^{-1}
Fertilizer application	:	The full dose of Urea was top dressed 30-35 days after seed emergence.
Seed yield (t ha^{-1})	:	1.45
Risk involvement in adopting the technology	:	No risk involvement
Impact on environment	:	No harmful effects on the environment
Procedure of transfer	:	Block demonstration, farmers training, field day booklet/ leaflet, radio talk, etc.
Expected outcome	:	Higher yield, as well as an economic benefit, can be achieved by using BARI Khesari-3.

Socioeconomic aspects :

	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Khesari-3	65750	32550	32700

Recommendation	:	The cultivation of grass pea as relay copping with T. Aman rice created a good impact on the large-scale adoption in the farmers' field. Being high yield potential with a relatively higher economic return, the grass pea variety (BARI Khesari-3) itself has made its suitability as relay cropping in T. Aman rice.

Technology 13	**:**	**Intercropping of onion with groundnut in Chaland of Tangail**
Name of the organization	:	Bangladesh Agricultural Research Institute
Contract division	:	CSO, On-Farm Research Division, BARI, Gazipur 1701
Location of Application		Tangail region and similar soils of other AEZs
Key characteristics of the technology	:	• Most suitable combination of groundnut (100%) and one row of onion in between two rows of groundnut were identified. • Groundnut equivalent yield was increased by about 380% compared to sole groundnut cultivation. • Gross margin increased by 659% compared to sole groundnut cultivation.
Year of the experiment		2021-22
Production guideline	:	
Crop	:	Groundnut (BARI Chinabadam-9) and Onion (Taherpuri)
Spacing	:	Groundnut (40 cm × 15 cm) and Onion (15 cm x 10 cm)
Sowing date	:	First week of November
Harvesting date	:	Second to lastweek of March
Fertilizer dose	:	12-32-43-54-2 kg NPKSB ha^{-1}
Fertilizer application	:	All fertilizers and 2/3rd of Urea were applied during final land preparation and the rest of the Urea was top dressed at two equal installments in between two rows of onion
Yield (t ha^{-1})	:	Groundnut= 1.62, Onion= 9.0 and Groundnut equivalent yield=9.12
Risk involvement in adopting the technology	:	No risk involvement
Impact on environment	:	No harmful effects on the environment
Procedure of transfer	:	Block demonstration, farmers training, field day booklet/ leaflet, radio talk, etc.
Expected outcome	:	Higher yield, as well as an economic benefit,can be achieved by using BARI Chinabadam-9.
Socioeconomic aspects	:	

	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Groundnut (100%) and one row of onion in between two rows of groundnut	547200	107045	440155

Recommendation	:	Groundnut can be successfully intercropped with onion without a significant reduction in the yield of groundnut. Farmers can earn better economic benefits by following the cultivation of one row of onions in between two rows of groundnut.

Technology 14	**Development of alternate cropping pattern Cauliflower-Boro-T. Aman rice against Vegetable-Fallow-T. Aman**		
Name of the Organization	Bangladesh Agricultural Research Institute		
Contract division	On-Farm Research Division, BARI, Narsingdi		
Location of application	Farmers field at Shibpur, Narsingdi.		
Key characteristic of the technology	• Inclusion of Boro which increases cropping intensity and total productivity. • Vegetable- Boro- T. Aman cropping pattern is more profitable than existing cropping pattern Vegetable- Fallow-T. Aman. • Improved cropping pattern increased rice equivalent yield by 39.80% over farmers existing pattern. • Improved pattern increases production efficiency and provides higher economic return.		
Year of the experiment	2019-2021		
Production guideline			
Crop	Cauliflower	Boro rice	T. Aman rice
Varieties	Var-770	BRRI dhan50	BRRI dhan57
Spacing	60cm×45cm	20cm×15cm	20cm×15cm
Sowing date/time	2nd week of November	3rd week of January	Last week of July
Fertilizer doses N-P-K-S-Zn-B kg ha^{-1}	138-40-125-16-0.7-0	130-22-35-10-2.5-0	130-20-30-12-2.5-0
Fertilizer application method	All P, S, Zn should be applied as basal during final land preparation. N and K should be applied at the time of 15, 35 days after transplanting in ring method.	Full dose of P, K, S and Zn should be applied as basal during final land preparation and N should be applied in three equal splits 10, 30, 45 DAT	Full dose of P, K, S and Zn should be applied as basal during final land preparation and N should be applied in three equal splits 10, 30, 45 DAT
Date of harvesting	2nd week of January	2nd week of May	Last week of October
Yield (t ha^{-1})	41.14	5.54	4.45
Intercultural operation	Irrigation, Pest management and other intercultural operations to be done as and when necessary.		
Field duration (days)	65	115	100
Risk involvement in adopting the technology	No risk in adoption or dissemination of the technology		
Impact on environment	No harmful effects on environment		
Procedure of transfer	Block demonstration, Farmers training, Field day, booklet/leaflet etc.		
Expected outcome	Increased yield, improved soil health and cropping intencity		
Socioeconomic aspects	Considering higher yield obtaining treatments		
	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Cauliflower	2,05,700	1,30,000	75,700
Boro	1,15,260	80,250	35,010
T. Aman	99,000	73,210	25,790
Recommendation	The result of experimentation indication that the improved cropping pattern Vegetable-Boro-T. Aman rice is economically profitable rather than existing cropping pattern and recommended to use in place of existing pattern. Rice-Rice-vegetable in Narsingdi region and similar areas of AEZ 9.		

PROGRESS REPORT
2021-22

Project I:
On-Farm Soil Fertility Management

NUTRIENT MANAGEMENT FOR BULB PRODUCTION OF BARI PIAZ-4 UNDER ONION-JUTE-T. AMAN CROPPING PATTERN IN FARIDPUR

S. AHMED AND A. F. M. R. QUDDUS

Abstract

A trial was conducted at the FSRD Site, Sholakundu, Faridpur during the rabi season of two consecutive years (2020-2021 and 2021-2022) to find out an optimum fertilizer packages for sustainable productivity of BARI Piaz-4 under farmers' field condition. Four treatments were considered as T_1 (STB following FRG, 2018)=144-30-47-9-2-0.7 kg N-P-K-S-Zn-B ha^{-1}, T_2 (IPNS basis Recommended Fertilizer Dose with cowdung as per FRG, 2018)=115-53-49-30-3-1.5 kg N-P-K-S-Zn-B ha^{-1} + cowdung (5 t ha^{-1}), T_3 (150% of chemical fertilizer)=210-90-90-45-4.5-2.2 kg N-P-K-S-Zn-B ha^{-1} and T_4 (Farmer's practice)=205-125-100-30-3-1-1.5 kg N-P-K-S-Zn-B-Mg ha^{-1}. The experiment was laid out in randomized complete block design with five dispersed replications. BARI Piaz-4 was used as planting material in the study. The highest average bulb yield (24.28 t ha^{-1}) was obtained from T_4 followed by T_3 (23.37 t ha^{-1}) treatment while the lowest bulb yield (21.61 t ha^{-1}) was recorded in T_2. Consequently, maximum gross return (Tk 509880 ha^{-1}) and gross margin (Tk 301061 ha^{-1}) were also obtained from farmer's practice. Maximum benefit cost ratio was obtained from T_4 (2.44) treatment followed by T_3 (2.38). All these data suggested that T_3 treatment is more sustainable for BARI Piaz-4 production in Faridpur.

Introduction

Onion likes sandy loam to clay loam soil rich in humus and fairly good content of potash. As it has a shallow root system, it needs friable soil enriched with enough plant nutrients and moisture in the upper 10 cm layer. Like tuber and root crops, onion consumes a large amount of potash which is needed to use in the transportation of photosynthates and increasing the bulb size. Farmers use fertilizer irrationally that hamper soil health. Judicial use of fertilizer is necessary conserving soil health. Onion is one of the most important and popular spices crops in Bangladesh. Onion bulb is widely cultivated in this country during rabi season. In Faridpur and Rajbari, total about 52 thousand ha of land is cultivated with onion seedling. BARI has developed BARI Piaz-4 in 2008. Farmers started to cultivate this variety for high yielder than BARI Piaz-1 (17-22 t ha^{-1}) or Taherpuri (12-16 t ha^{-1}). Experimental evidence revealed that the crop was highly responsive to different fertilizers along with organic manure and the yield could be increased remarkably through judicious fertilization. Thus, integrated nutrient management practices applied for onion can contribute to sustainable growth of yield and quality, influences plant health and reduces environmental risks. Use of organic manures with optimum rate of inorganic fertilizers including major and minor elements especially Zinc and Magnesium under intensive farming system increased the turnover of nutrients in the soil plant system. Therefore, the present study was undertaken to determine suitable nutrient package for onion and also to increase sustainable yield of onion bulb production for Faridpur region.

Materials and Methods

The trial was conducted at the FSRD Site, Sholakundu, Faridpur (AEZ 12) during the two consecutive rabi, 2020-21 and 2021-22 to find out optimum fertilizer packages for higher sustainable productivity of BARI Piaz-4 under farmers' field situation. The initial soil analysis of the experimental fields belongs to the Low Ganges River Flood Plain soil under AEZ-12 was shown in Table 1. The soil is neutral in nature and clay loam in texture and medium high land. Total nitrogen content was very low, P, K and B was medium, but S content was optimum.

Table 1. Initial soil status of the experimental field of onion at the FSRD Site, Sholakundu, Faridpur

Item	pH	OM (%)	Total N (%)	K (meq/100g soil)	S (µg/g soil)	Available P	Zn	B
						(ppm)		
Average	6.8	1.9	0.09	0.20	35.0	18.0	0.70	0.45
Interpretation	Neutral	M	VL	M	Opt	M	L	M

MHL: Medium high land, VL: Very low, L: Low, M: Medium, Opt: Optimum

The experiment was laid out in randomized complete block (RCB) design with five dispersed replications. Four treatments were considered as T_1 (STB following FRG, 2018) =144-30-47-9-2-0.7 kg N-P-K-S-Zn-B ha^{-1}, T_2 (IPNS basis Recommended Fertilizer Dose with cowdung as per FRG, 2018)=115-53-49-30-3-1.5 kg N-P-K-S-Zn-B ha^{-1}+cowdung (5 t ha^{-1}), T_3 (150% of chemical fertilizer)=210-90-90-45-4.5-2.2 kg N-P-K-S-Zn-B ha^{-1} and T_4 (Farmer's practice) = 205-125-100-30-3-1-1.5 kg N-P-K-S-Zn-B-Mg ha^{-1}. Soil test-based dose of fertilizers for onion calculated following Fertilizer Recommendation Guide, 2018. Farmers applied all nutrients with Magnesium @1.5 kg ha^{-1}. Onion var. BARI Piaz-4 was used as planting material. The unit plot size was 5m × 3m. The land preparation was done with power tiller operated two-wheeler tractor. Forty-five to Fifty day's old seedlings were transplanted on 29-30 December 2021 to 2-10 January 2022 maintaining 15cm × 10cm spacing. All of organic fertilizer, P, S, Zn and B, and half of N and K was applied as basal during final land preparation. Remaining N and K was applied in two equal splits at 22-25and 39-46 DAT under moist soil condition and mixed thoroughly with the soil. Recommended fertilizer for onion was 140-60-60-30-3-1.5 kg N-P-K-S-Zn-B ha^{-1}. Weeding and mulching was done thrice at 16-20, 36 & 40-57 DAT and the crop land was irrigated four times at pre planting, immediate after planting, 22-25 and 39-46 DAT. Imidacloprid (Imitaf 20 SL@ Auto crop care limited and Confidor 70 WG @ Bayer Crop Science Limited) was sprayed four times at 12-14, 20-22, 38-45, 50-64 DAP and Emamectin Benzoate (Guilder @ Aama Green Care) two times at 62-72, 75-80 DAT for controlling insects. For controlling fungus, two times Iprodione (Rovral 50 WP @ Bayer Crop Science Limited) at 10-14, 38-45 DAT, one-time Difenoconazole (Score 250EC @ Syngenta Bangladesh Limited) at 20-22 DAT, one-time Azoxystrobin (20%) + Difenoconazole (12.50%) group (Amistar Top @ Syngenta Bangladesh Limited) at 50-55 DAT, two times Tebuconazole (50%) +Trifloxystrobin (25%) group (Nativo 75 WP @ Bayer Crop Science Limited) at 65-68, 75-80 DAT were applied. For better crop growth, one-time Fulvic acid-based PGR (crop plus @ Haychem) at 38-42 DAT were also applied. The crop was harvested on 28 March -3 April during the study period. Data on yield contributing characters and yield were collected during maturity stage. The collected data were analyzed through R software and the means were separated by DMRT.

Results and Discussions

Yield attributes and bulb yield of onion was influenced by different fertilizer packages during 2020-21 and 2021-22 was presented in Table 2, 3 and 4. Fertilizer packages exerted significant influence on yield attributes except no. of leaves plant^{-1}, % of bolted bulb & no. of bulb per m^2 and bulb yield. The highest average plant height (55.56 cm) was recorded in farmers practice (T_4). The lowest plant height (52.22 cm) was recorded in Soil Test based treatment (T_1). Average number of leaves per plant was ranged between 5.48 (T_2) to 5.68 (T_4). Base diameter was found higher during 2021-22 than that of 2020-21. The highest (3.99 cm) average base diameter was obtained from farmer's practice (T_4) followed by T_3 where 150% RFD was applied. The lowest average base diameter was 3.57 cm which was found from T_1 treatment. The highest average % of bolting bulb (1.26%) was calculated from T_3 and lowest from T_1. Number of average bulbs m^{-2} was ranged between 72.67 (T_2) to 73.61 (T_4). The highest average weight of single bulb (32.56 g) was observed in T_4. The lowest average weight of single bulb was noted in T_2 (29.26 g). Extra application of chemical fertilizer especially P, K and Mg in farmer's practice exhibited relatively higher single bulb weight that may enhance optimum bulb growth and development as compared with other treatments. The bulb yield was varied in 2020-21 and 2021-22 due to varying of transplanting time. Because days earlier transplanting help to increase vegetative growth of onion plant. However, the maximum average bulb yield (24.28 t ha^{-1}) was obtained from T_4 followed by T_3 (23.37 t ha^{-1}). The lowest bulb yield (21.61 t ha^{-1}) was recorded in T_2. Relatively higher base diameter, number of bulb m^{-2} and single bulb weight may probably reason for increasing higher bulb yield in Farmer's practice (T_4).

Consequently, maximum average gross return (Tk. 509880 ha^{-1}) and gross margin (Tk. 301061 ha^{-1}) were obtained from farmer's practice (Table 5), but benefit cost ratio was calculated from T_4 (2.44) followed by T_3 (2.38).

Farmers' opinion

Farmers were happy and quite convinced to use optimum fertilizer in terms of yield and cost-benefit ratio.

Table 2. Bulb yield and yield attributes of onion as influenced by fertilizer management at the FSRD site, Faridpur during the *rabi* season of 2021-22

Treatments	Plant height (cm)	Leaves plant^{-1} (no.)	Base diameter (cm)	Bolted bulb (%)	Bulbs m^{-2} (Nos)	Single bulb wt. (g)	Bulb yield (t ha^{-1})
T_1 (STB)	55.28 b	5.52 a	3.63 b	1.39 a	73.66 a	32.14b	23.66 b
T_2 (IPNS basis RFD)	55.20 b	5.36 a	3.77 b	1.63 a	72.42 a	32.11 b	23.11 b
T_3 (150% RFD)	57.36 ab	5.24 a	4.07 a	1.88 a	73.92 a	35.46 a	26.24 a
T_4 (Farmer's practice)	57.84 a	5.44 a	4.08 a	1.44 a	72.58 a	36.64 a	26.60 a
CV (%)	3.04	5.24	3.02	22.64	3.38	5.57	4.41

Table 3. Bulb yield and yield attributes of onion as influenced by fertilizer management packages at FSRD site, Faridpur during the *rabi* season of 2020-21

Treatments	Plant height (cm)	Leaves plant^{-1} (no)	Base diameter (cm)	Bolted bulb (%)	Bulbs m^{-2} (no)	Single bulb wt. (g)	Bulb yield (t ha^{-1})
T_1 (STB)	49.16b	5.52	3.50c	0.51	73.27a	26.68 ab	19.90b
T_2 (IPNS basis RFD)	50.68b	5.60	3.70b	0.52	72.92a	26.41b	20.10b
T_3 (150% RFD)	52.84a	5.84	3.76b	0.63	72.82a	27.23ab	20.50b
T_4 (Farmer's practice)	53.28a	5.92	3.90a	0.50	74.63a	28.48a	21.95a
CV (%)	2.49	5.24	2.33	78.05	4.56	5.18	4.51

T_1 (STB following FRG, 2018) = $N_{144} P_{30} K_{47} S_9 Zn_2 B_{0.7}$ kg ha^{-1}, T_2 (IPNS basis Recommended Fertilizer Dose with cowdung as per FRG, 2018) = $N_{115} P_{53} K_{49} S_{30} Zn_3 B_{1.5}$ kg ha^{-1}+ cowdung (5 t ha^{-1}), T_3 (150% of RFD) = $N_{210} P_{90} K_{90} S_{45} Zn_{4.5} B_{2.2}$ kg ha^{-1} and T_4 (Farmer's practice) = $N_{205} P_{125} K_{100} S_{30} Zn_3 B_1 Mg_{1.5}$ kg ha^{-1}

Table 4. Cost and returns analysis of onion as influenced by fertilizer management package at the FSRD site, Faridpur during 2020-21 and 2021-22 ((average of 2 years)

Treatment	Bulb yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BC R
T_1 (STB)	21.78	457380	188338	269043	2.43
T_2 (IPNS basis RFD)	21.61	453810	202689	251121	2.24
T_3 (150% RFD)	23.37	490770	206234	284537	2.38
T_4 (Farmer's practice)	24.28	509880	208820	301061	2.44

Price of average input (Tk kg^{-1}): Urea: 16.00, TSP: 22.00, MoP: 15.00, Gypsum: 10.00, Zinc: 200.00, Boron: 240.00, seed: 3000.00
Output price (Tk kg^{-1}): Onion bulb: 21.00 (average of Y1-25.00, Y2-17.00)

Conclusion

In average of two years, the highest bulb yield (24.28 t ha^{-1}) and BCR 2.44) were obtained with farmers fertilizers package. The study recommended $N_{205}P_{125}K_{100}S_{30}Zn_3B_1Mg_{1.5}$ kg ha^{-1}fertilizer package for onion production (BARI Piaz-4) in Faridpur.

INTEGRATED NUTRIENT MANAGEMENT FOR BITTER GOURD CULTIVATION IN CALCAREOUS SOIL IN FARIDPUR

S. AHMED AND A. F. M. R. QUDDUS

Abstract

A trial was conducted at the FSRD Site, Sholakundu, Faridpur during the kharif I, 2020 and 2021 to find out a suitable nutrient package and to increase sustainable yield of bitter gourd under farmers' field situation. BARI Korola-2 was used as planting material in the study. The experiment was laid out in randomized complete block (RCB) design with three dispersed replications. Seven (7) treatments were considered as T_1 (Soil Test Based (STB) following

FRG, 2018)=80-25-25-5-1-1.5 kg N-P-K-S-Zn-B ha^{-1}, T_2 (120% of STB)=69-30-30-6-1.2-0.6 kg N-P-K-S Zn-B ha^{-1}, T_3 (IPNS basis T_1 with Cowdung) =55-18-14-5-1-0.5 kg N-P-K-S-Zn-B ha^{-1}+cowdung (5 t ha^{-1}), T_4 (IPNS basis T_1 with vermicompost)=55-40-4-13-1-0.5 kg N-P-K-S-Zn-B ha^{-1} + vermicompost (2 t ha^{-1}), T_5 (T_1 + 8 kg ha^{-1} Mg)=80-25-25-5-1-0.5-8 kg N-P-K-S-Zn-B-Mg ha^{-1}, T_6 (T_1 + 10 kg ha^{-1} Mg)=80-25-25-5-1-0.5-10 kg N-P-K-S-Zn-B-Mg ha^{-1} and T_7 (Farmer's practice)=115-50-50-45-4-2 kg N-P-K-S-Zn-B ha^{-1}. The highest average fruit yield was obtained from farmers practice treatment, T_7 (14.37 t ha^{-1}) for cumulative effect of the highest yield contributing parameters followed by STB dose with 8 kg ha^{-1} Mg treatment, T_5 (13.87 t ha^{-1}). The lowest average fruit yield was obtained from T_4 (8.19 t ha^{-1}). The maximum average gross return (Tk. 592763 ha^{-1}) and gross margin (Tk.392113 ha^{-1}) were obtained from farmer's practice followed by T_5. But the highest average benefit cost ratio was calculated from T_5 (2.99) followed by T_7 (2.95). The chemical fertilizer dose used in farmers practice treatment (T_7) was many times higher than all treatments that was irrational and may harmful to environment whereas treatment, T_5 (T_1 + 8 kg ha^{-1} Mg) = 80-25-25-5-1-0.5-8 kg N-P-K-S-Zn-B-Mg ha^{-1}) gave the statistically similar fruit yield for both the years against of farmers treatment (T_7) with rational use of fertilizer and reducing production cost.

Introduction

Bitter gourd (*Momordica charantia* L) is one of the most important and popular vegetable crops in Bangladesh (Nasreen *et al.,* 2013). It is popular due to its nutritive and medicinal values (Nadkarni, 1982). It is rich in vitamin C (88 mg/100g) (Akter *et al.*, 2009). Bitter gourd is widely cultivated in this country during kharif season. The fruit is a good source of iron, calcium, phosphorus and vitamin B. The crop yield in Bangladesh is generally low. The lower productivity of this vegetable mainly due to lack of high yielding varieties, its cultivation with inadequate nutrients and also continuous and imbalance use of inorganic fertilizer deteriorates soil health. Experimental evidence revealed that the crop was highly responsive to different fertilizers along with organic manure and the yield could be increased remarkably through judicious fertilization. Thus, integrated nutrient management practices applied for bitter gourd can contributes to sustainable growth of yield and quality, influences plant health and reduces environmental risks. Use of organic manures with optimum rate of inorganic fertilizers including major and minor elements especially zinc and magnesium under intensive farming system increased the turnover of nutrients in the soil plant system. Thus, the present study was undertaken to determine suitable nutrient package for bitter gourd and to increase sustainable yield of bitter gourd.

Materials and Methods

The trial was conducted at the FSRD Site, Sholakundu, Faridpur during the kharif I, 2020 and kharif II, 2021 to determine suitable nutrient package for bitter gourd and to increase sustainable yield of bitter gourd. The initial soil analysis of the experimental fields belongs to the Low Ganges River Flood Plain soil under AEZ-12 and nutrient status of cowdung and vermicompost were shown in Table 1a and 1b. The soil is slightly alkaline in nature clay loam in texture and medium high land. Total nitrogen content was very low, P & Zn were Low, and K & Mg was medium. S & B content were optimum. Ca was shown very high value.

Table 1a. Initial soil status of the experimental field of bitter gourd at the FSRD Site, Sholakundu, Faridpur

Item	pH	OM (%)	Total N (%)	S (µg/g soil)	Available P	Zn	B	K	Ca	Mg
					(ppm)			(meq/100g soil)		
Av	8.3	1.9	0.081	23.10	15.0	0.78	0.60	0.22	14.4	0.76
Interpretation	Slightly alkaline	M	VL	Opt	L	L	Opt	M	VH	M

MHL: Medium high land, VL: Very low, L: Low, M: Medium, opt: Optimum, VH: Very High

Table 1b. Nutrient status of cowdung and vermicompost

Item	N	P	K	S
Vermicompost	1.24	2.00	1.06	0.87
Cowdung	1.00	0.30	0.50	0.40

The experiment was laid out in randomized complete block (RCB) design with three dispersed replications. Seven treatments were considered as T_1 (Soil Test Based (STB) following FRG, 2018)=80-25-25-5-1-1.5 kg N-P-K-S-Zn-B ha^{-1}, T_2 (120% of STB)=69-30-30-6-1.2-0.6 kg N-P-K-S Zn-B ha^{-1}, T_3 (IPNS basis T_1 with Cowdung) =55-18-14-5-1-0.5 kg N-P-K-S-Zn-B ha^{-1}+cowdung (5 t ha^{-1}), T_4 (IPNS basis T_1 with vermicompost) = 55-40-4-13-1-0.5 kg N-P-K-S-Zn-B ha^{-1} + vermicompost (2 t ha^{-1}), T_5 (T_1 + 8 kg ha^{-1} Mg) = 80-25-25-5-1-0.5-8 kg N-P-K-S-Zn-B-Mg ha^{-1}, T_6 (T_1 + 10 kg ha^{-1} Mg) = 80-25-25-5-1-0.5-10 kg N-P-K-S-Zn-B-Mg ha^{-1} and T_7 (Farmer's practice) =115-50-50-45-4-2 kg N-P-K-S-Zn-B ha^{-1}. Soil test based (STB) dose of fertilizers for bitter gourd calculated following Fertilizer Recommendation Guide 2018. Bitter gourd var. BARI Korola-2 was used as planting material. The unit plot size was 3.75 m × 2 m and spacing was 1.25 m × 1.25m. The crop management practices used for conducting research is shown in Table 2. Fertilizers were applied according to treatments. All of Organic fertilizer, P, K, S, Zn, B and Mg was applied in pit 5-7 days before planting and mixed thoroughly with the soil. N was applied around the plant as side dressing at 21-22, 43-45 and 64-66 DAS and mixed thoroughly with the soil as soon as possible for better utilization. For controlling insect and disease, Pegasus @ 1ml L^{-1} of water for two times at 49-51 & 72-74 DAS and Autostin @ 2.5 ml L^{-1} of water two times at 26, 44 and Ridomil gold @ 2 g lt^{-1} at 58 and 78 DAS were sprayed. Other intercultural operations and plant protection measures were taken as and when required. Fruit was harvested ten times for two and half months (starts at 65 and ends at 142 DAS) during first year. But, in second year, fruit was harvested six times due to heavy rainfall occurred at growing season (a total of 1300 mm rainfall) resulting damage of plants and hampered pollination. Data on yield and yield contributing characters were recorded and analyzed statistically with R software and the means were separated by DMRT (Gomez and Gomez, 1984).

Table 2. Crop management practices of BARI Korola-2 in Faridpur

Year	Date of seed sowing	Irrigation (DAS)	Weeding and mulching (DAS)	Rainfall (mm)	Harvesting time
2020	19 May 2020	26-28 and 44-45	21-22, 43-45 and 64-66	579	Ten times: 23 July 2020 to 8 October 2020 ((65-142 DAS)
2021	9 May 2021			1300	Six times: 25 July 2021 to 2 September 2021 (78-117 DAS)

Results and Discussions

Yield attributes and fruit yield of bitter gourd as influenced by different fertilizer packages during kharif I, 2020, kharif I, 2021. Fertilizer packages exerted significant influence on yield attributes of bitter gourd. The number of average final plant population m^{-2} was ranged between 0.75 to 0.80. Different number of plant population observed under different treatments due to might be germination of seed. During Kharif I 2020, number of fruits plant^{-1} ranged between 37.33 to 53.67 but during kharif I 2021, the range was 18 to 33.33 due to might be heavy rainfall (1300 mm rainfall) throughout growing period. The statistically highest number of fruits plant^{-1} (53.67 for 2020 and 33.33 for 2021) was observed from farmers practice (T_7) which was similar with T_5 where additional 8 kg ha^{-1} Mg with STB dose was used. The average highest number of fruits plant^{-1} (43.50) was recorded from T_7 treatment. During first year, the s maximum t single fruit weight was obtained from T_7 (48.20 g) followed by T_5 (45.77 g). But, during second year, the maximum single fruit weight was obtained from T_6 (43.03 g) which was similar with other treatments except T_4. Thus, the average highest single fruit weight (44.04g) was calculated from T_7. Excess application of chemical fertilizer (about 44% of N, 100% of P & K, 180% of S, 250% of Zn and 300% of B) in farmer's practice (T_7), enhanced the fruit yield of bitter gourd only 4% as compared to treatment, T_5 where Mg was used along with STB dose. Due to heavy rainfall occurred at growing season (especially 464 mm and 359 mm during July and August, respectively) of second year resulting fruit and plant damage, fruit yield was lower than that of first year result. The average maximum gross return (Tk. 592763 ha^{-1}) and gross margin (Tk. 392113 ha^{-1}) were obtained from farmer's practice (Table 4), but the highest benefit cost ratio (BCR) was calculated from T_5 (2.99) followed by T_7 (2.95).

Postharvest soil analysis: The soil is slightly alkaline in nature and clay loam in texture. Decreased nutrient status was observed in organic matter and P (T_2, T_4 to T_7) whereas higher status was observed in K, S, Zn, B (in treatment T_1, T_5 and T_6, value was lower than initial), Ca and Mg. Same trend was showed in N.

Farmers' opinion

Farmers were happy to obtain higher yield using relatively lower fertilizer and quite convinced to follow STB dose with 8 kg ha^{-1} Mg. The fruit color was greener and more attractive where Mg used and obtaining higher market price than others.

Table 6. Post-harvest soil of the experimental field of bitter gourd

Treatment	pH	OM (%)	Total N (%)	P (ppm)	K (meq/ 100g soil)	S (µg/g soil)	Zn	B	Ca	Mg
							(ppm)		(meq/ 100g soil)	
T_1	7.5	1.3	0.07	14	0.25	22	1	0.56	18.5	3.4
T_2	8	1.3	0.07	10	0.32	26	0.9	0.66	18.2	3.3
T_3	8.1	1.3	0.07	16	0.34	26	0.7	0.67	17.6	3.2
T_4	8.1	1.3	0.07	9	0.37	34	0.8	0.74	18	3.3
T_5	8.2	1.2	0.06	8	0.25	32	0.9	0.24	17.8	3.2
T_6	8.1	1.2	0.06	6	0.25	38	1	0.52	17.8	3.2
T_7	7.8	1.4	0.07	17	0.33	37	0.8	0.98	16.2	3
Av	7.97	1.29	0.07	11.43	0.30	30.71	0.87	0.62	17.73	3.23
	Slightly alkaline	L	VL	L	Opt	H	L	H	VH	VH

T_1 (Soil Test Based (STB) following FRG, 2018)=80-25-25-5-1-1.5 kg N-P-K-S-Zn-B ha^{-1}, T_2 (120% of STB)=69-30-30-6-1.2-0.6 kg N-P-K-S Zn-B ha^{-1}, T_3 (IPNS basis T_1 with Cowdung) =55-18-14-5-1-0.5 kg N-P-K-S-Zn-B ha^{-1}+cowdung (5 t ha^{-1}), T_4 (IPNS basis T_1 with vermicompost)=55-40-4-13-1-0.5 kg N-P-K-S-Zn-B ha^{-1} + vermicompost (2 t ha^{-1}), T_5 (T_1 + 8 kg ha^{-1} Mg)=80-25-25-5-1-0.5-8 kg N-P-K-S-Zn-B-Mg ha^{-1}, T_6 (T_1 + 10 kg ha^{-1} Mg)=80-25-25-5-1-0.5-10 kg N-P-K-S-Zn-B-Mg ha^{-1} and T_7 (Farmer's practice)=115-50-50-45-4-2 kg N-P-K-S-Zn-B ha^{-1}

Table 3. Yield and yield attributes of bitter gourd as influenced by fertilizer management packages at FSRD site, Faridpur during the *kharif* season of 2020

Treatment	Final plant popn m^{-2} (no)	Fruits plant^{-1} (no)	Single fruit wt. (g)	Fruit wt. plant^{-1} (kg)	Fruit yield (t ha^{-1})
T_1: (STB)	0.77 ab	38.00 a	45.17 ab	1.69 c	12.76 bc
T_2: (120% STB)	0.73 ab	46.33 ab	45.53 ab	2.11 b	15.15 ab
T_3:(IPNS T_1 with 5 t ha^{-1} Cowdung)	0.77 ab	37.33 b	45.13 ab	1.68 c	12.85 bc
T_4:(IPNS T_1 with 2 t ha^{-1} vermicompost)	0.70 b	37.33 b	40.07 b	1.60 c	11.67 c
T_5: (T_1 + 8 kg ha^{-1} Mg)	0.80 a	47.67 a	45.77 ab	2.47 a	17.84 a
T_6: (T_1 + 10 kg ha^{-1} Mg)	0.70 b	52.00 a	44.20 ab	2.13 b	15.37 ab
T_7: (Farmers practice)	0.73 ab	53.67 a	48.20 a	2.57 a	18.09 a
CV (%)	5.99	12.17	9.10	8.89	13.14

Table 4. Yield and yield attributes of bitter gourd as influenced by fertilizer management packages at FSRD site, Faridpur during the *kharif* season of 2021

Treatment	Final plant popn m^{-2} (no)	Fruits plant^{-1} (no)	Single fruit wt. (g)	Fruit wt. plant^{-1} (kg)	Fruit yield (t ha^{-1})
T_1 (STB)	0.8	19.66 e	40.80 ab	0.80 bc	6.40 bc
T_1: (STB)	0.8	23.66 cd	38.33 ab	0.91 b	7.33 b
T_2: (120% STB)	0.8	21.33 de	37.00 ab	0.78 bc	6.31 bc
T_3:(IPNS T_1 with 5 t ha^{-1} Cowdung)	0.8	18.00 e	33.50 b	0.58 c	4.71 c
T_4:(IPNS T_1 with 2 t ha^{-1} Vermicompost)	0.8	30.66 ab	40.16 ab	1.23 a	9.91 a
T_5: (T_1 + 8 kg ha^{-1} Mg)	0.8	27.33 bc	43.03 a	1.15 a	9.25 a
T_6: (T_1 + 10 kg ha^{-1} Mg)	0.8	33.33 a	39.87 ab	1.29 a	10.65 a
T_7: (Farmers practice)	--	8.37	11.62	12.85	12.48

Conclusion

Two-year result showed that, the average highest fruit yield (14.37 t ha^{-1}) was obtained from farmer's treatment, T_7 (115-50-50-45-4-2 kg N-P-K-S-Zn-B ha^{-1}) but it was identical to 80-25-25-5-1-0.5-8 kg N-P-K-S-Zn-B-Mg ha^{-1}) in terms of yield (13.87 t ha^{-1}), soil nutrient status and benefit cost ratio (2.99).

EFFECT OF VARIETY AND FERTILIZER OF ONION BULB PRODUCTION UNDER ZERO TILLAGE CONDITION IN ONION-JUTE/B.AMAN CROPPING PATTERN IN SHARIATPUR

S. AHMED AND A. F. M. R. QUDDUS

Abstract

An experiment was carried out at farmer's field of Uttar Dubaldia under Jajira upazila, Shariatpur during the rabi season of 2019-2020 to 2020-2021 to select a suitable variety and to find out fertilizer dose for bulb production of onion under zero tillage condition. Six treatments i.e., T_1: BARI Piaz-1 + Soil Test Based Fertilizer Dose, T_2: BARI Piaz-1 + 150% STB, T_3: BARI Piaz-1 + Farmer's fertilizer dose, T_4: Local variety + Soil Test Based Fertilizer Dose, T_5: Local variety + 150% STB and T_6: Local variety + FFD were used. The experiment was design with randomized complete block with 4 dispersed replications. The highest bulb yield (17.91 t ha^{-1}) was obtained from T_4 followed by T_5 (16.72 t ha^{-1}). While the lowest bulb yield was found in T_2 treatment (15.08 t ha^{-1}). The highest gross return (Tk 1035100 ha^{-1}) and gross margin (Tk 735388 ha^{-1}) were accounted from T_4 due to obtain the highest yield. However, application of STB dose (120-60-80-25-3-1.5 kg N-P-K-S-Zn-B ha^{-1}) with local variety appeared as the best suitable combination of fertilizer for higher and economically profitable yield of bulb onion production under zero tillage condition in Shariatpur region.

Introduction

Zero tillage is a type of conservation tillage where minimal soil disturbance, surface cover through crop residue retention and diverse associations happened (Hobbs *et al*., 2008; Kassam *et al., 2009*). It also helps in reducing the costs of production, saving time, increasing yield through timely planting. In the district of Madaripur and Shariatpur, farmers normally practice dibbling of the onion bulb in moist soil with maintaining spacing after harvesting of T. Aman rice when flood water recedes. They do not use Soil Test Based chemical fertilizers doses resulting poor bulb yield. Hence, the present study was undertaken to find out suitable variety and fertilizer dose for increasing bulb yield of onion.

Materials and Methods

The experiment was carried out at Zajira, Shariatpur during the *rabi,* 2019-2020 and 2020-21 to find out suitable variety and fertilizer dose for increasing bulb yield of onion under zero tillage condition. It was laid out in RCB design with 4 dispersed replications. The initial soil analysis of the experimental fields belongs to the Low Ganges River Flood Plain soil under AEZ-12 is shown in Table 1. The soil is slightly alkaline in nature and clay loam in texture. Nitrogen and Phosphorus content was very low and S, Zn & B was low. K was medium. Six treatments i.e., T_1: BARI Piaz-1 + Soil Test Based Fertilizer Dose (STB), T_2: BARI Piaz-1 + 150% STB, T_3: BARI Piaz-1 + Farmer's fertilizer dose (FFD), T_4: Local variety + Soil Test Based Fertilizer Dose (STB), T_5: Local variety + 150% STB and T_6: Local variety + Farmer's fertilizer dose (FFD) was used. Farmer's used local variety. The soil test based fertilized dose was 120-60-80-25-3-1.5 kg N-P-K-S-Zn-B ha^{-1} and farmer's dose was 250-106-163-4-0-10 kg N-P-K-S-Zn-B ha^{-1} received from the source of urea, DAP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. All fertilizers were applied before bulb transplanting. The unit plot size was 5m × 4m with plant spacing 20 cm x 10 cm. The bulb was transplanted on 17 November 2019 and 12 November 2020. The crop was harvested on 17 February 2020 (90 days after planting) and 23 February 2021 (103 DAT). Data on yield and yield contributing parameters were recorded and analyzed statistically through R software and mean separation was done using DMRT value.

Table 1. Chemical properties of Initial soil of the experimental field of onion in Shariatpur

Item	pH	OM (%)	Total N (%)	K (meq/ 100gsoil)	S (µg/g soil)	Available P	Zn	B
						(ppm)		
Av. value	7.7	1.9	0.10	0.17	14.0	5.80	0.90	0.20
Interpretation	Slightly alkaline	M	VL	M	L	VL	L	L

Results and Discussions

Plant height and bulb diameter showed significant in 2019-20 but bulb diameter showed non-significant in 2020-21 (Table 2 & 3). For both the years, the highest plant height was observed from the treatment where farmer's fertilizer dose (FFD) was used (56.37 cm during 2020-21 and 60.25 cm during 2019-20). The maximum number of bulbs per m^2 (48.50 in 2020-21 and 57.25 in 2019-20) was found from T_4 where farmer's variety with soil test-based fertilizer dose (STB) was used. The lowest average number of bulbs per m^2 was found from T_3 (48.37). The range of bulb yield of 2020-21 (17.88 t ha^{-1} to 23.09 t ha^{-1}) found higher than that of 2019-20 (11.78 t ha^{-1} to 12.74 t ha^{-1}). For both the years, the bulb yield was obtained from the treatment where 150% STB dose was used (T_2 and T_5). Thus, in 2020-21, the lowest yield was obtained from T_2 (17.88 t ha^{-1}) and in 2019-20, T_5 gave the lowest bulb yield (11.78 t ha^{-1}).

In cost and return analysis, Table 5 reveals that, total variable cost of all the treatment was varied due to variability of seed bulb price (70-105 Tk. kg^{-1} for BARI Piaz-1 and 90-105 Tk. kg^{-1} for local cultivar), fertilizer dose and harvesting cost. The average highest gross return (Tk.1035100 ha^{-1}) and gross margin (Tk.735388 ha^{-1}) were accounted from T_4 due to obtain the highest bulb yield. The average lowest gross margin (Tk. 584275 ha^{-1}) was obtained from that treatment (T_2) where BARI Piaz-1 and 150% of STB was used. It may be due to the negative response of overuse of chemical fertilizer whereas STB fertilizer dose T_4 gave the highest bulb yield as a suitable combination of chemical fertilizer with variety.

Postharvest soil analysis: The soil is slightly alkaline in nature and clay loam in texture. Increased nutrient status was observed in organic matter, P, K, S (T_1 to T_3 it was lower than initial analysis), Zn, B. Same trend was showed in N.

Farmers' opinion

Farmers were interested to produce bulb production using local variety with Soil Test Based fertilizer dose. Farmers realized that excess fertilizer increase production cost but reduce yield and benefit.

Table 2. Chemical properties of average post-harvest soil of the experimental field of onion in Shariatpur

Treatment	pH	OM (%)	Total N (%)	K (meq/ 100g soil)	S (µg/g soil)	Available P	Zn	B
						(ppm)		
T_1	7.9	2.06	0.1	0.41	10	47	2.12	0.28
T_2	7.9	1.91	0.1	0.51	13	41	2.15	0.42
T_3	7.8	2.43	0.13	0.61	12	39	2.14	0.38
T_4	7.7	2.25	0.12	0.64	17	38	2.16	0.46
T_5	7.7	2.18	0.11	0.59	18	43	2.15	0.34
T_6	7.8	1.99	0.1	0.58	18	40	2.13	0.54
Average	7.8	2.14	0.11	0.56	14.67	41.33	2.14	0.40
Interpretation	Slightly alkaline	M	VL	VH	L	VH	H	M

T1: BARI Piaz-1 + Soil Test Based Fertilizer Dose (STB), T2: BARI Piaz-1 + 150% STB, T3: BARI Piaz-1 + Farmer's fertilizer dose (FFD), T4: Local variety + Soil Test Based Fertilizer Dose (STB), T5: Local variety + 150% STB and T6: Local variety + Farmer's fertilizer dose (FFD)

Table 3. Bulb yield and yield components of onion bulb production during 2020-2021

Treatments	Plant height (cm)	Bulb m^{-2} (no)	Bulb diameter (mm)	Yield (t ha^{-1})
T_1	50.30 b	46.50 ab	38.05	19.63 ab
T_2	51.90 b	46.00 ab	41.06	17.88 b
T_3	50.80 b	45.75 b	39.41	19.41 ab
T_4	53.00 ab	48.50 a	39.35	23.09 a
T_5	53.46 ab	45.50 b	39.88	21.66 ab
T_6	56.37 a	47.25 ab	41.95	20.94 ab
CV (%)	4.35	3.63	13.30	13.26

Table 4. Bulb yield and yield components of onion bulb production during 2019-2020

Treatments	Plant height (cm)	Bulb m^{-2} (no)	Bulb diameter (mm)	Yield (t ha^{-1})
T_1	54.40 b	52.50	29.63 ab	12.61
T_2	55.45 b	51.00	26.62 b	12.29
T_3	60.25 a	51.00	27.38 b	12.71
T_4	55.52 b	57.25	32.72 a	12.74
T_5	56.91 ab	53.25	29.36 ab	11.78
T_6	59.65 a	56.75	31.38 a	12.25
CV (%)	4.31	8.38	7.69	10.89

T_1: BARI Piaz-1 + Soil Test Based Fertilizer Dose (STB) (120-60-80-25-3-1.5 kg, N-P-K-S-Zn-B ha^{-1}), T_2: BARI Piaz-1 + 150% STB (180-90-120-38-4.5-2.25 kg, N-P-K-S-Zn-B ha^{-1}), T_3: BARI Piaz-1 + Farmer's fertilizer dose (FFD) (250-106-163-4 kg, N-P-K-Zn ha^{-1}), T_4: Local variety + Soil Test Based Fertilizer Dose (STB) ((120-60-80-25-3-1.5 kg, N-P-K-S-Zn-B ha^{-1}), T_5: Local variety + 150% STB (180-90-120-38-4.5-2.25 kg, N-P-K-S-Zn-B ha^{-1}), T_6: Local variety + Farmer's fertilizer dose (FFD) (250-106-163-4 kg, N-P-K-Zn ha^{-1})

Table 5. Cost and return analysis of onion bulb production during 2019-2020 and 2020-2021 (avr. of 2 yrs).

Treatments	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
T_1	16.12	960050	318017	642033
T_2	15.08	910650	326375	584275
T_3	16.06	960150	325646	634504
T_4	17.91	1035100	299712	735388
T_5	16.72	963300	308070	655230
T_6	16.59	970050	307341	662709

Conclusion

The study concludes that local onion variety gave the highest and economically profitable yield at 120-60-80-25-3-1.5 kg N-P-K-S-Zn-B ha^{-1}, respectively under zero tillage condition.

PERFORMANCE OF WATER HYACINTH RESIDUE AS AN ORGANIC MANURE FOR CAULIFLOWER PRODUCTION AT AEZ-14

M. M. HOWLADER

Abstract

The experiment was conducted at FSRD site, Gopalganj and Nazirpur, Pirojpur during rabi season 2021-22 to determine the amount of residue of water hyacinth as an organic source for production of cauliflower. There are four doses of different organic fertilizer viz. T_1= 5 t cowdung ha^{-1} (control) T_2=5 t water hyacinth residue ha^{-1}, T_3=8 t water hyacinth residue ha^{-1}, T_4=11 t water hyacinth residue ha^{-1} as treatment. Result revealed that treatment T_1 gave the maximum yield (44.69 t ha^{-1}) where 5 t cowdung ha^{-1} used as organic fertilizer followed by T_4 treatment (43.28 t ha^{-1}) where water hyacinth (11 t ha^{-1}) was used with recommended chemical fertilizer. The lowest yield (34.03 t ha^{-1}) was observed in T_2 treatment where 5 t ha^{-1} residue of water hyacinth was applied. The highest gross return (Tk. 893800 ha^{-1}) and BCR (3.61) were found from T_1 were used 5 t cowdung ha^{-1} as an organic fertilizer which followed

by T_4 treatment where residue of water hyacinth was used 11 t ha^{-1} and its gross return, BCR were Tk. 865600 $ha^{-1}$and 3.5, respectively.

Introduction

Farmers use fertilizer irrationally that hamper soil health. Judicial use of fertilizer is necessary for conserving soil health, but it is very difficult to maintain for deficit of organic manure like cowdung. The residue of water hyacinth is more available in Gopalganj region which can be used as alternate source of cowdung. Water hyacinth residue is the de composed of water hyacinth. Already, farmers of this region use this residue as alternate source of organic manure for vegetable production. But till to now they have no idea actually how much residue need for a unit land area for vegetable production. Thus, the present study was taken to determine suitable amount of water hyacinth residue for vegetable production.

Materials and Methods

The experiment was conducted at FSRD site, Gopalganj and Nazirpur, Pirojpur during *rabi* season 2021-2022 to determine the amount of residue of water hyacinth as an organic source for production of cauliflower. The experiment was laid out in RCBD design with six replications allocating three dose of water hyacinth residue with 5 t cowdung (control) per hectare viz. T_1=RDCF (Recommended dose of chemical fertilizers) + 5 t cowdung ha^{-1} (control), T_2=RDCF + 5 t water hyacinth residue ha^{-1}, T_3=RDCF + 8 t water hyacinth residue ha^{-1}, T_4=RDCF + 11 t water hyacinth residue ha^{-1}. The unit plot size was 4m × 4m. The initial soil of the experimental field was analyzed, and the analysis results were given in Table 1. The land was fertilized with organic fertilizer (as per treatment) 60-30-50-12-1.2-1 kg, N-P-K-S-Zn-B ha^{-1}. Seedling were transplanting on 27 and 30 November 2021 with 60cm × 40cm spacing. Half of N fertilizer and full dose of others fertilizer were applied as basal and remaining N was top dressed at 15, 30 and 45 days after transplanting. All the intercultural operations were done as and when necessary. The crop was harvested on 27 January to 12 February 2022. Data on yield and yield contributing characters were taken and statistically analyzed with MSTAT-C software.

Table 1. Initial soil nutrient status of experiment field at Gopalganj and Pirojpur district during *rabi* season in 2021-2022

Location	pH	OM	Ca	Mg	K	Total N	P	S	B
		(%)	(meq/100g)			(%)	(ppm)		
Sadar, Gopalganj	6.09	6.19	17.8	1.46	0.046	0.33	6.0	31	0.30
Nazirpur, Pirojpur	7.2	4.5	10.6	3.21	0.093	0.22	5.7	26	0.28

Results and Discussions

A significant variation was found in different dose of organic fertilizer (Table 2). The maximum plant height (51.18 cm) was found from RDCF with 5 t cowdung ha^{-1} (T_1) but statistically similar height with T_4 treatment (49.95 cm). The lowest plant height (40.78 cm) was recorded from treatment T_2. Curd length, curd diameter and single curd weight was found highest from the same treatment (T_1) which was 14.47cm, 20.61 cm and 1.66 kg, respectively but similar to T_4 treatment (13.93cm, 19.15cm and 1.61kg, respectively). The lowest curd length, diameter and single curd weight was found from T_2. The treatment T_1 gave the highest bulb yield (44.69 t ha^{-1}) which gave highest plant height, curd length, curd diameter and single curd weight but bulb yield of treatment T_4 (43.28 t ha^{-1}) was statistically similar of T_1. The lowest bulb yield (34.03 t ha^{-1}) was recorded from T_2 which showed lowest performance in case of others yield contributing characters.

Cost and return analysis

The maximum gross return (Tk. 893800 ha^{-1}), gross margin (Tk. 646455 ha^{-1}) and BCR 3.61 were observed from T_1which followed by T_4 treatment (gross return, gross margin and BCR were Tk. 865600 ha^{-1}, Tk. 646455 ha^{-1} and 3.5), respectively. The lowest gross return (Tk. 680600 ha^{-1}), gross margin (Tk. 451630 ha^{-1}) and BCR 2.97 (Table 3).

Table 2. Effect of different doses of water hyacinth residue on yield and yield contribution characters of cauliflower at Gopalganj region during *rabi* season in 2021-2022

Treatment	Plant height (cm)	Curd length (cm)	Curd diameter (cm)	Single curd wt. (kg)	Bulb yield (t ha^{-1})
T_1	51.18	14.47	20.61	1.66	44.69
T_2	40.78	10.39	15.19	1.31	34.03
T_3	44.12	11.39	17.79	1.39	37.36
T_4	49.95	13.93	19.85	1.61	43.28
LSD $_{(0.05)}$	4.65	2.01	4.28	0.20	5.36
CV (%)	5.66	7.05	10.17	6.53	6.3

T_1=RDCF (Recommended fertilizers dose) + 5 t cowdung ha^{-1} (control), T_2=RDCF+5 t water hyacinth residue ha^{-1}, T_3=RDCF + 8 t water hyacinth residue ha^{-1}, T_4=RDCF+11 t water hyacinth residue ha^{-1}

Table 3. Cost and benefit analysis of cauliflower production by using different doses of water hyacinth residue at Gopalganj region during *rabi* season in 2021-2022

Treatment		Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
T_1		893800	247345	646455	3.61
T_2		680600	228970	451630	2.97
T_3		747200	233470	513730	3.20
T_4		865600	246970	618630	3.50

Cost (t ha^{-1}): Cowdung 5000 Tk, Water hyacinth residue 3000Tk and Price: Cauliflower 20 Tk kg^{-1}.

Conclusion

The study reveals that 11 t ha^{-1} water hyacinth residue best for cauliflower production as an alternate source of 5 t cowdung ha^{-1}. The trial needs to be conducted in next year for the result confirmation.

EFFECT OF NUTRIENT MANAGEMENT ON THE YIELD OF SWEET POTATO IN KUSHTIA

J. A. MAHMUD

Abstract

An experiment was conducted at Kumarkhali, Kushtia during 2021-22 in farmer's field to observe the nutrient management of sweet potato. Three treatments viz., T_1=IPNS (126-15-115-8 kg N-P-K-S ha^{-1} + 3 t Poultry Manure ha^{-1}), T_2=IPNS (128-13-118-12 kg N-P-K-S ha^{-1} + 6 t cowdung ha^{-1}) and T_3= Farmer's practice (160-160-180-70 kg N-P-K-S ha^{-1}) were applied in this experiment. BARI released SP-12 was used in this trial. The highest tuber yield was obtained from T_1 (22.88 t ha^{-1}) and the lowest from T_3 (19.32 t ha^{-1}).

Introduction

Sweet potato is an important tuber crop in Bangladesh. It has potentiality to reduce pressure upon the staple food. The yield of sweet potato in Bangladesh is lower compared to that of other countries of the world. Yield and quality of variety is depending on nutrient management. Generally, farmers applied fertilizer in imbalanced way resulting lower yield and quality as well as deteriorate soil fertility. The farmers may be able to achieve higher yield and quality by using the newly developed fertilizer package. So, the experiment was conducted to determine fertilizer dose of sweet potato in Kushtia region.

Materials and Methods

The experiment was conducted at farmer's field of Kumarkhali, Kushtia during 2021-2022. The unit plot size was 3.0 m x 3.0 m for each treatment. BARI developed sweet potato variety BARI sweet potato-2 was used in the experiment. The treatments were: 4 level of nutrient management viz. T_1=IPNS (126-15-115-8 kg, N-P-K-S ha^{-1} + 3 t Poultry Manure ha^{-1}), T_2=IPNS (128-13-118-12 kg, N-P-K-S ha^{-1} + 6 t cowdung ha^{-1}) and T_3=Farmer's practice (160-160-180-70 kg, N-P-K-S ha^{-1}). Necessary data were recorded and analyzed as per objectives. Data on yield and yield contributing character were shown at (Table 1.) The experiment was laid out in RCB design with 4 replications. Planting was done on 25 November 2021. One irrigation was done 45 days after transplanting. One weeding and soil earthing up work was done. The tuber was harvested during 10 April 2022.

Results and Discussions

Results were presented in Table 1. Days to maturity of BARI Sweet potato12 were 135 days. The maximum number of tubers per plant was recorded (3.22) from T_1 treatment. The highest tuber yield was obtained from (T_1) (22.88 t ha^{-1}). The yield obtained from T_2 and T_3 were (21.57 t ha^{-1}) and (19.32 t ha^{-1}), respectively. The maximum gross return (Tk. 343200 ha^{-1}) and gross margin (Tk. 256820 ha^{-1}) were estimated from (T_1) and the lowest was from (T_3) (Tk. 211800 ha^{-1}) respectively.

Farmer`s opinion

Farmers were pleased to see the higher yield of (T_1) treatment. They were interested to practice new dose of fertilizer in future.

Table1. Agro-economic performance of different sweet potato varieties at Kushtia, 2021-22

Treat.	Length of main vine (cm)	Tuber plant^{-1} (no)	Weight of tuber plants^{-1} (kg)	Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
T_1	130.63	3.22	4.08	22.88	343200	86380	256820
T_2	107.40	3.00	3.85	21.57	323500	85000	238500
T_3	113.20	2.90	3.45	19.32	289800	78000	211800
LSD (0.05)	3.79	1.02	2.61	2.31	-	-	-
CV (%)	13.08	9.63	11.06	7.61	-	-	-

T_1=IPNS (126-15-115-8 kg N-P-K-S ha^{-1} + 3 t Poultry Manure ha^{-1}), T_2= IPNS (128-13-118-12 kg N-P-K-S ha^{-1} + 6 t cowdung ha^{-1}) and T_3= Farmer's practice (160-160-180-70 kg N-P-K-S ha^{-1}), GR = Gross return, TVC = Total variable cost and GM = Gross margin and Selling price of sweet potato: (Tk.15 kg^{-1})

Conclusion

Based on findings, it may conclude that using IPNS basis (126-15-115-8 kg, N-P-K-S ha^{-1} + 3 t Poultry Manure ha^{-1}) fertilizer dose was the suitable fertilizer package for sweet potato cultivation.

VALIDATION OF BIOFERTILIZER ON LENTIL IN KUSHTIA

J. A. MAHMUD

Abstract

An experiment was conducted at Kumarkhali, Kushtia during the rabi season of 2021-2022 to observe the effect of rhizobial biofertilizer on lentil. The effect of rhizobial biofertilizer to the performance of lentil was found positive. The seed yield of lentil (1.45 t ha^{-1}) was highest in rhizobial applied field than other treatments.

Introduction

Pulses play an important role in food crops of Bangladesh. It is called the meat of poor people. Because there is high protein in pulses like meat. But the price of pulses is lower than meat. In rabi season it has to compete with other winter vegetable, wheat, oil seed etc. Rhizobial inoculum increases seed yield of different legumes at least by 20 percent over control. This technology generates information on the application of bio-fertilizer in different pulses as well as biomass for human health and also maintenance of soil fertility. With this view in mind, the experiment was undertaken to observe the effect of rhizobial bio-fertilizer to the performance of lentil.

Materials and Methods

The experiment was conducted at Kumarkhali, Kushtia during the rabi season of 2021-22. The trial was laid out in RCB design with four dispersed replications. The plot size was 10m × 15m in each treatment. The treatments were: T_1= Without *Rhizobium* inoculant + P-K-S-Zn, T_2= With *Rhizobium* inoculant + P-K-S-Zn and T_3= N-P-K-S-Zn. The BARI Masur-8 were used as experimental varieties. Seeds were sown during 20 November 2021. Chemical fertilizers were applied at the rate of 50-22-42-20-5 kg, N-P-K-S-Zn ha^{-1} and rhizobium bio-fertilizer 1.5 kg ha^{-1}, respectively. All chemical fertilizers except urea were applied at the time of final land preparation. One weeding was done at 30 days after sowing. Provex- 200WP and Rovral were applied to control diseases. The crop was harvested during 18 March 2022. Data on yield and yield contributing character were recorded.

Results and Discussions

The effect of bio-fertilizer on yield and yield components of lentil at farmer's field were presented in (Table 1). Plant height, number of pods per plant and thousand seed weight was highest in with rhizobium inoculant plot. The maximum t seed yield was also obtained (1.45 t ha^{-1}) with rhizobium inoculant plot followed by only N-P-K-S-Zn (1.42 t ha^{-1}) and without rhizobium inoculant (1.35 t ha^{-1}). Gross return and gross margin were higher with rhizobium inoculant than that of without rhizobium inoculant and N-P-K-S-Zn t.

Cost and return analysis: The maximum gross return (Tk. 116000 ha^{-1}) and gross margin (Tk. 67058 ha^{-1}) were estimated from (T_1) and the lowest from (T_1) (Tk. 59058 ha^{-1}) respectively (Table 1).

Farmer's opinion

Farmers were impressed with the performance of rhizobium inoculant due to higher yield, bold size seed in lentil. They were interested to use this rhizobium inoculant if easily available in market.

Table 1. Agro-economic performance as affected by bio-fertilizer on yield and yield components of lentil during 2021-22

Treat.	Days to maturity	Plants m^{-2} (No.)	Plant height (cm)	Pods $plant^{-1}$ (no)	1000-Seed wt. (g)	Seed yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
T_1	110	68	60.00	72	21.27	1.35	108000	48942	59058
T_2	115	69	62.00	74	22.53	1.45	116000	48942	67058
T_3	115	67	64.00	73	22.23	1.42	113600	49042	64558
LSD (0.05)	3.16	1.93	2.00	3.21	1.33	1.11	-	-	-
CV (%)	9.21	11.06	7.23	8.61	9.66	7.33	-	-	-

T_1= Without Rhizobium inoculant + P-K-S-Zn, T_2= With Rhizobium inoculant + P-K-S-Zn and T_3= N-P-K-S-Zn, GR = Gross return, TVC = Total variable cost and GM = Gross margin, Rate: Lentil @ Tk. 80 kg^{-1}

Conclusion

The study suggests for getting higher seed yield of lentil, application of rhizobium biofertilizer with chemical fertilizer.

VALIDATION OF FERTILIZER MANAGEMENT OF BARI Bt BRINJAL

M. R. AMIN

Abstract

The field experiment was conducted at Ramnagar village under Shibaloya upazila of Manikganj district during Rabi season of 2021-22 to observe the response of fertilizers on the fruit yield performance of BARI Bt brinjal in the farmers' field. The experiment was conducted in RCB design with three replications. Three fertilizer treatment combinations viz. T_1=180-

54-135-22-3-1.50 kg, N-P-K-S-Zn-B ha^{-1} +5 t cowdung ha^{-1} (STB Recommended dose+50% NPK); T_2=150-45-112-18-2.5-1.25 kg, N-P-K-S-Zn-B ha^{-1} + 10 t cowdung ha^{-1} (STB Recommended dose+25% N-P-K+5 t cowdung ha^{-1}) and T_3= 150-45-112-18-2.5-1.25 kg, N-P-K-S-Zn-B ha^{-1} + 5 t cowdung ha^{-1} (STB Recommended dose + 25% of N-P-K-S-Zn-B) were evaluated. Among the treatments, T_1 gave the highest fruit yield (43.93 t ha^{-1}) followed by soil test-based fertilizer dose of T_2 (36.82 t ha^{-1}) whereas T_3 provided the lowest fruit yield (34.00 t ha^{-1}). Treatment T_1=180-54-135-22-3-1.50 kg, N-P-K-S-Zn-B ha^{-1} + 5 t cowdung ha^{-1} (STB Recommended dose +50% N-P-K) was found suitable dose as higher productivity and higher economic return with higher BCR (5.43).

Introduction

Brinjal *(Solanum melongena)* is the third most important vegetables in terms of both yield and production area in Bangladesh. Recently Bangladesh developed four Bt brinjal varieties. It has potentiality to bump up the yield and brinjal production of the country. From two years demonstration in farmers' field, it was observed that Bt brinjal needed additional fertilizer than recommended one for proper growth and yield. Bt brinjal has profuse bearing than non Bt brinjal. Hence, higher fertilizer dose may require for full exploitation of yield potentiality of Bt brinjal. Most of the flowering buds are active for fruiting. Probably Bt gene is also resistance of fungal disease development on flowering buds of Bt brinjal. Consequently, more active flowering buds produce more fruits plant^{-1} and higher yield of Bt brinjal. Now, there is a need to resort the fertilizer requirement for Bt brinjal. On the other hand, one of the major causes of low yield of brinjal might be due to low organic matter content as well as low nutrient status of soils those has been declined over time. Optimum dose of fertilizer application provides better agronomic and economic benefits to vegetable growers. Soil analysis provide a better understanding of what and how much fertilizer inputs to be allocated considering the high cost of fertilizer and the limited financial resources of farmers. Therefore, the present investigation was undertaken to validate the effect of variable rates of fertilizer on fruit yield of Bt brinjal in farmers' field.

Materials and Methods

The trial was conducted in the farmers' field at Ramnagar village under Shibaloya upazila of Manikganj district during Rabi season of 2021-22. The variety was BARI Bt Begun-4 and the Bt brinjal was grown against non-Bt in the border. The experiment was conducted in RCB design with three replications. The treatments were consisted of variable rates of fertilizer combinations viz. T_1=180-54-135-22-3-1.50 kg, N-P-K-S-Zn-B ha^{-1} +5 t cowdung ha^{-1} (STB Recommended dose+50% NPK); T_2=150-45-112-18-2.5-1.25 kg, N-P-K-S-Zn-B ha^{-1} +10 t cowdung ha^{-1} (STB Recommended dose+25% NPK+5 t cowdung ha^{-1}) and T_3= 150-45-112-18-2.5-1.25 kg, N-P-K-S-Zn-B ha^{-1} + 5 t cowdung ha^{-1} (STB Recommended dose+25% of N-P-K-S-Zn-B). Thirty days old seedlings were planted on 20 November 2021. Unit plot size was 5.10m × 4.3m with spacing of 100cm × 80cm. Stable bleaching powder was applied 15 days before transplanting @ 21 kg ha^{-1} as a preventive measure against bacterial wilt. Fertilizer treatments were assigned randomly in the plots. Half of cowdung was applied at the time of final land preparation. Remaining cowdung and full amount of phosphorus, sulphur, zinc and boron were applied in pit before one week of seedlings transplanting. Nitrogen and potassium were applied in four equal splits at 20, 40, 60 and 80 days after planting as ring method around the plants and mixed thoroughly with the soil. Nitro @ 2 ml L^{-1} water was sprayed at seedling and fruit setting stage to control whitefly, jassid and aphid in some infested plot. Similarly, Autostin @ 2 gm L^{-1} was sprayed in 2-3 times to control fusarium wilt. Weeding, watering and removal of side branching and other intercultural operations were done as and when necessary. Different sucking pests like whitefly, jassid, aphid, mite etc. and diseases (Fusarium wilt) were observed in some plots. These pests were controlled by appropriate management approaches. Initial soil samples were collected from each plot before fertilization and final samples after harvesting of fruits to determine uptake of nutrients from soil. Fruits were harvested from 03 March to 15 April 2022. The fruit yield was recorded from individual plots and yield was converted to express as ton per hectare.

Results and Discussions

The performance of BARI Bt Begun-4 as influenced by variable fertilizer treatments is shown in Table 1. Plant height did not differ significantly due to the variation in fertilizer treatments ranged from 63.21 to 66.41. The fruits plant^{-1} ranged from 13.33 to 15.66 among the treatments and the highest number of fruits were obtained from T_1 (15.66) treatment. The maximum t single fruit weight was produced in T_1 (286.76 g) treatment followed by T_2 (279.58 g) and the lowest in T_3 (258.67g). The weight of fruits plant^{-1} differ statistically among the treatments ranged from 3.44 to 4.37 kg but statistically similar between treatment T_1 (4.37 kg) and T_2 (3.82 kg). The maximum fruit yield (43.93 t ha^{-1}) was obtained from T_1but the fruit yield between T_2 (36.86 t ha^{-1}) and T_3 (34.00 t ha^{-1}) were statistically at par. The application of higher amount of chemical fertilizers might contribute to produce higher yield in treatment T_1. The maximum benefit cost ratio (5.43) was obtained from T_1 treatment followed by T_3 (4.51) whereas T_2 (4.31) the minimum because of higher amount of cowdung applied that increased cost of production.

Cost and return of BARI Bt Begun-4 as influenced by fertilizer treatments is shown in Table 1. Gross return (Tk. 878600 ha^{-1}) was higher in T_1 than T_2 (737200 ha^{-1}) and T_3 (Tk. 680000 ha^{-1}). Total variable cost in T_2 (Tk. 170690 ha^{-1}) was higher than T_3 (Tk. 150690 ha^{-1}) and was lower in T_1 treatment (Tk. 161656 ha^{-1}) due to lower amount of chemical fertilizer (Table 1). Therefore, treatment T_1 was found suitable dose in respect of yield and economics.

Farmers' opinion

Farmers opined that they generally grow brinjal without cowdung. But it was observed that higher dose of chemical fertilizer with cowdung produced higher yield. They would cultivate BARI Bt Begun-4 but using fertilizer (180-54-135-22-3-1.50 kg, N-P-K-S-Zn-B ha^{-1} + 5 t cowdung ha^{-1}) for higher yield.

Table 1. Fruit yield and yield attributes of BARI Bt brinjal as influenced by variable fertilizer treatments at Shibaloya, Manikganj during *Rab*i season of 2021-22

Variety	Plant height (cm)	Fruits plant^{-1} (no)	Single fruit w.t (g)	Wt. of fruit plant^{-1} (kg)	Fruit yield (t ha^{-1})	GR (Tk. ha^{-1})	TC (Tk. ha^{-1})	GM (Tk. ha^{-1})	BCR
T_1	66.41	15.66	286.76	4.37	43.93	878600	161656	716944	5.43
T_2	64.00	13.33	279.58	3.82	36.86	737200	170690	566510	4.31
T_3	63.21	13.33	258.67	3.44	34.00	680000	150690	529310	4.51
LSD $_{(0.505)}$	8.55	5.842	23.80	0.950	8.613				
CV (%)	5.85	8.17	5.42	10.60	9.93				

T_1= 180-54-135-22-3-1.50 kg, N-P-K-S-Zn-B ha^{-1} + 5 t ha^{-1} of cowdung (STB Recommended dose + 50% NPK) than T_2 = 150-45-112-18-2.5-1.25 kg, N-P-K-S-Zn-B ha^{-1} + 10 t ha^{-1} of cowdung) (STB Recommended dose + 25% NPK + 5 tha^{-1} of cowdung) and T_3= 150-45-112-18-2.5-1.25 kg, N-P-K-S-Zn-B ha^{-1} + 5 tha^{-1} cowdung (STB Recommended dose + 25% of N-P-K-S-Zn-B), GR = Gross return, TVC = Total variable cost, GM = Gross margin and Market price of BARI Bt Begun-4 @Tk. 20 kg^{-1}

Conclusion

The results indicated that fertilizer dose of 180-54-135-22-3-1.50 kg N-P-K-S-Zn and B ha^{-1} + 5 t cowdung ha^{-1} (based on soil test basis) is suitable to get optimum fruit yield and economic return of brinjal var. BARI Bt Begun-4 in the farmers' field at Shibaloya, Manikganj.

EFFECT OF PHOSPHORUS LEVELS ON YIELD AND YIELD ATTRIBUTES OF LENTIL UNDER DIFFERENT CROP ESTABLISHMENT METHOD IN RICE BASED SYSTEM

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Abstract

Performance of lentil under three tillage practices such as conventional tillage (CT), relay method and strip planting (SP) and also three levels of phosphorus (P) viz. recommended dose of P (P_1), 50% of recommended P (P_2) and 150% of recommended P (P_3) were evaluated in rice-based system in Bangladesh. The field experiment was conducted during November

2021 to March 2022 at Ganggarampur, Pabna. The crop sequence Mustard-Jute-T. Aman were practiced at SP site while Mustard-Sesame-T. Aman were practiced at relay and CT sites before commencing of the experiment. The crops under SP flowered 50% on average 8-5 days earlier than that of relay and CT methods. The maximum plants/m^2 counted in P_1 and P_3 levels under CT method (94) followed by SP and P_2 (83) while the lowest plant population counted in relay with P_3 method (48). The tallest plants counted in SP with P_1 and SP with P_2 (44) while the shortest plants in relay with P2 (34). The pods/plant of SP (66) was higher and the lowest pods/plant (55) from CT. Regardless of tillage methods, the pods/plant was higher at P_3 treatment (64) followed by P1 (60), and the lowest pods/plant from P_2 (55). The seed yield of SP had 11 % higher and the lowest seed yield was recorded from relay methods. However, the relay method reduced yield by 7.5 % than that of CT method. The seed yield was higher at P_1 and P_3 treatment (1.9 t ha^{-1}) and the lowest from P_2 (1.6 t ha^{-1}). This short-term effect was positive towards conservation agriculture than CT system. However, this study will be continued for a long-term period for a concrete conclusion.

Introduction

There are several cultivation methods and varieties of lentil are used in different agro-ecological zones of Bangladesh. Most commonly, broadcast seeding into traditional cultivated land/ conventional cultivated land (2-3 times tillage and 1-time laddering) is practiced in Bangladesh. However, the method is laborious and input intensive. The conventional method also delays crop establishment beyond the optimum time. As a result, the sustainability of the overall production system is now threatened under the conventional cultivation technique using unsuitable variety of lentil. In a method of relay cropping lentil with T. Aman rice, lentil is sown in rice field 10-15 days before harvesting of monsoon rice crop. Strip planting system, a novel technology and a component of conservation agriculture can be used for sowing lentil in lowland paddy soil. This cultivation technique would be another promising option to reduce huge amount of human labor, fuel, and time consumption and increase farm profit. This proven technology is practicing over the last decades in many parts of South Asia for growing lentil in rice-based system (Islam, 2017; Islam et al. 2019 and Islam et al. 2022). In pulse crop, phosphorus fertilizer has a significant effect on root development, stalk and stem strength, flower and seed formation, crop maturity and production. Lentil suffering from P deficiency stimulates the length of the primary root, length and number of lateral roots and root hairs (Sarker and Karmoker, 2009), the increment in lateral roots was more than the primary root and resulted to increase in root surface area. The increase in the root surface area enhances the phosphorus acquisition from phosphorus-deficient soils, however, the better cultivation techniques that enhances prolific root hair formation as a result of improved soil physical properties are better in the acquisition of various nutrients that are less available in soil. The information on different P levels under conventional cultivation technique is available, but there is no information available on the effects of P levels on the performance of lentil under different crop establishment methods in rice growing areas. Hence, this experiment has been undertaken to determine the appropriate level of phosphorus fertilizers under crop establishment method.

Materials and Methods

The field experiment was conducted at FSRD site, Ganggarampur, Pabna under the Agro-Ecological Zone of High Ganges River Floodplain (AEZ 11). The soil of the site is sandy loam in texture having moderate organic matter content of soil with pH value 7.5. The variety of lentil was BARI Masur-8. The cropping pattern was mustard-Jute-T. Aman at SP site while Mustard-Sesame-T. Aman practiced at relay and CT sites. The lentil crop under relay method was sown on 28 October 2021 and harvested on 18 March 2022 and the crop under SP and relay method was sown on 21 November 2021 and harvested on 14 March 2022. The experiment included three replications in a split-plot design where main plots consist of tillage methods: strip planting (SP), relay method and conventional tillage (CT) and three levels of phosphorus such as 100 % of recommended dose of P (90 kg ha^{-1})-P_1, 50 % of recommended dose of P (45 kg ha^{-1})–P_2 and 150 % of recommended dose of P (135 kg ha^{-1})–P_3 were assigned in a sub-plots. The experimental plots were fertilized at the rate of 20, 20, and 50, 1 kg N, K, S and B respectively (FRG, 2018). The procedure of all fertilizer application (hand broadcast) was same in all tillage treatments except P fertilizer. The P fertilizer was drilled using VMP in SP treatments while broadcasted in relay and CT treatments. The seeds were sown maintaining line spacing of 30 cm for SP and seed broadcasted at relay and CT treatments. The seed rate of lentil was used 35 kg ha^{-1}. One hand weeding was done at 25-30 days after sowing (DAS) for controlling weed. Knowin @ 2 g/L and Rovral-50 WP @ 2 g/L application was started from 21 DAS to pod initiation with 15 days interval for controlling root rot disease of lentil. Malathion 57 EC @ 2ml/L was applied at 58 and 70 DAS for controlling aphid. Data on yield and yield contributing characters were recorded. The crop was harvested when 80% of the pod turned to straw in colour. Grain yields were recorded at 12 % moisture content for lentil. Economic analysis for various sowing methods was conducted by using the variable costs and income from sale of seed and stover of sesame. Gross margin from all treatments was calculated by subtracting expenses for all variable inputs from the calculated gross return. The benefit cost ratio (BCR) was computed as the ratio of gross return and cost of production. The GenStat 17th Edition and R-software packages were used. The mean differences between treatments were separated by the least significant difference (LSD) at $P \leq 0.05$ for the measured variables.

Results and Discussions

Effect of tillage operations and P levels on yield and yield components of lentil: Tillage method significantly affected days to 50 % flowering where SP flower 50 % on average 8-5 days earlier than that of relay and CT methods (Table 1). The maximum plants/m^2 in P_1 and P_3 levels under CT method (94) followed by SP and P2 (83) while the lowest plant population in P_3 method (48). The tallest plants counted in SP with P1 and SP with P2 (44) while the shortest plants in relay with P2 (34). The pods/plant of SP (66) was higher than that of other treatments and the lowest pods/plant (55) from CT treatments. Regardless of tillage methods, the pods/plant was higher at P_3 treatment (64) followed by P_1 (60), and the lowest pods/plant from P_2 (55).

The seeds pod^{-1}, 1000-seed weight and straw yields were not significantly different either by tillage or P levels (Table 2). But finally, the seed yield of SP (2 t ha^{-1}) was higher by 11% than that of other treatments and the lowest seed yield (1.6) from relay methods. However, the relay method reduced yield by 7.5% than that of CT method. The seed yield was higher at P_1 and P_3 treatment (1.9 t ha^{-1}) and the lowest seed yield from P_2 (1.6 t ha^{-1}).

Cost and return analysis: The economic performance of sesame under different sowing options is shown in Table 3. The production cost for lentil was highest when farmers used CT (USD 571 ha^{-1}) and the lowest for SP system (USD 498 ha^{-1}). The production cost of relay method (USD 536 ha^{-1}) was also higher that of SP. This was due to high labour costs for weeding and includes sowing cost for relay method compared to SP system. In case of P levels, the production cost was higher in P_3 and lower in P_2 and P_1. The production cost increases with increasing P level. The gross return, gross margin and BCR were higher in SP treatment than relay methods while the lower gross return, gross margin and BCR were found in relay method. In case of P levels, the gross return, gross margin and BCR were higher in P_2 treatment than P_1 and P_3 treatments.

Table 1. Effects of tillage and P levels on days to 50 % flower, plant/m^2, plant height and pods/plant of lentil in 2021-22 at FSRD, Ganggarampur, Pabna

Tillage (T)	Days to 50 % flowering				Plant population/m^2				Plant height (cm)				Pods/plant			
	P-level				P-level				P-level				P-level			
	P1[1]	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
SP[1]	65	66	66	*65*	80	83	80	*81*	44	44	41	*43*	65	62	71	66
Relay	72	73	73	*73*	76	68	48	*64*	37	34	38	*36*	55	51	64	57
CT	69	69	67	*68*	94	83	94	*91*	40	45	39	*41*	60	51	56	55
Mean	*69*	*69*	*68*		*84*	*78*	*74*		*40*	*41*	*39*		60	55	64	
T	1.7				5.8				2.7				5.8			
P	1.4				8.8				5.6				6.4			
T x P	1.4				8.8				5.6				6.4			

Tillage (T)	Days to 50 % flowering				Plant population/m^2				Plant height (cm)				Pods/plant			
	P-level				P-level				P-level				P-level			
	P1[1]	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
T	2.7				10				2.5				7.8			
P	ns				7				ns				3.9			
T x P	ns				13				3.7				ns			

[1]P1 – 100 % of recommended dose of P; P2 – 50 % of recommended dose of P; P3 – 150 % of recommended dose of P; SP - strip planting; NT - no-tillage; CT - conventional tillage

Table 2. Effects of tillage and P levels on seeds pod^{-1}, 1000-seed weight, seed and stover yield of lentil in 2021-22 at Pabna

Tillage (T)	Seeds/pod				1000-seed weight (g)				Seed yield (t ha^{-1})				Stover yield (t ha^{-1})			
	P-level				P-level				P-level				P-level			
	P1[1]	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
SP[1]	1.8	1.8	1.7	*1.8*	24.0	22.6	23.2	*23.3*	1.9	1.8	2.2	*2.0*	1.3	1.3	1.6	*1.4*
Relay	1.9	1.9	1.9	*1.9*	24.5	25.2	25.5	*25.1*	1.8	1.4	1.7	*1.6*	1.4	1.1	1.3	*1.3*
CT	1.9	1.8	1.7	*1.8*	23.6	24.3	23.6	*23.8*	2.0	1.5	1.8	*1.8*	1.6	1.5	1.4	*1.5*
Mean	*1.9*	*1.8*	*1.7*		*24.0*	*24.0*	*24.1*		*1.9*	*1.6*	*1.9*		*1.4*	*1.3*	*1.4*	
T	3.0				2.6				4.0				7.1			
P	5.9				4.0				10.6				17.3			
T x P	5.9				4.0				10.6				17.3			
T	ns				ns				0.16				ns			
P	ns				ns				0.19				ns			
T x P	ns				ns				ns				ns			

Table 3. Effects of different sowing options on the economic performance of lentil in 2021 at Pabna

Tillage(T)	P-level			
	P1[1]	P2	P3	Mean
Production cost (USD ha^{-1})				
SP[1]	498	487	509	*498*
Relay	536	525	548	*536*
CT	571	559	582	*571*
Mean	*535*	*524*	*546*	
Gross return (USD ha^{-1}) Used Tk. ha^{-1} instead of USD				
SP[1]	1799	1679	2024	*1834*
Relay	1686	1333	1581	*1533*
CT	1892	1400	1693	*1661*
Mean	*1792*	*1471*	*1766*	
Gross return: Used Tk. ha^{-1} instead of USD				
SP[1]	1301	1193	1514	*1336*
Relay	1150	808	1033	*997*
CT	1321	840	1111	*1091*
Mean	*1257*	*947*	*1219*	
BCR				
SP[1]	3.6	3.5	4.0	*3.7*
Relay	3.1	2.5	2.9	*2.9*
CT	3.3	2.5	2.9	*2.9*
Mean	*3.4*	*2.8*	*3.3*	

[1]P1 – 100 % of recommended dose of P; P2 – 50 % of recommended dose of P; P3 – 150 % of recommended dose of P; SP - strip planting; NT - no-tillage; CT - conventional tillage.
Market price of sesame (USD kg^{-1}): grain – 0.91 and straw – 0.03

Conclusion

It can be concluded that adoption of SP increased lentil seed yield by 11% while relay method decreased lentil yield by 7.5 % over farmer practices. In case of P levels, both application of recommended P fertilizer and 150 % recommended of P fertilizer increased lentil yield by 7.5 %

as compared to half of recommended P fertilizer. The improved yield contributing attributes might be accounted to increase grain yield of lentil in SP and recommended P fertilizer or 150 % recommended of P fertilizer than CT and 50 % recommended of P fertilizer. However, this experiment will be continued in the next year for conclusion.

EVALUATION OF PLANT NUTRIENT MANAGEMENT ON YIELD OF ONION

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Abstract

The experiment was conducted at FSRD site Ganggarampur, Pabna during the rabi season of 2021-22 to find out the performance of onion under different nutrient management approaches. Different treatments viz. T_1 = recommended dose as FRG 2018, T_2= IPNS + 2 t ha^{-1} Vermicompost, T_3= IPNS+ 5 t ha^{-1} cowdung, T_4= IPNS + 5 t ha^{-1} ash and T_5=Farmer's practice was tested on onion var. BARI Piaj-1. The maximum t bulb yield (11.83 t ha^{-1}) was obtained from IPNS + 2 t ha^{-1} Vermicompost t which is statistically similar with IPNS+ 5 t ha^{-1} cowdung and IPNS + 5 t ha^{-1} ash treatments. The maximum economic return in terms of gross return and gross margin was obtained from IPNS + 5 t ha^{-1} cowdung due to lower cost of cowdung compared to Vermicompost.

Introduction

Onion is intensively grown in Pabna district. The area coverage of onion is increasing in the recent years due to high market price. In the current year farmers are planning to cultivate onion in more areas compare to previous years. It has been reported that farmers are not getting desired bulb yield due to declining soil fertility and improper fertilizer management. It is imperative to develop strategy for the improvement of sustainable soil health and optimum crop yield. In many cases synthetic fertilizer management exhibit threat for soil physical and chemical properties particularly degradation of soil microbial population. In this context, integrated plant nutrient system (IPNS) addressing chemical and organic residue management can be viable option for sustainable soil health and optimum crop yield. Therefore, the present experiment was carried out to find out better nutrient management approach for increasing bulb yield and farmers income.

Materials and Methods

The experiment was conducted at FSRD site Ganggarampur, Pabna during the *rabi* season of 2021-22 to find out the better nutrient management approach for increasing bulb yield and farmers income. Different treatments viz. T_1=RD as FRG, 2018 (105-45-60-10-1.5-1 kg N-P-K-S-Zn-B ha^{-1}), T_2 = IPNS+2 t ha^{-1} vermicompost, T_3=IPNS+5 t ha^{-1} cowdung, T_4=IPNS+5 t ha^{-1} ash and T_5=Farmer's practice was tested on popularly cultivated BARI Piaz-1. The experimental plot represents agro-ecological zone 11 (AEZ 11) having Gopalpur soil series. The experiment was laid out in randomized complete block design with three replications. Unit plot size was 7m×6m. The spicing was maintained 15cm×10cm spacing between two rows and bulb to bulb. The seeds were sown on December 26, 2021. Half of N and the entire quantity of recommended N, P, K, S, Zn and B were applied in the form of urea, TSP, MoP, Gypsum, Zinc sulphate and Boric acid during final land preparation. Rest of the urea was applied as two equal top dressing at 20 and 40 days after planting. Two weeding was done at early vegetative stage at 20 days after transplanting and again at 40 DAT to keep the plot weed free. Two irrigations were applied top dressing of urea. Necessary data on plant characters, yield and yield attributes were collected and analyzed with 'R' software.

Results and Discussions

Results revealed that onion bulb yield varied significantly due to variation in nutrient management approach while the plant height and individual bulb weight was found non-significant (Table 1). The maximum onion bulb yield (11.83 t ha^{-1}) was observed in IPNS+2 t ha^{-1}

vermin-compost treatment which was statistically identical to IPNS+5 t cowdung ha^{-1} and IPNS+ 5 t ash ha^{-1} treatments. The minimum onion bulb yield (10.11 t ha^{-1}) was obtained from recommended dose which was statistically similar with farmer's practice. About 17, 11 and 10% onion bulb yield were increased by IPNS+ 2 t ha^{-1} Vermicompost, IPNS + 5 t ha^{-1} cowdung and IPNS+5 t ha^{-1} ash over recommended dose of fertilizer. Besides, about 1, 9% and 8% onion bulb yields were increased by IPNS +2 t ha^{-1}vermicompost, IPNS+ 5 t ha^{-1} cowdung and IPNS+5 t ash ha^{-1}, respectively over Farmer's practice.

Cost and return analysis: The Maximum economic return in terms of gross return (Tk. 354900 ha^{-1}) was obtained from IPNS +2 t ha^{-1} Vermicompost but maximum gross margin Tk. 171015 ha^{-1}) was obtained from IPNS+5 t ha^{-1} cowdung treatment. Lower cost of cowdung compared to vermicompost was the reason for higher economic return. The minimum gross return and gross margin were noted in recommended dose of fertilizer (Table 1).

Farmer's opinion

Farmers opine that cultivation of onion using IPNS with all the three organic amendments shows better crop growth and increases yield**.** The results encourage them to apply IPNS +5 t ha^{-1} cowdung to their crop field next year as cowdung is available than other**.**

Table 1. Effects of different nutrient management approaches on plant height, individual bulb weight and bulb yield of onion in 2021-22 at FSRD site Ganggarampur, Pabna

Treat.	Plant height (cm)	Individual bulb wt. (g)	Bulb Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
T_1	41.5	29.1	10.11	303300	163288	140012
T_2	45.2	31.1	11.83	354900	184600	170300
T_3	43.9	29.6	11.23	336900	165885	171015
T_4	44.7	29.4	11.11	333300	163522	169778
T_5	41.8	29.3	10.33	309900	166585	143315
LSD $_{(0.05)}$	5.07	2.71	0.89	-	-	-
CV (%)	6.21	4.84	4.34	-	-	-

T_1=RD as FRG, 2018 (105-45-60-10-1.5-1 kg N-P-K-S-Zn-B ha^{-1}), T_2 = IPNS+2 t ha^{-1} vermicompost, T_3=IPNS+5 t ha^{-1} cowdung, T_4=IPNS+5 t ha^{-1} ash and T_5=Farmer's practice; GR = Gross return, TVC = Total variable cost and GM = Gross margin; Market price: Bulb= 30 Tk kg^{-1}

Conclusion

Application of IPNS +2 t ha^{-1} vermicompost, IPNS+5 t ha^{-1} cowdung and IPNS +5 t ha^{-1} ash exhibits positive response on yield traits and increases bulb yield of onion. Maximum economic return in terms of gross margin was obtained from IPNS+ 5 t ha^{-1} cowdung which was followed by IPNS+ 2 t ha^{-1} vermicompost and IPNS+ 5 t ha^{-1} ash. Therefore, application of IPNS+ 2 t ha^{-1} vermicompost, IPNS+ 5 t ha^{-1} cowdung and IPNS+ 5 t ha^{-1} ash in soil seems promising for onion production regarding yield and economic return.

EFFECT OF IRRIGATION AND RICE HUSK ASH ON YIELD AND POST HARVEST QUALITY OF ONION

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Abstract

The experiment was carried out at Agricultural Research Station, Pabna during the rabi season of 2021-2022 with a view to the performance of onion under four irrigation treatments such as one irrigation at 1 days after transplanting, two irrigations at 1 and 21 DAT, three irrigations at 1, 21 and 41 DAT and four irrigations at 1, 21, 41 and 61 DAT and two levels of rice husk ash 2 t ha^{-1} and without ash were evaluated on BARI Piaz-1. Application of two irrigations provided the highest plant height, bulb diameter and individual bulb weight which is identical to three-time irrigations and lowest from one irrigated treatment. The maximum onion bulb yield (11.1 t ha^{-1}) was obtained from two irrigations which was statistically similar with three irrigations. Minimum yield (9.38 t ha^{-1}) was found from one-

time irrigated plot. Application of 2 t ash ha^{-1} significantly increased plant height, leaves $plant^{-1}$ bulb diameter, individual bulb weight and bulb yield over without ash treated treatment. So, application of 2 to 3 irrigations with 2 t rice husk ash ha^{-1} are best treatment for yield of onion in Pabna region.

Introduction

Onion is one of the most important spices crops in Bangladesh. Pabna district is now recognized as top ranking onion growing area in the country in terms of production and area coverage. But due to some factors like cultivation of local variety, inefficient fertilizer and irrigation management, pest and disease management etc. farmers do not get desired production and economic return. Recently post-harvest rotting of onion in traditional storage and eventually reduced income is a growing concern. It has been reported that rainfall or irrigation before harvesting results in reduced shelf life of onion due to excess water content of bulb and hot and humid weather condition. It is generally agreed that sustaining optimum soil moisture during the growing period of onion demonstrate increased bulb production. Generally, farmers in Pabna region apply 1 or 2 irrigations at early to mid-growth stages of onion. In some scientific observation, application of rice husk ash has exhibited the positive response on bulb yield and reduces bulb rotting in storage at farmer's level. Presently understanding the effect of irrigation scheduling along with rice husk ash on growth, yield and post-harvest damage of onion is deemed important for the onion growers.

Materials and Methods

The field experiment was conducted at Agricultural Research Station (ARS), Pabna during the *rabi* season of 2021-22 to find out the better nutrient management approach for increasing bulb yield and farmers income. The experimental plot represents agro-ecological zone 11 (AEZ-11) having Gopalpur soil series. The experiment contained three replicates for each treatment in a split- plot design. The main plots consist of four irrigations: one irrigation at 1 days after transplanting, two irrigations at 1 and 21 DAT, three irrigations at 1, 21 and 41 DAT and four irrigations at 1, 21, 41 and 61 DAT; sub-plots consist of two levels of rice husk ash 2 t ha^{-1} and without ash. The unit plot size was 5m ×4m. The spacing was maintained 15cm×10cm spacing. The seedlings were transplanted on 9 January 2022. Recommended fertilizer dose (105-45-60-10-1.5-1 kg N-P-K-S-Zn-B ha^{-1}) was used for onion. Half of N, K and the entire quantity of recommended N, P, S, Zn and B were applied in the form of urea, TSP, MoP, Gypsum, Zinc sulphate and Boric acid during final land preparation. Rest of the urea and MoP was applied as two equal top dressing at 25 and 50 days after planting. Two weeding was done at early vegetative stage at 23 DAT and again at 48 DAT to keep the plot weed free. Irrigations were applied according to the treatment composition and amount of water was measured. Necessary data on plant characters, yield and yield attributes were collected and analyzed with 'R' software.

Results and Discussion

Results revealed that plant height, bulb diameter, individual bulb weight and bulb yield varied significantly due to variation in number of irrigation and ash level but interaction non-significant while leaves $plant^{-1}$ was found non-significant for irrigation but it significantly varied due to ash level (Table 1). Application of two irrigations provided the maximum plant height (52.5 cm), bulb diameter (11.7 cm) and individual bulb weight (42.5 g) which was identical to three times irrigations followed by four times irrigations while the lowest plant height (47.7 cm), bulb diameter (11.4 cm) and individual bulb weight (31.2 g) from one-time irrigated treatment. Plant height, leaves $plant^{-1}$, bulb diameter and individual bulb weight increased significantly by 4, 7, 1 and 17% for 2 t ha^{-1} rice husk ash over without ash treated plots. The maximum onion bulb yield (11.1 t ha^{-1}) was obtained from two-time irrigated treatment which was statistically identical to three times irrigation followed by four times irrigation. The minimum onion bulb yield (9.38 t ha^{-1}) was obtained from one irrigation applied treatment. Two times irrigation increased bulb yield 11 and 17% than four irrigation and one irrigation, respectively. Besides, about 6 and 13% bulb yield was increased by three times irrigation over four irrigations and one irrigation, respectively.

Onion bulb yield was significantly increased 5% by 2 t ha^{-1} ash application compared to without ash application.

Table 1. Effects of different nutrient management approaches on plant height, leaves $plant^{-1}$, individual bulb weight and bulb yield of onion in 2021-22 at ARS, Pabna

Treatments	Plant height (cm)	Leaves $plant^{-1}$	Bulb diameter (cm)	Individual bulb wt. (g)	Bulb Yield (t ha^{-1})
Irrigation					
I_1	47.7	6.73	11.4	31.2	9.38
I_2	52.5	6.9	11.71	42.5	11.1
I_3	51.2	6.95	11.61	40.4	10.6
I_4	51.1	6.8	11.42	36.2	10.0
$LSD_{(0.05)}$	1.39	0.24	0.15	4.25	0.83
CV (%)	2.42	3.11	1.12	10	7.12
Ash					
A_1	51.6	7.07	11.59	40.6	10.5
A_0	49.6	6.62	11.48	34.6	10.0
$LSD_{(0.05)}$	0.62	0.18	0.03	1.72	0.12
CV (%)	1.59	3.43	0.37	5.94	1.46

I_1=One irrigation at 1 DAT, I_2= Two irrigations at 1 and 21 DAT, I_3= Three irrigations at 1, 21 and 41 DAT and I_4= Four irrigations at 1, 21, 41 and 61 DAT

Conclusion

Application of 2 with 2 t ha^{-1} rice husk ash exhibits positive response on yield traits and bulb yield of onion. This is the first-year trial. So, for final recommendation it should be executed next year.

EVALUATION OF PROFITABLE AND AGRO-ECOLOGICALLY SUITABLE CROPPING PATTERN IN NORTHERN REGION OF BANGLADESH

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Abstract

To develop agro-ecologically suitable and profitable intensive cropping pattern with proper fertilizer combinations for increasing productivity and farmer's income trial was conducted at farmer's field of Rangpur district with the collaboration of OFRD, BARI and BAU, Mymensingh. Three promising alternative cropping patterns (viz. CP_1= Mustard (var. BARI Sarisha-14)-Mungbean (var. BARI Mung-6)-T. Aus (var. BRRI dhan48)-T. Aman (var. BRRI dhan75); CP_2= Potato (var. BARI Alu-25)-Maize (var. Kaveri)-Sesbania (Local)- T. Aman (var. BRRI dhan75); CP_3= Potato (var. BARI Alu-25)/Sweet gourd (Sweety)-Jute (var. BJRI Toshapat-8)-T. Aman (var. BRRI dhan75) were tested against existing cropping pattern i.e. CP_0 = Boro rice (var. BRRI dhan28)-Fallow-T. Aman rice (var. Swarna). The whole pattern rice equivalent yield (REY) was obtained 14.10, 18.65, 29.73 and 33.46 t ha^{-1} from cropping pattern CP_0, CP_1, CP_2 and CP_3, respectively. The total field duration of the cropping pattern was 233, 324, 343 and 332 days in CP_0, CP_1, CP_2 and CP_3, respectively.

Introduction

At present total cultivable land is 7.95 million hectare (BBS, 2016) which is decreasing at the rate of about 0.44% per year. The main challenge of the new millennium is to increase 50% yield per unit land area through manipulating the limited land resources. In order to produce more food within a limited area, the most important options are to increase the cropping intensity producing three or more crops over the same piece of land in a year and to increase the production efficiency of the individual crop by using optimum management practices. Recently with the development of short duration drought tolerant rice, opportunities of mustard, mungbean, potato and maize have been created to accommodate three or more than three crops like mustard, potato, pulses, maize etc. in same piece of land in a year.

Northern area of Bangladesh is recognized as drought prone area in Bangladesh and its soil fertility is low compared to other parts of the country. A task force of the Ministry of Agriculture recently stated that the productivity of crops for the last few years or so has either stagnated or declined even though fertilizer use in the country has almost increased three folds (G. Rahman, 2014). In addition, the high nutrient hunt exhaustive cropping pattern obviously brings the notice of degrading soil fertility issues (Bagayoko; 2007). Farmers should gradually reduce their dependence on the use of chemical fertilizers to maintain soil fertility. Supplementing the nutrient requirement of crops through organic manures plays a key role in sustaining soil fertility, and crop productivity. Combined applications of inorganic fertilizers with organics (cowdung, compost etc.), helps in increasing the availability of nutrients and crop yield. Crop rotation also improves soil fertility by ensuring the availability of nutrients from different sub-jones of the soil. Similarly, recycling crop residues reduces the need for fossil fuel-based fertilizer and helps in sustaining and restoring soil fertility in terms of available nutrients and major physical and chemical characteristics of the soil. In these context, suitable r cropping pattern, soil fertility degradation would also be addressed through combined organic and inorganic fertilizer application.

Materials and Methods

This is a coordinated project between the Department of Crop Botany, Bangladesh Agricultural University (BAU) and Bangladesh Agricultural Research Institute (BARI), OFRD, Rangpur. The trial was conducted at Mithapukur upazila of Rangpur district and Gabtali Upazila of Bogura district during 2020-21 and 2021-22 (partial). Evaluation of the performance of existing and proposed cropping patterns was conducted in two different locations which are overseen by BAU, Mymensingh and OFRD, BARI. Location component wise data on production, land utilization, economic return, soil fertility status and other socio-economic status were recorded from different locations and tabulated after appropriate statistical analysis. The activities under first year trial were conducted following participatory approach in the farmers' field at Janoki, Mithapukur, Rangpur to identify the suitable cropping pattern during 2020-21. The trial was carried out in RCB design with three dispersed replications. On the basis of partial baseline survey, three promising alternative/improved cropping patterns (CP) were selected against existing cropping pattern i.e. CP_0 (existing) = Boro rice (var. BRRI dhan28)-Fallow-T. Aman rice (Swarna); CP_1= Mustard (var. BARI Sarisha-14)-Mungbean (var. BARI Mung-6)-T. Aus (var. BRRI dhan48)-T. Aman (var. BRRI dhan75); CP_2= Potato (var. BARI Alu-25)-Maize (var. Kaveri)-Sesbania (Local) -T. Aman (var. BRRI dhan75); CP_3= Potato (var. BARI Alu-25)/Sweet gourd (var. Sweety)-Jute (var. BJRI Toshapat-8)-T. Aman (var. BRRI dhan75). Initial soil samples (0-15 cm depth) were collected from each farmer and analyzed from the SRDI Lab. The initial soil status of the experimental field was strongly acidic with low to very low organic matter. The initial soil status under different cropping patterns is given in Table 1a to 1d. Liming was done with dolomite @ 1 t ha^{-1}. All the selected alternative/improved cropping patterns were evaluated under recommended fertilizer dose against farmers practice dose in existing patterns. Regular monitoring and data collection of different crops were done a. Economic analysis was done on the basis of prevailing local market price of the commodities. Productivity of different cropping systems was compared in terms of rice equivalent yield (REY). The details of the used and cultural operations adopted in different crops under the both alternative and existing cropping pattern are given in Table 2a-5b. The rates of the fertilizers for different crops were used as per Fertilizer Recommendation Guide' 2018 (BARC, 2018). The sources of nutrients were urea for N, TSP for P, MOP for K, Gypsum for S, Zinc sulphate for Zn and Boric acid for B. All the crops were harvested at maturity from five spots with an area of 6.0 m^2 each. Data on yield of various crops in sequences were recorded and converted to ton per hectare. Total system productivity was calculated as summation of individual (component) crop yield of each cropping cycle. The productivity of crop sequences was compared by calculating their economic rice equivalent yield (REY) using formula given by Ahlawat and Sharma (1993).

Collected data were analyzed statistically using MS Excel, Statistic and 'R' software package (R Core Team, 2017). After completion of one cycle of a cropping pattern, post soil samples (0-15 cm depth) were collected treatment wise from all cropping patterns and finally, pattern-wise average results of different cropping patterns are shown in Tables 2a-5b & 6.

Table 1a. Initial soil status under Boro-Fallow-T. Aman cropping pattern in 1st year of the experimental plot at Janoki, Rangpur during 2020-21

Soil sample	pH	OM (%)	Total N (%)	P	S	K
				µg/g soil		meq/100g soil
Farmer-1 (Al amin)	5.2	0.75	0.04	76.75	10.09	0.11
Farmer-2 (Chan2)	5.3	0.82	0.05	67.25	8.12	0.10
Farmer-3 (Meri Begum)	5.1	0.93	0.06	58.14	7.15	0.13
Mean value	5.20	0.83	0.05	67.38	8.45	0.11
Interpretation	Strongly acidic	VL	VL	VH	L	L

VL=very low, L=Low, M=Medium, O=Optimum, H=High, VH=Very high, OM=Organic Matter

Table 1b. Initial soil status under Mustard-Mungbean-T. Aus-T. Aman cropping pattern in 1st year of the experimental plot at Janoki, Rangpur during 2020-21

Soil sample	pH	OM (%)	Total N (%)	P	S	K
				µg/g soil		meq/100g soil
Farmer-1 (Chan)	5.6	1.54	0.08	81.30	4.52	0.01
Farmer -2 (Dudu)	5.3	0.44	0.02	84.50	4.24	0.11
Farmer -3 (Rowshan)	5.3	0.30	0.01	77.60	11.30	0.13
Mean value	5.40	0.76	0.04	81.13	6.69	0.08
Interpretation	Strongly acidic	VL	VL	VH	VL	VL

Table 1c. Initial soil status under Potato-Maize-Sesbania-T. Aman cropping pattern in 1st year of the experimental plot at Janoki, Rangpur during 2020-21

Soil sample	pH	OM (%)	Total N (%)	P	S	K
				µg/g soil		meq/100g soil
Farmer-1 (Ashraful)	5.2	0.51	0.02	60.04	11.30	0.13
Farmer-2 (Sahin)	5.3	0.24	0.01	31.37	11.94	0.14
Farmer-3 (Saju)	5.3	0.85	0.40	35.93	9.18	0.11
Mean value	5.27	0.53	0.14	42.45	10.81	0.13
Interpretation	Strongly acidic	VL	L	VH	L	L

Table 1d. Initial soil status under Potato/Sweet gourd-Jute-T. Aman cropping pattern in 1st year of the experimental plot at Janoki, Rangpur during 2020-21

Soil sample	pH	OM (%)	Total N (%)	P	S	K
				µg/g soil		meq/100g soil
Farmer-1 (Anisur)	5.2	1.10	0.05	78.97	10.10	0.14
Farmer-2 (Dudu2)	5.1	1.30	0.06	82.45	12.23	0.15
Farmer-3 (Chan2)	5.1	1.02	0.10	75.86	25.55	0.14
Mean value	5.13	1.14	0.07	79.09	15.96	0.14
Interpretation	Strongly acidic	L	VL	VH	M	L

Results and Discussions

Cropping pattern-wise findings are given below;

Existing cropping pattern (CP_0): Boro rice (BRRI dhan28)-Fallow-T. Aman rice (Swarna)

Yield, yield attributes and economic performance of existing cropping pattern during 2020-21 are presented in Table 2.

Crop performance: The grain yield of boro rice was 6.20 t ha^{-1}, which was attributed by remarkable number of panicles per hill (20.33), grains per panicle (117.11) and 1000- grain weight (25.06g). The straw yield of boro rice was recorded as 6.90 t ha^{-1}. The above ground fresh and dry biomass of boro rice was 212.01 and 67.26 g plant^{-1}, respectively where the average plant height was 118.44 cm. On the other hand, the grain yield of T. Aman rice was 5.05 t ha^{-1}, which was attributed by remarkable number of panicles per hill (21.33), grains per panicle (109.67) and 1000 grain weight (22.82g). The straw yield of boro rice was recorded as 5.65 t ha^{-1}. The above ground fresh and dry biomass of T. Aman rice was 300.18 and 90.23 g plant^{-1}, respectively where the average plant height was 105.67 cm. The total field duration of the cropping pattern was 233 days and total turnaround time 132 days. The whole pattern rice equivalent yield (REY) was 14.10 t ha^{-1}.

Production efficiency (PE): The production efficiency was found 60.62 kg ha^{-1}day^{-1} from the existing cropping pattern.

Land use efficiency (LUE): Land use efficiency indicated that existing cropping pattern used the land for 63.84% time of the year.

The whole pattern gross return and margin was Tk. 310250 ha^{-1} and Tk. 157550 ha^{-1}, respectively.

Table 2. Crop performance of existing cropping pattern Boro-Fallow-T. Aman (CP_0) at Janoki, Rangpur during 2020-21

Crop	Boro	Fallow	T. Aman
Variety	BRRI dhan28	-	Swarna
Spacing	20 × 20 cm		20 × 20 cm
Fertilizer dose (N-P-K-S-Zn-B-cowdung Kg ha^{-1})	265-90-150-115-12-7-1500		165-60-105-70-0-0-10000
Transplanting date	15-20 Jan. 2021	-	24-27 July 2021
Harvesting date	18-22 May 2021	-	12-14 Nov 2021
Field duration (day)	124	-	109
Turnaround time (day)	67	-	65
Grain yield (t ha^{-1})	6.2	-	5.05
Straw yield (t ha^{-1})	6.90	-	5.65
Whole pattern REY (t ha^{-1})	14.10		
Production efficiency (kg ha^{-1}day^{-1})	60.52		
Land use efficiency (%)	63.84		
Gross return (Tk ha^{-1})	170900	-	139350
Total variable cost (Tk ha^{-1})	90200	-	62500
Gross margin (Tk ha^{-1})	80700	-	76850

Price (Tk. kg^{-1}): Urea-16, TSP-25, MP-15, Gypsum-10, Zinc Sulphate-200, Boric acid-500, Cowdung-1.5, Rice grain-22, Rice straw-5

Alternative cropping pattern (CP_1): Mustard (BARI Sarisha-14)**-**Mungbean (BARI Mung-6)**-**T. Aus (BRRI dhan48)**-**T. Aman (BRRI dhan75)

Yield, yield attributes and economic performance of alternative and existing cropping patterns during 2020-21 are presented in Table 3.

Crop performance: The seed yield of mustard was 1.35 t ha^{-1}, which was attributed by remarkable number of siliquae per plant (93.11), seeds per siliqua (23.11) and 1000 seed weight (3.60 g). The stover yield of mustard was recorded as 3.80 t ha^{-1}. The above ground fresh and dry biomass of mustard was 22.61 and 16.05 g plant^{-1}, respectively where the average plant height was 90.78 cm (Table 3b). The seed yield of mungbean was 0.90 t ha^{-1}, which was attributed by remarkable number of pods per plant (17.44), seeds per pod (9.00) and 1000 seed weight (50.10 g). The stover yield of mungbean was recorded as 1.83 t ha^{-1}. The above ground fresh and dry biomass of mungbean was 50.33 and 18.77 g plant^{-1}, respectively where the average plant height was 83.89 cm. The grain yield of T. Aus rice was 4.62 t ha^{-1}, which was attributed by remarkable number of effective tillers per plant (16.89), grains per panicle (132.78) and 1000 grain weight (20.73 g). The stover yield of T. Aus rice was recorded as 5.08 t ha^{-1}. The above ground fresh and dry biomass of T. Aus rice was 254.00 and 39.28 g plant^{-1}, respectively where the average plant height was 104.67 cm. The grain yield of T. Aman rice was 5.10 t ha^{-1}, which was attributed by remarkable number of effective tillers per plant (18.83), grains per panicle (140.44) and 1000 grain weight (21.91 g). The straw yield of T. Aman rice was recorded as 5.71 t ha^{-1}. The above ground fresh and dry biomass of T. Aman rice was 243.33 and 59.91 g plant^{-1}, respectively where the average plant height was 147.05 cm. The total field duration of the alternative cropping pattern was 324 days and total turnaround time was 41 days. The whole pattern rice equivalent yield (REY) was 18.65 t ha^{-1}, which was 32.27% higher than existing pattern.

Production efficiency (PE): Production efficiency was relatively low in alternative pattern (57.67 kg ha^{-1}day^{-1}) than existing pattern (60.52 kg ha^{-1}day^{-1}). The alternative pattern Mustard-Mungbean-T. Aus-T. Aman was found 4.71% less efficient than existing cropping pattern Boro-Fallow-T. Aman (Table 3a).

Land use efficiency (LUE): Land use efficiency indicated that alternative cropping pattern used the land for 88.77% time of the year, whereas farmers existing pattern used the land for 63.84% time of the year (Table 3a).

The whole pattern gross margin was higher in alternative pattern (Tk. 209790 ha^{-1}) than existing pattern (Tk. 157550 ha^{-1}). The MBCR was 2.07 in alternative pattern over existing pattern.

Table 3. Crop performance of improved cropping pattern Mustard-Mungbean-T. Aus-T. Aman against the existing pattern Boro-Fallow-T. Aman

Pattern	Existing cropping pattern			Improved cropping pattern			
Crop	Boro	Fallow	T. Aman	Mustard	Mungbean	T. Aus	T. Aman
Variety	BRRI dhan28	-	Swarna	BRRI Sarisha-14	MARI Mung-6	BRRI dhan48	BRRI dhan75
Spacing	20×20cm	-	20×20cm	Broadcast	Broadcast	20 × 15 cm	20 × 15 cm
Fertilizer dose (N-P-K-S-Zn-B Kg ha^{-1})	265-90-150-115-12-7-1500	-	165-60-105-70-0-0-10000	225-165-80-150-5-10-10000	44-85-35-55-10-00	135-55-85-0-0-10000	165-60-105-70-0-0-10000
Date of Sowing/ transplanting date	15-20 Jan. 2021	-	24-27 July 2021	26-27 Nov 2020	22-25 Feb 2021	03-05 May 2021	08-10 Aug 2021
Harvesting date	18-22 May 2021	-	12-14 Nov 2021	17-20 Feb 2021	24-26 April 2021	29-31 July 2021	10-13 Nov 2021
Field duration (day)	124	-	109	81	62	88	93
Turnaround time (day)	67	-	65	6	9	10	16
Grain/seed yield (t ha^{-1})	6.2	-	5.05	1.35	0.90	4.62	5.10
Straw/stover/stalk yield (t ha^{-1})	6.90	-	5.65	3.8	-	5.08	5.71
REY (t ha^{-1})	7.77	-	6.33	3.85	2.66	5.77	6.40
Whole pattern REY (t ha^{-}	14.10			18.69			
Production efficiency (kg ha^{-1}day^{-1})	60.52			57.67			
Land use efficiency (%)	63.84			88.77			
Gross return (Tk. ha^{-1})	170900	-	139350	84800	58500	127040	140750
Total variable cost (Tk. ha^{-1})	90200	-	62500	48000	40700	50100	62500
Gross margin (Tk. ha^{-1})	80700	-	76850	36800	17800	76940	78250
Whole pattern GM (Tk. ha^{-1})	157550			209790			
MBCR (Whole pattern)	-			2.07			

Price (Tk. kg^{-1}): Urea-16, TSP-25, MP-15, Gypsum-10, Zinc Sulphate-200, Boric acid-500, Cowdung-1.5, Mustard seed-65, Mustard stover-1, Mungbean-65, Rice grain-22, Rice straw-5

Alternative cropping pattern (CP_2): Potato (BARI Alu-25)**-**Maize (Kaveri)**-**Sesbania (Local)**-**T. Aman (BRRI dhan75)

Yield, yield attributes and economic performance of alternative and existing cropping patterns during 2020-21 are presented in Table 4a.

Crop performance: The tuber yield of potato was 32.00 t ha^{-1}, which was attributed by remarkable number of tubers per plant (7.44). The above ground fresh biomass of potato was 793.35 g plant^{-1}, where the average plant height was 85.56 cm (Table 4b). The grain yield of maize was 10.80 t ha^{-1}, which was attributed by remarkable number of grains per cob (635.67) and 1000 grain weight (460.89 g). The stover yield of maize was recorded as 12.14 t ha^{-1}. The above ground fresh and dry biomass of maize was 423.17 and 115.03 g plant^{-1}, respectively where the average plant height was 275.11 cm. The biomass yield of sesbania was 12.51 t ha^{-1}. The grain yield of T. Aman rice was 5.40 t ha^{-1}, which was attributed by remarkable number of effective tillers per plant (17.33), grains per panicle (122.78) and 1000 grain weight (22.73 g). The straw yield of T. Aman rice was recorded as 6.05 t ha^{-1}. The above ground fresh and dry biomass of T. Aman rice was 157.6 and 33.80 g plant^{-1}, respectively where the average plant height was 104.60 cm. The total field duration of the alternative cropping pattern was 343 days and total turnaround time 22 days. The whole pattern rice equivalent yield (REY) was 29.73 t ha^{-1}, which was 110.85% higher than existing pattern.

Production efficiency (PE): Maximum production efficiency (86.67 kg ha^{-1}day^{-1}) was obtained from alternative cropping pattern. The lower production efficiency 60.52 kg ha^{-1}day^{-1} was found in farmers existing pattern (Table 4a). The alternative pattern Potato-Maize-Sesbania-T. Aman was found 43.21% more efficient than existing cropping pattern Boro-Fallow-T. Aman (Table 4a).

Land use efficiency (LUE): Land use efficiency indicated that alternative cropping pattern used the land for 93.97% time of the year, whereas farmers existing pattern used the land for 63.84% time of the year (Table 4a).

The whole pattern gross margin was higher in alternative pattern (Tk. 382460 ha^{-1}) than existing pattern (Tk. 157550 ha^{-1}). The MBCR was 2.89 in alternative pattern over existing pattern.

Table 4. Crop performance of improved cropping pattern Potato-Maize-Sesbania-T. Aman against the existing pattern Boro-Fallow-T. Aman

Pattern	Existing cropping pattern			Improved cropping pattern			
Crop	Boro	Fallow	T. Aman	Potato	Maize	Sesbania	T. Aman
Variety	BRRI dhan28	-	Swarna	BRRI Alu-25	Kaveri	Local	BRRI dhan75
Spacing	20×20 cm	-	20×20cm	50×15 cm	60×20 cm	Broadcast	20×15 cm
Fertilizer dose (N-P-K-S-Zn-B Kg ha^{-1})	265-90-150-115-12-7-1500	-	165-60-105-70-0-0-10000	350-220-310-120-10-10-12000	550-250-260-220-12-10-13000	-	165-60-105-70-0-0-10000
Date of Sowing/ transplanting date	15-20 Jan. 2021	-	24-27 July 2021	25-28 Nov 2020	26-28 Feb 2021	10-14 July 2021	20-22Aug 2021
Harvesting date	18-22 May 2021	-	12-14 Nov 2021	23-25 Feb 2021	08-12 July 2021	15-16 Aug 2021	18-22 Nov 2021
Field duration (day)	124	-	109	87	132	34	90
Turnaround time (day)	67	-	65	04	04	06	08
Grain/fibre /tuber/fruit yield	6.2	-	5.05	32	10.80	-	5.4
Straw/stover/stalk yield(tha^{-1})	6.90	-	5.65	-	12.14	12.5	6.05
REY (t ha^{-1})	7.77	-	6.33	14.55	8.40	0	6.78
Whole pattern REY (t ha^{-1})	14.10			29.73			
Production efficiency (kg ha^{-1}day^{-1})	60.52			86.67			
Land use efficiency (%)	63.84			93.97			

Gross return (Tk. ha^{-1})	170900	-	139350	320000	184940	-	149050
Total variable cost (Tk. ha^{-1})	90200	-	62500	126560	76470	6000	62500
Gross margin (Tk. ha^{-1})	80700	-	76850	193440	108470	-	86550
Whole pattern GM (Tk. ha^{-1})	157550			382460			
MBCR (Whole pattern)	-			2.89			

Price (Tk. kg^{-1}): Urea-16, TSP-25, MP-15, Gypsum-10, Zinc Sulphate-200, Boric acid-500, Cowdung-1.5, Potato-10, Maize-16, Rice grain-22, Rice straw-5

Alternative cropping pattern (CP_3): Potato (BARI Alu-25)/Sweet gourd (Sweety)**-**Jute (BJRI Toshapat-8)**-**T. Aman (BRRI dhan75)

Yield, yield attributes and economic performance of alternative and existing cropping patterns during 2020-21 are presented in Table 5.

Crop performance: The tuber yield of potato was 32.05 t ha^{-1}, which was attributed by remarkable number of tubers per plant (7.00). The above ground fresh biomass of potato was 742.00 g $plant^{-1}$, where the average plant height was 79.33 cm (Table 5b). The fruit yield of sweet gourd was 23.50 t ha^{-1}, which was attributed by remarkable number of fruits per plant (6.67). The above ground fresh biomass of sweet gourd was 9170.00 g $plant^{-1}$, where the average plant height was 523.83 cm. The fibre and stalk yield of jute were 2.61 and 5.25 t ha^{-1}, respectively. The above ground fresh and dry biomass of jute was 313.62 and 81.74 g $plant^{-1}$, respectively where the average plant height was 335.56 cm. The grain yield of T. Aman rice was 5.05 t ha^{-1}, which was attributed by remarkable number of effective tillers per plant (17.17), grains per panicle (140.56) and 1000 grain weight (22.34 g). The straw yield of T. Aman rice was recorded as 5.56 t ha^{-1}. The above ground fresh and dry biomass of T. Aman rice was 204.00 and 55.57 g $plant^{-1}$, respectively where the average plant height was 115.83 cm. The total field duration of the alternative cropping pattern was 332 days and total turnaround time was 33 days. The whole pattern rice equivalent yield (REY) was 33.46 t ha^{-1}, which was 137.31% higher than existing pattern.

Production efficiency (PE): Maximum production efficiency (100.79 kg $ha^{-1}day^{-1}$) was obtained from alternative cropping pattern. The lower production efficiency 60.52 kg $ha^{-1}day^{-1}$ was found in farmers existing pattern (Table 5a). The alternative pattern Potato/Sweet gourd-Jute-T. Aman was found 66.54% more efficient than existing cropping pattern Boro-Fallow-T. Aman (Table 5a).

Land use efficiency (LUE): Land use efficiency indicated that alternative cropping pattern used the land for 90.96% time of the year, whereas farmers existing pattern used the land for 63.84% time of the year (Table 5a).

The whole pattern gross margin was higher in alternative pattern (Tk. 445459 ha^{-1}) than existing pattern (Tk. 157550 ha^{-1}). The MBCR was 3.09 in alternative pattern over existing pattern.

Table 5. Crop performance of improved cropping pattern Potato/Sweet gourd-Jute-T. Aman against the existing pattern Boro-Fallow-T. Aman

Pattern	Existing cropping pattern			Improved cropping pattern			
Crop	Boro	Fallow	T. Aman	Potato	Sweet gourd (relay)	Jute	T. Aman
Variety	BRRI dhan28	-	Swarna	BRRI Alu-25	Sweety	BJRI Toshapat-8	BRRI dhan75
Spacing	20×20cm	-	20×20cm	50×15cm	2×2 m	Broadcast	20×15 cm
Fertilizer dose (N-P-K-S-Zn-B Kg ha^{-1})	265-90-150-115-12-7-1500	-	165-60-105-70-0-0-10000	350-220-310-120-10-10-12000	500-400-300-0-0-4-12000	10-50-65-100-12-0-8000	165-60-105-70-0-0-10000
Date of Sowing/ transplanting date	15-20 Jan. 2021	-	24-27 July 2021	24-26 Nov 2020	01-03 Dec 2020	07-10 April 2021	01-03 Aug 2021
Harvesting date	18-22 May 2021	-	12-14 Nov 2021	22-24 Feb 2021	05-07 April 2021	20-24 July 2021	02-06 Nov 2021

Pattern	Existing cropping pattern			Improved cropping pattern			
Crop	Boro	Fallow	T. Aman	Potato	Sweet gourd (relay)	Jute	T. Aman
Field duration (day)	124	-	109	89	89+45	106	92
Turnaround time (day)	67	-	65	0	04	10	19
Grain/fibre/tuber/fruit yield (t ha^{-1})	6.2	-	5.05	32.05	23.50	2.61	5.05
Straw/stalk yield (t ha^{-1})	6.90	-	5.65	-	-	5.25	5.56
REY (t ha^{-1})	7.77	-	6.33	14.56	4.27	8.31	6.31
Whole pattern REY (t ha^{-1})	14.10			33.46			
Production efficiency (kg $ha^{-1}day^{-1}$)	60.52			100.79			
Land use efficiency (%)	63.84			90.96			
Gross return (Tk. ha^{-1})	170900	-	139350	320500	94000	182775	138900
Total variable cost (Tk. ha^{-1})	90200	-	62500	126560	42430	59226	62500
Gross margin (Tk. ha^{-1})	80700	-	76850	193940	51570	123549	76400
Whole pattern GM (Tk. ha^{-1})	157550			445459			
MBCR (Whole pattern)	-			3.09			

Price (Tk. kg^{-1}): Urea-16, TSP-25, MP-15, Gypsum-10, Zinc Sulphate-200, Boric acid-500, Cowdung-1.5, Potato-10, Rice grain-22, Rice straw-5, Sweet gourd-4, Jute fiber-65, Jute stick-2.5

Comparison among the cropping pattern: From the results, it was found that higher rice equivalent yield was 32.55, 110.85 and 137.31%; production efficiency was 4.71, 43.21 and 60.72%; land use efficiency was 39.05, 47.20 and 47.63%; whole pattern gross margin was 33.16, 142.76 and 182.74% in CP_1, CP_2 and CP_3, respectively compared to CP_0 (Table 6). The marginal benefit cost ratio (MBCR) was 2.07, 2.89 and 3.09 in CP_1, CP_2 and CP_3, respectively over CP_0. So, it can be concluded that the maximum profitable cropping pattern is CP_3 followed by cropping pattern CP_2 CP_1 and the minimum profitable cropping pattern CP_0.

Farmer's opinion

Farmers opined that potato-based cropping pattern including maize or sweet gourd is found suitable to them. They are now confident that four crops can be produced in their land in a year if followed by optimum time of planting and timely supply of inputs.

Table 6. Comparison of different cropping pattern considering the existing pattern Boro-Fallow-T. Aman

Cropping pattern	REY (t ha^{-1})	Production efficiency (kg $ha^{-1}day^{-1}$)	Land use efficiency (%)	GM (Tk. ha^{-1})	MBCR
CP_0	14.10	60.52	63.84	157550	-
CP_1	18.69	57.67	88.77	209790	2.07
CP_2	29.73	86.67	93.97	382460	2.89
CP_3	33.46	97.27	94.25	445459	3.09

Conclusion

From the findings it can be concluded that Potato/Sweet gourd-Jute-T. Aman and Potato-Maize-Sesbania-T. Aman cropping pattern is more profitable than other tested four crops or two crops-based cropping pattern in terms of rice equivalent yield, production efficiency, land use efficiency, gross margin and MBCR. Besides, the deep rooted and biomass additive crops i.e., jute or sesbania of these patterns may help to maintain the soil fertility. So, these two intensive cropping patterns may select for further experimentation in next year under different fertilizer combination to identify the proper fertilizer doses for those patterns.

ON FARM TRIAL OF SWEET POTATO YIELD AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT

M. Z. FERDOUS, M. S. H. MOLLA, S. A.H.M. KAMAL, AND M. A. A. H. TALUKDER

Abstract

The field experiment was conducted during the rabi season of 2021-2022 in the farmer's field of Multi-location Testing (MLT) site, Pirganj, Rangpur to determine the optimum dose of fertilizer of sweet potato. Three fertilizer doses viz. T_1= STB (100-40-100 kg, K-P-N ha^{-1}) + poultry manure 3 ha^{-1}, T_2 = STB (100-40-100 kg, K-P-N ha^{-1}) + Vermicompost 3 t ha^{-1} and T_3 = STB (100-40-100kg, K-P-N ha^{-1}) were used. The highest sweet potato yield was obtained from treatment T_2 (23.26 t ha^{-1}) whereas lowest from T_3 treatment. The highest gross return (Tk. 279120) and gross margin (Tk.152433) was recorded from T_2 treatment while lowest from T_3 treatment.

Introduction

Fertilizer is one of the most important inputs of increasing the productivity of crops (Anon., 1997). In order to obtain good yield, modern varieties of different crops require relatively high quantity of fertilizer compared to the traditional cultivars. However, the economic condition of Bangladesh farmers often does not support them to use required quantity of fertilizers due to its high cost. On the other hand, the organic matter content of most of the soils of Bangladesh is very low (0.8-1.8%) as compared to desired (2.5% and above) levels (Hossain *et al.,* 1995). Therefore, it becomes an immense need to formulate an optimum fertilizer recommendation that would produce satisfactory yields and would maintain soil health to ensure sustainable crop production. One of the alternatives to economize the use of chemical fertilizer is to incorporate crop residues or farmyard manure in combination with chemical fertilizers was reported by Ferdous *et al.,* 2018, 2020. Bhuiya and Akanda (1982) reported that organic matter in combination with chemical fertilizer showed excellent response to rice cultivation. The Integrated Plant Nutrient System (IPNS) emphasizes the need to develop fertilizer management practices for maintenance of proper soil health. The basic concept underlying the IPNS is to provide an ideal nutrition for a crop through a proper combination of various nutrient resources and their optimum utilization along with maintenance of soil productivity (Ferdous *et al.* 2020, 2021). Sweet potato is one of the important tuber crops in Bangladesh, but its actual yield of this crop is lower than the potential yield. Of the various factors responsible for low yield is the lack of proper management of soil (Elias *et al.,* 1991). Soil fertility and productivity status of medium high land in Kurigram district where sweet potato is grown is not satisfactory. Therefore, the present study was undertaken to develop a fertilizer recommendation for sweet potato in medium high land under AEZ 3 at farmer's field and to determine the profitability of different combinations of fertilizers.

Materials and Methods

The experiment was conducted at the farmer's field of Multiplication lest (MLT), site, Pirganj, Rangpur during the rabi season 2021-2022 with a view to finding the optimum dose of fertilizer of sweet potato. The soil belongs to the general soil type under AEZ-3. The land was medium high with loamy to sandy loam. Before conducting the experiment, the soil sample was analyzed from SRDI, Rangpur. The experiment was laid out in a randomized complete block design with six dispersed replications. There were three treatments. Vine of sweet potato variety was planted in lines on 28-29 November 2021 at the spacing of 60 cm x 30 cm. Vines of terminal and semi-matured portions were used for planting. The cutting was about 15 cm in length with 5-6 nodes. The unit plot size was 8 m × 5 m. One weeding was done at 30 days after planting (DAT). The source of NPKS and Zn were urea, TSP, MP, gypsum, and zinc sulphate. Half of urea and all other fertilizers were applied at final land preparation. Remaining urea was top-dressed in two equal splits at 30 and 55 days after transplanting (DAT). The crop was grown in rainfed condition. There was no incidence of disease and insect attack. The crop was harvested during 24-30 March 2022 at full maturity. Collected data were analyzed statistically and means were separated using LSD (0.05) test. Production costs of sweet potato included the cost of all operations (e.g., land preparation, seed, sowing, irrigation, application of organic manure and chemical fertilizer, spraying of insecticides and fungicides, and harvesting) were recorded. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. The total gross margin was calculated by subtracting the cost of production from the total gross return (Anwar *et al.* 2021).

Results and Discussions

The yield and yield contributing characters of sweet potato varieties differed significantly due to different nutrient management (Table 1). The longest plant (149.93 cm) was recorded from STB (100-40-100 KPN kg ha^{-1}) fertilizer dose. The treatment STB (100-40-100 KPN kg ha^{-1}) + poultry manure 3 t ha^{-1} treatment produced the shortest plant (131.07 cm). The maximum tuber wt./plant (418.67 g) was recorded from STB (100-40-100 KPN kg ha^{-1}) + Vermicompost 3 t ha^{-1}treatment and it was statistically similar to STB (100-40-100 KPN kg ha^{-1}) + poultry manure 3 t ha^{-1} based treatment. Minimum tuber wt./plant (395.77 g) was obtained from STB (100-40-100 KPN kg ha^{-1}) based treatment. The highest tuber yield (23.26 t ha^{-1}) was recorded From STB (100-40-100 KPN kg ha^{-1}) + Vermicompost 3 t ha^{-1} based treatment.

The present results are in line with the findings of Ferdous, *et al*. (2018 and 2020), Rahman et al. (2011), Yadav and Garg (2016), and Haque *et al*. (2018) about application of Vermicompost, poultry manure and biogas slurry. The lowest tuber yield (19.04 t ha^{-1}) was found in STB (100-40-100 KPN kg ha^{-1}) based treatment.

Cost and return analysis

Cost and return analysis are presented in Table 1. The highest gross return (279120 Tk. ha^{-1}) and gross margin (152273 Tk. ha^{-1}) was found in STB (100-40-100 KPN kg ha^{-1}) + Vermicompost 3 ha^{-1}based treatment. The variable cost was also higher in STB (100-40-100 KPN kg ha^{-1}) + vermicompost 3 ha^{-1} based treatment because of higher price of Vermicompost. Ferdous *et al*. (2018) also reported that variable cost in the treatment IPNS was higher because of additional cost of bio-slurry. The lowest gross return and gross margin recorded from STB (100-40-100 KPN kg ha^{-1}) based treatment. Similar results also found Ferdous *et al*. (2020).

Table 1. Tuber yield and yield contributing characters of sweet potato at MLT site, Pirganj, Rangpur during 2021-2022

Treat.	Plant height (cm)	Tuber plant^{-1} (no.)	Tuber wt. plant^{-1} (g)	Tuber Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
T_1	131.07	6.13	402.45	20.86	20.86	250320	116687
T_2	132.80	6.00	418.67	23.26	23.26	279120	126687
T_3	149.93	5.80	395.77	19.04	19.04	228480	107491
LSD (0.05)	17.02	0.708	4.55	2.45	-	-	-

T_1= STB (100-40-100 kg, K-P-N ha^{-1}) + poultry manure 3 ha^{-1}, T_2 = STB (100-40-100 kg, K-P-N ha^{-1}) + vermicompost 3 t ha^{-1} and T_3 = STB (100-40-100kg, K-P-N ha^{-1}), GR = Gross return, TVC = Total variable cost and GM = Gross margin

Conclusion

The maximum productivity and profitability were found from the combination of STB (100-40-100 KPN kg ha^{-1}) + Vermicompost 3 ha^{-1} based treatment. So, apply suitable fertilizer dose of 100-40-100 KPN kg ha^{-1}) + Vermicompost 3 ha^{-1} for sweet potato cultivation in Kurigram region of Bangladesh.

VALIDATION OF BIOFERTILIZER ON GROUNDNUT AT JAMALPUR REGION

M.M. RAHMAN, A.K.M.Z.U. NOOR AND M.S. RAHMAN

Abstract

The experiment was conducted at the farmers' field at Naovanghar Char, Jamalpur during rabi season, 2021-2022. The maximum nut yield 1.97 t ha^{-1} was obtained from T_2 treatment and the minimum (1.81 t ha^{-1}) from T_1 treatment. The highest gross return (Tk. 137900 ha^{-1}) and gross margin (Tk. 60580 ha^{-1}) were observed in T_2 treatment due to its higher yield. The lowest gross return (Tk. 126700 ha^{-1}) and gross margin (Tk. 50686 ha^{-1}) were found from T_1 treatment due to its lower yield.

Introduction

Groundnut (*Arachis hypogaea*) is an important leguminous oilseed crop. It is cultivated during rabi and kharif under rainfed condition. It contains high protein and fat. In Bangladesh groundnut cultivated in an area 34,857 hectare of land and production are 66,744 ton. (BBS, 2021) Bradyrhizobium bacteria forms nodules in the roots of groundnut plant which fixes atmospheric nitrogen and used for its own and groundnut plants are being benefited simultaneously. Farmers of different char land areas of Bangladesh grow groundnut after receding of flood water. BARI has developed a good number of high yielding varieties of groundnut. Therefore, the experiment was undertaken to popularize the rhizobium bio-fertilizer technology for producing groundnut in the farmer's level.

Materials and Methods

The experiment was carried out at farmer's field of Naovanghar Char, Jamalpur during rabi season, 2021-22. The study was set up in RCB design with four dispersed replications. Groundnut var. BARI Chinabadam-9 was used. The unit plot size was 3m × 4m. Treatments were: T_1=Without Rhizobium inoculant + P-K-S-Zn, T_2=With Rhizobium inoculant + P-K-S-Zn and T_3=N-P-K-S-Zn. Seeds were sown on 8 February 2022. The crop was fertilized with N-P-K-S-Zn @ 100-22-42-40-5 kg ha^{-1} and rhizobium bio-fertilizer @1.5 kg ha^{-1} during final land preparation. The intercultural operations such as weeding, irrigation, pest control etc. were done as and when necessary. The crop was harvested on 17 June 2022. Data on yield and yield contributing characters were taken statistically analyzed following IRRI STAR software package and mean separation was done as per LSD test.

Results and Discussions

Results obtained from the study have been presented in Table 1. The tallest plant (68.95 cm) was obtained from T_2 treatment and the shortest (57.92 cm) from T_1 treatment. The highest number of nut plant^{-1} (20.80) was found from T_2 treatment and the lowest (19.70) in T_1 treatment. The maximum yield of nut (1.97 t ha^{-1}) was found from T_2 which was followed by T_3 treatment (1.92 t ha^{-1}) and the minimum (1.81 t ha^{-1}) from T_1 treatment.

The higher gross return (Tk. 137900 ha^{-1}) and gross margin (Tk. 60580 ha^{-1}) were observed from T_2 treatment due to its higher yield. The lowest gross return (Tk. 126700 ha^{-1}) and gross margin (Tk. 50686 ha^{-1}) were found from T_1 treatment due to its lower yield.

Farmer's opinion

Farmers are interested to grow groundnut var. BARI Chinabadam-9 with application of rhizobium inoculant due to its higher yield as well as higher income.

Conclusion

Considering yield potentiality and economic point of view, it was found that T_2 rhizobium inoculum was applied gave the better performance. The experiment should be repeated for more confirmation.

Table 1. Yield and yield attributes of Groundnut at Naovanghar Char, Jamalpur during rabi season, 2021-22

Treat.	Plant height (cm)	Branch plant^{-1} (no)	Nut plant^{-1} (no)	Nut yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
T_1	57.92	4.60	20.55	1.81	126700	76014	50686
T_2	68.95	4.45	20.80	1.97	137900	77320	60580
T_3	61.08	5.20	19.70	1.92	134400	79534	54866
LSD (0.05)	**	NS	*	NS			
CV (%)	4.01	10.92	2.80	5.16			

T_1=Without Rhizobium inoculant + P-K-S-Zn @ 22-42-40-5 kg ha^{-1} T_2=With Rhizobium inoculant +P-K-S-Zn and T_3=N-P-K-S- Zn @ 22-42-40-5 kg ha^{-1}, 100-22-42-40-5 ha^{-1}; GR = Gross return, TVC = Total variable cost and GM = Gross margin; Price of groundnut = Tk. 70 kg^{-1}

EFFECT OF FERTILIZER DOSES ON TURMERIC AT MADHUPUR TRACT UNDER AEZ-28

M.A.H. KHAN, M. A. RAHAMAN, S. ROY, M.M. RAHMAN AND T. TASMIMA

Abstract

A field experiment was conducted at MLT site, Madhupur (AEZ-28), Tangail during 2021-22 to find out an optimum fertilizer dose for turmeric production in Madhupur tract. Six treatment combinations viz. T_1= STB, T_2= T_1 + 20% NK, T_3= T_1 + 20% NKS, T_4= T_1 + 20% NKSZn, T_5= IPNS fertilizer + CD 5 t ha^{-1}, T_6= Farmers' practice. The experiment was laid out in randomized complete block design with three compact replications. Significant differences were observed among the treatments in terms of yield and yield contributing characters. Nutrient management with application of STB dose +20% NKSZn significantly increased rhizome yield. The highest rhizome yield (18.83 t ha^{-1}) was recorded from T_4 treatment combination. The lowest rhizome yield (14.67 t ha^{-1}) was obtained from T_1 treatment. The highest gross return (Tk. 282450 ha^{-1}) and gross margin (Tk. 152558 ha^{-1}) were recorded in T_4 treatment whereas the lowest gross return (Tk. 220050 ha^{-1}) and gross margin (Tk. 90844 ha^{-1}) were obtained from T_1 treatment. The results indicated that the application of nutrient management of STB fertilizer with 20% NKSZn produce the maximum rhizome yield and higher economic return.

Introduction

Turmeric (*Curcuma longa*) is one of the major spices crops grown in Bangladesh. Turmeric is cultivated in 3257-hectare land and produces 14372-ton yield in Tangail District (DAE, Tangail, 2021). The farmers of the Madhupur are as usually growing local turmeric variety and they do not apply the proper fertilizer management in that area. As a result, farmer does not get the maximum benefit from turmeric cultivation. Spices Research Centre of BARI has no developed recommended fertilizer dose for Madhupur hill tract for turmeric cultivation. In hill area of Madhupur there is enough scope for improved and economically profitable fertilizer management package for turmeric cultivation. So, the present study was undertaken to find out the optimum fertilizer dose of turmeric in Madhupur tract and also increase productivity and economic return of farmers.

Materials and Methods

A field experiment was conducted at MLT site, Madhupur (AEZ-28), Tangail during 2021-22 to find out an optimum fertilizer dose for Turmeric in Madhupur tract. Before conducting the experiment, initial composite soil samples (0-15 cm) were collected from the experimental plots and collected samples were analyzed. The initial soil analysis values were presented in Table 1. Soil test values indicate that the soils of experimental plots are acidic in nature. To reclamation the soil acidity 4 kg per decimal agricultural lime ($CaCO_3$) was used 15 days prior to planting. The experiment was laid out in randomized complete block design with three compact replications. The unit plot size was 8m × 5m and BARI Halud-5 was used as the test crop in this experiment. Treatments were randomly distributed within the blocks as follows: T_1= STB fertilizer (116-27-77-8-1.5 kg, N-P-K-S-Zn ha^{-1}), T_2= T_1 + 20% extra NK (139-27-92-8-1.5 kg, N-P-K-S-Zn ha^{-1}), T_3=T_1 + 20% extra NKS (139-27-92-9.6-1.5 kg, N-P-K-S-Zn ha^{-1}), T_4= T_1 + 20% NKSZn (139-27-92-8-1.8 kg, N-P-K-S-Zn ha^{-1}), T_5= IPNS basis fertilizer with 5 t ha^{-1} cowdung (91-19.5-65.5-8-1.5 kg, N-P-K-S-Zn ha^{-1}), T_6= Farmers' practice (115-50-125-16-1.0 kg, N-P-K-S-Zn ha^{-1}). Except urea half of K and all other fertilizers were applied during final land preparation. Entire urea and rest K were top dressed in three installments at 50, 80 and 120 days after planting. The seeds (rhizome) were planted @ 2000 kg ha^{-1} during 14-20 April 2021. Weeding and other crop management practices were done properly for normal growth of the crop. No remarkable insect and disease were observed in the experimental field. But a little leaf blight was found at the middle to later growth stages of plant in the all treatment which was control successfully through application of tilt @ 1.0 ml L^{-1}. The crop was harvested during 25-30 March 2022. Necessary data were collected plot wise and analyzed statistically using Crop Stat analytical package and presented in Table 2.

Table 1. Chemical properties of initial soil (0 -15 cm depth) of the experimental field at MLT site Madhupur during 2021-22.

	pH	OM	Total N	K	Ca	Mg	P	S	Zn	B
		(%)	(%)	Meq/100 g soil			$\mu g\ g^{-1}$ soil			
Soil test value	5.1	1.39	0.01	0.25	1.7	1.8	8.08	22.18	0.462	0.30
Interpretation	-	-	Low	Medium	Low	High	Low	Low	Medium	Low

Results and Discussions

Yield and yield contributing characters: It were revealed that yield and yield contributing characters were significantly influenced by the nutrient management. The result showed that plant height was significantly different among the treatment combination but T_2 treatment gave the highest plant height (140.67 cm) which followed by T_4 treatment combination, and the lowest plant height (114.67 cm) was obtained from T_5 treatment. Maximum number of primary fingers per plant was found T_4 treatment (6), which was statistically identical with other treatments. Number of secondary fingers per plant was statistically significant due to different nutrient management. The highest number of secondary fingers per plant was obtained from T_4 treatment (13), though it was at par with T_5 treatment. The lowest number of secondary fingers per plant was obtained from T_2 treatment (8). The maximum rhizome yield per plant was recorded from T_4 treatment (201.62 g) and the lowest in T_1 treatment (155.20 g). The rhizome yield varied from 14.67 to 18.83 t ha^{-1} in the different treatments. The highest rhizome yield (18.83 t ha^{-1}) was recorded in T_4 treatment which was statistically identical with T_5 treatment. The STB fertilizer dose T_1 gave the lowest rhizome yield (14.67 t ha^{-1}). As the number of fingers per plant and the rhizome yield per plant were higher in T_4 treatment, the highest yield obtained in that treatment was justified (Table 2).

Cost and return analysis: From the cost and return analysis, the maximum gross return (Tk. 282450 ha^{-1}) and gross margin (Tk. 152558 ha^{-1}) were recorded from the T_4 treatment. The lowest gross return (Tk. 220050 ha^{-1}) and gross margin (Tk. 90844 ha^{-1}) were obtained from T_1 treatment (Table 2).

Farmers' opinion

Farmers are impressed to see the higher yield and economic return of BARI Halud-5 as well as nutrient management of STB along with 20% extra N, K, S and Zn dose. They will apply STB along with 20% extra of N, K, S and Zn fertilizer in the next year for higher yield and economic return.

Table 2. Effect of nutrient management packages on yield and yield contributing characters of turmeric at MLT site Madhupur (AEZ-28) during 2021-22

Treat.	Plant height (cm)	Primary finger plant^{-1} (no.)	Secondary finger plant^{-1} (no.)	Finger wt. plant^{-1} (g)	Rhizome yield (t ha^{-1})	GR (Tk ha^{-1})	TVC (Tk ha^{-1})	GM (Tk ha^{-1})
T_1	122.47	5	9	155.20	14.67	220050	129206	90844
T_2	140.67	5	8	157.14	15.00	225000	129799	95201
T_3	124.13	5	11	163.33	15.27	229050	129823	99227
T_4	131.60	6	13	201.62	18.83	282450	129892	152558
T_5	114.69	5	13	185.61	18.07	271050	128487	142563
T_6	114.76	5	11	183.39	16.67	250050	130397	119653
LSD $_{(0.05)}$	15.78	0.61	2.02	22.05	2.24			
CV (%)	7.00	6.40	10.20	7.20	7.40			

T_1= STB as per FRG 2018, T_2= T_1 + 20% extra NK, T_3= T_1 + 20% extra NKS, T_4= T_1 + 20% extra N K S Zn, T_5= IPNS basis fertilizer with cowdung (5 t ha^{-1}), T_6= Farmers' practice; GR = Gross return, TVC = Total variable cost and GM = Gross margin; Market price: Rhizome (Tk. /kg) =Tk. 15.00

Conclusion

From the study, it may be concluded that soil test-based fertilizer with 20% NKSZn extra (139-27-92-8-1.8 kg N-P-K-S and Zn ha^{-1}) dose is superior to other nutrient management in respect of yield and economic return. For final conclusion the experiment should be repeated in the next year.

EFFECT OF FERTILIZER APPLICATION METHODS ON MAIZE GROWN UNDER STRIP TILLAGE SYSTEM IN HIGH BARIND TRACT

M.S. HOSSAIN, M.E.A. PRAMANIK AND J.C. BARMAN

Abstract

A field experiment was conducted in the farmer's field at the FSRD site, Basantapur, Godagari, Rajshahi during Rabi 2019-20, 2020-21, and 2021-22 to develop the best fertilizer application method in conservation agriculture for Maize cultivation in High Barind Tract. The experiment was performed using a randomized complete block design with three replications. There were four treatments namely, T_1= fertilizer and seeds sown simultaneously on the same row by strip machine, T_2= fertilizer and seeds sown simultaneously on a different row by strip machine, T_3= fertilizer applied on strip manually and T_4= fertilizer broadcasted on whole plot manually. The maximum germination rate (90%) and grain yield (7.34, 7.22, and 7.04 t ha^{-1} in Yr1, Yr2, and Yr3, respectively) were recorded in T_2 when fertilizer and seeds were sown in different rows simultaneously with strip machine. Contrarily, treatment T_1 where fertilizer and seeds were presented on the same row simultaneously showed poor performance regarding germination rate (65, 63, and 66% in Yr1, Yr2, and Yr3, respectively), grain yield (4.11, 4.09, and 4.07 t ha^{-1} in Yr1, Yr2, and Yr3, respectively) and other parameters.

Introduction

In Bangladesh, food demand is increasing day by day due to high population growth. At this juncture, only rice and wheat could not fulfill the total cereal food demand of the country. To meet up this challenge, maize can be selected as a better supplement of rice and wheat to reduce this food deficiency because of its higher yield potentiality as compared to rice and wheat. Being C_4 plant Maize can accumulate dry matter faster than rice, wheat, or other cereals, contributing to more yields. It has multiple uses, such as human food, animal feed and fodder, and agro-based industrial raw materials. Maize is consumed as green cob both by boiling or roasting and as popcorn. The use of Maize flour mixed with wheat for making flat bread (chapati) is increasing. Maize area and production are increasing day by day due to multiple use, high yield potentiality, profitability etc. Again, labor shortage is becoming an acute problem in agriculture sector. In the meanwhile, Bangladesh Govt. is enforcing mechanization as well as conservation agriculture. Conservation agriculture (CA) is said to result in sustainable farming systems as it saves time, economic inputs and natural resources. Strip tillage is a prominent technology for Maize cultivation in drought-prone area. Seed germination or emergence, growth and development facilitated by reduced tillage system over the conventional cultivation practices. But fertilizer management system is a challenge for ensuring better crop growth as well as grain yield. Therefore, it is necessary to find out the sustainable or efficient fertilizer application methods for the betterment of the crop.

Material and Methods

The field trial was conducted at the Farming System Research and Development site, Basantapur, Godagari, Rajshahi during *Rabi* 2019-20, 2020-21, and 2021-22 to find out the best method for fertilizer application in resource conservation technology for Maize cultivation. Before conducting the experiment, the soil of the experimental field was chemically analyzed in the Soil Resource Development Institute (SRDI) laboratory, Shyampur, Rajshahi. The soil of the experimental plots belongs to Amnura series under AEZ-26. The levels of the fertilizers were calculated based on high yield goal as per Fertilizer Recommendation Guide' 2018. The chemical properties of soil are presented in Table 1. The STB fertilizer doses were 300-75-96-34-5-1.5 kg, N-P-K-S-Zn-B ha^{-1}, respectively. The experiment was laid out in a randomized complete block design with three replications. There were four methods of basal fertilizer application, namely T_1= fertilizer and seeds sown simultaneously on the same row by strip machine, T_2= fertilizer and seeds sown simultaneously on a different row by strip machine, T_3= fertilizer applied on strip manually, and T_4= fertilizer broadcasted on whole plot manually. Only di-ammonium phosphate (DAP) was applied mechanically. Other fertilizers were applied with top dressing. The seeds were sown at 60 cm row to row distance and seed to seed 25 cm. Seeds were sown at proper soil moisture conditions on early December in each of the three years. NK-40, a commercial Maize hybrid was used as test material. After the establishment of seedling, the necessary management practice was done to support the normal growth of the Maize plant. The land was fertilized as per treatment. Pesticides were applied as per schedule. The crop was harvested in early May each year. Data were recorded on phenological, agronomic, yield and yield components and analyzed statistically with open-source software R (R Core Team, 2020).

Table 1. Chemical properties of initial soil (0-15 and 16-30 cm depth) of the experimental field at FSRD site, Basantapur, Godagari, Rajshahi

Depth (cm)	pH	Organic matter (%)	K	Total N (%)	P	S	B	Zn
			meq/100g soil		Micro gram/g soil			
0-15	7.4	1.0	0.23	0.06	15.3	6.3	0.18	0.16
16-30	7.8	0.87	0.21	0.05	7.8	10.6	0.17	0.29
Mean	7.60	0.94	0.22	0.06	11.55	8.45	0.16	0.23
	Slightly alkaline	Low	Medium	Very low	Low	Low	Low	Very low

Results and Discussions

Most of the parameters that differed significantly among the treatments were presented in Table 2. Germination rate (%) was the highest in T_2 (90%) in all the years when fertilizer and seed were planted simultaneously on different rows. The T_4 where fertilizer was broadcasted on the whole plot manually showed similar germination performance (86-88%) to T_2. The lowest germination rate (63-66%) was recorded in T_1 when fertilizer and seed were sown on the same row simultaneously indicating that Maize seed is sensitive to fertilizer especially N which might damage seed viability. Similar to germination rate, plant population (m^{-2}) was the highest in treatment T_2 (6.40-6.91) in all three years. Treatments T_3 (5.40-5.77) and T_4 (5.44-5.83) gave similar no. of plant population which were statistically lower than T_2. The highest plant height, grains cob^{-1}, cob length, and 100-grain weight were found in the same treatment T_2. The lowest performance of aforesaid parameters was recorded in T_1. Grain yield is a complex character, and it depends upon many characters. The T_2 (7.34, 7.22 and 7.04 t ha^{-1} in Yr1, Yr2, and Yr3, respectively) produced the highest grain yield among the treatments due to higher no. of plant per unit area and better performance of yield components. The T_3 and T_4 gave similar grain yields between themselves in all the years. The lowest grain yield was obtained from T_1 (4.11, 4.09, and 4.30, t ha^{-1} in Yr1, Yr2, and Yr3, respectively).

Table 2. Effect of Fertilizer application method on yield and yield contributing characters of hybrid Maize at Godagari, Rajshahi

Treat	Germination (%)	Pl. Popn. (m^{-2})	Plant height (cm)	Ear height (cm)	Grains cob^{-1} (no)	Cob length (cm)	100-grain wt. (g)	Grain yield (t ha^{-1})
2019-2020								
T_1	65.67c	3.08c	175.33b	78.33	374.00a	16.5c	28.06b	4.11b
T_2	90.00a	6.91a	197.00a	75.33	454.33a	21.2a	30.63a	7.34a
T_3	82.33b	5.77b	182.67b	70.16	434.66a	20.1ab	28.13b	6.75b
T_4	88.00ab	5.83b	184.33ab	75.00	425.66a	18.1bc	29.63a	6.36b
LSD $_{(0.05)}$	5.75	0.81	13.76	NS	90.32	2.93	1.35	0.57
CV (%)	3.54	7.55	3.73	6.07	10.70	7.74	2.32	8.73
2020-2021								
T_1	63.00c	3.46c	183.67ab	74.67	364.67d	15.63c	26.63c	4.09b
T_2	90.33a	6.73a	192.33a	78.00	490.00a	20.72a	31.50a	7.22a
T_3	78.00b	5.40b	180.33b	82.00	445.33b	17.53b	27.57bc	6.33b
T_4	86.33a	5.44b	186.67ab	83.00	412.67c	16.88bc	29.40ab	6.33b
LSD $_{(0.05)}$	6.11	1.14	10.06	NS	27.72	1.60	2.43	0.59
CV (%)	5.85	10.86	6.71	7.54	5.24	5.52	5.23	9.77
2021-2022								
T_1	66.33c	3.31c	175.33	76.67	315.67c	15.41b	28.32b	4.30c
T_2	90.00a	6.40a	184.67	70.00	482.67a	20.57a	31.32a	7.04a
T_3	84.00b	5.69ab	177.67	75.83	437.00b	20.32a	29.03b	6.58ab
T_4	86.33ab	5.56b	178.33	79.33	417.33b	18.76a	29.49ab	6.07b
LSD $_{(0.05)}$	5.83	0.71	NS	NS	30.47	2.18	2.10	0.57
CV (%)	3.57	6.79	8.56	5.01	7.69	5.81	3.56	6.73

Conclusion

From the result, it can be concluded that fertilizer and seed could be shown in separate rows simultaneously for the cultivation of Maize in the CA system.

DEVELOPMENT OF FERTILIZER RECOMMENDATION FOR MAIZE-T.AUS-T. AMAN CROPPING PATTERN IN KARATOA BENGALI FLOODPLAIN

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Abstract

The trial was conducted in the farmers' field of Multilocation Testing Site, Sherpur, Bogura, during the Rabi season of 2020-21 to develop a suitable fertilizer recommendation for Maize-T. Aus-T. Aman rice cropping pattern. For the first crop maize, the treatments were T_1= STB dose, T_2= T_1 +25% extra NPK, T_3= T_1+50% extra NK, T_4= IPNS based on T_1 @ 5 t cowdung ha^{-1} of and T_5 = IPNS based on T_3 @5 t cowdung ha^{-1}. In case of maize, maximum grain yield (8.56 t ha^{-1}) was recorded from the T_3 treatment and was statistically similar to T_2 and T_5, and the minimum (6.92 t ha^{-1}) from the T_4 treatment. A similar trend was also observed for stover yield. Higher grain yields of both T. Aus rice and T. Aman rice were associated with a higher dose of NPK or NK in T_3 and T_2. The highest gross return (Tk. 381230 ha^{-1}) amounted to T_3 treatment against the cultivation cost of Tk. 220725 ha^{-1} but the higher gross margin (Tk. 161657 ha^{-1}) from T_2. Lower gross return (Tk. 338430 ha^{-1}) and gross margin (Tk. 119578 ha^{-1}) were obtained from the T_4 treatment.

Introduction

The major challenge for the agriculture sector of Bangladesh is to increase and sustain crop yield and production. Higher yield is possible through cropping intensification with high-yielding varieties of balanced fertilizer and proper soil fertility management. The present soil fertility status of Bangladesh is alarming. The use of organic manures to meet the nutrient requirements of the crop would be an inevitable practice in the years to come for sustainable agriculture since organic manures not only improve the soil's physical, chemical, and biological properties (Heitkamp *et al.*, 2011) But also improves the moisture-holding capacity of the soil, thus resulting in enhanced crop productivity along with the better quality of crop produce (Premsekhar and Rajashree, 2009). Hence, fertilizers, manures, and other amendments, either alone or in combination, could be used to develop a nutrient supplying capacity of the soil (Dutta and Sangam, 2014). The application of poultry manure increases the pH, P, K, Ca, Mg, and Mn, in the soil more effectively when compared to other animal manures (Wijejawardena 2000). In a rice-based cropping system, Maize-T. Aus-T. Aman is one of the major cropping patterns in Sherpur Upazila of Bogura, which cover around 1330 hectare of land. The present cropping intensity of Sherpur is 251% by improving the present cropping pattern. Sustainable crop production in Bangladesh through improving cropping patterns in rice-based cropping systems is regarded as increasingly important in national issues such as food security, poverty alleviation, and job opportunities. However, there is still no recommended fertilizer dose for Maize-T. Aus-Taman cropping pattern crop production, fertilizer management is the most logical way to raise total production. Thus, it is necessary to determine the optimum fertilizer dose for Maize-T. Aus-T. Aman cropping pattern in the Bogura region. Hence the trial was undertaken to find a suitable and economical fertilizer dose for sustainable crop productivity and soil fertility for Maize-T. Aus-Taman cropping pattern and increase the productivity and income of the farmers.

Material and Methods

The trial was conducted in the farmers' field of MLT site, Sherpur, Bogura, during the *Rabi* season of 2020-21 cropping season to develop a suitable fertilizer recommendation for Maize- T. Aus- T. Aman rice cropping pattern. The experiment was laid out in a randomized complete block design with three replications. There were five treatments for each crop, and maize was the first crop in the sequence, followed by T. Aus and T. Aman rice. The soils belong to the AEZ-4. Initially, the soil samples were collected from different points of the experimental field and analyzed to determine the nutrient status of the soils. Nutrient status of the soils is presented in Table 1. Based on soil test values, fertilizer doses for respective treatments were estimated.

Table 1. Average nutrient status of initial soil (0-15 & 15-30 cm depth) of the experimental fields at MLT site, Sherpur, Bogura

Item	pH	OM (%)	Total N (%)	K (meq 100g^{-1}	P	S	Zn	B
					µg g^{-1} soil			
Value	5.95	1.55	0.085	0.172	8.254	17.145	0.321	0.263
Interpretation	N	L	L	M	L	L	VL	L

N= Neutral, M=Medium, L=Low, VL=Very low

Crops cultivation

Maize: The fertilizer doses for each treatment were calculated based on the soil test. For the first crop (maize), the treatments were T_1: STB dose, T_2: T_1 + 25% extra NPK, T_3: T_1 + 50% extra NK, T_4: IPNS based on T_1 @5 tha^{-1} of cowdung and T_5: IPNS based on T_3 @5 tha^{-1} of cowdung. According to the treatment specifications, the STB and other doses were estimated as T_1 = 238.07-72.74-68.93-32.32-4.68-1.20 kg , N-P-K-S-Zn-B ha^{-1}; T_2 = 297.59-72.74-86.17-32.32-4.68-1.20 kg, N-P-K-S-Zn-B ha^{-1}; T_3 = 297.59-90.93-86.17-32.32-4.68-1.20 kg, N-P-K-S-Zn-B ha^{-1}; T_4 = 5000-213.07-65.24-57.43-32.32-4.68-1.20 kg, CD-N-P-K-S-Zn-B ha^{-1}; T_5 = 5000-272.59-83.43-74.67-32.32-4.68-1.20 kg, CD-N-P-K-S-Zn-B ha^{-1} respectively. Before seed sowing, all the fertilizers except urea were applied as basal and thoroughly mixed with the soils. Treatments were assigned randomly, and fertilizer doses were applied following the RCB design. The unit plot size was 40 m^2. Seeds of maize var. BARI Hybrid Maize

(BHM-9) @ 25 kg seed ha^{-1} were sown on 26 November 2020 following a spacing of 60cm × 20cm. At the final land preparation stage, one-third of the approved urea and other fertilizers were broadcast, followed by tilling and levelling. The remaining urea was applied in equal to 2 splits where first dose was applied at 35 days after seed germination (8-10 leaf stage) and the second dose at 60-65 days after seed germination. The crop was then sprayed with Proclaim 5 SG @1g/L at 7-10 days intervals to control Fall Armyworm. Besides this, SNPV @ 0.2 g/L was applied as biocontrol measurement against fall armyworm.

In some cases, leaf blight was observed, and Rovral 50wp @ 2g/L was sprayed to control blight. The crop was harvested on 13 May 2020. The economic indices, i.e., gross return, gross margin, and cultivation cost, were also calculated based on the prevailing market price of the commodities. Relevant data were taken and analyzed statistically.

T. Aus rice: T. Aus was the second crop in the sequence. Twenty-two days old seedlings were transplanted into the main field after the harvest of maize. The fertilizer doses of the corresponding treatments were as T_1 = 71.44-7.6-24.23-0-7.5-0-0 kg, N-P-K-S-Zn-B ha^{-1}; T_2 = 89.30-7.6-30.28-7.5-0-0 kg, N-P-K-S-Zn-B ha^{-1}; T_3 = 89.30-9.5-30.28-7.5-0-0 kg, N-P-K-S-Zn-B ha^{-1}; T_4 = 5000-46.44-0-12.73-7.5-0-0 kg, CD-N-P-K-S-Zn-B ha^{-1}; T_5 = 5000-64.30-2-18.78-7.5-0-0 kg, CD-N-P-K-S-Zn-B ha^{-1} respectively. One-third of urea and other fertilizers were mixed well with the soils during final land preparation. One-third of urea was applied 15 days after planting, and the remaining one third at 30 days just at the tillering stage.

T. Aman rice: T. Aman was the third crop in the sequence and grown after the harvest of T. Aus rice. Twenty-five days old seedlings were transplanted into the main field after the harvest of maize. The fertilizer doses of the corresponding treatments were as T_1 = 67.01-9.43-30.23-6.5-0-0 kg, N-P-K-S-Zn-B ha^{-1}; T_2 = 83.77-9.43-30.23-6.5-0-0 kg, N-P-K-S-Zn-B ha^{-1}; T_3 = 83.77-11.79-37.79-6.5-0-0 kg, N-P-K-S-Zn-B ha^{-1}; T_4 = 5000-42.01-2.0-18.73-6.5-0-0 kg, CD-N-P-K-S-Zn-B ha^{-1}; T_5 = 5000-58.77-4.29-26.29-6.5-0-0 kg, CD-N-P-K-S-Zn-B ha^{-1} respectively. One-third of urea and other fertilizers were mixed well with the soils during final land preparation. One-third of urea was applied 15 days after planting, and the remaining one third at 30 days just at the tillering stage.

In T. Aus and T. Aman, rice, stem borer and sheath blight were observed in some plots. Folicur @ 0.5 ml/L was sprayed to control sheath blight and Virtako 40 WG @1.5g/10 L for stem borer. Other management options are given in Table 2.

Table 2. Crop management information for maize, T. Aus and T. Aman rice in MLT site, Sherpur, Bogura during 2020-21 cropping season

Parameters	Cropping Pattern		
Crop	Maize	T. Aus	T. Aman
Variety	Kaveri-50	BRRI dhan82	BRRI dhan75
Spacing	60cm × 20cm	20cm × 15cm	20cm × 15cm
Date of transplanting/sowing	16 Nov 20	6 May 21	6 Aug 21
Date of harvesting	29 Apr 21	30 Jul 21	16 Nov 21
Fertilizer application	Broadcasting	Broadcasting	Broadcasting
Intercultural Operation	Earthing up, irrigation three times at 35, 55 and 75 days	Irrigation at 26 days weeding two times at 30 and 45 days	Weeding two times at 30 and 45 days
Field duration (days)	164	85	101

The economic indices, i.e., gross return, gross margin, and cultivation cost, were also calculated based on the prevailing market price of the commodities. Relevant data were taken and analyzed statistically.

Results and Discussions

Yield and yield contributing parameters of maize are presented in Table 3. All the parameters varied significantly among the treatments. Maize plants responded better to the higher fertilizer applied to the field. Higher yield and yield contributing characters were associated with more fertilizer. Higher plant height (175.36 cm) was recorded from the T_3 treatment identical to T_2 and T_5 treatments, and the lower (161.48 cm) from the T_4 treatment. Extra N-P-K applied to the T_2, T_3, and T_5 treatments might be helpful for better plant growth and development.

On the contrary, plants under T_1 and T_5 showed slightly stunting as N-P-K were applied less in the said treatments. Healthy plants produced longer cobs than those of stunted ones. Cob length was maximum (17.24 cm) in T_4 treatment, which is statistically identical to T_2 and T_5, and the minimum (15.10 cm) in T_4 treatment followed by T_1. The maximum grain cob^{-1} (460.23) was obtained from the T_3 treatment followed by T_2 treatment (450.67) and the minimum (402.15) from the T_4. A similar trend was observed for hundred-grain weight. Which ranged from 22.21 g in T_4 to 26.65 g in T_3 treatment. It was observed that higher grain weight was associated with the boldness of the seeds. Higher yield contributing characters resulted in higher yield for the respective treatments. Maximum grain yield (8.56 tha^{-1}) was recorded from T_3 treatment that was statistically similar to T_2 and T_5 and the minimum (6.92 t ha^{-1}) from T_4 treatment. A more or less similar trend was observed for the stover yield of the maize. However, the stover yield ranged from 6.16 t ha^{-1} in T_4 to 7.70 t ha^{-1} in T_3 treatment.

T. Aus rice and T. Aman rice: The yield and yield parameters of T. Aus rice and T. Aman rice are presented in Table 4 and 5. It was observed that the higher grain yield of both T. Aus rice and T. Aman rice were associated with the higher dose of NPK in T_3 treatment followed by NK in T_2 treatment. T_5 also contributed to satisfactory yield as compared to T_4 and T_1 treatments. A similar trend was observed for the stover yield of both rice varieties. It was noted that increased fertilizer doses enhanced yield parameters and contributed to higher grain yield.

System Productivity: System productivity was considered as rice equivalent yield (REY). The system REY noticeably differed among the treatments (Table 6). Maximum REY (15.25 t ha^{-1}) was recorded from the T_3 treatment, which is almost close to that of T_2 (15.17 t ha^{-1}) and the minimum REY (13.54 t ha^{-1}) from the STB dose (T_1).

Production Efficiency (PE): The cropping patterns showed a variation in production efficiency (PE) as per different treatments (Table 6). The pattern generated the higher PE (43.45 kg ha^{-1} day^{-1}) in T_3 followed by T_2 (43.22 kg ha^{-1} day^{-1}) and T_5 (41.79 kg ha^{-1} day^{-1}) and the lower in T_4 treatment (38.57 kg ha^{-1} day^{-1}). Higher production efficiency is associated with the higher productivity with increased doses of fertilizer in this sequence.

Cost and return analysis: Cost and return-related information were presented in Table 6. The highest gross return (Tk. 381230 ha^{-1}) amounted to T_3 treatment against the cultivation cost of Tk. 220725 ha^{-1}. But the maximum gross margin (Tk. 161657 ha^{-1}) was recorded from the T_2 treatment, followed by T_3. Lower gross return (Tk. 338430 ha^{-1}) and gross margin (Tk. 119578 ha-1) were obtained from the T_4 treatment. Though higher doses in T_1 and T_2 treatments coexisted with higher cultivation costs, the higher return from the higher yield resulted in a higher gross margin in said treatments.

Table 3. Yield parameter and yield of maize as influenced by different nutrient treatment combinations in MLT site, Sherpur, Bogura during 2020-21 cropping season

Treatment	Plant height (cm)	Cob length (cm)	Grain cob^{-1} (no)	100- grain weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	165.72 b	15.12 b	408.82b	22.67 b	7.15 b	6.31 b
T_2	172.57 a	16.78 a	450.67 a	24.59 ab	8.34 ab	7.52 a
T_3	175.36 a	17.24 a	460.23 a	26.65 a	8.56 a	7.70 a
T_4	161.48 c	15.10 b	402.15 b	22.21 b	6.92c	6.16 b
T_5	171.25 ab	16.95 a	438.54 ab	24.42 ab	7.85 ab	7.13 ab
CV%	8.34	5.61	4.68	4.72	6.17	7.38

T_1: STB dose, T_2: T_1 + 25% extra NPK, T_3: T_1 + 50% extra NK, T_4: IPNS based on T_1 @5 tha^{-1} of cowdung and T_5: IPNS based on T_3 @5 tha^{-1} of cowdung

Table 4. Yield parameter and yield of T. Aus as influenced by different nutrient treatment combinations in MLT site, Sherpur, Bogura during 2020-21 cropping season

Treatment	Plant height (cm)	Effective tiller hill^{-1} (no)	Grains panicle^{-1} (no)	100- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	79 c	16.4	111 c	19.63bc	3.48 c	4.2 ab
T_2	92.26 a	18.6	117.3 ab	20 ab	3.54 ab	4.26 a
T_3	93.66 ab	17.5	118.8 a	20.4 a	3.56 a	4.27 a
T_4	82.2 c	16.9	112.4bc	19.23 c	3.41 d	4.11 c
T_5	92.2 b	17.2	116.3 ab	20.16 a	3.53ab	4.25ab
CV%	4.32	NS	5.36	3.45	2.96	4.11

Table 5. Yield parameter and yield of T. Aman as influenced by different nutrient treatment combinations in MLT site, Sherpur, Bogura during 2020-21 cropping season

Treatment	Plant height (cm)	Effective tiller hill^{-1} (no)	Grain panicle^{-1} (no)	100- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	76.13 c	14.86	112.73 b	21.01bc	3.63c	4.41 ab
T_2	79.73 a	15.13	115.86 a	21.40 ab	3.81 a	4.45 a
T_3	80.0 a	15.06	115.06 a	21.83 a	3.68b	4.47 a
T_4	76.66bc	15.06	112.33 b	20.58 c	3.54 d	4.38 c
T_5	78.53 ab	15.13	112.86 b	21.58 a	3.74 b	4.42bc
CV%	4.26	NS	4.88	4.12	3.14	3.92

Table 6. System production and productivity and cost and return as influenced by different nutrient treatment combinations during 2020-21 cropping season

Treat.	Rice equivalent yield (t ha^{-1})	Production Efficiency (kg ha^{-1}day^{-1})	GR (Tk. ha^{-1})			TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
			Grain	Stover/straw	Total		
T_1	13.90	39.60	320750	26765	347515	213910	133605
T_2	15.17	43.22	350550	28700	379250	217593	161657
T_3	15.25	43.45	352200	29030	381230	220725	160505
T_4	13.54	38.57	312150	26280	338430	218852	119578
T_5	14.67	41.79	338750	27935	366685	224^{-1}	141908

Input Price (Tk/kg); Urea: 16; TSP: 22; MoP: 15; Gypsum: 10; $ZnSO_4$: 150; Boric acid: 150; Cowdung: 1
Output price (Tk/kg): Maize grain: 20; Stover: 1.5, Rice grain: 25; Straw: 2

Conclusion

Considering the yield and economic return, T_2, T_3, and T_5 were found suitable for the Maize-T. Aus-T. Aman pattern. Extra application of N, P, and K essential nutrient elements were found suitable for better plant growth and development and consequently for higher grain yield of maize and rice crops. Despite a slightly higher cultivation cost due to a higher rate of fertilizers, treatments T_2, T_3, and T_5 were profitable for higher grain yield. Therefore, it could be recommended that farmers may apply 25% NPK or 25% NK as extra with the STB dose for higher yield and return from the pattern.

DEVELOPMENT OF FERTILIZER RECOMMENDATION FOR LENTIL-MAIZE-T. AMAN RICE CROPPING PATTERN

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Abstract

The experiment was conducted in the farmer's field of Paba MLT site, Rajshahi from the rabi season of 2020-2021 to evaluate the effect of nutrients management packages on lentil, maize and rice cultivation and to find out a suitable combination of different fertilizers for Lentil-Maize-T. Aman rice cropping pattern. The experiment was laid out in RCBD design with four fertilizer treatments viz. T_1=Soil test-based fertilizer dose (FRG, 2018), T_2=75% of T_1,

T_3=125% of T_1 and T_4=Farmers dose. Among the treatment, the highest yield and gross margin was obtained from T_3 followed by T_2 and the lowest was obtained from T_4.

Introduction

Lentil-Maize-T. Aman rice cropping pattern is a cropping pattern for AEZ 11 Rajshahi. The practice of Lentil-Maize-T. Aman rice cropping pattern is increasing in Paba, Rajshahi. The present system of fertilizer application is mostly based on the nutrient requirement of individual crops ignoring the carry-over effect of the fertilizer applied to the preceding crop(s). Some nutrient (P, K) applied to the previous crop can benefit the succeeding crops to a good extent and the system productivity may become economic through cropping pattern-based fertilizer application. Therefore, the trial has been undertaken to find out a cropping pattern based economically viable fertilizer dose and increase crop productivity.

Materials and Methods

The experiment was carried out at MLT site Paba, Rajshahi from November 2020 in High Ganges River Flood Plain soil (AEZ-11). The initial soil samples of the experimental field were collected and analyzed presented in Table 1. The rates of the fertilizers for different fertilizer management packages were calculated using soil test values based (STB) as per Fertilizer Recommendation Guide' 2018. The experiment was laid out in RCB design with three replications. There were four fertilizer treatment viz. T_1=Soil test-based fertilizer dose (FRG, 2018), T_2=75% of T_1, T_3=125% of T_1 and T_4=Farmers dose were presented in Table 2. Lentil var. BARI Masur-8 was sown on 30 November 2020 and harvested on 21 March 2021. After lentil, Laltir 339 commercial variety of Maize sown on 26 March 2021 and harvested on 14 July 2021. Then T. Aman rice var. BRRI dhan75 was sown on 27 July 2021 and harvested on 02 November 2021. The intercultural operations such as weeding, removed plant residues and irrigations were done as and when necessary. All necessary data were collected and analyzed through R Software.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field at Paba, Rajshahi

Sample	Soil pH	Organic carbon (%)	Total N (%)	P (ppm)	K meq/100g soil	S (ppm)	Zn (ppm)	B (ppm)
Value	7.2	0.85	0.08	9.75	0.28	25.2	0.41	0.35
Critical level	-	-	0.12	10	0.12	10.00	0.6	0.2
Interpretation	N	L	VL	L	O	O	VL	M

Note: N-Neutral, M-Medium, H-High, L-Low, VL-Very Low, VH-Very High, Al- Alkaline and O-optimum

Table 2. Different fertilizer treatment packages (kg ha^{-1}) for, Lentil at MLT site, Paba, Rajshahi

Crop	Treatment	N	P	K	S	Zn	B	CD
Lentil	T_1=Soil test-based fertilizer dose	22.46	6.9	6.18	3.12	1.26	0.2	5 ton
	T_2=75% of T_1	16.93	5.17	4.61	2.32	0.94	0.153	5 ton
	T_3=125% of T_1	14.23	8.62	7.72	3.92	1.58	0.25	5 ton
	T_4= Farmers practices	21.65	6.6	5.5	2.72	-	-	5 ton
Maize	T_1=Soil test-based fertilizer dose	170.96	46	20	5.94	-	-	-
	T_2=75% of T_1	128.22	34.5	15	4.46	-	-	-
	T_3=125% of T_1	213.71	57.5	25	7.43	-	-	-
	T_4= Farmers practices	170.51	44	20	5.4	-	-	-
T. Aman rice	T_1=Soil test-based fertilizer dose	71.26	7.35	6	2.02	1.81	-	-
	T_2=75% of T_1	53.45	5.55	4.5	1.51	1.35	-	-
	T_3=125% of T_1	88.71	9.18	7.5	2.53	2.26	-	-
	T_4= Farmers practices	69.12	7	5	1.8	1.68	-	-

Results and Discussions

The yield and yield attributes of lentil was found significantly differed under different nutrient management packages (Table 3). The maximum plant height (45 cm) was obtained from treatment T_3 followed by T_1 (43.33 cm), T_2 (42.33 cm) and T_4 (42 cm). Maximum number of branches of plant was obtained from treatment T_3 (6.66) followed by T_1 (6), T_4 (5) and T_2 (4.66). Similarly Maximum number of pods of plant was obtained from treatment T_3 (84.66) followed by T_1 (80.66), T_4 (77.93) and T_2 (77.33). Maximum number seed per plant was obtained from treatment T_3 (107.66) followed by T_1 (102.33), T_4 (95.33) and T_2 (95.33). The highest seed yield was obtained from treatment T_3 (2.34 tha^{-1}) followed by T_1 (2.18 tha^{-1}), T_4 (2.08 t ha^{-1}) and T_2 (2.04 t ha^{-1}). The highest straw yield was obtained from treatment T_3 (2.11 tha^{-1}) followed by T_1 (1.96 t ha^{-1}), T_4 (1.87 t ha^{-1}) and T_2 (1.83 t ha^{-1}).

Table 6 revealed that in Maize, the tallest plant (166.46 cm) was obtained from treatment T_3 followed by T_1 (163.4 cm), T_2 (158.4 cm) and T_4 (156.93 cm). The longest cob length was obtained from treatment T_3 (18.73) followed by T_1 (17.66), T_4 (17.2) and T_2 (16.86). Similarly, maximum number of grains per cob was obtained from treatment T_3 (516) followed by T_1 (496.66), T_4 (481) and T_2 (448.33). The maximum 100 grain weight was obtained from treatment T_3 (297 g) followed by T_1 (288.66 g), T_4 (283.33g) and T_2 (274 g). The maximum grain yield was obtained from treatment T_3 (9.76 tha^{-1}) followed by T_1 (8.61 tha^{-1}), T_4 (7.94 t ha^{-1}) and T_2 (7.45 t ha^{-1}). The maximum stover yield was obtained from treatment T_3 (14.28 t ha^{-1}) followed by T_1 (12.47 t ha^{-1}), T_4 (11.62 t ha^{-1}) and T_2 (12.47 t ha^{-1}) (Table 4).

In T. Aman rice, the maximum t plant height (97.1 cm) was obtained from treatment T_2 followed by T_1 (95.93 cm), T_3 (91.06 cm) and T_4 (88.6 cm). The maximum number of tillers per hill was obtained from treatment T_3 (13) followed by T_1 (11.66), T_4 (10.33) and T_2 (9.66). Similarly Maximum number of grains per panicle was obtained from treatment T_3 (102.66) followed by T_1 (99), T_4 (96.33) and T_2 (91). Higher 1000 grain weight was obtained from treatment T_3 (23.16 g) followed by T_1 (22.06 g), T_4 (21.8 g) and T_2 (21.33 g). Higher grain yield was obtained from treatment T_3 (5.5 t ha^{-1}) followed by T_1 (5.33 t ha^{-1}), T_4 (5.17 t ha^{-1}) and T_2 (5.07 t ha^{-1}). The maximum straw yield was obtained from treatment T_3 (6.97 t ha^{-1}) followed by T_1 (6.66 t ha^{-1}), T_4 (6.45 t ha^{-1}) and T_2 (6.35 t ha^{-1}) (Table 5).

Cost and return analysis: Economic performance showed that l maximum gross margin (Tk. 101514 ha^{-1}) and BCR (3.61) were recorded from T_3 followed by T_1 (GM: Tk. 93180 ha^{-1}, BCR: 3.47), T_4 (GM: Tk. 87790 ha^{-1}, BCR: 3.37) and T_2 (GM: Tk. 86060 ha^{-1}, BCR: 3.36) (Table 8). Similarly in maize, maximum gross margin (Tk. 112575 ha^{-1}) and BCR (2.36) were also recorded from T_3 followed by T_1 (GM: Tk. 93700 ha^{-1}, BCR: 2.19), T_4 (GM: Tk. 80600 ha^{-1}, BCR: 2.03) and T_2 (GM: Tk. 74625 ha^{-1}, BCR: 2). In T. Aman rice, maximum gross margin (Tk. 85535 ha^{-1}) and BCR (2.64) were also recorded from T_3 followed by T_1 (GM: Tk 82395 ha^{-1}, BCR: 2.62), T_4 (GM: Tk. 79725 ha^{-1}, BCR: 2.61) and T_2 (GM: Tk. 78375 ha^{-1}, BCR: 2.61) (Table 6).

Framers' opinion

Farmers are interested to use 75% soil test-based fertilizer dose (FRG, 2018), for Lentil-Maize-T. Aman rice production for higher yield and income.

Table 3. Yield of Lentil under different fertilizer Management packages in Paba, Rajshahi during 2021-2022

Treatment	Plant height (cm)	Branch plant^{-1} (no)	Pod Plant^{-1} (no)	Seeds plant^{-1} (no)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	43.33 b	6 ab	80.66 b	102.33 ab	2.18 ab	1.966 b
T_2	42.33 b	4.66 c	77.33 c	95.33 b	2.04 b	1.83 b
T_3	45 a	6.66 a	84.66 a	107.66 a	2.34 a	2.11 a
T_4	42 b	5 bc	77.93 c	95.33 b	2.08 b	1.87 b
LSD $_{(0.05)}$	1.66	1.33	2.105	7.203	0.165	0.138
CV (%)	5.93	11.94	7.317	3.599	5.823	3.56

Table 4. Yield of Maize under different fertilizer Management packages in Paba, Rajshahi during 2021-2022

Treatment	Plant height (cm)	Cob length (cm)	Grains Cob^{-1} (no)	100- grain weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	163.4 ab	17.66 b	496.66 ab	288.66 b	8.61 b	12.47 b
T_2	158.4 bc	16.86 c	448.33 c	274 d	7.45 c	10.71 d
T_3	166.46 a	18.73 a	516 a	297 a	9.76 a	14.28 a
T_4	156.93 c	17.2 c	481 b	283.33 c	7.94 c	11.62 c
LSD $_{(0.05)}$	5.34	1.20	12.08	4.45	3.87	0.341
CV (%)	6.65	4.422	7.27	5.78	0.65	3.39

T_1=Soil test-based fertilizer dose, T_2=75% of T_1, T_3=125% of T_1, T_4= Farmers practices; Market price of Lentil Tk. 60 kg^{-1}, Maize Tk. 20 kg^{-1}, grain Tk. 22.5 kg^{-1}and straw Tk. 2 kg^{-1}

Table 5. Yield of T. Aman rice under different fertilizer Management packages in Paba, Rajshahi during 2021-22

Treatment	Plant height (cm)	Tiller hill^{-1}	Grain panicle^{-1} (no)	1000 -grain wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	95.93 a	11.66 ab	99 a	22.06 ab	5.33 b	6.66 b
T_2	97.1 a	9.66 c	91 b	21.33 b	5.07 c	6.35 c
T_3	91.06 b	13 a	102.66 a	23.16 a	5.5 a	6.97 a
T_4	88.6 b	10.33 bc	96.33 ab	21.8 ab	5.17 c	6.45 c
LSD $_{(0.05)}$	4.099	1.372	7.28	1.449	0.14	0.12
CV (%)	4.202	6.153	3.75	3.28	4.32	3.91

Table 6. Cost and return analysis of Lentil-Maize-T. Aman rice cropping patter under different fertilizer Management packages in Paba, Rajshahi during 2021-22

Crop	Treatments	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
Lentil	T_1	130800	37620	93180	3.47
	T_2	122400	36340	86060	3.36
	T_3	140400	38886	101514	3.61
	T_4	124800	37010	87790	3.37
Maize	T_1	172200	78500	93700	2.19
	T_2	149000	74375	74625	2.00
	T_3	195200	82625	112575	2.36
	T_4	158800	78200	80600	2.03
T. Aman rice	T_1	133245	50850	82395	2.62
	T_2	126775	48400	78375	2.61
	T_3	137690	52155	85535	2.64
	T_4	129225	49500	79725	2.61

T_1=Soil test-based fertilizer dose, T_2=75% of T_1, T_3=125% of T_1, T_4= Farmers practices; Market price of Lentil Tk. 60 kg^{-1}, Maize Tk. 20 kg^{-1}, grain Tk. 22.5 kg^{-1}and straw Tk. 2 kg^{-1}

Conclusion

Judicious application of fertilizer is essential for yield and income maximization of Lentil-Maize-T. Aman rice cropping pattern. This is first year one cycle result. For concrete conclusion it should be repeated in 2nd year.

DEVELOPMENT OF FERTILIZER RECOMMENDATION FOR GARLIC/BRINJAL-T. AMAN RICE CROPPING PATTERN

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Abstract

The experiment was conducted in the farmer's field of Shibpur, Rajshahi from the rabi season of 2020 to evaluate the effect of nutrients management packages on Garlic, Brinjal and T. Aman rice cultivation to find out a suitable combination of different fertilizers for Garlic/Brinjal-T. Aman rice cropping pattern. The experiment was laid out in RCBD design with four fertilizer treatments viz. viz. T_1=Soil test-based fertilizer dose (FRG, 2018), T_2=75% of T_1, T_3=125% of T_1 and T_4=Farmers dose. Among the treatment, the highest yield and gross margin was obtained from T_3 followed by T_2 and lowest obtained from T_4.

Introduction

Garlic/Brinjal-T. Aman rice cropping pattern is newly developed cropping pattern for AEZ-11. The practice of Garlic/Brinjal-T. Aman rice cropping pattern is increasing in Rajshahi. The present system of fertilizer application is mostly based on the nutrient requirement of individual crops ignoring the carry over effect of the fertilizer applied to the preceding crop(s). Some nutrients (P, K) applied to the previous crop can benefit the succeeding crop to a good extent and the system productivity may become economic through cropping pattern-based fertilizer application. Therefore, the trial has been undertaken to find out a cropping pattern based economically viable fertilizer dose and increase crop productivity.

Material and Methods

The experiment was carried out at MLT site Shibpur, Rajshahi from November 2020 in High Ganges River Flood Plain soil (AEZ-11). The initial soil samples of the experimental field were collected and analyzed, and results presented in Table 1. The rates of the fertilizers for different fertilizer management packages were calculated using soil test values based (STB) as per Fertilizer Recommendation Guide' 2018 (BARC, 2018). The experiment was laid out in RCB design with three replications. There were four fertilizer treatment viz. *viz.* T_1=Soil test-based fertilizer dose (FRG, 2018), T_2=75% of T_1, T_3=125% of T_1 and T_4=Farmers dose were presented in Table 2. Garlic var. Itali (local) that sown on 22 November 2020 and harvested on 27 March 2021. Twenty-two days after garlic sowing commercial variety of Brinjal (Rangila) sown on 15 December 2020 and harvested from 6 March to 29 May 2021. Then T. Aman rice var. BRRI dhan75 was sown on 28 July 2021 and harvested on 3 November 2021. The intercultural operations such as weeding, earthing up, removed plant residues and irrigations were done as and when necessary. All necessary data were collected and analyzed through R Software.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field at Shibpur, Rajshahi

Sample	Soil pH	Organic carbon (%)	Total N (%)	P (ppm)	K meq/100g soil	S (ppm)	Zn (ppm)	B (ppm)
Item	7.7	0.85	0.11	19.2	0.34	30	1.64	0.52
Critical level	-	-	0.12	10	0.12	10.00	0.6	0.2
Interpretation	N	L	L	M	O	O	O	O

Note: N-Neutral, M-Medium, H-High, L-Low, VL-Very Low, VH-Very High, Al- Alkaline and O-optimum

Table 2. Different fertilizer treatment packages (kg ha^{-1}) for Garlic at MLT site, Shibpur, Rajshahi

Crop	Treatment	Fertilizer treatment packages (kg ha^{-1})						
		N	P	K	S	Zn	B	CD
Garlic	T_1	114	32	30	10	1	1	5 ton
	T_2	85.5	24	22.5	7.5	0.75	0.75	5 ton
	T_3	142.5	40	37.5	12.5	1.25	1.25	5 ton
	T_4	115	30	25	7	0.5	0.5	5 ton

Crop	Treatment	Fertilizer treatment packages (kg ha^{-1})						
		N	P	K	S	Zn	B	CD
Brinjal	T_1	135	24	35	5	-	-	-
	T_2	101.25	18	26.25	3.75	-	-	-
	T_3	168.78	30	43.75	6.25	-	-	-
	T_4	136	22	30	4	-	-	-
T. Aman rice	T_1	54	6	15	3	-	-	-
	T_2	40.5	4.5	11.25	2.25	-	-	-
	T_3	67.5	7.5	18.75	3.75	-	-	-
	T_4	55	5	10	2	-	-	-

T_1=Soil test-based fertilizer dose, T_2=75% of T_1, T3=125% of T_1 and T_4= Farmers practices

Results and Discussions

The yield and yield attributes of Garlic was found significantly differed under different nutrient management packages (Table 3). The maximum plant height (68.53 cm) was obtained from treatment T_3 followed by T_1 (66.6 cm), T_4 (66.2 cm) and T_2 (63.33 cm). Maximum number of leaves per plant was obtained from treatment T_3 (7.16) followed by T_1 (6.8), T_2 (6.06) and T_4 (6). Similarly Maximum number of cloves per bulb was obtained from treatment T_3 (25.03) followed by T_1 (22.93), T_4 (22.26) and T_2 (20.33). Maximum individual bulb weight was obtained from treatment T_3 (19.8 g) followed by T_1 (16.8 g), T_4 (16.2 g) and T_2 (13 g). Higher t bulb yield was obtained from treatment T_3 (10.29 t ha^{-1}) followed by T_1 (9.35 t ha^{-1}), T_4 (9.16 t ha^{-1}) and T_2 (8.44 t ha^{-1}).

On the other hand, in Brinjal, the maximum height (110.66 cm) was obtained from treatment T_4 followed by T_3 (108.6 cm), T_2 (108.6 cm) and T_1 (107.73 cm). Maximum number of branches per plant was obtained from treatment T_3 (4.6) followed by T_4 (4.36), T_1 (4.13) and T_2 (3.86). Similarly maximum number of fruits per plant was obtained from treatment T_3 (19.13) followed by T_1 (17.46), T_4 (16.2) and T_2 (15). The maximum individual fruit weight was obtained from treatment T_3 (142.13 g) followed by T_1 (140.13 g), T_4 (137.66 g) and T_2 (133.15 g). Higher fruit weight per plant was obtained from treatment T_3 (2.21 kg) followed by T_1 (2.13 kg), T_4 (2.1 kg) and T_2 (1.99 kg). The maximum fruit yield was obtained from treatment T_3 (27.56 t ha^{-1}) followed by T_1 (25.43 t ha^{-1}), T_4 (25.03 t ha^{-1}) and T_2 (23.67 t ha^{-1}) (Table 4).

Similarly in T. Aman rice, the maximum height (113 cm) was obtained from treatment T_3 followed by T_4 (110.86 cm), T_1 (110.53 cm) and T_2 (108.66 cm). The maximum number of tillers per hill was obtained from treatment T_3 (12.33) followed by T_1 (10.8), T_4 (10.53) and T_2 (10.06). Similarly Maximum number of grains per panicle was obtained from treatment T_3 (146.06) followed by T_1 (143.68), T_4 (142) and T_2 (139.83). The maximum 1000 grain weight was obtained from treatment T_3 (23.15 g) followed by T_1 (23.09 g), T_4 (23.05 g) and T_2 (23 g). Higher grain yield was obtained from treatment T_3 (5.43 t ha^{-1}) followed by T_1 (5.15 t ha^{-1}), T_4 (5.05 t ha^{-1}) and T_2 (4.86 t ha^{-1}). The maximum stover yield was obtained from treatment T_3 (6.5 t ha^{-1}) followed by T_1 (6.43 t ha^{-1}), T_4 (6.27 t ha^{-1}) and T_2 (6.02 t ha^{-1}) (Table 5).

Cost and return analysis: Economic performance showed that Garlic provided maximum gross margin (Tk. 108675 ha^{-1}) and BCR (1.88) from T_3 followed by T_1 (Tk. 89850 ha^{-1}, 1.74), T_4 (Tk. 87600 ha^{-1}, 1.73) and T_2 (Tk. 71700 ha^{-1}, 1.6) (Table 6). Similarly, in Brinjal, maximum gross margin (Tk. 503937 Tk. ha^{-1}) and BCR (3.72) were also recorded from T_3 followed by T_1 (Tk. 457250 ha^{-1}, 3.56), T_4 (Tk. 450250 ha^{-1}, 3.56) and T_2 (Tk. 419812 ha^{-1}, 3.44) (Table 6). In T. Aman rice, maximum gross margin (Tk. 82775 ha^{-1}) and BCR (2.58) were also recorded from T_3 followed by T_1 (Tk. 77815 ha^{-1}, 2.52), T_4 (Tk. 76665 ha^{-1}, 2.54) and T_2 (Tk. 72890 ha^{-1}, 2.5) (Table 6).

Framers' opinion

Farmers are interested to use optimum fertilizers dose to Garlic / Brinjal-T. Aman rice production for higher yield and income.

Table 3. Garlic yields as affected by different fertilizer packages in Shibpur, Rajshahi, 2021-22

Treatment	Plant height (cm)	No. of leaves /plant	No. of cloves /bulb	Individual bulb wt. (g)	Bulb yield (t ha^{-1})
T_1	66.6 a	6.8 ab	22.93 b	16.8 ab	9.35 b
T_2	63.33 b	6.06 c	20.33 c	13 b	8.44 c
T_3	68.53 a	7.16 a	25.03 a	19.8 a	10.29 a
T_4	66.2 a	6 b	22.26 b	16.2 ab	9.16 b
LSD $_{(0.05)}$	2.45	0.446	1.189	4.08	0.692
CV (%)	5.85	3.53	5.62	12.42	7.36

T_1=Soil test-based fertilizer dose, T_2=75% of T_1, T3=125% of T_1 and T_4= Farmers practices

Table 4. Brinjal yield as affected by different fertilizer packages in Shibpur, Rajshahi, 2021-22

Treatment	Plant height (cm)	Branch $plant^{-1}$ (no)	Fruit $plant^{-1}$ (no)	Individual fruit wt. (g)	Fruit wt. $plant^{-1}$ (kg)	Fruit yield (t ha^{-1})
T_1	107.73 b	4.13 bc	17.46 b	140.13 ab	2.13 b	25.43 b
T_2	108.6 ab	3.86 c	15 d	133.15 c	1.99 b	23.67 b
T_3	108.6 ab	4.6 a	19.13 a	142 13 a	2.21 a	27.56 a
T_4	110.66 a	4.36 ab	16.2 c	137.66 b	2.1 b	25.03 b
LSD $_{(0.05)}$	2.47	0.445	1.07	3.76	0.172	2.04
CV (%)	7.13	5.25	7.18	9.36	4.029	4.02

T_1=Soil test-based fertilizer dose, T_2=75% of T_1, T3=125% of T_1 and T_4= Farmers practices

Table 5. Rice yield as affected by different fertilizer packages in Shibpur, Rajshahi during 2021-22

Treatment	Plant height (cm)	Tiller $hill^{-1}$	Grain $Panicle^{-1}$	1000- grain wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	110.53 b	10.8 b	143.68 ab	23.09ab	5.15 b	6.43 ab
T_2	108.66 c	10.06 c	139.83c	23 c	4.86 c	6.02 c
T_3	113 a	12.33 a	146.06 a	23.15 a	5.43 a	6.5 a
T_4	110.86 b	10.53 bc	142 bc	23.05 bc	5.05bc	6.27 b
LSD $_{(0.05)}$	1.76	0.484	3.69	0.075	0.101	0.21
CV (%)	4.79	5.21	3.29	3.162	4.23	5.29

T_1=Soil test-based fertilizer dose, T_2=75% of T_1, T3=125% of T_1 and T_4= Farmers practices

Table 6. Cost and return analysis of Garlic-Brinjal-T. Aman rice cropping pattern influenced by different fertilizer packages in Shibpur, Rajshahi during 2021-22

Crop	Treatment	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
Garlic	T_1	210375	120525	89850	1.74
	T_2	189900	118200	71700	1.6
	T_3	231525	122850	108675	1.88
	T_4	206100	118500	87600	1.73
Brinjal	T_1	635750	178500	457250	3.56
	T_2	591750	171938	419812	3.44
	T_3	689000	185063	503937	3.72
	T_4	625750	175500	450250	3.56
T. Aman rice	T_1	128735	50920	77815	2.52
	T_2	121390	48500	72890	2.50
	T_3	135175	52400	82775	2.58
	T_4	126165	49500	76665	2.54

T_1=Soil test-based fertilizer dose, T_2=75% of T_1, T3=125% of T_1 and T_4= Farmers practices.
Market price of Garlic Tk. 22.5 kg^{-1}, Brinjal Tk. 25 kg^{-1} and grain Tk. 22.5 $kg^{-1}$and straw Tk. 2 kg^{-1}

Conclusion

Judicious application of fertilizer is essential for yield and income maximization of Garlic /Brinjal-T. Aman rice cropping pattern. For concrete conclusion it should be repeated again.

EFFECT OF ORGANIC FERTILIZER TO MITIGATE SOIL SALINITY AND MAXIMIZE YIELD OF POTATO IN COASTAL SALINE SOIL

M.M. ISLAM, K.N. ISLAM AND M.S.I. KHAN

Abstract

An experiment was conducted at MLT site Kuakata, Patuakhali in the Rabi season of 2021-2022 to observe the effect of different organic matter to mitigate soil salinity and maximize yield under farmers' field condition. Different types of organic matter along with soil test based inorganic fertilizers were used in this trial. The treatments of the trials were as T_1=STB + 3 t cowdung ha^{-1}, T_2= STB+1.5 compost t ha^{-1}, T_3=STB + Vermicompost 2 t ha^{-1} and T_4 = Control (Soil Test Based chemical fertilizer only). The significant effect was found in yield and yield contributing parameters in combination of various level of organic fertilizer with inorganic fertilizer for potato production in coastal region. Soil Electrical conductivity was found lower in organic fertilizer treated plots. Vermicompost reduced salinity more than compost and cowdung. The highest number of tubers per plant (7.16), weight of tuber per plant (590 g) as well as highest yield (29.47 t ha^{-1}) was found in T_3 treatment. The highest gross return (Tk 353640 ha^{-1}), gross margin (Tk. 145940 ha^{-1}) and BCR (1.71) was also recorded from T_3 treatment. The lowest gross return (Tk. 264240 ha^{-1}) and BCR (1.53) was recorded from T_4. From the finding of the trial, it may be recommended that Vermicompost application is the best way of maximizing potato yield in coastal saline soil.

Introduction

Soil salinity is one of the major environmental hazards to global agriculture. The saline area in Bangladesh is about 0.83 million hectares and presently estimated that it has increased up to 1.2 m ha (Islam *et al.,* 2008). The coastal area of the country constitutes about 20% of the country of which about 53% are affected by different degrees of salinity (Haque, 2006). Soil salinity in Bangladesh is a seasonal problem that affects crop production severely in the saline belt during Rabi season whereas in Kharif-II season soil salinity reaches about neutral and does not affect crop production. Soil salinity affects crop growth, yield and quality. As potato is cultivated in Rabi season, it provides very poor yields in saline coastal areas compared to its potential as soil salinity reaches to maximum during Rabi season in coastal saline soil (Chaves, *et al,* 2009). Organic fertilizer enhanced fertilizer activities and emission carbon-dioxide that's reducing soil salinity (Munns *et al*., 2008.). Cultivation of potato in Rabi season with improved management practices including organic fertilizer could increase tuber yield significantly compared to traditional method under saline ecosystem. Thus, the experiment was undertaken to find out the effect of organic fertilizer to maximize yield of potato and to reduce soil salinity of the field.

Material and methods

The experiment was conducted at MLT site Kuakata, Patuakhali during the Rabi season of 2021-2022 under farmer's field condition. Three types of organic fertilizer i.e., Cowdung, Compost and Vermicompost along with Soil Test Based inorganic fertilizers were used in this trial. The treatment combinations were T_1 = STB + 3 CD (cowdung) t ha^{-1}, T_2=STB + 1.5 Compost t ha^{-1}, T_3 = STB + 2 Vermicompost t ha^{-1} and T_4 = Control (Soil Test Based chemical fertilizer only). The experiment was laid out in RCB design with three compact replications having unit plot size 5m × 4m. The organic fertilizers were applied during land preparation with inorganic fertilizers. Required inorganic fertilizers were calculated as per initial soil nutrient status. Required nutrient for potato as per STB vale was 118-30-60-23 kg N-P-K-S ha^{-1}. Initial soil nutrient status is given in Table 1. Seeds of BARI Alu-72 were sown on 23 December 2021 and harvested on 25 March 2022. Recommended cultural practices were done as and when necessary. Data were collected plot wise and analyzed statistically.

Table 1. Initial soil nutrient status of experimental plot during 2021-22

Nutrient status								
pH	EC (dS/m)	OM (%)	K (Meq. /100g soil)	Total N (%)	P (µg/g soil)	S	Zn	B
						(µg/g soil)		
5.0	0.98	1.1	0.20	0.06	2.68	21	1.0	0.20
Acidic	Low	Very low	Low	Very low	Very low	High	Low	Low

Table 2. Nutrient status of Vermicompost, compost and cowdung used in the experimental field

Manure	PH	OC	Ca	Mg	K	Total N	P	S	B	Zn
		%								
Compost	7.1	16.3	1.50	2.10	1.17	1.23	0.79	0.50	0.013	0.14
Cowdung	7.5	15.4	2.23	0.44	0.69	1.15	0.57	0.36	0.011	0.15
Vermicompost	7.2	17.9	2.10	2.60	1.39	1.68	1.18	0.87	0.015	0.16

Moisture content of Compost =12.15%, Cowdung=12.46% and Vermicompost=11.96%

Results and Discussions

Based on the results it was observed that organic fertilizer supplied significant benefits in potato production in coastal region. Organic fertilizer contributes 17 to 33% more tubers yield over only chemical dose (Table 3). Among different types of organic fertilizers Vermicompost effects were prominent and it increased 33.9% potato yield over chemical fertilizer. The highest plant height at 60 days after sowing (50.36 cm), number of tubers per plant (7.16) with the highest weight of tuber per plant (590 g) was obtained from T_3 treatments where 2 t ha^{-1} Vermicompost were used along with STB chemical fertilizers. Consequently, this treatment produced the highest tuber yield (29.47 t ha^{-1}). The lowest yield (22.02 t ha^{-1}) was recorded in T_4 where only chemical fertilizer was used. Combining inorganic fertilizer and organic manure showed significant effect particularly on yield parameters of potato (Suh *et al*., 2015). From the cost and return analysis, the maximum gross return (Tk. 353640 ha^{-1}), gross margin (Tk. 145940 ha^{-1}) and BCR (1.71) were recorded from T_3 treatment, followed by T_2. The lowest gross return (Tk. 264240 ha^{-1}) and BCR (1.53) was recorded from control plot (T_4) (Table 4). Salinity level of the experimental plots was 1.36 during plantation then it increased with time up to 9.86 dS /m throughout the growing season (Fig. 1). It was observed that salinity levels were lower in organic fertilizer treated treatments that enhance productivity of potato yield coastal saline soil. The highest salinity was observed in T_4 (control) where no organic fertilizer was used. Among the organic fertilizer treated plots salinity reducing effect was observed as Vermicompost > Compost > cowdung. Walpola, *et al*. (2010) stated that the organic matter turnover process and the C and N mineralization could depend on the type of organic material incorporated into the soil. So, this result confirms that incorporation of organic manure can be an effective approach to minimize toxicity conditions induced by salinization.

Farmer's opinion

Farmers opined that organic manure improved potato yield, and they showed their interested to use Vermicompost in their potato field next year as it gave more production.

Table 3. Tuber yield and yield parameters of potato as affected by fertilizer packages, 2021-22

Treat.	Emergence at 30 DAP (%)	Plant height at 60 DAP (cm)	Tuber per plant (No.)	Tuber wt. plant^{-1} (g)	Tuber Yield (t ha^{-1})	OM increased yield over FP (%)
T_1	94	45.73	6.83	555	25.76	17
T_2	97	49.06	6.98	572	26.85	22
T_3	98	50.36	7.16	590	29.47	33.9
T_4	91	44.32	6.43	514	22.02	-
LSD $_{(0.05)}$	6.61	5.78	1.77	19.85	8.87	-
CV (%)	4.71	6.53	3.47	10.19	6.04	-

T_1 = STB + 3 CD (cowdung) t ha^{-1}, T_2=STB + 1.5 Compost t ha^{-1}, T_3 = STB + 2 Vermicompost t ha^{-1} and T_4 = Control (Soil Test Based chemical fertilizer only).

Table 4. Economic performance as influenced by fertilizer packages during 2021-22

Treat.	Gross return (Tk ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
T_1	309120	187700	121420	1.65
T_2	322200	193700	128500	1.67
T_3	353640	207700	145940	1.71
T_4	264240	173700	90540	1.53

Potato Price (Tk kg^{-1}) = 12

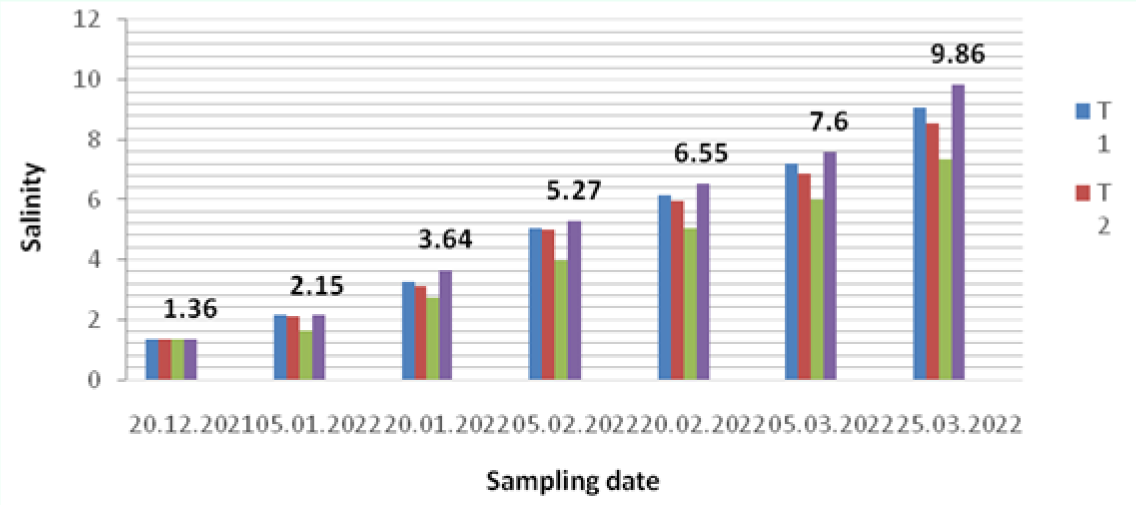


Fig 1. Salinity level of different treatments

Conclusion

Organic fertilizer has a positive effect on reduction of soil salinity and to increase potato yield. Usually, coastal farmers do not apply any organic fertilizer in their field. As per finding of the trial it may be recommended organic fertilizer specially Vermicompost application to maximize potato yield in coastal saline soil.

CHARACTERIZATION OF NEW POLDER IN COASTAL REGION

M.S.I. KHAN, M.M. ISLAM AND K.N. ISLAM

Abstract

A polder characterization program was conducted at polders named Polder No. 44 (Kachufatra, Taltoli, Borguna), Polder No. 46 (Sonatala, Kalapara, Patuakhali) & 48 (Diaramkhola, Kalapara, Patuakhali) to know the soil properties and salinity status of the crop fields during 2021-22. It was observed that the polder soils carrying favorable physical and chemical properties for crop production with some limitations like N and B deficiency. Ground water, pond water and canal water salinity were found 1.72-4.20 dS/m, 0.65-1.0 dS/m and 2.8 to 18.5 dS/m, respectively. So, ground water and reserved pond water should be considered to irrigate the crops instead of canal water.

Introduction

The coastal zone of Bangladesh includes 139 polders, low-lying tracts of land surrounded by embankments constructed in the 1960s and 1970s to protect farmers from saline water intrusion and tidal floods. Out of the 2.8 million ha in the coastal zone, almost half (1.2 million ha) are poldered. Polder is formed the earthen structure surrounded by embankment of river. During 2016-2020 a project entitled 'Cropping systems intensification in the salt affected coastal zones of Bangladesh and West Bengal, India' was carried out at polder no-43 at Amtoli, Borguna. The findings of the project are applicable in the adjacent polders. So, 2nd phase of the project entitled "Mitigating risk and scaling-out profitable cropping system intensification practices in the salt-affected coastal zones of the Ganges Delta" has been launched. The project activities were done in polder no-44, 46 and 48 situated at Taltoli, Borguna and Kalapara, Patuakhali. To obtain findings of previous project in new polders, it is necessary to characterize the polders in terms of local ecology, land type, soil and water properties, existing cropping tradition, and socio-economic status. So, the characterization of the polders has been undertaken to find out some intrinsic soil and water properties of three new polders.

Materials and Methods

A survey was conducted at new polders named Polder No. 44 (Kachufatra, Taltoli, Borguna), Polder No. 46 (Sonatala, Kalapara, Patuakhali) & 48 (Diaramkhola, Kalapara, Patuakhali) to know the cropping system and socioeconomic status of the farmers. Twelve soil samples from each site were collected for analyzing some intrinsic properties (*viz*. pH, EC, moisture content, bulk density, particle density, porosity, salinity and chemical properties). A piejo meter was installed in each polder to find ground water table depth and underground water salinity at 15 days interval during Rabi season. Surface water, exist in pond and canal, salinity was also measured. Data on soil physical and chemical properties of each polder, salinity status of ground water, pond water and canal water were collected and analyzed statistically.

Results and Discussion

Knowledge of soil physical properties is essential for soil management as well as planning of modern farming in a polder. Bulk density, porosity, organic matter, pH etc. are basic properties influenced soil characters of a region. Soil pH and electrical conductivity (EC) of different polders at Kalapara, Patuakhali are presented in Table 1. The pH of soil samples ranges from 5.1 to 5.3 *i.e.,* the soil samples were acidic in nature. On the other hand, the observed EC values were found between 0.2-0.5 dS/m indicating the soil samples were not saline during starting of Rabi season. Organic matter status of the polders was 1.1 to 1.3 that influenced the bulk density and porosity of the soil. Ranges of bulk density in soils were 1.14 to 1.49 gcm^{-3} while particle density was almost double of it *i.e.*, 2.35 to 3.0 gcm^{-3} which denoted the ideal condition of soils. As bulk density is indicator of root penetration in soil it indicates the favorable condition of plant growth of the sampling area of the studied polders in Kalalpara, Patuakhali.

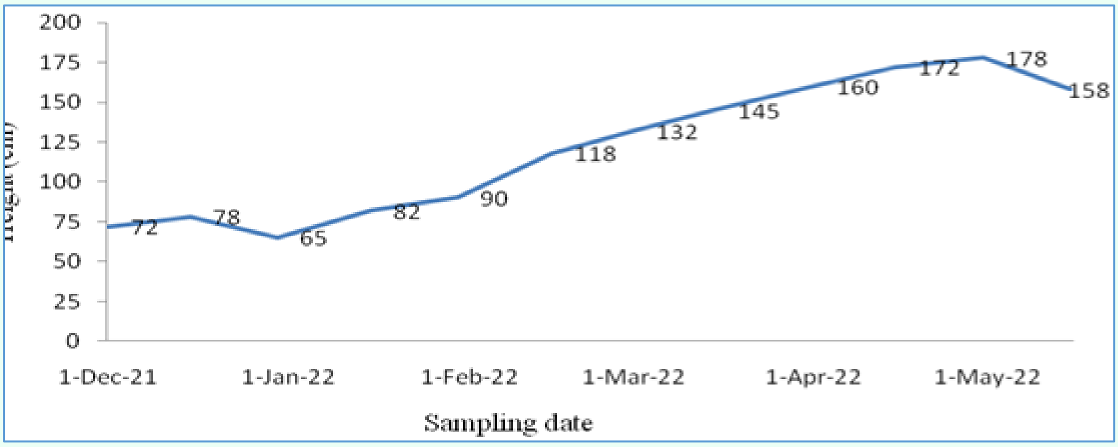
Chemical properties of the polder soils are presented in Table 2. N status was found below critical level in both polders, but other macro elements were above critical level. It means N amendment is essential for crop production in the new polder 46 and 48. Among micronutrients Boron was found below critical level in Polder 46 but it was at per at Polder 48. Average ground water table in the polders was 72 cm during December 202. It increased with time and reached at pick (178 cm) during late April than it reduced with the onset of seasonal precipitation (Fig. 1). Ground water, pond water and canal water salinity were also measured with time. It was observed salinity of water in all sources increased with advancement of Rabi period. During 01 December 21 to 01 May 22, ground water and pond water salinity increased 1.72-4.20 dS/m, 0.65-1.0 dS /m, respectively then it declined. Canal water salinity increased up to 01 April 22, 2.8 to 18.5 dS /m then it declined due to intrusion of tidal water in the canal.

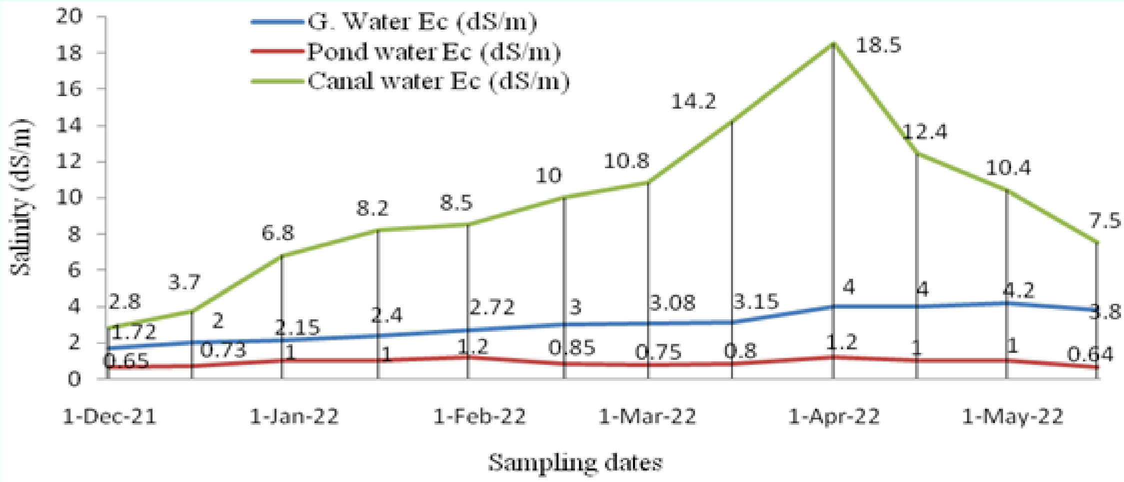
Table 1. Soil physical properties of different polders

Polder No.	Location	pH	Ec (dS/m)	OM (%)	Particle Density (g/cc)	Bulk density (g/cc)	Porosity (%)
46	Sonatala, Kalapara	5.3	0.3-0.5	1.3	2.35-2.59	1.45-1.49	49.39-52.67
48	Nobinpur, Kalapara	5.1	0.2-0.3	1.1	2.91-3.00	1.14-1.35	47.98-51.34

Table 2. Soil chemical properties of different polders

Polder No	K (meq/100 ml)	Total N (%)	P	S	B	Zn
			ppm			
46	0.18-0.20	0.07	10-12	19-21	0.08-0.1	1.0-1.2
48	0.12-0.20	0.06	12-21	15-17	0.20-0.32	0.7-1.0
C.L.	0.12	0.20	10	10	0.20	0.60





Conclusion: Soils of polders 44, 46 and 48 are suitable for growing crops in coastal region.

EFFECT OF FOLIAR APPLICATION OF BORON ON THE YIELD OF MUNGBEAN

M. RAZIUDDIN

Abstract

Foliar application of boron can increase pollen fertilization, seed size and seed weight. Mungbean being a dominant rainfed rabi crop in Barishal, faces high temperature in flowering stage in short term drought situation. Pollen fertilization hampers, seed size and weight decreases. To overcome the problem, a field study was carried out at the farmer's field of Babuganj, Barishal to evaluate the different doses of foliar application of Boron in mungbean cultivation in late rabi season of 2022. The experiment was carried out with four different doses of foliar application of Boron viz. T_1= Control, T_2=1% Boron solution, T_3=2% Boron solution, and T_4=3% Boron solution under randomized complete block design with three replications. BARI Mung-6 was used as the test crop. Results revealed that, application of 2% Boron solution gave the maximum pod per plant, hundred seed weight and seed yield (1363 kg ha^{-1}) compared to other treatments. Application of 2% Boron solution has been found profitable to other treatments. So foliar application of Boron in can be a good option for quality and exportable seed production and to combat high temperature induced pollen sterility of mungbean production in Barishal region.

Introduction

Mungbean (*Vigna radiata*) is an important component in the intensive crop production system for its short life cycle and is one of the most leading pulse crops in south central coastal region of Bangladesh. Mungbean plants uptake boron by foliage system and this mineral metabolically activates enzymes ultimately uphold the stickiness of stigma to successful fertilization. Moreover, grain size might be enlarged and bold culminating in desired yield. In AEZ-13, mungbean pollination and fertilization hampered due to high temperature. If fertilization happens, seed size and seed weight may not be satisfactory. Farmers are encouraged to produce bold sized mungbean seed for export purpose. Hence, the investigation was undertaken to justify the doses of boron foliar application and its impact on seed yield.

Material and Methods

The experiment was conducted at farmer's field of Babuganj, Barishal in single factor randomized complete block design with three replications during March 2022. The unit plot size was 4m × 4m. Initially, the experimental area was divided into three blocks to represent three replications. Mungbean var. BARI Mung- 6 was used. The crop was sown maintaining 30 cm line and 10 cm plant distance. The experimental field was fertilized with 20-40-20-10 kg of N-P-K-S ha^{-1} as basal dose. The treatments were: i) T_1= Control ii) T_2=1% Boron solution, iii) T_3=2% Boron solution, iv) T_4=3% Boron solution. Before flowering stage (30-35 days after emergence), boron solutions were sprayed according to the concentrations over the treatment plot.

Formulation of concentrations and application method: Different boron concentrations were made by dissolving commercial boron fertilizer Bingo (18% B) to water. For a spray can of 10000 ml water 10 g of boron fertilizers (For 1% Boron Solution) were mixed and shacked until dissolve. The concentration was used for three randomized 1% Boron conc. treatment plots. Following identical path, other boron solution concentrations were formulated and sprayed. The concentrations were sprayed over the canopy only.

Yield and different yield contributing characters were measured at harvest. The collected data were analyzed by the statistical software R and the least significant differences were calculated at 5% level of significance (Gomez and Gomez, 1984).

Initial soil nutrient status of the experimental plot was represented in Table 1. Data reveals that, boron status level was critical (0.13 microgram/ml).

Table 1. Initial soil nutrient status of the experimental plot, Rahmatpur, Barishal during 2022

pH	OM (%)	Ca	Mg	K	Total N%	P	S	B	Cu	Fe	Mn	Zn
		meq/100 ml				microgram/ml						
5.7	1.55	4.2	1.4	0.11	0.082	20.8	19.4	0.13	1.0	38	5	0.53
Critical values		2.0	0.5	0.12		7.0	10	0.2	0.2	4.0	1.0	0.6

Results and Discussions

Yield and contributing characters of mungbean as influenced by different doses of foliar application of Boron was represented in Table 2. Data revealed that, number of pod plant^{-1}, hundred seed weight and seed yield differed significantly among the treatments. The maximum pod yield was observed from spraying of 2% Boron solution (45 Pods plant^{-1}). All the boron application treatments showed statistically similar hundred grain weight (About 4 g). Seed yield was higher for 2% Boron solution (1363.3 kg ha^{-1}) and the lowest from control (943.3 kg ha^{-1}).

Cost and return analysis

Application of 2% Boron solution was found profitable considering the highest gross margin and BCR (Tk. 56798 ha^{-1} and 3.27) (Table 2). Application of 1% B solution gave a satisfactory gross margin and BCR (Tk. 45100 ha^{-1}, 2.84). The lowest gross margin and BCR can be observed from 3% Boron solution application (Tk. 33702 ha^{-1} and 2.32).

Farmer's opinion

Farmers usually do not spray Boron in mungbean. But they used to spray commercial micronutrient complex for vegetables. They liked the bold size grain. They said that boron spray can be good for quality seed production.

Table 2. Seed yield and yield attributes of mungbean and its economic performance as influenced by different doses of foliar application of boron during late rabi of 2022

Treat.	Plants m^{-2}	Pod $plant^{-1}$	Seed pod^{-1}	100 seed weight (g)	Seed Yield (kg ha^{-1})	GR (Tk. ha^{-1})	TC (Tk. ha^{-1})	GM (Tk. ha^{-1})	BCR
T_1	36.67	31 b	10.22	2.66 b	943 c	56598	24000	32598	2.35
T_2	41.33	27.22 b	10.67	4.02 a	1160 b	69600	24500	45100	2.84
T_3	41.33	45.22 a	9.88	4.81 a	1363 a	81798	25000	56798	3.27
T_4	41.67	21.66 b	9.22	4.65 a	987 c	59202	25500	33702	2.32
$LSD_{(0.05)}$	NS		NS			-	-	-	-
CV (%)	7.40	22.38	8.45	11.05	7.24	-	-	-	-

Note: T_1= Control (No spray), T_2=1% Boron solution, T_3=2% Boron solution, T_4=3% Boron solution; GR = Gross return, TVC =Total variable cost, GM = Gross margin and BCR = Benefit cost ratio and
Mungbean price: 60 Tk. kg^{-1}

Conclusion

Application of Boron in foliar spray formulation can be a good option for quality and exportable seed production and to combat high temperature induced pollen sterility. Moreover, further trial is necessary to fine tune the findings.

INTEGRATED NUTRIENT MANAGEMENT OF BARI SHAHEBIKACHU-1 IN SOUTHERN REGION OF BANGLADESH

M. RAZIUDDIN

Abstract

BARI Shahebikachu-1 is a recently developed upland taro variety with high nutritive and qualitative edible attribute. As being a tuber crop, its fertilizers requirement is quite high and judicious fertilizer packages still not determined in farmers field condition. An approach was undertaken to justify some fertilizer packages based on soil test and IPNS were evaluated and compared with farmer's practice. The experiment was carried out with three fertilizer doses viz. T_1=Soil test based inorganic dose on RDF (120-46-128-20 kg, N-P-K-S ha^{-1}) (FRG, 2018), T_2=T_1+5 t cowdung ha^{-1} (IPNS approach), T_3=Farmers practice. As the crop was in growth stage, observable estimated yield and yield contributing characters were measured. The results indicated that, all yield and yield contributing characters were satisfactory in IPNS approach. The highest estimated rhizome length (18.46 cm) and rhizome yield (718 g) was observed from IPNS based approach.

Introduction

Taro (*C. esculent* Linn.) is a vegetative propagated tropical root having its origin from South-east Asia. Taro tubers are important sources of carbohydrates as an energy source and are used as staple foods in tropical and sub-tropical countries. It is largely produced for its underground corms containing 70 to 80% starch. Its ability to produce a crop under extremes of water regimes from upland to shady moist places or flooded conditions makes it a valuable crop for selective development programs (Chadha, 1993). BARI has recently developed a taro variety (BARI Shahebikachu-1) through selection method. But, due to newly released variety, suggestions on its fertilizer doses yet not established. Therefore, the study will be undertaken to evaluate integrated plant nutrient management on BARI Shahebikachu-1.

Material and Methods

The experiment was conducted in farmer's field of Babuganj, Barishal during 2021-22 to evaluate three fertilizer packages viz. T_1=Soil test based inorganic dose on RDF (120-46-128-20 kg, N-P-K-S ha^{-1}) (FRG, 2018), T_2=T_1+5 t cowdung ha^{-1} (IPNS approach), T_3=Farmers practice. The experiment was laid out in Randomized Complete Block Design with three replications. The unit plot was 8m × 5m with spacing 2m × 1m. The experiment was established during August 2021. Weeding and irrigation was done as per need. Initial soil fertility status was measured prior to the initiation of the experimentation (Table 1). STB dose was calculated from initial soil nutrient status. Organic fertilizer dose based on the STB dose treatment was also measured and calculated. The total plot was subdivided into subplots and the drainage system was developed to prevent fertilizer admixture. All of organic manure, phosphorus, potassium and sulphur were applied as basal during final land preparation. Nitrogen was side dressed in two equal splits at 25-30 and 55-60 days after planting and mixed thoroughly with the soil. Ring method was used to apply fertilizers in split doses. Data on yield contributing characters were recorded randomly selected plants from each plot. As a long duration crop, rhizome was in growth stage so that rhizome yield (kg ha^{-1}) was recorded from the whole plot by observation. Data were analyzed statistically by using R software at 5% level of significance.

Table 1. Initial fertility status of the soil samples of the experimental field at farmers field, Babuganj Barishal during 2021

Soil Properties	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Cu	Fe	Zn
			meq 100g^{-1}				µg g^{-1}					
Result	6.8	0.92	8.6	2.5	0.07	0.08	12	4	0.09	1.5	92	0.60
Critical level	-	-	2.0	0.8	0.20	-	14	14	0.20	1	10	2.0

Results and Discussions

Yield and yield contributing characters of BARI Shahebikachu-1 were represented in Table 5. It can be observed from the Table 2, plant width, estimated rhizome length and rhizome weight were significant among different fertilizer packages. There was no significant difference for plant height and leaflet number among different fertilizer packages. Plant width was found optimum in T_2 treatment (29 cm). The data were statistically identical for T_1 and T_2 treatment (25 cm and 23 cm). Estimated rhizome length was highest for T_2 treatment (18.46 cm) whereas for T_1 and T_3 treatment it was about 17 cm and 16 cm. estimated rhizome weight was the highest for T_2 treatment (717.9 g). For T_1 and T_2 treatment rhizome weight did not differ significantly.

Farmer's opinion

Farmers cultivate taro near homestead. They do not usually engage their rice land for taro cultivation. They do not use fertilizers before for taro cultivation. They were interested to see its economic profitability and marketability.

Conclusion

In respect of plant width, estimated rhizome length and estimated rhizome weight IPNS approach fertilizer management was found satisfactory during the growth stage of the crop. The final suggestion can be drawn out after harvesting of the crop.

Table 2. Yield and yield contributing characters of BARI Shahebikachu-1 at farmers field of Babuganj, Barishal during 2021-22

Treatment	Plant height (cm)	Plant width (cm)	Leaflet (no)	Estimated rhizome length (cm)	Estimated rhizome weight (g)
T_1	39.67	25.73b	2.8	17.33ab	516.47b
T_2	49.53	29a	3.67	18.46a	717.90a
T_3	37.6	23.13b	2.87	16.33b	399.27b
Level of Sig.	NS	*	NS	*	*
CV (%)	13.33	5.45	13.03	3.51	10.18

Note: T_1 Soil test based inorganic dose on RDF (120-46-128-20 kg N-P-K-ST_2=T_1+5 t ha^{-1} cowdung (IPNS approach) T_3= Farmers practice

EFFECT OF LIME AND FERTILIZER MANAGEMENT ON YIELD OF ONION IN SYLHET REGION

M. I. NAZRUL

Abstract

Field experiments were carried out in 2021-22 at the farmer's field in acidic clay loam soil at FSRD site, Kamalbazer, South Surma, Sylhet. Two factors experiment viz. A) Fertilizer management, M_1: Soil test-based fertilizer recommendation, M_2: 80% of STB dose and M_3: Farmers practice and B) Level of limes viz. L_1: 0 t ha^{-1}, L_2: 1 t ha^{-1} and L_3: 2 t ha^{-1} were considered as treatments. The tested variety was BARI Piaz-4. The trial was laid out in randomized complete block factorial design with three replications, where lime levels were allotted to main plot and level of fertilizers were in the subplots. Bulb yield of onion (13.78 t ha^{-1}) was obtained from treatment combination L_2M_1 (2.00 t lime ha^{-1} and STB fertilizer dose) followed by L_3M_1. The highest gross margin (Tk 31878 ha^{-1}) was obtained from L_2M_1, but the maximum MBCR (6.60) was recorded in L_1M_1, where the lime was absent though it is essential for onion cultivation in acidic soil.

Introduction

The optimal soil pH for onion crop is 6.2 to 6.8 with the sandy loam types of soil (Karim and Ibrahim, 2013). At the high end of this range, soil nutrients are most easily accessed. If soil isn't in the proper pH range for growing onions, it can be adjusted with organic substances, ammonium sulfate and dolomitic lime will also boost acidity. The soil of Sylhet region is mostly strongly acidic that adversely affects crop production. Presently, farmers in this region are using dolomite in different quantities to correct the soil acidity. Results of on-farm trial with lime indicated that it had good effect on bulb yield of onion. Soil pH management through liming is a basic practice for increasing crop yield. Liming optimizes nutrient availability in soil and its utilization by plants. Therefore, it was necessary to determine the optimum dose of lime and fertilizer for better growth and yield of onion.

Materials and Methods

An experiment was carried out during 2021-2022 at the farmer's field on an area with acidic clay loam soil at farming system research and development (FSRD) site, Kamalbazer under South Surma in Sylhet. Two factors experiment viz. A) Fertilizer management, M_1: Soil test-based fertilizer recommendation, M_2: 80% of STB fertilizer dose and M_3: Farmers practice and B) Level of limes viz. L_1: 0 t ha^{-1}, L_2: 1 t ha^{-1} and L_3: 2 t ha^{-1} were considered as treatments. Trial was laid out in randomized complete block (factorial) design with three replications where levels of lime to main plot and fertilizer management were distributed in the sub-plots. Topsoil (0-15 cm depth) was sampled in the experimental plots before applying lime and after the cultivated onion crop was harvested. The chemical properties of the analyzed initial soils are given in Table 1**.** The crop with variety, plot size with spacing, date of sowing or transplant and harvest date have been shown in Table 2. Intercultural operation and crop protection measures were taken as per requirement during the conduction of experiment. Irrigation, insect control and other intercultural operations were done as and when necessary. The fungicide mixture (Rovral @ 2% and Ridomil @ 0.2) was sprayed to control purple blotch disease. The amendments of different levels of lime were applied on 10-15 November and were incorporated into the soil by ploughing. Data on yield of onion and farmers opinion were recorded. The collected data were analyzed statistically, and means were separated by LSD (0.05). Cost benefit analysis ware done based on the market price of the inputs and outputs.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field in Eastern Surma Kushiara Flood plain of Sylhet

pH	OM (%)	Total N (%)	K	P	S	Zn	B
			meq/100g soil	Micro gram/g soil			
4.1-5.3	1.63	0.08	0.12	2.47	10.80	1.24	0.33
-		0.12	0.12	8.0	10	0.6	0.2
Strong acidity	Low	Very low	low	Low	Low	Medium	Optimum

Table 2. Fertilizers doses, plot size, spacing, date of transplanting and date of harvest

Fertilizer (Kg ha^{-1}) (N-P-K-S-Zn-B)		Plot size	Spacing (cm × cm)	Date of	
				Planting	Harvest
M_1	100-67-79-23-3-1.4				
M_2	80-54-63-78-2.5-1	20 m^2	15 × 7	17-20 Dec 2020	25-27 March 2021
M_3	86-52-74-20-1.9-1				

Results and Discussions

Effect of Lime: The effect of lime on the yield and yield component of onion has been shown in Table 2. The maximum bulb yield (13.26 t ha^{-1}) was obtained from 2.0 t lime ha^{-1} followed by 1.0 t ha^{-1} with bulb yield (12.85 ha^{-1}). The application of lime was contributed up to 15% higher bulb yield over control.

Effect of Fertilizer Management: The balance fertilizer dose played a significant role in the yield and yield attributes of onion (Table 3). The highest bulb yield of onion (13.14 t ha^{-1}) was found in soil test base fertilizer management (M_1), which was significantly higher over rest of the treatments. There was no significant difference between 80% of STB fertilizer dose (M_2) and farmer practice (M_3).

Interaction Effect of Lime and Fertilizer Management: The interaction between lime and fertilizer management practice was found statistically significant for bulb yield and yield components of onion (Table 3). Combined application of both lime and fertilizer management augmented higher results than single effect. Higher bulb weight (30.80g) and bulb diameter (3.73 cm) was found when 2.0 t lime ha^{-1} followed by 80% of STB fertilizer. The bulb yield of onion also increased significantly due to combined use of lime and fertilizer management practice. The highest bulb yield (13.78 t ha^{-1}) was obtained from L_2M_1, followed by L_3M_1. On the contrary, the treatment combinations with zero lime (L_1M_1, L_1M_2 and L_1M_3) produces the lowest bulb yields of onion as compared to that of lime mixed treatment combinations.

Cost and return analysis

Cost and return analysis showed that the highest gross margin (Tk 318787 ha^{-1}) was obtained from L_2M_1 (Table 4). The second highest gross margin (Tk 306037 ha^{-1}) was recorded in L_3M_1, which was closely followed by L_3M_2. However, the highest MBCR (6.60) was recorded in L_1M_1 where lime was absent but that was essential for onion cultivation in acidic soil. On the contrary, incorporation of increased lime dose along with fertilizer provides higher cost involvement due to lime and which gave lower MBCR.

Table 3. Effect of fertilizer management and level of liming on the bulb yield of onion in acidic soil of Sylhet during 2021-2022

Treatment	Plant height (cm)	Bulb weight (g)	Bulb diameter (cm)	Bulb Yield (t ha^{-1})
A. Level of liming				
L_1	42.88	21.09	3.32	11.52
L_2	46.87	27.89	3.78	12.85
L_3	42.80	26.68	3.59	13.26
LSD $_{(0.05)}$	0.45	3.57	0.21	0.84
CV (%)	0.78	8.51	4.35	5.08
B. Fertilizer management				
M_1	46.05	25.62	3.52	13.14
M_2	44.10	26.71	3.81	12.34
M_3	42.40	26.20	3.36	12.14
LSD $_{(0.05)}$	0.01	3.57	0.17	0.43
CV (%)	09	7.97	4.77	3.13
Fertilizer management × Level of liming				
L_1M_1	41.50	21.67	3.34	12.04
L_1M_2	42.63	19.93	3.51	11.33
L_1M_3	41.53	21.67	3.11	11.19
L_2M_1	48.87	29.07	3.61	13.78
L_2M_2	46.87	27.80	4.21	12.50
L_2M_3	44.87	26.80	3.53	12.27
L_3M_1	44.80	26.13	3.61	13.59
L_3M_2	42.80	30.80	3.73	13.21
L_3M_3	40.80	23.13	3.43	12.97
LSD $_{(0.05)}$	0.52	5.03	0.51	1.35
CV (%)	4.40	8.11	4.67	3.71

M_1: Soil test based (STB) fertilizer recommendation, M_2: 80% of STB dose and M_3: Farmers practice (FP) and Level of limes L_1: 0 t ha^{-1}, L_2: 1 t ha^{-1} and L_3: 2 t ha^{-1}

Table 4. Cost and return analysis of fertilizer management with levels of limes on the bulb yield of onion in Sylhet during 2021-22

Treatment	Bulb yield (t ha^{-1})	Gross return	Total variable cost	Gross margin	Marginal gross margin	Marginal variable cost	MBCR
		(Tk. ha^{-1})					
L_1M_1	12.04	301000	17713	283287	21250	3218	6.60
L_1M_2	11.33	283250	14103	269147	3500	-392	-8.93
L_1M_3	11.19	279750	14495	265255	0	0	0
L_2M_1	13.78	344500	25713	318787	64750	11218	5.77
L_2M_2	12.50	312500	22103	290397	32750	7608	4.30
L_2M_3	12.27	306750	22495	284255	27000	8000	3.38
L_3M_1	13.59	339750	33713	306037	60000	19218	3.12
L_3M_2	13.21	330250	30103	300147	50500	15608	3.24
L_3M_3	12.97	324250	30495	293755	44500	16000	2.78

Price of input and output (Tk. kg^{-1}): Dolomite lime- $CaMg(CO_3)_2$-8.00, Urea-20.00, TSP-22.00, MoP-15.00, Cowdung-1.00, Onion-25.00.

Conclusion

For achieving a good harvest of bulb onion from clay loam textured acidic soil, proper application of dolomite lime and balance dose of fertilizer is essential. Considering the overall benefits, the bulb yield of onion can be maximized with the treatment package viz. 1 ton lime ha^{-1} along with STB fertilizer (100-67-79-23-3-1.4 kg N-P-K-S-Zn-B ha^{-1}) dose contributed higher bulb yield (13.78 t ha^{-1}) than all other treatments combination.

EFFECT OF LIME AND FERTILIZER MANAGEMENT ON THE YIELD OF MUKHIKACHU IN ACIDIC SOILS OF SYLHET REGION

M. I. NAZRUL

Abstract

An experiment was carried out in 2021-2022 at the farmer's field in acidic clay loam soil at multilocation testing site, Moulvibazar. Two factors experiment viz. A) Fertilizer management, M_1: Soil test-based fertilizer dose M_2: 80% of STB dose and M_3: Farmers practice and B) Level of limes viz. L_1: 0 t ha^{-1}, L_2: 1.0 t ha^{-1} and L_3: 2.0 t ha^{-1} were used as treatments. These was tested on BARI Mukhikachu-1. Trials were laid out in split plot design with three replications, where lime levels were allotted to main plot and level of fertilizers were distributed in the subplots. The yield of Mukhikachu in a total of nine treatment combinations varied significantly with different lime doses and fertilizer management practices. The highest yield of Mukhikachu (34.63 t ha^{-1}) was obtained from 2.0 t lime ha^{-1} with STB fertilizer dose $N_{263}P_{50}K_{100}S_{34}Zn_{1.07}B_{0.5}$ (L_3M_1) followed by L_3M_2 and L_2M_1. The highest gross margin (Tk 478050 ha^{-1}) was obtained from L_3M_3. Moderate lime dose (1.0 t ha^{-1}) along with 80% of STB fertilizer might be useful for Mukhikachu cultivation in acidic soil of Moulvibazar region.

Introduction

Mukhikachu (*Colocasia esculenta* L.) is a popular indigenous vegetable and the most widely cultivated edible aroid in Bangladesh. The crop is extensively grown in the kharif season, and it can contribute considerably part to the total supply of bulky vegetables during the late summer when other vegetables are scarce in the market (Ahmed and Rashid, 1975). Its nutritional values are rich than other root crops such as cassava, yam, sweet potato (Plucknett *et al*., 1970) such as carbohydrate, protein, vitamin C and certain other constituents. Taro flour is used as baby food and also used for making chips. The corm is an excellent source of carbohydrate, the majority being starch of which 17-28% is amylase and the remainder is amylo-pectin. It is grown all over the country but commercially cultivated in Chittagong, Bogra, Sylhet and Pabna districts of Bangladesh (Rashid, 1993). Application of chemical fertilizers may increase its yield. But the imbalanced and excess use of chemical fertilizers degrades the soil and the environment (Higa, 1991). The area and production of Mukhikachu is increasing gradually and becoming popular among farmers all over the country including Sylhet region. The Sylhet region is mostly under the AEZ-20 and the soils of this region are strongly acidic that adversely affects crop production in Sylhet. Presently, farmers in this region are using agricultural lime/dolomite in different quantities to correct the soil acidity. Results of on-farm trial with lime indicated that it had good effect on grain yield of different crops as reported by Nazrul *et al*. (2020). Soil pH management through liming is a basic practice for increasing crop yield. Liming optimizes nutrient availability in soil and its utilization by plants. It also reduces availability of Al and Mn, improve microbial activity. Therefore, the experiment has been conducted to determine the optimum dose of lime and fertilizer management option for better growth and yield of Mukhikachu in acidic soil of Sylhet region.

Materials and Methods

Field experiments were carried out during years of 2021-2022 at the farmer's field on an area with acidic clay loam soil at multilocation testing site, Moulvibazar. Mukhikachu var. BARI Mukhikachu-1 was used as planting material. Two factors experiment viz. A) Fertilizer management, M_1: Soil test-based fertilizer recommendation M_2: 80% of STB dose and M_3: Farmers practice and B) Level of limes viz. L_1: 0 t ha^{-1}, L_2: 1 t ha^{-1} and L_3: 2 t ha^{-1} were considered as treatments. Trials were laid out in randomized complete block (RCB) factorial design with three replications where lime levels were allotted to main plot and level of fertilizers in the sub-plots. Topsoil (0-15 cm depth) was sampled in the experimental plots before applying lime and after the cultivated Mukhikachu was harvested. The chemical properties of the collected soils are given in Table 1. Intercultural operation and crop protection measures were taken as per requirement during the conduction of experiment. The insecticides (Tracer 45 SE @ 0.4 ml/L) were sprayed to control cutworm infestation and Mancojeb @ 4g/L was applied for effective control of leaf blight. Irrigation, insect control and other intercultural operations were done as and when necessary. The amendments of different levels of lime were applied on 15-20 November and were incorporated into the soil by ploughing. Data on yield of Mukhikachu and farmer's opinion were recorded. The collected data were analyzed statistically, and means were separated by (LSD 0.05). Cost benefit analysis ware done based on the market price of the inputs and outputs.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field in MLT site, Moulvibazar

pH	OM (%)	Total N (%)	K	P	S	Zn	B
			meq/100g soil	Micro gram/g soil			
4.2-5.5	0.98	0.06	0.16	11.52	8.31	1.27	0.56
-	-	0.12	0.12	8.0	10	0.6	0.2
Strong acidity	Low	Very low	low	Low	Low	Medium	Optimum

Table 2. Fertilizers doses, plot size, spacing, date of sowing and date of harvest

Fertilizer (kg ha^{-1}) (N-P-K-S-Zn-B)		Plot size	Spacing (cm × cm)	Date of	
				Sowing	Harvest
M_1	263-50-100-34-1.07-0.5	20 m^2	60 × 35	25-28 February	10-15 Oct. 2021
M_2	210-40-80-27-0.86-0.27				
M_3	302-58-115-39-0-0				

Results and Discussions

Effect of Lime: The effect of lime on the yield and yield component of Mukhikachu has been shown in Table 2. The highest yield (33.11 t ha^{-1}) of Mukhikachu was obtained from 2.0 t lime ha^{-1}. The application of lime contributed up to 15 % higher corm yield over control.

Effect of Fertilizer Management: The balance fertilizer dose played a significant role in the yield and yield attributes of Mukhikachu (Table 3). The highest rhizome yield (32.59 t ha^{-1}) was found with soil test based (STB) fertilizer management (M_1), which was significantly higher over rest of the treatments. There was no significant difference between 80% of STB fertilizer dose (M_2) and farmer practice (M_3).

Interaction Effect of Lime and Fertilizer Management: The interaction between lime and fertilizer management practice was found statistically significant for yield and yield components of Mukhikachu (Table 3). From the interaction effect of lime and fertilizer management revealed that yield and yield attributes gradually increased with the increasing of lime dose. The higher levels of lime produced maximum yield to that of non-lime treatment combinations. The treatment combination (L_3M_1) gave the highest yield (34.63 t ha^{-1}) of Mukhikachu which was statistically different to that of all other treatment combinations. The lowest corm yield (27.33 t ha^{-1}) was obtained from the combination of L_1M_3.

Cost and return analysis : Cost and return analysis showed that the highest gross margin (Tk. 478050 ha^{-1}) was obtained from L_3M_3 (Table 4). However, the highest MBCR (77.01) was recorded in L_2M_2 (1.0 t lime ha^{-1} and 80% of STB fertilizer). On the contrary, incorporation of increased lime dose along with higher dose of fertilizer provides higher cost involvement for lime and gives lower MBCR. Anyway, the moderate and higher doses of lime along with the STB fertilizer and 80% of STB dose provided maximum MBCR (77.01 and 15.86) over control and any other treatment combinations.

Table 3. Effect of fertilizer management and levels of lime on the corm yield of Mukhikachu in acidic soil of Sylhet during 2021-22

Treatment	Plant height (cm)	Leaves plant^{-1}	Spreading (cm)		Cormels Plant^{-1}	Corm length (cm)	Corm girth (cm)	Wt. corm (g)	Rhizome Yield (tha^{-1})
			N-S	E-W					
A. Level of liming									
L_1	52.33	3.56	52.22	47.11	11.67	4.77	8.13	20.63	28.82
L_2	59.89	3.78	50.67	46.67	12.22	5.10	8.83	21.60	30.84
L_3	66.22	4.33	54.78	47.89	13.56	5.47	9.83	22.47	33.11
LSD $_{(0.05)}$	NS	0.63	NS	NS	1.08	0.30	0.61	0.88	1.53
CV (%)	22.18	16.55	6.48	8.61	8.81	6.05	7.03	4.18	5.07
B. Fertilizer management									
M_1	71. 56	4.44	53.56	50.44	13.44	5.42	9.53	22.51	32.59
M_2	63.44	4.00	50.78	48.33	12.44	5.10	8.98	21.59	30.79
M_3	43.44	3.22	53.33	42.89	11.56	4.81	8.29	20.60	29.40
LSD $_{(0.05)}$	6.36	0.47	NS	2.05	1.09	0.34	0.80	0.85	1.99
CV (%)	10.94	12.39	6.91	4.44	8.95	6.76	9.19	4.02	6.57
Fertilizer management × Level of liming									
L_1M_1	62.33	4.00	54.00	50.00	12.33	5.10	8.57	21.57	30.30
L_1M_2	57.00	3.67	48.33	48.67	11.67	4.73	8.23	20.60	28.83
L_1M_3	37.67	3.00	54.33	42.67	11.00	4.47	7.60	19.73	27.33
L_2M_1	72.00	4.33	49.67	50.67	13.00	5.40	9.50	22.83	32.83
L_2M_2	64.33	4.00	49.67	49.00	12.33	5.13	8.93	21.57	30.70
L_2M_3	43.33	3.00	52.67	40.33	11.33	4.77	8.07	20.40	29.00
L_3M_1	80.33	5.00	57.00	50.67	15.00	5.77	10.53	23.13	34.63
L_3M_2	69.00	4.33	54.33	47.33	13.33	5.43	9.77	22.60	32.83
L_3M_3	49.33	3.67	53.00	45.67	12.33	5.20	9.20	21.67	31.87
LSD $_{(0.05)}$	3.35	1.03	8.71	5.05	2.16	0.46	0.86	0.58	1.90
CV (%)	1.94	9.09	5.71	3.68	5.95	3.11	3.32	0.93	2.11

M_1: Soil test based (STB) fertilizer recommendation, M_2: 80% of STB dose and M_3: Farmers practice (FP) and Level of limes L_1: 0 t ha^{-1}, L_2: 1 t ha^{-1} and L_3: 2 t ha^{-1}

Table 4. Cost and return analysis of fertilizer management with levels of lime on the corm yield of Mukhikachu in Sylhet during 2021-2022

Treatment		Gross return	Variable cost	Gross margin	Marginal gross margin	Marginal variable cost	MBCR
		(Tk. ha^{-1})					
L_1M_1		454500	108365	351021	57436	-2490	-23.06
L_1M_2		432450	103479	321595	28010	-7376	-3.80
L_1M_3		409950	110855	293585	0	0	0
L_2M_1		492450	116365	380971	87386	5510	15.86
L_2M_2		460500	111479	341645	48060	624	77.01
L_2M_3		435000	118855	310635	17050	8000	2.13
L_3M_1		519450	124365	399971	106386	13510	7.87
L_3M_2		492450	119479	365595	72010	8624	8.35
L_3M_3		478050	126855	478050			11.53

Price of input and output (Tk kg^{-1}): Mukhikachu-15, Dolomite lime-$CaMg(CO_3)_2$-8.00, Urea-20.00, TSP-22.00, MoP-15.00, Gypsum-15, Zinc-100, Buron-140, Cowdung-1.00,

Conclusion

One ton lime along with $N_{210}P_{40}K_{80}S_{27}Zn_{0.86}B_{0.27}$ kg ha^{-1} is suitable for maximizing the yield of mukhikachu in acidic soil Moulvibazer having pH 4.20-4.5.

EFFECTS OF TILLAGE, RESIDUE RETENTION AND PHOSPHORUS MANAGEMENT ON THE PERFORMANCE OF LENTIL IN RICE-BASED SYSTEM

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Abstract

Performance of lentil under three tillage treatments such as conventional tillage (CT), no-tillage (NT) and strip planting (SP), two levels of residue retention – high residue (HR) and low residue retention (LR) and three levels of phosphorus (50 % of recommended dose of P, 100 % of recommended dose of P and 150 % of recommended dose of P) were evaluated in rice-based system of Bangladesh. The cropping sequence mustard-mung bean-T. Aman is practicing since November 2018 at Ishurdi, Pabna. The current cropping sequence of lentil-sesame-T. Aman has started from November 2021. In the present report, only the Crop number 19 (lentil) grown in rabi season (cool dry season) of 2021-22 are presenting. The results showed that the application of SP increased the number of plant populations/m2, pods/plant which may lead to increase seed yield by 8.3 % and NT increased lentil yield by 2.4 % over CT. In case of P levels, the increased dose of P (150 % of recommended P) increased plant height, pods/plant and consequently, the seed yield of lentil increased. However, this study will be continued for a long-term period to concrete conclusion.

Introduction

The detrimental effects of conventional systems such as soil degradation, organic matter depletion, erosion, falling biodiversity and increased production cost has stimulated the search for alternative food production strategies and to reverse the process of soil degradation. This led to promote conservation agriculture (CA) in many countries in the world. At this time, CA based on minimum soil disturbance, residue retention and pulse-based crop rotations are being promoted and increasingly appreciated globally due to its more sustainable soil management outcomes (Islam *et al*., 2016; Johansen *et al*., 2012). Conventional crop production system in an agro-eco system is the most input intensive process and therefore more efficient alternative share urgently needed. During the last decades potential solutions include a shift from intensive to reduce or zero tillage and rice residue retention have been evaluated in cereal systems (Gathala *et al*., 2011; Ladha *et al*., 2009). However, the information of CA effects on the performance of pulse dominated rice-based system is scanty. In addition, nutrient management for crop production in rice-based system is still largely based on blanket recommendation made similar to that for CT system in South Asia. This may lead to lower crop yields, low nutrient use efficiency, lower economic profitability and greater environmental footprints. Presently, limited information is available on the evaluation of nutrient management especially P management in CA system on soil health and crop productivity in rice-based system of South Asia. Therefore, an attempt has been undertaken to evaluate CA practices (tillage, residue along pulse-based rotation crop) and P management on crop performance and soil fertility of mustard-mungbean-rice cropping pattern in northwest Bangladesh. We hypothesized that adopting the CA-based management practices together with precise nutrient management especially P management would improve system productivity and soil fertility in northwest Bangladesh. Keeping these facts in mind, an experiment of mustard-mungbean-rice has been undertaken to evaluate the effects of P management in CA on the performance of mustard in rice-based system of northern Bangladesh.

Materials and methods

The field experiment was conducted at Pulses Research Centre, Ishurdi, Pabna, under the Agro-Ecological Zone of High Ganges River Floodplain (AEZ 11). The experimental field situated at 24° 7′ 15.08″ N latitude and 89° 4′ 45.95″ E longitude with an altitude 44 at the elevation of 26 m above the sea level. The soil belongs to the ‘Sara’ soil series sandy loam in texture having moderate organic matter content of soil with pH value 7.5. Field experiment for the present study was initiated with lentil (BARI Masur-6 and 8 used in 2015-17 and 2017-18, respectively) in

November (the cool dry season) in 2015, followed by mungbean (BARI Mung bean-6) in the pre-monsoon season (March-June) then rice established in the monsoon season (July – October). This rotation was continuing for the first three years at Ishurdi. However, the rotation has been changed with mustard (BARI Sharisha-17) – mung bean (BARI Mung bean-6) –T. Aman rice (BRRI Dhan 71) in November 2018 and ended up in with T. Aman rice (Crop 15) in 2021. The rotation of mustard – mung bean – T. Aman rice was practiced for three years (2018-19 to 2020-21) and the current rotation of lentil – sesame – T. Aman rice is practicing from 2021-22. In this report, we are only presenting the data of Crop 19 i.e., lentil crop in the rotation for 2021-22. The lentil crop (variety: BARI Masur 8) was sown on 21 November 2021 and harvested on 11 March at Ishurdi. The experiment included four replicates for each treatment in a split-split-plot design. The main plots consist of three types of tillage – strip planting (SP), no-tillage (NT) and conventional tillage (CT); two levels of crop residue – high (HR) and low residue (LR) retention in the sub-plots, and three levels of phosphorus levels such as 50 % of recommended dose of P (9 kg ha^{-1}), 100 % of recommended dose of P (18 kg ha^{-1}) and 150 % of recommended dose of P (27 kg ha^{-1}) were assigned in a sub-sub-plots. However, in case of first mustard crop in 2018-19, three levels of phosphorus e.g., 75 % of recommended P, 100 % of recommended P (27 kg ha^{-1}) and 125 % recommended P were used. The P treatments imposed into the existing CA experiments in 2018 with mustard crop and from then it is still continuing. The dimensions of the main-plots are 16 m X 16 m, the sub-plots are 16 m x 8 m, and the sub-plots are 16 m x 2.2 m at Ishurdi. The experimental plots were fertilized at the rate of 21, 40, and 10, 1 kg N, K, S and B respectively (FRG-2018). Full doses of all fertilizers were broadcasted before planting. The procedure of all fertilizer application (hand broadcast) was same in all tillage treatments except P fertilizer. The P fertilizer was drilled using VMP in SP and NT treatments while broadcasted in CT. The seeds were sown maintaining line spacing of 30 cm for lentil. The seed rate of mustard was used 34 kg ha^{-1}. One hand weeding was done at 24-30 days after sowing (DAS) for controlling weed. Rovral-50 WP @ 2 g/L was sprayed two times at 55 DAS and 70 DAS for controlling Stemphylium disease of lentil. Malathion 57 EC @ 2ml/L was applied at 60 and 72 DAS for controlling aphid. Data on yield contributing characters such as plant population/m2, plant height, number of branches/plant, number of pods/plant, number of seeds/pod and 1000-seeds weight were recorded from ten randomly selected plants of each plot. The crop was harvested at maturity stage i.e., when 80% of the pod turned straw brown in colour. The seed and straw yield was recorded from the pre-selected central area of two square meters (4 m X 1 m) of each plot and converted to tones per hectare (t ha^{-1}). The GenStat 17th Edition and R-software packages were used for all statistical analyses. The mean differences between treatments were separated by the least significant difference (LSD) at $P \leq 0.05$ for the measured variables.

Results and discussion

The plant population/m2 was significantly affected by tillage and residue retention (Table 1). The plant population/m2 of SP (91) was higher as compared to CT (82) and NT (70). The plant population/m2 was higher in LR (84) as compared to HR treatment (78). The maximum tallest plants recorded from SP (44.7) as compared to CT (41.7) and NT (41.2). In case of residue levels, the highest plant height was recorded from HR treatment (43.3) and the lowest at LR treatment (41.8). The plant height increased with increasing P dose, and the highest plant height was recorded at P3 treatment (44 cm) while the lowest plant height was in P1 treatment (41 cm), and the intermediate type (43 cm) plant found in P2 (Table 1). The branches/plant was significantly affected by tillage and residue retention (Table 1). The highest branches/plant was recorded from NT (2.8) and in CT (2.5). The branches/plant under HR (2.8) was higher than that of LR treatment (2.5). The adoption of SP increased the pod number/plant (63) while the lowest pod number/plant was recorded from NT and CT (58). Regarding residue levels, the highest pods/plant was recorded in HR (61) than LR (59). With increasing P levels, the pod number/plant increased (63) in P3 treatment and the decreased pod number/plant recorded at P2 (59) and P1 treatments (56) (Table 1). The seeds/pod was not significantly different due to tillage, residue retention and P-levels (Table 1).

Table 1. Effects of tillage, residue and P management on yield attributes of lentil in lentil-sesame-rice cropping system

Tillage	Residue retention						Mean	LSD				
	HR			LR				T	R	P	T X R	TX P
	P levels											
	P1	P2	P3	P1	P2	P3						
Plants/m2												
SP	86	90	84	94	94	96	*91*	6.3**	5.1*	ns	ns	ns
NT	71	65	66	69	80	71	*70*					
CT	78	83	81	81	85	83	*82*					
Mean		78			84							
CV (%): Tillage (4.5), Tillage *Residue (6.8), Tillage *Residue* P levels (10.9)												
Plant height (cm)												
SP	42.4	45.8	46.0	43.0	45.9	45.3	*44.7*	0.6**	1.3*	1.2**	ns	ns
NT	41.4	42.9	44.0	36.9	39.8	42.5	*41.2*					
CT	42.0	41.3	43.8	39.0	41.3	43.0	*41.7*					
Mean		43.3			41.8							
CV (%): Tillage (0.8), Tillage *Residue (3.4), Tillage *Residue* P levels (4.8)												
Branches/plant												
SP	2.7	2.6	2.9	2.5	2.5	2.2	*2.6*	0.2**	0.2**	ns	ns	ns
NT	2.8	3.1	3.2	2.6	2.6	2.7	*2.8*					
CT	2.5	2.5	2.9	2.3	2.4	2.5	*2.5*					
Mean		2.8			2.5							
CV (%): Tillage (3.9), Tillage *Residue (7.1), Tillage *Residue* P levels (12.8)												
Pods/plant												
SP	62	66	71	57	59	63	63	1.4**	1.7*	1.4**	ns	ns
NT	53	57	59	55	59	63	58					
CT	57	58	63	55	56	61	58					
Mean		61			59							
CV (%):Tillage (1.4), Tillage *Residue (3.1), Tillage *Residue* P levels (4.1)												
Seeds/Pod												
SP	2.0	2.0	1.9	1.9	1.9	1.9	*1.9*	ns	ns	ns	ns	ns
NT	1.8	1.9	1.9	1.9	1.8	1.8	*1.9*					
CT	1.9	2.0	2.0	1.9	1.9	2.0	*1.9*					
Mean		1.9			1.9							
CV (%): Tillage (2.1), Tillage*Residue (2.3), Tillage *Residue* P levels (5)												
Nodule/plant												
SP	20	22	23	20	19	19	21	ns	0.7**	1.0**	1.7**	ns
NT	19	19	24	18	17	17	19					
CT	18	20	20	19	20	20	20					
Mean		21			19							
CV (%): Tillage (4.7), Tillage*Residue (2.8), Tillage *Residue* P levels (8.7)												
1000-Seed weight (g)												
SP	24.1	24.9	25.8	24.9	24.6	25.0	*24.9*	ns	ns	0.6*	ns	ns
NT	24.6	25.2	25.8	24.3	24.8	24.9	*24.9*					
CT	24.5	24.8	25.2	24.2	25.2	25.5	*24.9*					
Mean		25.0			24.8							
CV (%): Tillage (1.2), Tillage*Residue (2.4), Tillage *Residue* P levels (4.4)												

[1]HR - high residue; LR - low residue, SP - strip planting; NT - no-tillage; CT - conventional tillage; [2]the least significant difference (LSD) at the P≤0.05, ns - not significant, * - significant at P≤0.05 and ** - significant at P≤0.01; T – tillage; R – residue; CV - Coefficient of variation

Nodules/plant

The nodules/plant was significantly different due to different crop residue levels, P levels and the interaction of tillage and residue (Table 2). The nodule number of HR treatment was significantly higher in HR treatment (21) than LR treatment (19). In case of P levels, the highest nodule number/plant was recorded in P3 treatment (20.6) than that of P1 (19.0) and P2 (19.5) treatments. The interaction of SP and HR increased nodule numbers (22) and the lowest nodule number was recorded in NTLR treatment (17). Except P levels, 1000-seed weight are not significantly affected due to tillage and residue retention (Table 2). The highest 1000-seed weight was recorded in P3 treatment (25.4 g), followed by P2 (24.9) and the lowest 1000-seed weight was recorded in P1 (24.4 g).

Table 2. Effects of tillage, residue and P management on **nodules/plant** of lentil in lentil-sesame-rice cropping system

Tillage	Residue retention						Mean	LSD				
	HR			LR				T	R	P	T X R	TX P
	P levels											
	P1	P2	P3	P1	P2	P3						
Nodules/plant												
SP	20	22	23	20	19	19	21	ns	0.7**	1.0**	1.7**	ns
NT	19	19	24	18	17	17	19					
CT	18	20	20	19	20	20	20					
Mean	21			19								
CV (%): Tillage (4.7), Tillage*Residue (2.8), Tillage *Residue* P levels (8.7)												

Abbreviations as in Table 1

Seed yield of lentil

The plots under SP had significantly higher (2015 kg ha^{-1}) seed yield of lentil followed by NT (1908 kg ha^{-1}) and CT plots (1863 kg ha^{-1}) (farmers' practice) (Figure 1a). Regarding P levels, the highest seed yield of lentil recorded from P3 (2012 kg ha^{-1}) followed by P2 (1914 kg ha^{-1}) while the lowest seed yield was recorded from P1 (1861 kg ha^{-1}) (Figure 1b).

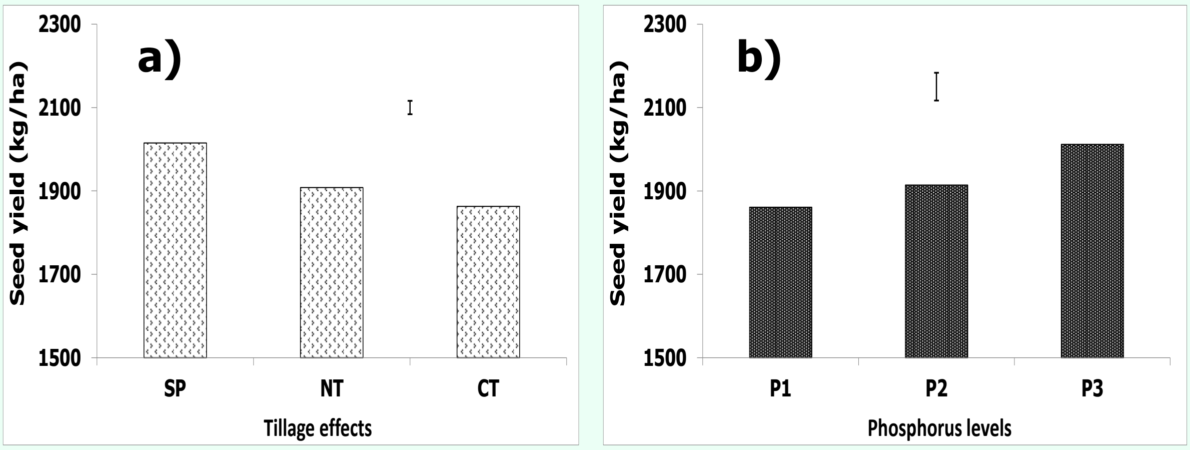

Figure 1. Tillage (a) and phosphorus (b) effects on seed yield of lentil

Correlation Matrix

Correlation coefficient among yield and yield contributing characters of lentil are given in Table 3. In correlation study, the significant positive relationship was recorded for plant population/m2 with plant height and pods/plant while significant negative relationship was recorded for plant population/m2 with branches/plant (-0.36). Plant height also positively correlated with pods/plant (0.50), nodules/plant (0.33) and seed yield (0.45). The branches/plant was positively correlated with nodules/plant (0.23). The pods/plant had a positive correlation with seed/pod (0.23) and nodules/plant (0.28) and had a strong positive correlation with seed yield (0.44). The nodule number/plant also positively correlated with seed yield (0.23).

Table 3. Correlation matrix of different yield contributing characters and yield of lentil under different tillage, residue and P levels. Pearson's correlation coefficients (r) describing the relation of yield contributing characters and yield of lentil

	PP	PH	BR	PD	SP	*ND*	*TSW*	*SY*
PP	1							
PH	0.31**	1						
BR	-0.36**	0.14	1					
PD	0.31**	0.50**	0.10	1				
SP	0.07	0.16	0.03	0.23*	1			
ND	-0.01	0.33**	0.23*	0.28*	0.17	1		
TSW	-0.09	0.10	0.04	0.11	-0.12	0.19	1	
SY	0.12	0.45**	0.14	0.44**	0.16	0.23*	0.15	1

Legend: Plant/m2 –PP, Plant height. – PH, Branches/plant–BR, Pods/plant–PD, Seeds/pod–SP, ND– Nodule/plant, 1000-seed weight–TSW, Seed yield–SY

**Significant at 0.01 level of probability *: Significant at 0.05 level of probability.

Conclusion

It can be concluded that practicing SP increased seed yield of lentil (8.2 %) over farmer practices at Ishurdi in 2021-22. The results suggested that the improved performance of yield components such as higher number of plant population, branches/plant, pods/plant, taller plant height and increased nodule/plant might be attributed to increase yield of lentil in SP and NT over CT. The higher load of residue also increased lentil yield. The increased level of recommended P fertilizer (150 % of recommended P) increased the seed yield of lentil, which might be due to increase plant height, branches/plant, pods/plant, seeds/plant and 1000-seed weight. However, this study will be continued for a long-term period to concrete conclusion.

EFFECT OF OCP COMPOUND FERTILIZER ON THE YIELD OF LENTIL

M. A. ISLAM, M.S. ALAM AND M.R.A MOLLAH

Abstract

The study was conducted at Ramchandrapur area under Dewli union, Shibganj, Bogura during the Rabi season of 2021-22 to determine the effect of OCP compound fertilizer and improved practice on yield of lentil with collaborative project of OCPF-BARI-ICARDA. Lentil var. BARI Moshur-8 was used as the test crop. The experiment was laid out in an RCB design with four replications, and three different fertilizer management packages were considered for the trial as treatment, viz. T_1 = OCP compound fertilizer, T_2 = Farmer's practice and T_3= SRC recommended dose. The dose of OCP compound fertilizer was adjusted with the SRC recommended fertilizer doses. The highest seed yield (1.91 t ha^{-1}) was weighted from the OCP compound fertilizer application plot, which was identical to PRC recommended fertilizer (1.82 t ha^{-1}), and the lowest seed yield (1.72 t ha^{-1}) from the farmer practice. Application of both OCP compound fertilizer and recommended dose of fertilizer showed better performance over farmer's practice and significantly increased lentil seed yield. Upon cost and return analysis, the highest BCR (3.05) was recorded from OCP compound fertilizer treated plots (T_1), followed by PRC recommended fertilizer treated plots (T_3) and the lowest (2.88) from farmers practiced (T_2).

Introduction

Pulses are vital components in diversifying Bangladesh's predominantly rice-based cropping system. Lentil is the second most important pulse crop in terms of area (145,000 ha) and production (167,000 t) but ranks the highest in consumer preference and total consumption (BBS, 2015). Bangladeshis consume about 12.0 g of pulses per capita per day, far below the 45 g per day recommended by FAO/WHO (Islam and Ali, 2002). Hence the trial was undertaken to evaluate the optimum management-based production over the farmer's one.

Material and Methods

The study was conducted at Ramchandrapur under Dewli union, Shibganj, Bogura during the Rabi season of 2021-22 to determine the effect of OCP compound fertilizer and improved practice on the yield of the yield onion funded by the OCPF-BARI-ICARDA collaborative project. The experimental site represents an agro-ecological zone (AEZ-25) recognized as “Level Barind Tract” and situated at 25°021809′ North latitude and 89°418277′ East longitude under Bangladesh (FAO, 1988). The initial Physico-chemical properties of the experimental field are given in Table 1.

Table 1. Initial physio-chemical properties of experimental field

Soil Parameter	Analytical value	Interpretation
pH	6.15	Neutral
Organic Matter (%)	1.53	Low
Total Organic Carbon (%)	0.8	Low
Total Nitrogen (%)	0.08	Very low
Phosphorous (ppm)	15.36	Medium
Potassium (meq/100g soil)	0.169	Medium
Calcium (meq/100g soil)	2.58	Low
Magnesium (meq/100g soil)	0.93	Medium
Sulphur (ppm)	20.45	Medium
Zinc (ppm)	0.86	Low
Boron (ppm)	0.164	Low

Treatments

Three fertilizer management was considered as the treatment for the trial. The treatments are explained below:

OCP compound fertilizer: The OCP compound fertilizer combines Nitrogen, Phosphorus, Sulphur and Boron. The dose used for this trial was T_1= OCP 91 kg ha^{-1} + TSP 14 kg ha^{-1} + MoP 38 kg ha^{-1} + Line sowing

The total amount of OCP fertilizer, TSP and half of MoP was applied at final land preparation, and the rest of MoP was top-dressed 30 days after sowing.

Farmer's practice: In general, the farmer of our country uses a lower amount of fertilizer and minimum management practices for cultivating lentil. The dose used for this treatment was T_2= Urea 38 kg ha^{-1} + TSP 53 kg ha^{-1} + MoP 30 kg ha^{-1} + Broadcast

A total amount of TSP, ½ MoP and ½ Urea was applied at final land preparation. Rest Urea and MoP were top-dressed at 30 days after seeding.

PRC recommended fertilizer: Spices Research Centre (SRC) developed six onion varieties and optimized the fertilizer dose for cultivating onion. The SRC recommended dose was T_3 = Urea 38 kg ha^{-1} + TSP 90 kg ha^{-1} + MoP 38 kg ha^{-1} + Gypsum 53 kg ha^{-1} + Boric acid 8 kg ha^{-1}+ Line sowing

The total amount of TSP, Boric acid & Gypsum, half Urea and MoP were applied at final land preparation. Rest Urea and MoP were top-dressed at 30 days after seeding.

Seeds sowing of BARI Mosur-8 @ 30 kg seed ha^{-1} was 15 November 2021. Single weeding along with thinning was done at 25 DAS. Two times spay with Tundra, Karate 55 EC@ 2ml/L was made to control insects like leaf feeders. Nativo 2g/L was sprayed twice at ten-day intervals to control fusarium wilt and collar rot diseases. Rovral 50WP and Luna sensation 500SC @ 2g/L were applied to prevent Stemphylium blight disease. Harvest was done on 25 March 2022.

Results and Discussions

The effect of different fertilizer treatments on yield and yield contributing parameters of lentil are shown in Table 2. The taller plant (52.41 cm) was measured from the OCP compound fertilizer application plot identical to the PRC recommended fertilizer (50.89 cm). The farmer's practice measured the shorter plant (46.62 cm). It was found that plants/m^2 was non-significant. It was found that pods/plants were statistically significant among the OCP compound fertilizer, PRC recommended fertilizer application, and farmer's practice. The maximum pods/plants (112.35) were recorded from T_1 followed by T_3 (105.66) and the lowest from T_2 (92.88) treatment. Line sowing and optimum nutrient supplement ensured a higher number of pods/plant in T_1 and T_3 treatments than in T_2. 1000- seed weight (g) varied non-significantly among the different fertilizer applications. The higher seed yield (1.91 t ha^{-1}) was weighted from the OCP compound fertilizer application plot identical to PRC recommended fertilizer (1.82 t ha^{-1}) whereas the lower seed yield (1.72 t ha^{-1}) from the farmer's practice. The higher stover yield (2.28 t ha^{-1}) was weighted from the OCP compound fertilizer application plot identical to PRC recommended fertilizer (2.18 t ha^{-1}) while lower amount of stover (1.95 t ha^{-1}) was weighted from the farmer's practice.

Cost and return analysis

The economic performance of lentil as influenced by different fertilizer practices are presented in Table 3. The highest gross return (Tk. 147810 ha^{-1}) and gross margin (Tk. 99350 ha^{-1}) against the total cultivation cost (Tk. 48460 ha^{-1}) were obtained from the application of OCP compound fertilizer. The lowest gross return (Tk. 130450 eedha^{-1}) and gross margin (Tk. 85170 ha^{-1}) against the total cultivation cost (Tk. 45280 ha^{-1}) were obtained from farmer practice. Upon considering the return and production cost, the highest BCR (3.05) was recorded from OCP compound fertilizer treated plots (T_1), followed by PRC recommended fertilizer treated plots (T_3) and the lowest (2.88) from farmers practiced (T_2).

Table 2. Effect of different doses of fertilizer on yield and yield attributes of lentil at Bogura during 2021-2022

Treatment	Plant height (cm)	Plant m^{-2} (no)	Pods $plant^{-1}$ (no)	1000 -seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	52.41 a	145.18 a	112.35 a	22.52 a	1.91 a	2.28 a
T_2	46.62 b	138.64 ab	92.88 c	21.13 ab	1.69 b	1.85 b
T_3	50.89 a	142.73 a	105.66 b	22.18 a	1.82 a	2.18 a
CV (%)	4.11	5.52	4.33	2.48	4.92	6.53

T_1= OCP 91 kg ha^{-1} + TSP 14 kg ha^{-1} + MoP 38 kg ha^{-1} + Line sowing

Table 3. Economic performance of lentil as influenced by different fertilizer treatments

Treatment	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
T_1	147810	48460	99350	3.05
T_2	130450	45280	85170	2.88
T_3	140860	48460	92400	2.91

Urea-Tk.18 kg^{-1}, TSP-Tk. 22 kg^{-1}, MoP Tk. 18 kg^{-1}, Ploughing by tractor: 6000 ha^{-1}, Labour: Tk. 400-man day^{-1}, Seed: Tk 100 kg^{-1}. Sale price: seed Tk. 72 kg^{-1}, stover Tk. 1.5 kg^{-1}.

Conclusion

Application of OCP compound fertilizer showed better performance than the improved as well as farmers practice regarding seed yield of lentil. Therefore, the OCP compound can be suggested for combined application with chemical fertilizer for a higher yield of lentil.

EFFECT OF OCP COMPOUND FERTILIZER ON THE YIELD OF ONION

M.A. ISLAM, M.S. ALAM AND M.R.A. MOLLAH

Abstract

The study was conducted at the Laxmikhola area under Dewli union, Shibganj, Bogura, during the Rabi season of 2021-22 to determine the effect of OCP compound fertilizer and improved practice on the yield of onion with collaborative project of OCPF-BARI-ICARDA. Onion var. BARI Piaz-4 was used as the test crop, and the experiment was laid out in an RCB design with four replications. Three different fertilizer managements were considered as the treatment for the trial, viz. T_1: OCP compound fertilizer, T_2: Farmer's practice and T_3: SRC recommended dose. The dose of OCP compound fertilizer was adjusted with the SRC recommended fertilizer doses. Most bulb parameters and yield contributing characters were statistically significant among the different fertilizer practices. The higher bulb yield (13.32 t ha^{-1}) was weighted from the OCP compound fertilizer application plot, which was identical to SRC recommended fertilizer (12.85 t ha^{-1}) and the lower amount of bulb (11.73 t ha^{-1}) was weighted from the farmer practice. Upon cost and return analysis, the highest gross return (Tk. 466200 ha^{-1}) and BCR (2.33) were obtained from the application of OCP compound fertilizer, and the lowest gross return (Tk. 410550 ha^{-1}) and BCR (2.09) from farmer practice. Application of OCP compound fertilizer exhibited better performance than other practices regarding bulb yield, and similar trends were obtained in the last year's observation.

Introduction

According to BBS, 2016, the total production of onions in the country is 16.36 million tons, which was 16.8 tons last year. The import is about 11 lakh tons. The soil and climate of Bangladesh are very good for onion cultivation and seed production. Yield and total production can be increased by cultivating modern onion variety with fertilizer management. In our country, the demand for almost all spice crops is less than the production. Hence, the trial was undertaken to evaluate the optimum management-based production over the farmer's one.

Material and Methods

The study was conducted at the Laxmikhola area under the Dewli union, Shibganj, Bogura, during the Rabi season of 2021-22 to determine the effect of OCP compound fertilizer and improved practice the yield of onion funded by OCPF-BARI-ICARDA collaborative project. The experimental site represents an agro-ecological zone (AEZ-25) recognized as "Level Barind Tract" and situated at 25°016585 North latitude and 89°399902 East longitude under Bangladesh (FAO, 1988). The initial Physico-chemical properties of the experimental field are given in Table 1.

Table 1. Initial Physico-chemical properties of experimental field

Soil Parameter	Analytical value	Interpretation
pH	5.95	Neutral
Organic Matter (%)	1.51	Low
Total Organic Carbon (%)	0.72	Low
Total Nitrogen (%)	0.072	Very low
Phosphorous (ppm)	43	Very high
Potassium (meq/100g soil)	0.25	Medium
Calcium (meq/100g soil)	2.6	Low
Magnesium (meq/100g soil)	0.89	Medium
Sulphur (ppm)	15.2	Medium
Zinc (ppm)	1.21	Medium
Boron (ppm)	0.11	Very low

Treatments

Three fertilizer management was considered as the treatment for the trial. The treatments are explained below:

OCP compound fertilizer: The OCP compound fertilizer combines Nitrogen, Phosphorus, Sulphur and Boron. The dose used for this trial was$_1$= OCP 311 kg ha^{-1} + Urea 59 kg ha^{-1} + MoP 188kg ha^{-1} + Gypsum 1.64kg ha^{-1} + CD 5.25 t ha^{-1}

The total amount of cowdung, OCP fertilizer, Gypsum and one-third of MoP were applied at final land preparation, and the rest of MoP and extra dose of N from Urea were top-dressed into two equal splits at 25 and 50 days after transplanting.

Farmer's practice: In general, the farmer of our country uses a lower amount of fertilizer and minimum management practices for cultivating onion. The dose used for this treatment was $_2$= Urea 150 kg ha^{-1} + TSP 188 kg ha^{-1} + MoP 150 kg ha^{-1} + CD 4.5 t ha^{-1}

The total amount of cowdung, TSP, MoP and ½ Urea was applied at final land preparation. Rest Urea was top-dressed into two equal splits at 25 and 50 days after planting.

SRC recommended fertilizer: Spices Research Centre (SRC) developed six onion varieties and optimized the fertilizer dose for cultivating onion. The SRC recommended amount was T_3=Urea 188 kg ha^{-1} + TSP 263 kg ha^{-1} + MoP 188 kg ha^{-1} + Gypsum 113 kg ha^{-1} + CD 5.25 t ha^{-1}

The total amount of cowdung, TSP & Gypsum, one-third Urea and one-third MoP were applied at final land preparation. Rest Urea and MoP were top-dressed into two equal splits at 25 and 50 days after transplanting.

Intercultural operation: The onion var. BARI Piaz-4 following improved practices was conducted at Laxmikhola under Dewli union, Shibganj, Bogura during the 2021-22 cropping season to produce quality seeds at the farmer's level. Seeds of BARI Piaz-4 @ 7.5 kg ha^{-1} were sown on 5 December 2021 for raising seedlings. Then 45 days aged seedlings were transplanted to the main field on 20 January 2022. Three times weeding was done at 10-15, 25-30 and 40-45 DAS. Five times spay with Tundra, Pegasus, and Confidor @ 2ml/L was made at seven-day intervals to control insects like leaf feeders and thrips. Amistertob, Iprozim 26WP, Rovral 50WP and Luna sensation 500SC @ 2g/L were sprayed six times at seven days to control fungal diseases like leaf blight and purple blotch. Harvest was done on 15 April 2022.

Results and Discussions

The effect of different fertilizer treatments on yield and yield contributing parameters of onion are shown in Table 2. The plant spacing was 15 cm x 10 cm. No variations in the total number of plants/plots among the treatments was observed. The maximum plant height (61.45 cm) was measured from the OCP compound fertilizer treated plot identical to SRC recommended fertilizer (58.38 cm) where farmer's practice calculated the shortest plant (53.67 cm). It was found that the number of leaves/plants was statistically non-significant. The heaviest bulb (36.53 g) was weighted from the OCP compound fertilizer application plot, and the lightest bulb from the farmer's practice (33.48 g). The longest bulb (4.56 cm) was measured from the OCP compound fertilizer application plot, and the shortest bulb from the farmer's practice (3.47 cm). The wider bulb (4.87 cm) was measured from the OCP compound fertilizer application plot, and the narrowest bulb from the farmer's practice (3.65 cm). The maximum amount of bulb (13.32 t ha^{-1}) was weighted from the OCP compound fertilizer application plot, which was identical to SRC recommended fertilizer (12.85 t ha^{-1}) and the lower amount of bulb (11.73 t ha^{-1}) from the farmer's practice.

Cost and return analysis: The economic performance of onions is influenced by different fertilizer practices presented in Table 3. The highest gross return (Tk. 466200 ha^{-1}) and gross margin (Tk. 265975ha^{-1}) was obtained from the application of OCP compound fertilizer against a cultivation cost of (Tk. 200225 ha^{-1}) and the lowest gross return (Tk. 410550 ha^{-1}), gross margin (Tk. 214225 ha^{-1}) from farmer practice against a cultivation cost (Tk. 196325 ha^{-1}). Upon considering the return and production cost, the highest BCR (2.33) was recorded from OCP compound fertilizer treat plots (T_1), followed by SRC recommended fertilizer treated plots (T_3) and the lowest (2.09) from farmers practiced plots (T_2).

Table 2. Effect of different doses of fertilizer on the morphological, yield and yield contributing parameters of onion at Shibganj, Bogura during 2021-2022

Treatment	Plants plot^{-1} (no)	Plant height (cm)	Leaves plant^{-1} (no)	Single bulb wt. (g)	Bulb length (cm)	Bulb diameter (cm)	Bulb yield (t ha^{-1})
T_1	1125	61.45 a	12.26	36.53 a	4.56 a	4.87 a	13.32 a
T_2	1110	53.67 b	11.52	33.48 c	3.47 c	3.65 b	11.73 b
T_3	1118	58.38 a	11.95	35.89 b	4.12 a	4.56 a	12.85 a
CV (%)	8.75	4.73	5.61	4.88	5.71	5.12	4.38

T_1= OCP 311 kg ha^{-1} + Urea 59 kg ha^{-1} + MoP 188 kg ha^{-1} + Gypsum 1.64kg ha^{-1} + CD 5.25 t ha^{-1}

Table 3. Cost and return analysis of onion as influenced by different fertilizer treatments at Shibganj, Bogura during 2021-2022

Treatment	Bulb yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
T_1	13.32	466200	200225	265975	2.33
T_2	11.73	410550	196325	214225	2.09
T_3	12.85	449750	200225	249525	2.25

Urea: Tk.18 kg^{-1}, TSP-Tk. 22 kg^{-1}, MoP-Tk. 18 kg^{-1}, ploughing by tractor: Tk. 6000 ha^{-1}, Irrigation-Tk. 2000 ha^{-1}/ irrigation, Labour: Tk. 400/man-day, Seed-Tk. 3000/kg. Sale price-Tk. 35 Tk/kg bulb.

Conclusion

Application of OCP compound fertilizer showed better performance than the improved practice and significantly increased bulb yield of onion. Similar trends were obtained in the last year's observation. Therefore, the OCP compound can be suggested for combined application with chemical fertilizer for a higher yield of onion.

EFFECT OF OCP COMPOUND FERTILIZER ON THE YIELD OF GARLIC

M.A. ISLAM, M.S. ALAM AND M.R.A. MOLLAH

Abstract

The study was conducted at Laxmikhola under Dewli union, Shibganj, Bogura, during the Rabi season of 2021-22 to determine the effect of OCP compound fertilizer and improved practice on the yield of garlic funded by the OCPF-BARI-ICARDA collaborative project. Garlic var. BARI Rasun-1 was used as the test crop. The experiment was laid out in an RCB design with four replications. Three fertilizer managements were, viz. OCP compound fertilizer, SRC recommended dose and farmer practice. The dose of OCP compound fertilizer was calculated from the SRC recommended dose. The higher bulb (9.17 t ha^{-1}) was weighted from the OCP compound fertilizer application plot, identical to SRC recommended practice (8.92 t ha^{-1}). The farmer's practice weighted the lowest amount of bulb (7.89 t ha^{-1}). Application of OCP compound fertilizer and optimum fertilizer management options showed better performance over the farmer's practice regarding bulb yield of garlic. Upon cost and return analysis, The maximum gross return (Tk. 687750 ha^{-1}) and BCR (2.57) were obtained from the application of OCP compound fertilizer-based treatment (T_1) followed by improved management practice. The lowest gross return (Tk. 591750 ha^{-1}) and BCR (2.26) were from the farmer's practiced plots (T_2).

Introduction

Among the species grown in Bangladesh, garlic is undoubtedly one of the important crops cultivated during the winter season.

Garlic has been considered a rich source of carbohydrates, proteins and phosphorus (Bose and Som, 1990). Garlic is a profitable crop based on its return on investment. Among the competitive crops like mustard, groundnut and cabbage, the highest net return was obtained from garlic cultivation. Non-availability of HYV seed at the proper time, lack of technical knowledge, an infestation of insects and diseases and low market price were the major problems of garlic cultivation (Haque et al., 2013). Bangladesh imports large amounts of garlic from neighbouring countries and others to meet the demand of its population. The main purpose of this research is to identify the Auto-Regressive Integrated Moving Average (ARIMA) model that could be used to forecast garlic production in Bangladesh. Hence, the trial was undertaken to evaluate the optimum management-based production over the farmer's one.

Material and Methods

The study was conducted at Laxmikhola under Dewli union, Shibganj, Bogura during the Rabi season of 2021-22 to determine the effect of OCP compound fertilizer and improved practice on yield garlic funded by the OCPF-BARI-ICARDA collaborative project. The experimental site represents an agro-ecological zone (AEZ-25) recognized as "Level Barind Tract" and situated at 25°00'59.9"N latitude and 89°24'01.1"E longitude. The initial physio-chemical properties of the experimental field are given in Table 1.

Table 1. Initial Physico-chemical properties of experimental field

Soil Parameter	Analytical value	Interpretation
pH	6.24	Neutral
Organic Matter (%)	1.48	Low
Total Organic Carbon (%)	0.69	Low
Total Nitrogen (%)	0.070	Very low
Phosphorous (ppm)	17.27	Medium
Potassium (meq/100g soil)	0.213	Medium
Calcium (meq/100g soil)	2.70	Low
Magnesium (meq/100g soil)	0.93	Low
Sulphur (ppm)	18.35	Medium
Zinc (ppm)	0.81	Low
Boron (ppm)	0.156	Low

Treatments

Three fertilizer managements were considered as the treatment for the trial. The treatments are explained below:

OCP compound fertilizer: The OCP compound fertilizer consists of Nitrogen, Phosphorus, Sulphur and Boron in combination. The dose used for this treatment was T_1= OCP 320 kg ha^{-1} + Urea 18 kg ha^{-1} + 338 kg ha^{-1} + CD 5.25 t ha^{-1}

The total amount of Cowdung (CD), OCP and ½ MoP were applied at final land preparation, and the rest of the MoP and supplementary dose of N from Urea were top-dressed into three equal splits 25, 50 and 80 days after planting.

Farmers' practice: In general, farmers of our country use a lower amount of fertilizer and minimum management practices for cultivating garlic. The dose used for this treatment was T_2= Urea 150 kg ha^{-1} + TSP 188 kg ha^{-1} + MoP 150 kg ha^{-1} + CD 4.5 t ha^{-1}

The total amount of cowdung, TSP, MoP and ½ Urea will be applied at the final land preparation. Rest Urea will be top dressed into three equal splits at 25, 50 and 80 days after planting.

SRC recommended fertilizer: Spices Research Centre (SRC) developed four garlic varieties and optimized the fertilizer dose for cultivating garlic. The SRC recommended dose was T_3=Urea 150 kg ha^{-1} + TSP 270 kg ha^{-1} + MoP 338 kg ha^{-1} + Gypsum 75 kg ha^{-1} + CD 5.25 t ha^{-1}

The total amount of cowdung, TSP, Gypsum and ½ MoP were applied at final land preparation. Rest MoP and Urea were top-dressed into three equal splits at 25, 50 and 80 days after planting.

The trial of garlic with var. BARI Rasun-1 following improved practices was conducted at Gujia, Laxmikhola, and Dewli under the MLT site Shibganj, Bogura. Clove sowing of garlic @ 400 kg ha-

[1] was done on 12 November 2021. Weeding was done at 25-20 and 30-40 days after sowing. Two times spay with Tundra and Pegasus @ 2ml/L was made to control insects like leaf feeders and thrips. Iprozim 26WP @ 2g/L was applied to prevent leaf blight disease. Harvest was done on 28 March 2022.

Results and Discussions

The effect of different fertilizer treatments on garlic yields and yield contributing parameters are shown in Table 2. It was found that plants/plots, plant height, and leaves/plants were statistically non-significant. Sumarni *et al.* (2012) stated that the number of tillers or bulbs was more determined by genetic factors than environmental factors such as fertilization. The heaviest bulb (29.32g) was weighted from the OCP compound fertilizer application plot, and the lightest bulb from the farmer's practice (25.13g). The longest bulb (4.42cm) was measured from the OCP compound fertilizer application plot, which was identical to SRC recommended practice (4.17cm) and the shortest bulb was measured from the farmer's practice (3.91cm). The widest bulb (3.77cm) was measured from the OCP compound fertilizer application plot, and the narrowest bulb was measured from the farmer's practice (3.12cm). The OCP compound fertilizer application plot showed highest number of cloves/bulbs (25.37), and the lowest from the farmer practice (18.72). The higher bulb yield (9.17 t ha^{-1}) was weighted from the OCP compound fertilizer application plot, which was identical to SRC recommended practice (8.92 t ha^{-1}). The farmer's practice weighted the lowest amount of bulb (7.89 t ha^{-1}). These findings indicated that optimum management options in the treatment T_1 and T_3 provided sufficient soil nutrients that helped the plants grow better (Maisura *et al.*, 2019).

Cost and return analysis: The economic performance of garlic as influenced by different fertilizer practices is presented in Table 3. The highest gross return (Tk. 687750 ha^{-1}), and gross margin (Tk. 420075ha^{-1}) against the total cultivation cost (Tk. 267675ha^{-1}) was obtained from the application of OCP compound fertilizer followed by improved management practice and the lowest gross return (Tk. 591750ha^{-1}), gross margin (Tk. 329865ha^{-1}) was obtained from farmer's practice. Upon considering the return and production cost, the maximum BCR (2.57) was recorded from OCP compound fertilizer treat plots (T_1) followed by SRC recommended fertilizer treated plots (T_3) with a value of 2.50 and the lowest (2.26) from farmers practiced plots (T_2).

Table 2. Effect of different doses of fertilizer on the morphological parameters of garlic at Shibganj, Bogura during 2021-2022

Treatment	Plant plot^{-1} (no.)	Plant height (cm)	Leaves plant^{-1} (no.)	Single bulb wt. (g)	Bulb length (cm)	Bulb diameter (cm)	Cloves bulb^{-1} (no)	Bulb yield (t ha^{-1})
T_1	1132	71.27	9.48	29.32 a	4.42 a	3.77 a	25.37 a	9.17 a
T_2	1113	64.38	8.65	25.13 b	3.91 b	3.12 b	18.72 b	7.89 b
T_3	1125	69.19	9.08	28.88 a	4.17 a	3.58 a	23.44 a	8.92 a
CV (%)	6.12	6.21	5.33	4.56	4.28	5.11	6.56	5.76

T_1= OCP 320 kg ha^{-1} + Urea 18 kg ha^{-1}+ 338 kg ha^{-1} + CD 5.25 t ha^{-1}

Table 3. Cost and return analysis of onion as influenced by different treatments at Shibganj, Bogura during 2021-2022

Treatment		Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
T_1		687750	267675	420075	2.57
T_2	7	591750	261885	329865	2.26
T_3		669000	267675	401325	2.50

Urea-Tk.18 kg^{-1}, TSP-Tk. 22 kg^{-1}, MoP-Tk. 18 kg^{-1}, Ploughing by tractor-6000 ha^{-1}, Irrigation-2000 ha^{-1}/irrigation, Labour-Tk. 400/man-day, Land Leas value-Tk. 22500 ha^{-1} for four months, Seed-Tk 150/kg bulb, Sale price-Tk. 75/kg bulb.

Conclusion

Application of OCP compound fertilizer showed better performance than the improved practice and significantly increased bulb yield of garlic. Similar trends were obtained in the last year's observation. Therefore, the OCP compound can be suggested for combined application with chemical fertilizer for a higher yield of garlic.

EFFECT OF OCP COMPOUND FERTILIZER ON THE GROWTH AND YIELD OF BLACKGRAM

M.A. ISLAM, M.S. ALAM AND M.R.A. MOLLAH

Abstract

The study was conducted at the on-station, OFRD, BARI, and Bogura during the Rabi season of 2021-22 to find out the effect of OCP compound fertilizer and improved practice on the yield of blackgram funded by the OCPF-BARI-ICARDA collaborative project. Blackgram var. BARI Mash-3 was used as the test crop. The experiment was laid out in an RCB design with four replications. Three different fertilizer managements were considered: viz. OCP compound fertilizer, PRC recommended dose and farmer practice. Application of OCP compound fertilizer and optimum fertilizer management options showed better performance over the farmer's practice regarding yield and economic return. The higher seed yield (1.63t ha^{-1}) was weighted from the OCP compound fertilizer application plot, which was identical to PRC recommended practice (1.51 t ha^{-1}) and the lower (1.32 t ha^{-1}) from the farmer practice. Cost and return analysis showed that the higher seed yield contributed to the higher economic return from OCP compound fertilizer plots (T_1) followed by PRC recommended fertilizer treated plots (T_3) and the lower return from the farmers practiced plots (T_2). The highest gross return (Tk. 102180 ha^{-1}) and BCR (2.83) were obtained from the application of OCP compound fertilizer-based treatment (T_1), followed by improved management practice. The lowest gross return (Tk. 83060ha^{-1}) and BCR (2.39) from the farmers practiced plots (T_2).

Introduction

Blackgram is one of the important pulse crops which used in various forms such as grain for human consumption and fodder for cattle, green manure, cover crop and short-lived forage. It is a fast growing, short season, drought-tolerant (Pillai and Arasuya, 1997). The national average yield of black gram in Bangladesh is low due to the cultivation of the low yielding local varieties, the incidence of diseases and insects, lack of technical knowledge and no use of balanced fertilizer. BARI has already developed some high yielding blackgram varieties. These varieties can help generate farmers' income in a very short period. Hence, the present study was undertaken to evaluate the performance of the blackgram variety under different fertilizer management practices under farmer's field conditions and make it popularized among the farmers to promote their adoption in different areas of Bogura.

Material and Methods

The study was conducted at on-station, OFRD, Bogura, during the Rabi season of 2021-22 to determine the effect of OCP compound fertilizer and improved practice on the yield of blackgram funded OCPF-BARI-ICARDA collaborative project. The experimental site represents the agro-ecological zone (AEZ-4) recognized as "Karatoa Bangali Flood plain" and situated at 24°51'06.4"N latitude and 89°22'53.4"E longitude. The initial physio-chemical properties of the experimental field are given in Table 1.

Table 1. Initial Physico-chemical properties of experimental field

Soil Parameter	Analytical value	Interpretation
pH	6.45	Neutral
Organic Matter (%)	1.52	Low
Total Organic Carbon (%)	0.75	Low
Total Nitrogen (%)	0.075	Very low
Phosphorous (ppm)	16.89	Medium
Potassium (meq/100g soil)	0.215	Medium
Calcium (meq/100g soil)	2.91	Low
Magnesium (meq/100g soil)	0.73	Low
Sulphur (ppm)	15.19	Low
Zinc (ppm)	1.24	Medium
Boron (ppm)	0.182	Low

Treatments

Three different fertilizer managements were considered as the treatment for the trial. The treatments are explained below:

OCP compound fertilizer: The OCP compound fertilizer consists of Nitrogen, Phosphorus, Sulphur and Boron in combination. The dose used for this treatment was T_1= OCP 90 kg ha^{-1} + Urea 0 kg ha^{-1} + TSP 14 kg ha^{-1} + MoP 38 kg ha^{-1}.

The total amount of OCP and other fertilizers except urea were applied at final land preparation. Supplementary dose of N from Urea was top-dressed at 20 days after sowing.

Farmers' practice: In general, our country's farmers use less fertilizer and minimum management practices for cultivating blackgram. The dose used for this treatment was T_2= Urea 38 kg ha^{-1} + TSP 46 kg ha^{-1} + MoP 36 kg ha^{-1}

The total amount of all fertilizers except urea was applied at final land preparation. An extra dose of N from Urea was top-dressed at 20 days after sowing.

PRC recommended fertilizer: Pulses Research Centre (PRC) developed high yield potential blackgram varieties and optimized the fertilizer dose for cultivating blackgram. The PRC recommended dose was T_3=Urea 38 kg ha^{-1} + TSP 90 kg ha^{-1} + MoP 38 kg ha^{-1} + Gypsum 52 kg ha^{-1} + Boric 7.5 kg ha^{-1}

The total amount of all fertilizers except urea was applied at final land preparation. A supplementary dose of N from Urea was top-dressed at 20 days after sowing.

Intercultural operation: The trials of blackgram var. BARI Mash-3 following improved practices were conducted at on-station, OFRD, Bogura. Seeds of blackgram @ 30 kg ha^{-1} were sown on 02 September 2021. Weeding was done at 25-20 and 30-40 days after sowing. Two times spay with Tundra and Pegasus @ 2ml/L were made to control insects like leaf feeders and thrips. Acrobat MZ @ 2g/L was applied to prevent leaf spot disease. Harvest was done on 25 November 2021.

Results and Discussions

The effect of different fertilizer treatments on the various parameters of blackgram is shown in Table 2. Total number of plants/m^2 was found higher in T_2 treatment (38.5) as farmers used slightly higher seed rate (5-6 kg for 1320 m^2) than the recommended one. Higher plant density led to lower plant height and number of branch/plant height in T_2 treatment (45.48 cm and 5.17, respectively). The number of branch/plants is probably one of the genetical characteristics of BARI Mash-3 and was not influenced by the different fertilizer applications. Sumarni *et al.* (2012) stated that the number of tillers was more determined by genetic factors than environmental factors such as fertilization while studying spices crops. No. pods/plant varied significantly among the different fertilizer applications. The higher number of pods/plant (54.78g) was recorded from the OCP compound fertilizer, which was statistically identical with PRC recommended based fertilizer application plot (52.34) and the lower number from the farmer practice (42.47g). The maximum pod length (4.85 cm) was recorded from the OCP compound fertilizer, which was statistically identical t with PRC recommended based fertilizer application plot (4.81 cm) and the lower number from the farmer practice (3.94cm). The higher number of seeds/pod (7.87) was obtained from OCP based treatment which was identical to the PRC recommendation based one, and lower (6.13) from farmers' practice. Higher and identical 1000-seeds weight was observed in T_1 and T_3 treatments and lower in T_2 treatment. Probably OCP compound fertilizer and PRC based recommended fertilizer both provided balanced nutrients to the plants for better development of seeds. Higher yield contributing characters of blackgram in T_1 and T_3 treatments provided higher yield than that of farmers' practice. However, numerically, maximum seed yield (1.63 t ha^{-1}) was recorded from T_1 treatment where OCP compound fertilizer was applied in combination with chemical fertilizers, which was statistically identical to the yield (1.51 t ha^{-1}) of PRC recommended fertilizer dose (T_3) and the lower (1.32t ha^{-1}) from farmers' practice (T_2). Stover yield followed a similar trend as seed yield.

Cost and return analysis: The economic performance of blackgram as influenced by different fertilizer practices is presented in Table 3. The highest gross return (Tk. 102180 ha^{-1}) and gross margin (Tk. 66130 ha^{-1}) against the total cultivation cost (Tk. 36050 ha^{-1}) were obtained from the application of OCP compound fertilizer, followed by improved management practice. The lowest gross return (Tk. 83060ha^{-1}) and gross margin (Tk. 48240 ha^{-1}) were obtained from farmers' practices. The highest BCR (2.83) was recorded from OCP compound fertilizer treat plots (T_1) followed by PRC recommended fertilizer treated plots (T_3) with a value of 2.63 and the lowest (2.39) from farmers practiced plots (T_2).

Table 2. Effect of different doses of fertilizer on the morphological, yield contributing and yield parameters of blackgram in 2021-22

Treatment	Plants m^{-2} (no)	Plant height (cm)	Branch $plant^{-1}$ (no)	Pod $plant^{-1}$ (no)	Pod length (cm)	Seed pod^{-1} (no)	1000-seed wt. (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	31.57 b	48.56 a	8.20	54.78 a	4.85 a	7.87 a	34.29 a	1.63 a	2.19 a
T_2	38.5 a	45.48 b	5.17	42.67 b	3.94 b	6.13 b	32.47 b	1.32 c	1.93 b
T_3	30.49 b	47.25 ab	7.46	52.34 a	4.81 a	7.58 a	33.42 a	1.51 b	2.17 a
CV (%)	5.41	4.37	5.34	4.61	3.95	3.89	4.25	5.24	4.46

T_1= OCP 90 kg ha^{-1}+ Urea 0 kg ha^{-1}+ TSP 14 kg ha^{-1}+ MoP 38 kg ha^{-1}

Table 3. Economic performance of blackgram as influenced by different treatments

Treatment	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
T_1	102180	36050	66130	2.83
T_2	83060	34820	48240	2.39
T_3	94940	36050	58890	2.63

Urea-Tk.18/kg, TSP-Tk. 22/kg, MoP-Tk. 18/kg, Ploughing by tractor-6000 ha^{-1}, Labour-Tk. 400/man-day, Land Leas value-Tk. 22500 ha^{-1} for four months, Seed-Tk 100/kg, Sale price- Grain @Tk. 60/kg; Stover@ 1Tk/kg.

Conclusion

Application of OCP compound fertilizer showed better performance than the improved practice and significantly increased seed yield of blackgram. Therefore, the OCP compound can be suggested for combined application with chemical fertilizer for a higher yield of blackgram. However, the trial will be repeated in the next year for confirmation of the result.

EFFECT OF OCP COMPOUND FERTILIZER ON THE GROWTH AND YIELD OF CHILLI

M.A. ISLAM, M.S. ALAM AND M.R.A. MOLLAH

Abstract

The study was conducted at Voria, Purbapara of Dewli union under the MLT site Shibganj, Bogura, during the Kharif-1 season of 2021 to determine the effect of OCP compound fertilizer and improved efficiency practice on the yield of chilli funded by OCPF-BARI-ICARDA collaborative project. BARI Morich-2 was used as the test crop. The experiment was laid out in an RCB design with four replications. Three different fertilizer management treatments were considered for the trial, viz. OCP compound fertilizer, SRC recommended dose and farmer practice. The dose of OCP compound fertilizer was calculated from the SRC recommended dose. The morphological parameters and yield contributing characters were statistically significant among the different fertilizer practices. The greater green chilli (14.56 t ha^{-1}) was harvested from the OCP compound fertilizer application plot. The farmer's practice harvested the lowest amount of green chilli (11.45 t ha^{-1}). Also, the highest gross return (Tk. 582400 ha^{-1}), net return (Tk. 459525 ha^{-1}) and benefit-cost ratio (4.74) were obtained from the application of OCP compound fertilizer and the lowest gross return (Tk. 458000 ha^{-1}), net return (Tk. 335125 ha^{-1}) and benefit-cost ratio (3.73) was obtained from farmer practice. Application of OCP compound fertilizer showed better performance than the improved practice and significantly increased bulb yield of garlic.

Introduction

Chilli or pepper (*Capsicum annuum* L.) belongs to the family Solanaceae, emerging as one of the commercial vegetable crops at the global level and is probably the most important vegetable after Tomato (Grubeen, 1977). Chilli is a very important and major spice crop in Bangladesh. It ranks second in area coverage and fourth in production among the spice's crops cultivated in the country. About 141177 metric tons of chilli (both green and dry) produces from 1,01,113 hectares of land (BBS, 2018). But the yield is not satisfactory in contrast to the worldwide average yield. The low production may be attributed to low soil fertility, pests and diseases pressure, unavailability and high cost of irrigation systems, inadequate knowledge of improved technologies, and unimproved varieties (MiDA, 2010). Most of the pepper varieties farmers cultivate are unimproved varieties that are low yielding. Applying fertilizer to crops is necessary for better yields and a quick method of achieving maximum productivity. For successful commercial cultivation of this crop, many factors such as climate, soil, irrigation, fertilizer and nutrient management, spacing, sowing season, etc., should be considered. Among these management practices, fertilizer and nutrient management plays an important role in the crop's proper growth, yield, and quality. Inorganic fertilizers quickly release nutrients and result in the maximum growth and yield of crops (Sitaula *et al.*, 2019). Spices Research Centre, BARI, Shibganj, Bogura has developed four chilli varieties and standardized fertilizer recommendations for chilli. But no combined fertilizer is available, and no research work has been done on mixed fertilizer in chilli production. The OCP foundation produces a compound fertilizer consisting of N, P, S and B. This trial was undertaken to find out the effect of OCP compound fertilizer and improved practice on the yield of chilli.

Material and Methods

The study was conducted at Voria, Purbapara of Dewli union under the MLT site Shibganj, Bogura, during the *Kharif-1* season of 2021 to determine the effect of OCP compound fertilizer and improved practice on the yield of chilli funded by OCPF-BARI-ICARDA collaborative project.

The experimental site represents the agro-ecological zone (AEZ-4) recognized as the "Karatoa Bangali Flood plain" and situated at 24°51′ North latitude and 89°22′ East longitude under Bangladesh (FAO, 1988). The initial Physico-chemical properties of the experimental field are given in Table 1.

Table 1. Initial physic-chemical properties of experimental field

Soil Parameter	Analytical value	Interpretation
pH	6.11	Neutral
Organic Matter (%)	1.44	Low
Total Organic Carbon (%)	0.85	Low
Total Nitrogen (%)	0.09	Very low
Phosphorous (ppm)	41	Very high
Potassium (meq/100g soil)	0.23	Medium
Calcium (meq/100g soil)	2.35	Low
Magnesium (meq/100g soil)	0.89	Medium
Sulphur (ppm)	14.65	Medium
Zinc (ppm)	1.16	Medium
Boron (ppm)	0.11	Very low

BARI Morich-2 was used as the test crop. The experiment was laid out in a Randomized Complete Block design with four replications. The seeds were broadcasted in the nursery bed on 25 February 2021 for raising seedlings. Thirty-five days old seedlings were transplanted in the experimental plot on 1 April 2021, maintaining 50 cm line to line and 50 cm plant to plant distance.

Treatments

Three fertilizer management were considered as the treatment for the trial. The treatments are explained below:

OCP compound fertilizer: The OCP compound fertilizer consists of Nitrogen, Phosphorus, Sulphur and Boron in combination. The dose used for this treatment was T_1= OCP 400.00 kg ha^{-1} + Urea 60.00 kg ha^{-1} + MoP 225.00 kg ha^{-1} + Gypsum 12.00 kg ha^{-1} + CD 5.25 t ha^{-1}.

The total amount of Cowdung (CD), OCP, Gypsum and one-third of MoP were applied at final land preparation, and the rest of MoP and extra dose of N from Urea were top-dressed into three equal splits at 25, 50 and 70 days after planting.

Farmers' practice: In general, the farmer of our country uses a lower amount of fertilizer and minimum management practices for cultivating chilli. The dose used for this treatment was T_2= Urea 188.00 kg ha^{-1} + TSP 150.00 kg ha^{-1} + MoP 150.00 kg/bigha+ CD 5.25 t ha^{-1}

The total amount of cowdung, TSP, MoP and ½ Urea will be applied at the final land preparation. Rest Urea will be top dressed into three equal splits at 25, 50 and 70 days after planting.

SRC recommended fertilizer: Spices Research Centre (SRC) developed chilli varieties and optimized the fertilizer dose for cultivating them. The SRC recommended dose was T_3=Urea 225.00 kg/bigha + TSP 338.00 kg ha^{-1} + MoP 225.00 kg ha^{-1} + Gypsum 113.00 kg ha^{-1} + CD 5.25 t/bigha.

The total amount of cowdung, TSP, Gypsum and one-third of MoP was applied at the final land preparation. Rest MoP and Urea were dressed into three equal splits at 25, 50 and 70 days after planting. Top dresses were followed by irrigation. Three weeding were done at 20, 45 and 65 DAT. Irrigation and other intercultural operations were done as necessary. Irrigation and other intercultural operations were done as per necessity. Harvesting of green chilli was started on 12 June and continued till 5 September 2021. The collected data were statistically analyzed with the open-source software R.

Results and Discussions

The effect of different fertilizer treatments on chilli yield and yield parameters are shown in Table 2. Plant Height (cm) of chilli varied significantly among the fertilizer applications. The tallest plant (65.45 cm) was measured from the OCP compound fertilizer application plot, which was identical to SRC recommended practice (64.13 cm), and the shortest plant from the farmer's practice

(61.78 cm). The higher number of primary branches/plant (5.35 no's) was counted from the OCP compound fertilizer application plot, and the lower number of primary branches/plant (4.24 no's) from the farmer practice. The longest fruit (7.21 cm) was observed from the OCP compound fertilizer application plot, followed by SRC recommended practice (6.95 cm). The shortest fruit was observed from the farmer's practice (6.16 cm). The highest fruit diameter (7.17 mm) was recorded from the OCP compound fertilizer application plot, followed by SRC recommended practice (6.13 mm). The farmer's practice recorded the lowest fruit diameter (5.66 mm). The higher number of fruits/plant (242.46) was counted from the OCP compound fertilizer application plot followed by SRC recommended practice (225.17), and the lower number of fruits/plants from the farmer practice (190.48). The green chilli yield (kg ha^{-1}) was also statistically significant among the fertilizer applications. The higher amount of green chilli (14.56 t ha^{-1}) was weighted from the OCP compound fertilizer application plot followed by SRC recommended practice (13.29 t ha^{-1}), and the lowest amount of green chilli (11.45 Tk. ha^{-1}) from the farmer practice.

Cost and return analysis: The economic performance of chilli as influenced by different fertilizer practices is presented in Table 3. The highest gross return (Tk. 582400 ha^{-1}), gross margin (Tk. 459525 ha^{-1}) and benefit-cost ratio (4.74) was obtained from the application of OCP compound fertilizer. The lowest gross return (Tk. 458000 ha^{-1}), gross margin (Tk. 335125 ha^{-1}), and benefit-cost ratio (3.73) were obtained from farmer practice.

Table 2. Effect of different doses of fertilizer on the performance of chilli

Treatments	Plant height (cm)	Primary branches plant^{-1} (no)	Fruit length (cm)	Fruit diameter (mm)	Fruits plant^{-1} (no)	Fruit yield (kg ha^{-1})
T_1	65.45a	5.35a	7.21 a	7.17 a	242.46 a	14.56 a
T_2	61.78b	4.24c	6.16 b	5.66 b	190.48 c	11.45 c
T_3	64.13a	5.46b	6.95 ab	6.13 ab	225.17b	13.29 b
CV (%)	6.14	4.32	5.18	3.95	8.72	5.47

T_1= OCP 53.30 kg/bigha + Urea 7.98 kg/bigha + MoP 30 kg/bigha + Gypsum 1.64 kg/bigha + CD 700kg/bigha

Table 3. Economic performance of chilli as influenced by different fertilizer treatments

Treatments	Gross return (Tk. ha^{-1})	Total cultivation cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
T_1	582400	122875	459525	4.74
T_2	458000	122875	335125	3.73
T_3	531600	122875	408725	4.33

Urea-Tk.16/kg, TSP-Tk. 22/kg, MoP-Tk. 15/kg, Gypsum -Tk. 10/kg, chilli seed-Tk 600/kg. Sale price-Tk. 40/kg green chilli

Conclusion

Application of OCP compound fertilizer showed better performance than the existing practices and significantly increased the fruit yield of chilli.

PERFORMANCE OF PLANT GROWTH REGULATOR (EAST GOLD) ON CABBAGE

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Abstract

The study was conducted at the on-station research field of On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), Gazipur, and at the farmers' field of Shibpur, Narsingdi conducted by OFRD, BARI, Narsingdi during rabi season 2021-22 to evaluate the effect of 'East Gold' plant growth regulator (PGR) on cabbage. There were seven treatments viz. T_1: 0 ppm PGR, T_2: 250 ppm PGR at 25 days after planting (DAP), T_3: 500 ppm PGR at 25 DAP, T_4: 750 ppm PGR at 25 DAP, T_5: 250 ppm PGR at 25 DAP + 250 ppm PGR at 25 DAP, T_6: 375 ppm PGR at 25 DAP + 375 ppm PGR at 50 DAP and T_7: 500 ppm PGR at 25 DAP + 500 ppm at 50 DAP. The experiment was laid out in a randomized complete block design with three replications. The highest curd yield (103.9 t ha^{-1}) was obtained from the spray of 500 ppm both at 25 DAP and 50 DAP in Gazipur. However, in Narsingdi, the highest yield (80.0 t ha^{-1}) was obtained from the spray of 750 ppm PGR at 25 DAP. The spray of East Gold increased the yield of cabbage by 10.2-25.2% at Gazipur and by 3.9-18.5% at Narsingdi compared to the non-spray control.

Introduction

Cabbage (*Brassica oleraceae* var. *capitata*) is a leafy vegetable that is popular for fleshy leaves as the edible part. It has been reported that 100 g of the green edible portion of cabbage contains 92% water, 18 mg Sodium, 170 mg Potassium, 1.28 g Protein, 5.8 g Carbohydrate, 4% Calcium and 2% mg Iron. The production of winter cabbage has increased tremendously in Bangladesh (Sharmin et al., 2018). The growth of area under cabbage cultivation is about 3% per annum (Sharmin et al., 2018). Plant growth regulator (PGR) is the organic chemical other nutrients that promote, inhibit, or otherwise modify the physiological processes. It increases the yield and improves the quality by altering the behavior of plant and number of physiological processes in plant systems. They help in synthesis of metabolites and translocation of nutrients and assimilation of these into different plant parts which ultimately resulting higher yields and improve the quality. Chhonkar and Singh (1964) reported that Gibberellic acid (GA) is responsible for quick and percent recovery, early head formation and quality of cabbage. Therefore, the present study was conducted to evaluate the effect of East Gold PGR on the yield and yield components of cabbage.

Materials and Methods

The study was conducted at the on-station research field of On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), Gazipur, and at the farmers' field of Shibpur, Narsingdi conducted by OFRD, BARI, Narsingdi during *rabi* season 2021-22 to evaluate the effect of 'East Gold' plant growth regulator (PGR) on cabbage. There were seven treatments viz. T1: 0 ppm PGR, T2: 250 ppm PGR at 25 days after planting (DAP), T3: 500 ppm PGR at 25 DAP, T4: 750 ppm PGR at 25 DAP, T5: 250 ppm PGR at 25 DAP + 250 ppm PGR at 25 DAP, T6: 375 ppm PGR at 25 DAP + 375 ppm PGR at 50 DAP and T7: 500 ppm PGR at 25 DAP + 500 ppm at 50 DAP. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (5.0 m × 4.0 m). Thirty days old seedlings of cabbage (Autumn queen) were transplanted on 29 November 2021 in Gazipur and on 24-28 November 2021. The crop was fertilized with recommended dose of N-P-K-S-B @ 150-150-120-100-3 kg ha^{-1}, respectively. Half of the muriate of potash with full dose of all fertilizers was applied in the field during final land preparation except urea. Urea was applied in three split doses at 10 DAT, 25 DAT and 40 DAT. Rest of muriate of potash was added with 2nd and 3rd split of Urea. Organic fertilizer was applied @ 3 and 1 t ha^{-1} with the respective treatments at one time. Imitaf and noin were applied as preventive. Secure and acrobat was applied against leaf blight disease. The crop was irrigated thrice at 20 DAT, 35 DAT, and 60 DAT. Harvesting was done from 17 February 2022 to 23 February 2022 in Gazipur and from 10 February 2022 to 20 February 2022 in Narsingdi. At maturity, data on yield and yield contributing characters were taken and analyzed statistically by using 'R' package (R Core Team, 2017).

Results and Discussion

The effects of East Gold PGR on plant height, individual curd weight, and curd yield of cabbage were significant at Gazipur (Table 1). At Narsingdi, a significant effect of this PGR was obtained only in the case of curd diameter (Table 2). The lowest curd yield was recorded from no spray of PGR. The maximum curd length and weight of individual curd and the highest curd yield (103.9 t ha^{-1}) were obtained from the spray of 500 ppm PGR at 25 DAP + 500 ppm PGR at 50 DAP at Gazipur. At Narsingdi, the highest curd yield was gotten from the plots that received 750 ppm PGR at 25 DAP. Application of East Gold PGR increased the cabbage yield by 10.2-25.2% at Gazipur and by 3.9-18.5% at Narsingdi over the control.

Table 1: Effect of East Gold PGR on plant height, yield, and yield contributing characteristics of cabbage at on-station research fields of OFRD, BARI, Gazipur during *rabi* season of 2021-2022

Treatment	Plant height (cm)	Curd length (cm)	Curd Diameter (cm)	Weight of Individual Curd (kg)	Curd yield (t ha^{-1})	Yield increased over control (%)
T_1: 0 ppm PGR	28.8 d	24.7 b	66.0 c	2.61 d	82.9 d	-
T_2: 250 ppm PGR at 25 DAP	32.1 ab	25.7 b	69.7 ab	3.04 abc	97.2 abc	17.1
T_3: 500 ppm PGR at 25 DAP	29.3 cd	25.5 b	65.0 c	2.86 c	91.4 c	10.2
T_4: 750 ppm PGR at 25 DAP	30.7 bcd	25.8 b	69.1 abc	3.12 ab	99.9 ab	20.4
T_5: 250 ppm PGR at 25 DAP + 250 ppm at 50 DAP	30.6 bcd	25.9 b	67.2 abc	2.97 bc	94.9 bc	14.4
T_6: 375 ppm PGR at 25 DAP + 375 ppm at 50 DAP	31.4 abc	26.0 ab	68.8 abc	3.15 ab	100.8 ab	21.5
T_7: 500 ppm PGR at 25 DAP + 500 ppm at 50 DAP	33.8 a	27.5 a	71.3 a	3.25 a	103.9 a	25.2
Level of sig.	*	ns	ns	***	***	-
CV (%)	4.41	3.45	3.60	4.04	4.11	-

Table 2. Effect of East Gold PGR on plant height, yield, and yield contributing characters of cabbage at farmers' fields of OFRD, BARI, Shibpur, Narsingdi during *rabi* season of 2021-2022

Treatment	Plant height (cm)	Curd length (cm)	Curd Diameter (cm)	Weight of Individual Curd (kg)	Curd yield (t ha^{-1})	Yield increased over control (%)
T_1: 0 ppm PGR	44.0	27.0	62.7 c	2.11	67.5	-
T_2: 250 ppm PGR at 25 DAP	44.3	32.3	64.7 bc	2.19	70.1	3.9
T_3: 500 ppm PGR at 25 DAP	42.7	33.0	71.3 a	2.23	71.36	5.7
T_4: 750 ppm PGR at 25 DAP	41.3	32.7	67.0 b	2.49	80.0	18.5
T_5: 250 ppm PGR at 25 DAP + 250 ppm at 50 DAP	40.7	32.0	67.7 ab	2.37	75.7	12.1
T_6: 375 ppm PGR at 25 DAP + 375 ppm at 50 DAP	40.3	31.7	64.0 bc	2.34	74.9	11.0
T_7: 500 ppm PGR at 25 DAP + 500 ppm at 50 DAP	39.7	33.3	66.7 b	2.25	71.9	6.5
Level of significance	ns	ns	**	ns	ns	-
CV (%)	5.41	8.10	3.27	9.11	9.06	-

Conclusion

The study confirmed that spray of East Gold PGR increased cabbage yield by 4-25% compared to the plot that received no spray of PGR; the percentage of yield increase may vary with the locations.

Project II:

Improvement of Cropping Systems

A. Cropping Patterns

B. Intercropping

C. Mixed Cropping

D. Relay Cropping

E. Component Technologies

F. Plant Protection Measures

G. Agroforestry

A. Cropping Patterns

DEVELOPMENT OF FOUR CROPS BASED CROPPING PATTERN MUSTARD-MUNGBEAN-T. AUS-T. AMAN AGAINST MUSTARD-D. AUS-T. AMAN RICE CROPPING PATTERN IN BHOLA

G. N. HASAN AND M. R. H. ANIK

Abstract

On-farm trial was conducted at MLT site Daulatkhan and Bhola sadar under AEZ-18 during 2021-2022 to increase cropping intensity and productivity through a four crop-based cropping pattern against farmer's existing practice of Mustard-D. Aus-T. Aman. The four crops based cropping pattern was Mustard- Mungbean-T.Aus-T. Aman corresponding to variety of each crop were BARI Sarisha-14, BARI Mung-6/8, BRRI dhan82 and BRRI dhan72/87 respectively. It was observed that four crop patterns produced the highest rice equivalent yield (REY) (18.78 t ha^{-1}) at MLT site Daulatkhan and (18.63 t ha^{-1}) at Bhola sadar. Cost-benefit analysis showed that the four-crop pattern gave the highest gross return in both locations. The marginal benefit-cost ratio of the four crop patterns over the existing pattern was 3.73 and 3.53 in Daulatkhan and Bhola sadar, respectively.

Introduction

Mustard-D.Aus-T.Aman rice is one of the important cropping patterns in Bhola. Mustard is one of the important oil crops in Bhola area. According to DAE, Mustard-D.Aus-T.Aman pattern covers as an area of 8035 ha of land in 2019-20. In order to produce more food within a limited area, two most important options to be adopted are i) to increase the cropping intensity producing four or more crops over the same piece of land round the year and ii) to increase the productive efficiency of the individual crop. After harvesting of T.Aman, farmers' usually grow mustard. After harvesting of mustard, land remains fallow before sowing of D.Aus rice which may be utilize by growing short duration mungbean variety. The present experiment has taken to evaluate the agroeconomic performance of improved pattern over farmer's existing pattern.

Materials and Methods

The experiment was conducted at Daulatkhan and Bhola sadar Upazila under Bhola district during 2021-22. The trial field belongs to the agro-ecological zone (AEZ-18) of Young Meghna Estuarine Floodplain. The improved cropping pattern Mustard-Mungbean-T. Aus-T. Aman was tested against existing cropping pattern Mustard-D. Aus-T. Aman rice. Crop varieties used in the alternate cropping pattern viz., Mustard (BARI Sarisha-14), Mungbean (BARI Mung-6 & 8), T.Aus (BRRI dhan82) and T.Aman(BRRI dhan72/87) whereas , the crop variety used in the existing cropping pattern as Mustard (Local), D.Aus (BRRI dhan48) and T.Aman (BRRI dhan52), respectively. Four farmers were selected as dispersed replications covering a total of 120 decimals of land in two different locations. Recommended fertilizer package (FRG, BARC, 2018) along with the application methods were followed in the trial. Pest management and other intercultural management practices were done to support the normal growth of the crops.

Aphid was observed in the mustard field, and it was controlled by sprayed with Imitaph @ 2 g L^{-1} water. For controlling flower thrips of mungbean, Intrapid @ 1.ml L^{-1} water was applied 2 times starting from flowering at an interval of 7 days. For controlling of pod borer, alternate spray was done with Success and Volume flexi @ 1.2 ml L^{-1}and 0.5 ml L^{-1} water, respectively. In T. Aman rice, Vittaco was applied @ 80 gm ha^{-1} to control stem borer and Folicure was sprayed @ 2 ml L^{-1} at 65 DAT for controlling leaf blight.

Cost and return analysis for two crop sequences, the yield of all crops was converted into rice equivalent yield based on the prevailing market price of individual crops (Ahlawat and Sharma, 1993).

Data on the yield of various crops in sequences were recorded and converted to ton per hectare. The data of farmer's practice was recorded from adjacent farmers' plots. Total system productivity was calculated as the summation of the individual (component) crop yield of each cropping cycle. The productivity of crop sequences was compared by calculating rice equivalent yield (REY) using formula given by Ahlawat and Sharma (1993) were Rice Equivalent Yield (REY) was calculated with the following formula (Ahlawat and Sharma, 1993).

The collected data were averaged and presented in tabular form. Economic analysis was done on the basis of prevailing market price of the commodities. Agronomic performance like field duration, production efficiency and rice equivalent yield of cropping patterns were calculated.

Table 1. Agronomic Parameters of Mustard-Mungbean-T. Aus-T. Aman against Mustard-D. Aus-T. Aman rice cropping pattern in Bhola during 2021-22.

Parameters	Existing Cropping Pattern			Improved Cropping pattern			
Crop	Mustard	D. Aus	T. Aman	Mustard	Mungbean	T. Aus	T. Aman
Variety (Dawlatkhan)	Local	BRRI dhan48	BRRI dhan52	BARI Sarisha-14	BARI Mung-6	BRRI dhan82	BRRI dhan87
Variety (Bhola sadar)	Local	BRRI dhan48	BRRI dhan52	BARI Sarisha-14	BARI Mung-8	BRRI dhan82	BRRI dhan72
Spacing	Broadcast (6 kg/seed ha^{-1})	Dibbling	30×30 cm	Broadcast	30 x 6cm	20 x 15cm	25 x 15 cm
Fertilizer dose NPKSZnB kg ha^{-1}	90-27-60-15-5-2-0	150-50-75-35-5	150-110-50-30-10	90-27-60-15-5-2-0	24-32-24-18-2-1	150-52-75-38-5	180-120-100-68-12
Date of transplanting/sowing	28 Dec 21-05 Jan.22	15-20 April. 21	20-24 August,21	30 Nov. 21	20-25, Feb.22	12-15 May,21	14-18 Aug. 21
Date of harvesting	01-05 April, 22	05-10 Aug. 21	15-20 Dec, 22	14-20 Feb,22	25 April to 05May,22	07-10 Aug. 21	24-26 Nov. 21
Field duration (days)	90	110	115	80	65-80	85	100
Turn-around (days)	13	15	15	6	6	7	7

Results and Discussion

Crop management: Crop management practices, of existing and alternate cropping patterns, are shown in Table 1. Existing cropping pattern, Mustard-D.Aus-T. Aman rice required 315 days and alternate cropping pattern Mustard-Mungbean-T. Aus-T. Aman took 339 days (excluding seedling age of rice) to complete the cycle. Turnaround time in the existing cropping pattern was 50 days whereas it was 26 days in four crops based alternate cropping pattern.

Yield performance: Yield and economic return of existing and alternate cropping pattern are shown in Table 2 & Table 3. In MLT site Daulatkhan the average yield of different four crops in alternate cropping pattern of Mustard, Mungbean, T. Aus and T. Aman was 1.38, 1.32, 4.28 and 5.20 t ha^{-1} while in existing cropping pattern of Mustard, D. Aus, T. Aman and was 0.97, 3.70 and 4.80 t ha^{-1}, respectively (Table-2). On the other hand at Bhola sadar, the average yield of different four crops in alternate cropping pattern of Mustard, Mungbean, T. Aus and T. Aman was 1.18, 1.41, 4.35 and 5.40 t ha^{-1} while in existing cropping pattern of Mustard, D. Aus, T. Aman and was 0.92, 3.75 and 4.60 t ha^{-1} respectively (Table-3).Higher rice equivalent yield was obtained in alternate cropping patterns due to the introduction of new crops and varieties with management practices.

Cost and return: In MLT site Daulatkhan, the higher gross return (Tk.375600ha^{-1}) and gross margin (Tk. 167570ha^{-1}) were obtained in alternate pattern over existing pattern (gross return: Tk. 246900 ha $^{-1}$ and gross margin: Tk. 73350ha^{-1}). In Bhola sadar, the higher gross return (Tk.372600ha^{-1}) and gross margin (Tk. 164570ha^{-1}) were obtained in alternate pattern over existing pattern (gross return: Tk. 240200 ha^{-1} and gross margin: Tk. 69650ha^{-1}). The MBCR was calculated at 3.73 and 3.53 at Daulatkhan whereas Bhola sadar indicating that alternate cropping patterns could l produce more returns than the existing farmer's pattern (Table 2& 3).

Farmers' opinion

The concepts of four crops-based cropping patterns were acceptable to the farmers in the locality. They expressed their consciousness for maintaining time frame of the four-crop based pattern. Income and production efficiency was higher than existing cropping pattern. Neighboring farmers showed their interest to adopt the alternate cropping pattern. They demand quality seed in due time.

Table 2. Yield, cost and return analysis of existing and improved cropping pattern at Daulatkhan, Bhola during 2021-22

Observations	Existing Cropping Pattern			Alternate Cropping pattern			
Crop	Mustard	D. Aus	T. Aman	Mustard	Mungbean	T. Aus	T. Aman
Seed/grain Yield (t ha^{-1})	0.97	3.70	4.80	1.38	1.32	4.28	5.20
Straw yield (t ha^{-1})	-	-	4.50	-	-	-	5.10
Gross return (Tk ha^{-1})	67900	74000	105000	96600	79200	85600	114200
TVC (Tk ha^{-1})	42750	62500	68300	42750	34280	58500	72500
Gross margin (Tk ha^{-1})	25150	11500	36700	53850	44920	27100	41700
Whole pattern REY (t ha^{-1})	12.34			18.78			
Whole pattern GR (Tk. ha^{-1})	246900			375600			
Whole pattern TVC (Tk ha^{-1})	173550			208030			
Whole pattern GM (Tk. ha^{-1})	73350			167570			
MBCR	3.73						

Input (Tk.kg^{-1}) : Seed (Mustard= 80/-, Mungbean =. 100/-, D. Aus rice= 50/- and T.Aman= 40/-, Urea=.16/-, TSP= 22/-, MoP = 15/-, Zinc sulphate= 190/- and Gypsum=. 20/- , Output: (Tk. kg^{-1}): Mustard=75.00, Mungbean = 60, Rice = 20.00, Rice straw = 2.00

Table 3. Yield, cost and return of existing and improved cropping pattern at Bhola sadar during 2021-22

Observations	Existing Cropping Pattern			Alternate Cropping pattern			
Crop	Mustard	D. Aus	T. Aman	Mustard	Mungbean	T. Aus	T. Aman
Seed/ grain Yield (t ha^{-1})	0.92	3.75	4.60	1.18	1.41	4.35	5.40
Straw yield (t ha^{-1})	-	-	4.40	-	-	-	5.20
Gross return (Tk ha^{-1})	64400	75000	100800	82600	84600	87000	118400
TVC (Tk ha^{-1})	42750	62500	65300	42750	34280	58500	72500
Gross margin (Tk ha^{-1})	21650	12500	35500	39850	50320	28500	45900
Whole pattern REY (t ha^{-1})	12.01			18.63			
Whole pattern GR (Tk. ha^{-1})	240200			372600			
Whole pattern TVC (Tk ha^{-1})	170550			208030			
Whole pattern GM (Tk. ha^{-1})	69650			164570			
MBCR	3.53						

Input (Tk.kg^{-1}) : Seed (Mustard= 80/-, Mungbean =. 100/-, D. Aus rice= 50/- and T.Aman= 40/-, Urea=.16/-, TSP= 22/-, MoP = 15/-, Zinc sulphate= 190/- and Gypsum=. 20/- , Output: (Tk. kg^{-1}): Mustard=75.00, Mungbean = 60, Rice = 20.00, Rice straw = 2.00

Conclusion

At the end of the one-year cycle, four crop-based cropping patterns Mustard- Mungbean-T.Aus-T. Aman gave higher rice equivalent yield and gross margin over the existing pattern Mustard-T.Aus-T. Aman. The MBCR (Daulatkhan Bhola sadar 3.73 and 3.53 respectively) of alternative cropping pattern over existing cropping pattern was much higher indicating the profitability of the improved cropping pattern. Farmers were possitively motivated to alternate cropping pattern due to relatively higher total production and economic benefit.

IMPROVEMENT OF EXISTING CROPPING PATTERN SOYBEAN-D. AUS-T. AMAN OF BHOLA

G. N. HASAN AND M. R. H. ANIK

Abstract

The study was carried out at Bhola sadar under Bhola district during 2021-22 cropping season. The experimental design was RCB with three dispersed replications. In improved pattern, the yield of Soybean, -T. Aus and T.Aman rice was 1.71, 4.50 and 5.15 t ha^{-1} where as in existing pattern, the yield of Soybean-D. Aus and T.Aman rice were found 1.28, 3.85 and 4.37 t ha^{-1} respectively. The improved cropping pattern gave higher Rice Equivalent Yield (14.86 t ha^{-1}) over existing cropping pattern (12.17 t ha^{-1}). Rice Equivalent Yield was 22.10 % higher in improved pattern due to addition of high yielding improved varieties with improved management practices. The improved cropping pattern performed 52.47% higher profit with higher MBCR (3.84) existing pattern.

Introduction

About 60% of the total land area is used as cultivated area in Bangladesh (BBS, 2016). The population is still increasing by 1.37% every year (BBS, 2017), however, the cultivated land is decreasing simultaneously. The agricultural land is converted by the uncontrolled urbanization, industrialization as well as with the increasing of human activities (Ahmed, 2013). This land to human ratio decreasing phenomenon is the serious encounters of food security in Bangladesh (Royet al.,2019). The food security can be ensured by adopting new technologies like improved varieties that produce more food than local varieties. In Bhola the cropping intensity is 250% (2020-21, source: DAE, Bhola). Still farmers use local varieties or in some cases old HYVs that's yield potentiality is low as well as pest susceptible. Different research organizations developed high yielding crop varieties which is high yielder and less pest susceptible. The crop production can be increased by inclusion of high yielding variety in the existing cropping system. Farmers of Bhola generally grow local variety of Soybean and rice in Soybean-D.Aus-T.Aman crop sequences. They usually obtained lower return from their local varieties. So, growing improved high yielding varieties may be a good option to increase crop productivity as well as economic return.

Materials and Methods

The experiment was conducted at Daulatkhan, Bhola sadar under Bhola district during 2021-22 cropping season. The experimental design was RCB with three dispersed replications. The improved cropping pattern Soybean (var. BARI Soybean-6)-T. Aus (var.BRRI dhan82)-T.Aman (var. BRRI dhan87) was tested against the existing cropping pattern Soybean (Local)-D. Aus (var. BRRI dhan48)-T.Aman (var. BRRI dhan52). The average plot size was 600 m^2. All agronomic practices including sowing date/transplanting and harvesting dates, seed rate, plant spacing, fertilizer etc. were mentioned in Table 1. Fertilizer packages (FRG, 2018) and the standard application methods were used for all the crops. Irrigation, pest managements and other protective measures were taken for normal growth of the crops. Rice hispa infestation was observed before the tillering stage and Virtako was used as per instruction. In case of soybean common cut warm like insects, yellow mosaic disease infestation was observed. The cost and return analysis was calculated on the basis of prevailing market price of the inputs and outputs. The data on yield and cost and return analysis of all the crops were taken plot wise and made up of average and stated in Table 2.

Table 1. Crop management practices used in existing cropping pattern (Soybean-D. Aus-T. Aman) and improved cropping pattern (Soybean-T.Aus- T.Aman) during 2021-22

Items	Existing cropping pattern (EP)			Improved cropping pattern (IP)		
Crop	D. Aus	T. Aman	Soybean	T. Aus	T. Aman	Soybean
Variety	BRRI dhan48	BRRI dhan52	Local	BRRI dhan82	BRRI dhan87	BARI Soybean-6

Items	Existing cropping pattern (EP)			Improved cropping pattern (IP)		
Crop	D. Aus	T. Aman	Soybean	T. Aus	T. Aman	Soybean
Date of sowing/ Transplanting	05-10 May 2021	28-05 Sep. 2021	24-26 Jan. 2022	16-18 May 2021	24-26 Aug 2021	10-12 Jan 2022
Seedling age (days)	dibbling	35	-	20	25	-
Seed rate (kg ha^{-1})	50	50	100	50	50	60
Spacing (cm)	30 x 20	30 x 30	Broadcast	20 x 15	25 x 15	30 x 6
Fertilizer dose (NPKSZn kg ha^{-1})	150-50-75-35-5	150-110-50-30-10	40-200-140-80-0	150-52-75-38-5	180-120-100-68-12	55-175-120-100-0
Date of harvesting (range)	12-20 Aug 2021	14-20 Jan. 2022	04-07 April 2022	10-14 Aug. 2021	10-15 Dec. 2021	25-28 April 2022
Field duration (days)	100	142	110	100	130	100

Result and Discussion

Crop management: Crop management practices of existing and improved cropping patterns are shown in Table 1. Existing cropping pattern D. Aus-T.Aman-Soybean required 352 day and improved cropping pattern T.Aus-T.Aman-Soybean took 330 days (excluding seedling age of rice) to complete the cycle.

Yield performance: Yield and economic return of improved cropping pattern and existing pattern are shown in Table 2. In improved pattern, the yield of Soybean, -T. Aus and T.Aman rice was 1.71, 4.50 and 5.15 t ha^{-1} where as in existing pattern, the yield of Soybean, D. Aus and T.Aman rice were found 1.28, 3.85 and 4.37 t ha^{-1} respectively. The improved cropping pattern gave higher Rice Equivalent Yield (14.86 t ha^{-1}) over existing cropping patten (12.17 t ha^{-1}). Rice Equivalent Yield was 22.10% higher in improved pattern due to addition of high yielding improved varieties with improved management practices

Cost and return: Higher gross return (Tk. 297250 ha^{-1}) and gross margin (Tk. 115790 ha^{-1}) were obtained in improved cropping pattern over existing cropping pattern (gross return: Tk. 243400 ha^{-1} and gross margin: Tk. 75940 ha^{-1}). The gross margin of the improved cropping pattern was 52 % higher than that of the existing pattern. The MBCR was calculated at 3.84 indicating that improved cropping pattern could produce more returns than the existing farmers, pattern (Table 2).

Farmers' opinion

Farmers realized that use of high yielding modern varieties instead of local varieties or old HYVs can increase production as well as their income. Farmers like rice var. BRRI dhan87 as early maturing variety but rat and bird infestation were high during ripening stage.

Table 2. Yield, cost and return analysis of improved cropping pattern and existing cropping pattern in Bhola district during 2021-22.

Items	Farmers existing cropping pattern (EP)			Improved cropping pattern (IP)		
Crop	D. Aus	T. Aman	Soybean	T. Aus	T. Aman	Soybean
Grain/seed yield (t ha^{-1})	3.85	4.37	1.28	4.50	5.15	1.71
Straw yield (t ha^{-1})	-	4.30	-	-	5.10	-
Gross return (Tk. ha^{-1})	77000	96000	70400	90000	113200	94050
TVC (Tk. ha^{-1})	58500	55500	50460	60500	65500	55460
Gross margin (Tk ha^{-1})	18500	37500	19940	29500	44700	38590
Whole pattern REY (t ha^{-1})	12.17			14.86		
Whole Pattern GR (Tk. ha^{-1})	243400			297250		
Whole pattern TVC (Tk ha^{-1})	167460			182460		
Whole Pattern GM (Tk. ha^{-1})	75940			115790		
MBCR	3.84					

Output: Unit price (Tk. kg^{-1}): Soybean =55.00, Rice = 20.00, Rice straw = 2.00

Conclusion

From the experimentation, the cultivation of improved cropping pattern is profitable than that of existing cropping pattern. Inclusion of soybean var. BARI Soybean-6 and T.aman var. BRRI dhan87 gave higher yield and economic benefit. Thus, the cultivation of improved pattern would help to increase total production and enhance farmers income.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN POTATO-MAIZE + CORIANDER - T. AMAN RICE AGAINST POTATO-MAIZE-T. AMAN RICE CROPPING PATTERN

S. K. BHOWAL AND M. M. BASHIR

Abstract

A field experiment was conducted at the farmers' field of Daudkandi Upazila under AEZ 19 of Cumilla district during,2020-21 to fit Coriander in the existing cropping pattern and to increase cropping intensity and productivity. Two treatments i.e., T_1: Existing cropping pattern (Potato-Maize-T. Aman) and T_2: Alternate cropping pattern (Potato-Maize + Coriander-T. Aman) were evaluated in the farmer's field. Result revealed that Rice equivalent yield (REY) in alternate cropping pattern is 51.1 t ha^{-1}, which is almost 63% higher over existing pattern (31.4 t ha^{-1}). Higher gross return (Tk. 1022000 ha^{-1}) and gross margin (Tk. 791620 ha^{-1}) as well as higher MBCR (11.42) were also obtained from alternate cropping pattern over existing cropping pattern due to additional yield of coriander leaves and higher yield of improved potato var. BARI Alu-46.

Introduction

Bangladesh is one of the most densely populated countries of the world with population growth rate of 1.579%. The present cropping intensity of the country is 194%. Food requirement is estimated to be doubled in the next 25 years. Under such situations, it is very important to increase cropping intensity and productivity. Therefore, suitable crop(s) should be accommodated in the existing cropping pattern. The main challenge of the new millennium is to increase per unit yield by at least 50% through manipulating the limited land resource. In order to produce more food within a limited area, two most important options to be adopted are i) to increase the cropping intensity producing three or more crops over the same piece of land round the year and ii) to increase the productive efficiency of the individual crop. Considering the above issues, the present study was undertaken with the objectives- (i) to fit Coriander as intercrop with maize in the Potato-Maize-T. Aman cropping pattern and increase cropping intensity–(ii) to increase production and economic return of the farmers by improving the cropping system.

Materials and Methods

The trial was conducted at the farmers' field of Daudkandi, Cumilla under AEZ 19 during 2020-21. The experiment was laid out in a Randomized Complete Block Design with six dispersed replications. Soil properties from soil chemical analysis of initial soil sample of the cropping patter are presented in (Table 1).

There were two treatments *i.e,* T_1: Existing cropping pattern (Potato-Maize-T. Aman) and T_2: Alternate cropping pattern (Potato-Maize + Coriander-T. Aman). The details of the crop management for the cropping patterns have been presented in the Table 2. Potato was planted as a first crop during last week of November in the improved cropping pattern. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to Kabir and Haque (2012). Seeds of coriander variety BARI Dhonia-2 were broadcasted in between the two lines of maize as intercropping system just after maize sowing in improved cropping pattern. Leaves of coriander were harvested at second week of April.

Transplanted Aman rice was grown during the Kharif –II season and it was the last crop of the sequence. Fertilizer management and intercultural operations like weeding, irrigation and pest management were done according to Rahman *et al.* (2008). Seedlings were grown in adjacent plot and transplanting was done with 18-22 days old seedling of rice var. BRRI dhan49 at a spacing of 20cm x 15cm during third week of July in improved cropping pattern. T. Aman rice was harvested during third week of November. Transplanted Aman rice was harvested at 12-15 cm height from soil surface and remaining parts of the plant was incorporated with soil. Data on yield of the all crops were recorded carefully. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Table 1. Initial and final soil properties of improved cropping pattern field at Daudkandi, Cumilla during 2020-21 and 2021-22.

Soil Properties	Land type	pH	Organic matter (%)	K	Total N (%)	P	Zn	B
				Meq100 ml^{-1}		µgml^{-1}		
Initial (2020-21)	MHL	5.5	1.85	0.26	0.11	86	15	0.20
Final (2021-22)	MHL	5.0	0.78	0.32	0.10	95	4.42	0.21
Critical Level	-	-	-	0.12	0.12	8. 0	0.6	0.20

Table 2. Details of the crop management practices and yield of Potato-Maize+Coriander-T.Aman rice cropping pattern against Potato-Maize-T. Aman rice pattern at Daudkandi, Cumilla during 2020-21.

Observations	Existing CP (T_1)			Improved CP (T_2)			
Crop	Potato	Maize	T. Aman	Potato	Maize	Coriander	T. Aman
Variety	BARI Alu-7	NK-40	BRRI dhan32	BARI Alu-46	BHM-16	BARI Dhonia-2	BRRI dhan49
Planting date (days)	03-05 Dec. 2020	15 Mar.2021	28-29 Aug. 2021	27-28 Nov, 2020	5-6 Mar. 2021	5-6 Mar. 2021	24-25 July, 2021
Harvesting date (days)	07-08 Mar. 2021	12-15 Jul. 2021	27-28 Nov, 2021	1-2 Mar. 2021	1-3 July, 2021	18-20 April, 2021	22-23 Nov, 2021
Field duration (days)	94-95	117-120	90-94	90-91	116-118		118-120
Turn around time (days)	07-08	45-46	05-06	03-04	21-22		05-06

Results and Discussion

Crop management: Crop management practices of existing and alternate cropping patterns are shown in Table 2. Existing cropping pattern Potato-Maize-T. Aman required 305 day and improved cropping pattern Potato-Maize+Coriander-T.Aman took 326 days (excluding seedling age of rice) to complete the cycle. Turnaround time in the existing cropping pattern was 60 whereas it was only 39 days in improved cropping pattern.

Yield performance: Yield and economic performance of alternate and existing cropping pattern during 2020-21 are presented in Table 2. The results revealed that the average tuber yield of potato, grain yield of maize, green leaf yield of coriander and grain yield of rice in alternate cropping pattern were recorded as 47.1, 10.1, 1.7 and 4.3 t ha^{-1}, respectively, whereas in the existing cropping pattern of Potato (BARI Alu-7), Maize (NK-40) and T. Aman (BRRI dhan32) produced 29.6, 9.5 and 4.2 t ha^{-1}, respectively. Higher yield of Potato, Maize and T. Aman were recorded in alternate cropping pattern compared to the existing cropping pattern. Higher Rice equivalent yield was (51.1 t ha^{-1}) was recorded from the alternate cropping sequence i.e Potato-Maize+ Coriander-T. Aman and the lower (31.4 t ha^{-1}) from the existing cropping sequence such as Potato-Maize-T.Aman. Rice equivalent yield in the improved cropping pattern which was almost 63% higher than the existing cropping pattern due to the inclusion of one short duration culinary herb (Coriander) as inter crop with maize and use of modern high yielding variety of potato (BARI Alu-40). The result of the study similar with the Naher *et.al* (2016) and Hossain *et. al* (2014) who stated that short duration varieties and improved four crop-based cropping pattern increases total productivity and profitability over farmers existing pattern.

Cost and return analysis: Cost and return analysis was done on the basis of prevailing market price of the commodities shown in Table 3. The higher gross return (Tk. 1022000 ha^{-1}) and gross margin (Tk. 791620 ha^{-1}) were obtained in improved (Potato-Maize+Coriander-T. Aman) cropping pattern, and which were 63 and 83% over existing pattern (Potato-Maize-T. Aman). Higher total variable cost (Tk. 230380 ha^{-1}) was recorded from cropping sequence Potato-Maize+Coriander-T. Aman, due to the inclusion of hybrid coriander as intercrop with maize and improved varieties and modern technologies in alternate cropping pattern whereas lower total variable cultivation cost (Tk. 195880ha^{-1}) from the existing cropping sequence Potato-Maize-T. Aman rice. The MBCR was calculated at 11.42 indicating that improved cropping pattern could produce more returns than the existing farmers, pattern (Table 3).

Farmers' opinion

Farmers opined that potato, maize, coriander and rice can be grown successfully in the same field in a year. Bbut they expressed their concern due to increased labour cost at pick period and lower market price of products.

Table 3. Yield and economic return of improved pattern (Potato-Maize + Coriander-T.Aman rice) and existing cropping pattern (Potato-Maize-T. Aman rice) at Daudkandi, Cumilla during 2020-21

Items	Farmers existing cropping pattern (EP)			Improved cropping pattern (IP)			
Crop	Potato	Maize	T. Aman	Potato	Maize	Coriander	T. Aman
Grain/Leaf yield (t ha^{-1})	29.6	9.5	4.2	47.1	10.1	1.7	4.3
Straw yield (t ha^{-1})	2.27	4.80	4.62	2.15	2.46	0.5	4.12
Whole pattern REY (t ha^{-1})	31.4			51.1			
Whole Pattern GR (Tk. ha^{-1})	628000			1022000			
Whole pattern TVC (Tk ha^{-1})	195880			230380			
Whole Pattern GM (Tk. ha^{-1})	432120			791620			
Whole pattern MBCR	11.42						

Market price of Potato @ 12 Tk kg^{-1}, Maize@ 20 Tk kg^{-1}, Coriander leaf @ Tk. 100 kg^{-1}, T. Aman rice @ Tk. 20 kg^{-1} ,Urea @ 16, TSP @ 24, MP @15,Zypsum @10, Zinc Sulphate @ 120 and Boric acid@ 150 Tk kg^{-1}; Existing CP (T_1) =Potato-Maize-T. Aman and Improved CP (T_2) =Potato-Maize+Coriander-T. Aman rice

Conclusion

Based on the cropping pattern study, it may be concluded that improved cropping pattern: Potato (var. BARI Alu-46)-Maize (var. BARI Hybrid Bhutta-16) + Coriander (var. BARI Dhonia-2)-T. Aman (var. BRRI dhan49) is agronomically feasible and economically profitable compared to the existing farmers cropping pattern Potato (var. BARI Alu-7)-Maize (NK-40)-T. Aman (var. BRRI dhan32). Due to growing of four crops in a year in the same piece of land cropping intensity and productivity were increased, more employment opportunity for male and female labors are generated. Increased production of potato, maize, coriander leaves and rice, enhance food and nutritional security for the farmers.

DEVELOPMENT OF IMPROVED CROPPING PATTERN POTATO/AROID-T. AMAN RICE AGAINST POTATO-FALLOW-T. AMAN RICE

S. K. BHOWAL AND M. M. BASHIR

Abstract

A field experiment was conducted at the farmers' field of Amratoli, Barura, Cumilla under AEZ 19 with rice based cropping pattern during 2020-21 to fit Aroid in the Potato-Fallow-T. Aman cropping pattern and increase cropping intensity. Two treatments i.e., T_1: Existing cropping pattern (Potato -Fallow-T. Aman) and T_2: Alternate cropping pattern (Potato/Aroid-T. Aman) was studied. It is revealed that Rice equivalent yield (REY) in alternate cropping pattern 63.5 t ha^{-1}, which is almost 176% higher over existing pattern (23.0 t ha^{-1}). Higher gross return (Tk. 952500.00 ha^{-1}) and gross margin (Tk. 756814.00 ha^{-1}) as well as higher MBCR (4.86) were also obtained from improve cropping pattern over existing cropping pattern due to additional stolon yield of aroids and higher yield of improved potato var. BARI Alu-46.

Introduction

Sustainable crop production in Bangladesh through improvement of cropping intensity in rice based cropping system is regarded as increasingly important in national issues such as food security, poverty alleviation and creation of job opportunity. The main challenge of the new millennium is to increase 50% yield per unit land area through manipulating the limited land resource. In order to produce more food within a limited area, the most important options are to increase the cropping intensity producing three or more crops over the same piece of land in a year and to increase the production efficiency of the individual crop by using optimum management practices (Mondol *et al*., 2015). Recently with the development of short duration varieties of rice, potato, aroid and jute, opportunities have been created to accommodate three/four crops in same piece of land in a year. Cropping intensity can be increased from 191-400 % by cultivation of four crops in one cropping, two cropping and three cropping land (BARI, 2017). Cumilla is the highest rice growing district in Bangladesh. Potato-Fallow- T. Aman. is one of the major cropping patterns in Cumilla. According to DAE, about 3000 ha of lands were cultivated under the pattern in Cumilla during 2013 (DAE, 2013). Potato is a promising cash crop in this region. The land remains fallow after potato harvest. Aroids can be easily fitted in Potato-Fallow-T. Aman cropping pattern, without disturbing T. Aman rice. There is a scope to include a vegetable like aroid in Potato-Fallow- T. Aman cropping pattern to increase cropping intensity and productivity in Cumilla region. Potential adoption of this improved cropping pattern intensifying Aroids as relayed in Potato-Fallow-T. Aman cropping system can generate employment and the additional income for the rural poor and save foreign exchange through producing these crops (Hossain *et al.*, 2017). Considering the above issues, the present study was undertaken with the objectives- to increase the cropping intensity and productivity through improved cropping pattern and to also increase production and economic return of the farmers by improving the cropping system.

Materials and Methods

The trial was conducted at the farmers' field of Barura, Cumilla under AEZ 19 with the following rice based cropping pattern during 2020-21 to fit Aroid in the Potato-Fallow-T. Aman cropping pattern and increase cropping intensity. The experiment was laid out in a randomized complete block design with five dispersed replications. Soil properties from soil chemical analysis of initial soil sample of the cropping patter are presented in (Table 1). There was no definite trend followed with respect to other elements but all the elements maintained above critical level. Organic matter added to soil through incorporation of non-economic plant parts in the improved cropping patterns and it helped to improve the quality of soil by increasing total organic matter in every succeeding year (Mondal et al., 2015). There were two treatments i.e., T_1: Existing cropping pattern (Potato-Fallow-T. Aman) and T_2: Alternate cropping pattern (Potato/Aroid-T. Aman). The details of the crop management for the cropping patterns have been presented in the Table 2. Aroid as relayed with Potato was the second crop of the crop sequence. Fertilizer management and other intercultural operations were done according to BARI (2017). Seedlings of aroids var. BARI Panikachu-1 was planted in pit basis around the sides of potato ridges with 60 cm x 45 cm spacing during 10-15 days before potato harvesting in improved cropping pattern. Stolon harvesting was continued at first week of August and leaves of the aroid plant were incorporated into the soil for adding organic matter in the soil. Transplanted Aman rice was grown during the Kharif season and it was the third crop of the sequence. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to Rahman et al. (2008). Data on yield of the all crops were recorded carefully. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Table 1. Initial soil properties of cropping pattern field at Amratoli, Barura, Cumilla, 2020-21

Soil Properties	Land type	pH	Organic matter (%)	K	Total N (%)	P	Zn	B
				Meq100 ml^{-1}		µgml^{-1}		
Initial (2020-21)	MHL	5.7	1.89	0.28	0.11	86	15	0.21
Critical Level	-	-	-	0.12	0.12	8. 0	0.6	0.20

Source: Regional Laboratory, SRDI, Cumilla (2020) & FRG (2012)

Table 2. Crop Management practices of existing pattern (Potato- Fallow-T. Aman rice) and alternate pattern (Potato/Aroid-T. Aman) rice at Barura, Cumilla during 2020-21

Observations	Existing CP			Improved CP		
Crop	Potato	Fallow	T. Aman	Potato	Aroid	T. Aman
Variety	BARI Alu-7	-	BRRI dhan49	BARI Alu-46	BARI Panikachu-1	Binadhan-16
Date of sowing/ transplanting	10 Dec, 2020	-	27-28 Aug.2021	8-10 Dec, 2020	10-16Feb, 2021	17-18 Aug. 2021
Date of harvesting	7 March, 2021	-	18-20 Nov, 2021	1-7March, 2021	13 April- 08 August, 2021	30-31Oct, 2021
Field duration (days)	88	-	82-85	204-241		74-75
Turn around time (days)	20-22	-	165-170	35-40		8-9

Results and Discussion

Crop management: Crop management practices of existing and improved cropping patterns are shown in Table 2. Existing cropping pattern Potato-Fallow-T. Aman required 173 day and improved cropping pattern Potato/Aroid-T.Aman took 316 days (excluding seedling age of rice) to complete the cycle. Turnaround time in the existing cropping pattern was 192 whereas it was only 49 days in improved cropping pattern.

Yield and Productivity of Cropping Pattern: Yield and economic performance of developed and existing cropping pattern during 2020-21 are presented in Table It was revealed that the average yield of potato, aroid and rice in improved cropping pattern were recorded as 37.1, 18.2 and 4.2 t ha^{-1}, respectively, where in the existing cropping pattern of Potato T. Aman produces 22.9 and 5.2 t ha^{-1}, respectively. Higher yield of Potato, stolons and T. Aman were recorded in alternate cropping pattern compared to the existing cropping pattern.

In alternate cropping pattern Potato/Aroid-T. Aman rice REY was obtained (63.5 t ha^{-1}) which was 176 % higher over existing cropping pattern Potato -Fallow-T.Aman. due to inclusion of one vegetable crop (Aroid) as relay and use of modern high yielding varieties and modern technologies. The result of the study similar with the Naher et. al (2016) and Hossain et. al (2014) who stated that short duration varieties and improved cropping pattern increases total productivity and profitability over farmers existing pattern.

Cost and return analysis: Higher gross return (Tk. 952500 ha^{-1}) and gross margin (Tk. 756814 ha^{-1}) were obtained in improved cropping pattern and lower gross return (Tk. 345000 ha^{-1}) and gross margin (Tk. 214414 ha^{-1}) were found in existing cropping pattern (Table 3). Higher total cost (Tk. 195686.00 ha^{-1}) was recorded from cropping sequence Potato/Aroid -T. Aman, due to the inclusion of BARI Panikachu-1 as relay crop with potato and improved varieties and modern technologies in alternate cropping pattern whereas lower total cultivation cost (Tk. 130586.00 ha^{-1}) from the existing cropping sequence Potato -Fallow-T. Aman. The MBCR was found 9.33 which indicate the profitability of the improved cropping pattern against existing pattern.

Farmers' opinion: Farmers opined that aroids can be relayed successfully with potato in the same field in a year. But they expreseed their concern due to increased labour cost at pick period and lower market price of products.

Table 3. Yield and economic return of existing pattern (Potato- Fallow-T. Aman rice) and alternate pattern (Potato/Aroid-T. Aman) rice at Barura, Cumilla during 2020-21

Observations	Existing CP			Improved CP		
Crop	Potato	Fallow	T. Aman	Potato	Aroid	T. Aman
Grain/Tuber/Stolon yield (t ha^{-1})	22.9	-	5.2	37.1	18.2	4.2
Straw yield (t ha^{-1})	2.27	-	4.62	2.15	2.46	4.12
Whole pattern REY (t ha^{-1})	23.0			63.5		
Whole Pattern GR (Tk. ha^{-1})	345000			952500		
Whole pattern TVC (Tk ha^{-1})	130586			195686		
Whole Pattern GM (Tk. ha^{-1})	214414			756814		
MBCR	9.33					

Market price of Potato @ 12 Tk kg^{-1}, Rice@ 15 Tk kg^{-1}, Aroid stolon @ Tk. 25 kg^{-1}, Urea @ 16, TSP @ 24, MP @15,Zypsum @10, Zinc Sulphate@ 120 and Boric acid@ 150 Tk kg^{-1}; Existing CP (T_1) =Potato-Fallow-T. Aman and Improved CP (T_2) =Potato/Aroid- T. Aman rice

Conclusion

It may be concluded that improved cropping pattern such as Potato (var. BARI Alu-46)/Aroid (var. BARI Panikachu-1)-T. Aman (var. Binadhan-16) is agronomically feasible and economically profitable compared to the existing farmers cropping pattern Potato-Fallow-T. Aman. Due to growing of three crops in a year in the same piece of land cropping intensity and productivity were increased, more employment opportunity for male and female labors is generated.

DEVELOPMENT OF CROPPING PATTERN WHEAT-MUNGBEAN-T. AMAN AGAINST WHEAT- FALLOW-T. AMAN RICE IN MEDIUM HIGHLAND OF AEZ-1

M.NURUZZAMAN AND M. S. HUDA

Abstract

An experiment was executed at multi-location testing (MLT) site Pirgonj, Thakurgaon during 2019-20 and 2020-21 to improve the existing cropping pattern for increasing cropping intensity and productivity by inclusion of Mungbean and to increase crop yield and farmer's income. The alternate cropping pattern was Wheat-Mungbean-T. Aman rice against the existing Wheat-Fallow-T. Aman rice pattern. The variety of Wheat, Mungbean, T. Aman was BARIGom-31, BARI Mung-8 and BRRIdhan87, respectively. The whole pattern rice equivalent yield in alternate cropping pattern was 17.02 t ha^{-1} while 10.87 t ha^{-1} in existing pattern. The higher gross return and gross margin were substantially higher in the alternate pattern than the farmer's existing pattern. The mean marginal benefit cost ratio (MBCR) was found 3.70 which indicated the superiority of alternate pattern over the farmer existing pattern.

Introduction

In Bangladesh total cultivable land is 7.9 million land it is shrinking day by day. In Dinajpur and Thakurgaon follow different types of cropping pattern. Boro rice-Fallow-T.Aman is one the major cropping patterns covered about 48.60% land area. Only 1 % area is under Wheat-Mungbean-T. Aman rice cropping pattern in this region. Most of the farmers use Swarna/Gutty Swarna/Ranjit for T. Aman, local Sonamung for Mungbean and BARI Gom-26 for Wheat (low yielding and disease susceptible) but BARI and BRRI have developed high yielding short duration wheat, mungbean and rice varieties. By introducing this variety in Wheat-Mungbean -T. Aman rice cropping pattern would increase cropping intensity and productivity and additional income of the farmers. On-Farm Research Division, BARI has also validated this potential cropping pattern in some parts of the country. It is needs to popularize these HYVs of Mungbean among the farmers by fitting them in the alternate cropping pattern of Wheat-Mungbean-T. Aman rice. With this view in mind, the experiment was undertaken to improve the existing cropping pattern for increasing cropping intensity and productivity by inclusion of Mungbean and to increase crop yield and farmer's income.

Materials and Methods

The experiment was conducted at the MLT site Pirganj, Thakurgaon during 2019-20 and 2020-21. The experiment was laid out in a randomized complete block design with 4 dispersed replications. Crop management practices of the patterns are shown in Table 1. The land area of four farmers was 10 decimals. Variety of different crops in the pattern was selected considering its duration and yield performance. Recommended fertilizer dose based on FRG' 2018 and agronomic practices were followed for each crop. Nativo 50 WP was sprayed 2 times in wheat, rice and mungbean for controlling fungal diseases (Blast/Blight).Aphid, white fly infestation was controlled by sprayed with Ripcord /Movento@ 1 ml liter^{-1}water. Marshal 20 EC @ 3ml liter^{-1} was sprayed to control rice stem borer at 15 and 30 DAT. For economic analysis Rice Equivalent Yield (REY) was calculated with following formula (Ahlawat and Sharma, 1993).

Table 1. Crop management practices of alternate cropping pattern (Wheat-Mungbean-T. Aman) and existing cropping patterns (Wheat-Fallow-T. Aman) at Pirganj, Thakurgaon during 2020-21

Observations	Alternate cropping pattern			Existing cropping pattern		
Crop	Wheat	Mungbean	T. Aman rice	Wheat	Fallow	T. Aman rice
Variety	BARI Gom-31	BARI Mung-8	BRRI dhan87	BARI Gom-26	-	Swarna
Spacing	Broadcast	Broadcast	20cm×15cm	Broadcast	-	20cm×15cm
Sowing/Transplanting	5thDec.	1st April	20th July	5-10 Dec.	-	20 -30 July
Fertilizer dose (NPKSZnB kg ha^{-1})	100-30-65-15-1.5-1	45-90-30-4-1-1.19	90-10-35-12-1-0	100-30-50-20-1-1	-	102-20-60-12-1-0
Fertilizer application	Basal & top-dress	Basal & top-dress	Basal & top-dress	Basal & top-dress	-	Basal & top-dress
Irrigation (DAT/DAS)	3 times 20,50&75 days	1 times	-	3 times 20,50&75 day	-	-
Intercultural operation	Weeding	Weeding	Weeding	Weeding	-	Weeding
Date of harvest	20 March	10 July	5 Nov.	25-30 March	-	15-20 Nov.

Results and Discussion

Yield performance: Yield of different crops of the patterns is shown in Table 2. The grain and straw yield of BARI Gom-31 in the alternate cropping pattern was 4.61 and 6.50 t ha^{-1}. On the other hand, the existing pattern grain and straw yield was 4.63 and 6.67 t ha^{-1} respectively. The seed and stover yield of BARI Mung-8 was 1.36 and 2.15 t ha^{-1} from the alternate cropping pattern. The alternate cropping pattern gave higher grain yield over existing pattern due to BARI Mung-8 inclusion with higher agronomic practices. The grain and straw yield of BRRI dhan87 in the alternate cropping pattern was 5.71 and 5.23 t ha^{-1}. On the other hand, the existing pattern grain and straw yield was 4.55and 5.30 t ha^{-1}. This might be due to high yielding variety, seed sowing in optimum time followed by balanced fertilizer application and better agronomic practices.

Rice equivalent yield: Rice equivalent yield of alternate cropping pattern was higher over farmer's cropping pattern (Table 2). The whole pattern rice equivalent yield in alternate cropping pattern was 17.02 while 10.87t ha^{-1} year^{-1}in existing pattern. The whole pattern REY was 58 %

higher over existing pattern due to inclusion of a new crop and high yielding varieties and improve management practices.

Cost and return analysis: Gross return and gross margin in alternate cropping pattern was calculated Tk.306360 and Tk.195722 ha^{-1} which was higher compared to that of farmers existing pattern. The higher gross margin of the alternate pattern was achieved mainly due to inclusion a new crop and higher yield advantages of components crops.

Farmer's opinion

Farmers are happy to get additional seed yield of Mungbean from the fallow period of that location. The yield performance of BARI Mung-8 was satisfactory and easily fit in three crops cropping pattern. They also opined that after harvest of Wheat, short duration high yielding BARI Mung-8 can easily be grown without hamper the Aman cultivation.

Table 2. Yield and economic return of alternate cropping pattern Wheat-Mungbean -T. Aman rice cropping pattern and existing cropping Wheat-Fallow-T. Aman at MLT site Pirganj, Thakurgaon during 2019-20 and 2020-21(average of 2 years).

Observations	Alternate cropping pattern			Existing cropping pattern		
Crop	Wheat	Mungbean	T. Aman rice	Wheat	Fallow	T. Aman rice
Grain yield (t ha^{-1})	4.61	1.36	5.71	4.63		4.55
Straw yield (t ha^{-1})	6.50	2.15	5.23	6.67		5.30
Rice equivalent yield(t ha^{-1})	5.99	5.03	6.00	6.029		4.844
Gross return (Tk. ha^{-1})	107820	90540	108000	108530		87192
TVC (Tk. ha^{-1})	42540	28540	45476	42540		44100
Gross margin (Tk. ha^{-1})	66810	62000	62524	65990		43092
Whole pattern REY (t ha^{-1})	17.02			10.87		
Whole Pattern GR (Tk. ha^{-1})	306360			195722		
Whole Pattern TVC (Tk. ha^{-1})	116556			86640		
Whole Pattern GM (Tk. ha^{-1})	189804			109082		
MBCR	3.70					

Unit price: Wheat = Tk. 22 kg^{-1}, BARI mung-8 = Tk. 65 kg^{-1}, BRRI dhan87= Tk. 18 kg^{-1} and Swarna = TK. 18 kg^{-1}, straw of Rice, Mungbean and Wheat = Tk. 1 kg^{-1}

Conclusion

From the experimentation, it is clear that performance of alternate cropping patterns is profitable than that of existing cropping pattern. So, dissemination of alternate cropping patterns would help to increase total production, farmer's income and enhance nutritional security.

DEVELOPMENT OF CROPPING PATTERN MAIZE-MUNGBEAN-T. AMAN AGAINST MAIZE- FALLOW-T. AMAN RICE IN MEDIUM HIGH LANF OF DINAJPUR REGION

M. NURUZZAMAN AND M. S. HUDA

Abstract

The field experiment was conducted at MLT site Raniganj, Dinajpur for two consecutive years 2019-20 and 2020-21 to improve the existing cropping pattern for increasing cropping intensity and productivity by inclusion of mungbean. The alternate cropping pattern was Maize-Mungbean-T. Aman rice against the existing Maize-Fallow-T. Aman rice pattern. The variety of Maize, Mungbean and T. Aman was Miracle, BARI Mung-7 and BRRI dhan34, respectively. The experiment was laid out in randomized complete block design with four dispersed replications. Two years mean data showed that the improve management practice for the pattern provided significantly higher yield in improved pattern. The rice equivalent yield in alternate cropping pattern was 22.65 while 14.85 t ha^{-1} year^{-1} in existing pattern. The higher gross return of the alternate pattern was Tk.407656 ha^{-1}which was more than 52.54

% higher than farmers pattern (Tk.267237ha^{-1}) and gross margin were substantially higher in the alternate pattern than that of the farmer's existing pattern.

Introduction

The main challenge in Bangladesh is to increase 50% yield per unit land by manipulating limited resources. In order to produce more food within a limited area, the most important options are to increase the cropping intensity and to increase the production efficiency of the individual crop by using optimum management practice (Mondal *et al.,* 2015) Recently, with the introduction of short-duration rice varieties, an opportunity has been created to accommodate mustard, potato, pulses, maize, jute etc. following rice is same piece of land in a yearly sequence (Azad *et al.,* 2020).

In Dinajpur and Thakurgaon different types of cropping patterns are followed by the farmers. Boro rice -Fallow-T. Aman is one the major cropping patterns covered about 48.60% land area. So there is a big opportunity to include pulses in the fallow period like mungbean. By introducing Mungbean in cropping pattern would increase cropping intensity and productivity and additional income of the farmers. On-Farm Research Division, BARI has also validated this cropping pattern in some parts of the country. It needs to popularize these HYVs of Mungbean among the farmers by fitting them in the alternate cropping pattern of Maize-Mungbean-T. Aman rice. With this view in mind, the experiment was undertaken to improve the existing cropping pattern for increasing cropping intensity and productivity by inclusion of Mungbean and to increase crop yield and farmer's income.

Materials and Methods

An experiment was conducted at the MLT site Raniganj, (latitude-25°.687845 N, and longitude-88°.661124 E*)* Dinajpur during 2019-20 and 2020-21. The experiment was laid out in a randomized complete block design with 4 dispersed replications. Crop management practices of the patterns are shown in Table 1. The land area of four farmers was 10 decimals. Variety of different crops in the pattern was selected considering its duration and yield performance. Recommended fertilizer dose based on FRG 2018 and agronomic practices were followed for each crop. All season's rice was transplanted at a spacing of 20cm × 15cm. Broadcast seeding was followed in Maize @ 25-30 kg seed ha^{-1} Mungbean-15kg seed ha^{-1} and Aman dhan50 kg seed ha^{-1}. Nativo 50 WP was sprayed 2 times in maize and mungbean for controlling fungal diseases. Aphid, White fly infestation was controlled by sprayed with Ripcord @ 1 ml liter^{-1} water. Marshal 20 EC @ 3ml liter^{-1} was sprayed to control rice stem borer at 15 and 30 DAT. Contaf 5 EC @ 1 ml liter^{-1} was also sprayed in rice to control sheath blight at 57 DAT. Yield and yield attributes were recorded properly and analyzed statistically. For economic analysis Rice Equivalent Yield (REY) was calculated with following formula (Ahlawat and Sharma, 1993).

Table 1. Crop management practices of alternate cropping pattern (Maize-Mungbean-T.Aman) and existing cropping patterns (Maize-Fallow-T.Aman) at Ranigonj, Dinajpur during 2020-21

Observations	Alternate cropping pattern			Existing cropping pattern		
Crop	Maize	Mungbean	T.Aman rice	Maize	Fallow	T. Aman rice
Variety	Miracle	BARI Mung-7	BRRI dhan34	Miracle	-	Swarna
Spacing (cm)	60 ×25	30×8	20×15	60 ×25	-	20×15
Sowing/Transplanting	25th Nov.	1st May	20th July	5-10 Dec.	-	20 -30 July
Fertilizer rate: (NPKSZnB Kg ha^{-1})	185-45-85-30-2-1	20-18-17-10-1-1.19	90-15-45-12-1-0	185-30-70-20-2-1	-	102-20-60-12-1-0
Fertilizer application	Basal & top-dress	Basal	Basal & top-dress	Basal & top-dress	-	Basal & top-dress
Intercultural operation	Weeding	Weeding	Weeding	Weeding	-	Weeding
Date of harvest	25 April	10 July	10 Nov.	25-30 April	-	15-20 Nov.

Results and Discussion

Yield performance: Yield of different crops of the patterns is shown in Table 2. The grain yield of maize in the alternate cropping pattern was 10.65 t ha^{-1} on the other hand the existing pattern grain yield was 10.50 t ha^{-1}. The seed and Stover yield of BARI Mung-7 was 1.30 and 2.05 t ha^{-1} from the alternate cropping pattern. The alternate cropping pattern gave additional grain yield over existing pattern due to inclusion of BARI Mung-7 in the fallow period and proper agronomic practices. The grain and straw yield of BRRI dhan34 in the alternate cropping pattern was 3.65 and 5.06 t ha^{-1} and existing cropping pattern grain and straw yield of Swarna was 4.65 and 5.37 t ha^{-1} respectively.

Rice equivalent yield: Rice equivalent yield revealed that alternate cropping pattern produced higher rice equivalent yield over farmer's traditional cropping system (Table 2). The whole pattern rice equivalent yield in alternate cropping pattern was 22.65 t ha^{-1} while 14.85 t ha^{-1} in existing pattern. Inclusion of a new crop and high yielding varieties and improve management practices the alternate pattern increased 52.52 % rice equivalent yield over existing pattern. Lower rice equivalent yield was obtained in the existing pattern.

Cost and return analysis: The higher gross return of Tk.407656 ha^{-1} in alternate pattern, which was higher of that of farmers existing pattern. The gross margin was substantially higher in the alternate pattern Tk.259566 ha^{-1} over the existing pattern Tk.151137 ha^{-1}. The higher gross margin of the alternate pattern was achieved mainly due to inclusion a new crop and higher yield advantages of components crops.

Farmer's opinion

Farmers are very much happy to obtained additional yield of Mungbean from the fallow period of that location. The yield performance of BARI mung-7 was satisfactory and easily fit in three crops cropping pattern. After harvest of Maize, short duration high yielding BARI Mung-7 can easily be grown which doesn't hamper or delay the Aman cultivation.

Table 2. Yield and economic performance of alternate cropping pattern Maize-Mungbean -T. Aman rice cropping pattern and existing cropping pattern Maize-Fallow-T. Aman at Raniganj, Dinajpur during 2019-20 and 2020-21. (average of 2 years)

Observation	Alternate cropping pattern			Existing cropping pattern		
Crop	Maize	Mungbean	T. Aman rice	Maize	Fallow	T. Aman
Grain/seed yield (t ha^{-1})	10.65	1.30	3.65	10.50	-	4.65
Straw yield (t ha^{-1})	-	2.05	5.06	-	-	5.37
Rice equivalent yield (t ha^{-1})	10.05	4.81	7.79	9.92	-	4.93
Gross return (Tk. ha^{-1})	181050	86550	140056	178500	-	88737
TVC (Tk. ha^{-1})	72000	28540	47550	72000	-	44100
Gross margin (Tk. ha^{-1})	109050	58010	92506	106500	-	44637
Whole pattern REY (t ha^{-1})	22.65			14.85		
Whole pattern GR (Tk. ha^{-1})	407656			267237		
Whole pattern TVC (Tk. ha^{-1})	148090			116100		
Whole pattern GM (Tk. ha^{-1})	259566			151137		
MBCR	4.38					

Unit price : Maize = Tk. 17 kg^{-1}, BARI mung-7 = Tk. 65 kg^{-1}, BRRI dhan34= Tk. 37 kg^{-1} and Swarna = TK. 18 kg^{-1}, straw of Rice, and Mungbean = Tk. 1 kg^{-1}

Conclusion

From the experimentation, it is clear that cultivation of alternate cropping patterns is profitable than that of existing cropping pattern. The highest rice equivalent yield, gross return and gross margin were recorded in the alternate cropping pattern compared to existing cropping pattern due to additional yield of Mungbean. So, cultivation of alternate cropping patterns would help to increase total production, farmer's income and enhance soil fertility.

DEVELOPMENT OF CROPPING PATTERN WHEAT-SUMMER ONION-T. AMAN AGAINST WHEAT- FALLOW-T. AMAN RICE IN MEDIUM HIGHLAND OF AEZ-1

M. NURUZZAMAN AND M. S. HUDA

Abstract

A trial was conducted at multi-location testing (MLT) site Raniganj, Dinajpur during 2020-21 to increase cropping intensity and productivity by inclusion of Summer onion. The alternate cropping pattern was Wheat-Summer onion -T. Aman rice against the existing Wheat-Fallow-T. Aman rice pattern. The variety of Wheat, Summer onion and T. Aman was BARIGom-31, BARI Piaz-5 and BRRIdhan87, respectively. The whole pattern rice equivalent yield in alternate cropping pattern was 28.21 while 10.24 t ha^{-1} in existing pattern. The higher gross return and gross margin were found higher in the alternate pattern than the farmer's existing pattern.

Introduction

Crop diversification increases cropping intensity, raising the productivity of land and labour, generate income and employment which in turn will eliminate food and nutritional insecurity and poverty of farming in future. Increasing population in future when the natural resources, land and water are shrinking and degrading. Horizontal expansion is very limited but increase in crop production could be possible with vertical expansion through increasing crop yield per unit area and by reducing postharvest losses. Most area of Bangladesh at present under two crops based cropping pattern, but there prerequisite to increase crop number to meet up the demand. The areas where, Wheat-Fallow-T. Aman cropping patterns were practiced there are a great scope of introducing summer onion. Keeping this view in mind, the present study was designed to introduce summer onion (var. BARI Piaz-5) in the fallow period.

Materials and Methods

An experiment was conducted at the MLT site Raniganj *(Lat.25.8810387 N, Lon 88.379858 E)* Dinajpur during 2020-21. The experiment was laid out in a randomized complete block design with 4 dispersed replications. A list of the cropping patterns with crop and variety, date of sowing seeds in the seed bed, sowing/transplanting and date of harvesting of different crops is given in Table 1. The land area of four farmers was 10 decimals. Variety of different crops in the pattern was selected considering its duration and yield performance. Recommended fertilizer dose based on FRG' 2018 and agronomic practices were followed for each crop. All season's rice was transplanted at a spacing of 20cm×15cm. Broadcast seeding was followed in wheat @ 120 kg seed ha^{-1}, Summer onion 3-4kg seed ha^{-1}.and Aman dhan-50 kg seed ha^{-1}. Nativo 50 WP was sprayed (2-4) times in wheat and summer onion for controlling fungal diseases. Aphid infestation was controlled by sprayed with Ripcord @ 1 ml liter^{-1}water. Marshal 20 EC @ 3ml liter^{-1} was sprayed to control rice stem borer at 15 and 30 DAT. Contaf 5 EC @ 1 ml liter^{-1} was also sprayed in rice to control sheath blight at 57 DAT. Yield and yield attributes were recorded properly and analyzed statistically. For economic analysis Rice Equivalent Yield (REY) was calculated with following formula (Ahlawat and Sharma, 1993):

Table 1. Crop management practices of alternate cropping pattern (Wheat-Summer onion-T.Aman) and existing cropping patterns (Wheat-Fallow-T.Aman) at Raniganj, Dinajpur during 2020-21

Observations	Alternate cropping pattern			Existing cropping pattern		
Crop	Wheat	Summer onion	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-31	BARI Piaz-5	BRRI dhan87	BARI Gom-26	-	Swarna
Spacing (cm)	Broadcast		20×15	Broadcast	-	20cm×15cm
Seedling age (days)	-	40-45	26-30	-	-	30-35
Sowing/Transplanting	6th Dec.	1-5 April	20th July	5-10 Dec.	-	20 -30 July

Observations	Alternate cropping pattern			Existing cropping pattern		
Crop	Wheat	Summer onion	T. Aman	Wheat	Fallow	T. Aman
Fertilizer dose (NPKSZnB Kg ha^{-1})	100-30-65-15-1.5-1	75-30-60-24-2-1.	90-10-35-12-1-0	100-30-50-20-1-1	-	102-20-60-12-1-0
Fertilizer application	Basal & top-dress	Basal & top-dress	Basal & top-dress	Basal & top-dress	-	Basal & top-dress
Intercultural operation	Weeding	Weeding	Weeding	Weeding	-	Weeding
Date of harvest	20-25 March	10-15June	5 Nov.	25-30 March	-	15-20 Nov.

Results and Discussion

Yield performance: The grain and straw yield of BARI Gom-31 in the alternate cropping pattern was 4.25 and 5.90 t ha^{-1}. On the other hand, the existing pattern grain and straw yield was 4.48 t ha^{-1} and 6.15 t ha^{-1} respectively (Table 2). The bulb yield of BARI Piaz-5 was 20 t ha^{-1} from the alternate cropping pattern. The alternate cropping pattern gave additional onion bulb yield over existing pattern due to BARI Piaz-5 inclusion in the fallow period of the pattern. The grain and straw yield of BRRI dhan87 in the alternate cropping pattern was 5.97 and 5.25t ha^{-1}. The grain and straw yield of existing pattern of T. Aman was 4.75 and 5.35 t ha^{-1}. This might be due to high yielding variety, seed sowing in optimum time followed by balanced fertilizer application and better agronomic practices.

Rice equivalent yield: Rice equivalent yield revealed that alternate cropping pattern produced higher rice equivalent yield over farmer's traditional cropping system (Table 2). The whole pattern rice equivalent yield in alternate cropping pattern was 28.21 while 10.24 t ha^{-1} in existing pattern. Inclusion of a new crop and high yielding varieties and improve management practices the alternate pattern increased 56.83% rice equivalent yield over existing pattern.

Cost and return analysis: The higher gross return of Tk.564050 ha^{-1} was found in alternate pattern. The gross margin was substantially higher in the alternate pattern Tk.229484 ha^{-1} than that of the existing pattern Tk.114420 ha^{-1}. The higher gross margin of the alternate pattern was achieved mainly due to inclusion a new crop and higher yield advantages of component crops.

Farmer's opinion

Farmers are very much happy to get additional yield of summer onion from the fallow period of that location. The bulb yield of BARI Piaz-5 was satisfactory and easily fit in three crops cropping pattern. After harvest of Wheat, short duration high yielding BARI Piaz-5 can easily be grown which doesn't hamper or delay the Aman cultivation.

Table 2. Yield and economic performance of alternate cropping pattern Wheat-Summer onion -T. Aman rice cropping pattern and existing cropping pattern Wheat-Fallow-T. Aman at Raniganj, Dinajpur during 2020-21

Observations	Alternate cropping pattern			Existing cropping pattern		
Crop	Wheat	Onion	T. Aman rice	Wheat	Fallow	T. Aman rice
Grain yield (t ha^{-1})	4.25	20	5.97	4.48	-	4.75
Straw yield (t ha^{-1})	5.90	-	5.25	6.15	-	5.35
REY (t ha^{-1})	4.98	17	6.23	5.23	-	5.01
Gross return (Tk. ha^{-1})	99400	340000	124650	104710	-	100350
TVC (Tk. ha^{-1})	45540	240550	48476	45540	-	45100
Gross margin (Tk. ha^{-1})	53860	99450	76174	59170		55250
Whole pattern REY (t ha^{-1})	28.21			10.24		
Whole pattern GR (Tk. ha^{-1})	564050			205060		
Whole pattern TVC (Tk. ha^{-1})	334566			90640		
Whole pattern GM (Tk. ha^{-1})	229484			114420		
MBCR	1.48					

Unit price (Tk. kg^{-1}) : Wheat = 22.00, BARI Piaz-5= 17.00, BRRI dhan87= 20.00 and Swarna = 20.00, straw of Rice, and Wheat = 1.00

Conclusion

The improved cropping pattern Wheat-Summer onion-T. Aman could be suitable but final recommendation may be drawn after completion of second cycle.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN BORO-T. AMAN-MUSTARD AGAINST BORO-T. AMAN-FALLOW IN FARIDPUR

S. AHMED AND A. F. M. R. QUDDUS

Abstract

A trial was conducted at FSRD site, Faridpur started during rabi 2021 with alternate cropping pattern Boro-T.Aman-Mustard against existing cropping pattern Boro-T.Aman-Fallow to increase yield and economic. The trial field belongs to the agro-ecological zone of Low Ganges River Floodplain Soil (AEZ # 12). Boro-T.Aman/Mustard var. BRRI dhan89, BRRI dhan75 and BARI Sarisha-14 were given as the improved variety in the alternate pattern whereas; the varieties of the existing cropping pattern were BRRI dhan28 and BRRI dhan39. The product yield of Boro, T.Aman and mustard was 7.21, 4.51 and 0.55 t ha^{-1} while in existing pattern boro and T. Aman yield was 5.65 and 4.17 t ha^{-1}, respectively. Alternate cropping pattern gave higher rice equivalent yield (REY) (15.64 $t^{-1}ha^{-1}yr^{-1}$) against existing cropping pattern (11.58 $t^{-1}ha^{-1}yr^{-1}$). Higher rice equivalent yield (35% over existing pattern) was obtained in alternate cropping pattern due to inclusion of mustard. The production efficiency was slightly higher (1.82%) in existing cropping pattern due to the lower yield of relay mustard. The seed yield of mustard lower for cyclone "Jawad" (6-7 December, 2021). The higher gross return (Tk.429940ha^{-1}) and gross margin (Tk.150100ha^{-1}) were obtained in alternate Boro-T.Aman-Mustard cropping pattern and lower gross return (To318570 ha^{-1}) in existing cropping pattern: Boro-T.Aman-Fallow. The MBCR of alternate cropping pattern was 2.41 over existing cropping pattern.

Introduction

One of the major cropping pattern is practiced by farmers' in medium highland of Faridpur region is Boro-T.Aman-Fallow. This pattern covers 18790 ha of land which is 13% of total cropping pattern practiced in Faridpur. After harvest of *T.Aman* and before going to transplanting Boro rice, around 80-85 days remains fallow. To increase the cropping intensity, this fallow period might be utilized by inclusion of any short duration crop like mustard. BARI released mustard var. BARI Sarisha-14 is a high value oil crop might be introduced after T. Aman harvesting without hampering the existing cropping sequence. Again, the productivity of existing pattern is low due to local varieties and poor management practices. However, introducing modern variety and improved technology of Boro and *T.Aman* offered the opportunity to overcome the situation. Hence, the trial was conducted with alternate cropping pattern Boro-T.Aman-Mustard against existing cropping pattern Boro-T.Aman-Fallow to increase yield and economic return.

Materials and Methods

On-farm trial was conducted at the FSRD site, Faridpur started during the *rabi* 2021 with alternate cropping pattern: Boro-T.Aman-Mustard against existing cropping pattern Boro-T. Aman-Fallow to increase yield and economic return through rice based cropping system. The trial field was belongs to the agro-ecological zone (AEZ# 12) of Low Ganges River Floodplain Soil. Boro-T.Aman-Mustard var. BRRI dhan89, BRRI dhan75 and BARI Sarisha-14 were given as the improved variety in the alternate pattern, whereas the varieties of the existing cropping pattern were BRRI dhan28 and BRRI dhan39, respectively. Three farmers have been selected as dispersed replications covering a total of 120 decimals of land. The crop cycle was started with the Boro rice for alternate and existing cropping pattern at rabi season. The crop management practices from first cycle of alternate cropping pattern were stated in Table 1.

Data on yield along with other parameters were collected and subjected to mathematical analysis. Agronomic performance like field duration, production efficiency and rice equivalent yield of cropping patterns were calculated. Cost and return analysis were done on the basis of prevailing market price of the commodities for gross return and marginal benefit cost ratio (MBCR). Production efficiency value in terms of kg ha^{-1}/day was calculated by total main product in a cropping pattern divided by total duration of crops in that pattern (Tomar and Tiwari, 1990).

Cost an return analysis was done for gross return, gross margin and marginal benefit cost ratio was calculated on the basis of prevailing market price of the produces. Economic analysis involved collection of data on prices and quantities of inputs used and output produced. The inputs used included seed, fertilizer, labour and insecticides. The output and inputs were valued at market prices. MBCR of the farmer's prevalent pattern and any replacement for it can be computed as the marginal value product ((MVP) over the marginal value cost (MVC). The Marginal of prevalent pattern (F) and any potential replacement (E) for it was computed as (CIMMYT, 1988).

Table 1. Management practices followed in alternate and existing cropping pattern at the FSRD site, Faridpur during 2021-22

Parameters	Alternate cropping Pattern			Existing cropping pattern		
Crop	Boro	T.Aman	Mustard	Boro	T.Aman	Fallow
Variety	BRRI dhan89	BRRI dhan75	BARI Sarisha-14	BRRI dhan28	BRRI dhan39	--
Seed rate (kg ha^{-1})	50	50	10	50	50	--
Spacing	20 cm x 15 cm	20 cm x 15 cm	Broadcast	20 cm x 20 cm	20 cm x 20 cm	--
Fertilizer dose (kg ha^{-1})	$N_{160}P_{25}K_{50}S_{12}$ Zn_2B_0	$N_{80}P_{16}K_{40}S_9$ $Zn_{1.2}B_0$	$N_{120}P_{36}K_{40}S_{15}$ Zn_2 B_1	$N_{130}P_{30}K_{50}S_{22}$ $Zn_{2.7}B_{1.3}$	$N_{120}P_{25}K_{40}$ $S_{22}Zn_2B_1$	--
N Top dress (DAT/DAS)	9, 25-30, 50-55 DAT	11-14, 29-35, 47-52 DAT	28 DAS	9, 25-30, 50-55 DAT	11-14, 29-35, 47-52 DAT	--
Date of planting/sowing	2-6 Feb. 21	10-16 Jul. 21	28 Oct. 21	2-6 Feb. 21	10-16 Jul. 21	--
Seedling age (days)	48-50	25-28	--	48-50	25-28	--
Irrigation (no.)	7	3	2	7	3	--
Weeding (no.)	2	2	1	2	2	--
Date of harvesting	16-20 May 2021	3-7 October 2021	2 January 2021	12-18 May 2021	12-17 October 2021	--
Field duration (day)	104	84-86	67	100-102	95-100	--

Result and Discussions

Yield performance: Yield performance in alternate cropping pattern and existing pattern were presented in Table 2. The product yield of different three crops in alternate cropping pattern of Boro, T.Aman and mustard was7.21, 4.51 and 0.55 tha^{-1} while in existing pattern 5.65 and 4.17 tha^{-1}, respectively (Table 2). Alternate cropping pattern gave higher rice equivalent yield (REY) (15.64 t^{-1}ha $^{-1}$yr^{-1}) against existing cropping pattern (11.58 t^{-1}ha^{-1}yr^{-1}). Higher rice equivalent yield was obtained in alternate cropping pattern due to introduction of mustard and varieties. REY was found to increase 35% over existing cropping sequence. Existing cropping pattern required in an average 202 days field duration and alternate cropping pattern required 257 days (excluding seedling age of rice) to complete the cycle. The production efficiency was slightly higher (1.82%) in existing cropping pattern due to might be lower field duration for fallow practice. Result indicated that short duration mustard (var. BARI Sarisha-14) could easily be fitted in the existing cropping pattern.

Economics of system productivity of three crop sequences in alternate cropping pattern and two crop sequences in existing cropping pattern revealed that the gross return was different for different cropping patterns. The higher gross return (Tk.429940ha^{-1}) and gross margin (Tk.150100 ha^{-1}) were obtained in alternate Boro-T. Aman-Mustard cropping pattern and lower gross return (Tk. 318570 ha^{-1}) was found in existing cropping pattern: Boro-T.Aman-Fallow. The MBCR of alternate cropping pattern was 2.41 over existing cropping pattern.

Farmers opinion

Farmers were happy to get higher income from alternate cropping pattern over existing cropping pattern.

Table 2. Yield and economics of improved and farmer's existing cropping pattern in Faridpurduring 2021-22

Parameters	Alternate cropping pattern			Existing cropping pattern		
Crop	Boro	T.Aman	Mustard	Boro	T.Aman	Fallow
Grain/seed yield (t ha^{-1})	7.21	4.51	0.55	5.65	4.17	
Straw/Stover yield (t ha^{-1})	5.81	3.88	--	3.75	3.72	
Gross return (Tk ha^{-1})	233135	147305	49500	192000	126570	
TVC (Tk ha^{-1})	129725	108282	41890	125135	108485	
Gross margin (Tk ha^{-1})	103410	39023	7610	66865	18085	
REY for individual crop	8.48	5.36	1.80	6.98	4.60	
Whole pattern REY (t ha^{-1})	15.64			11.58		
PE (kg ha^{-1}day^{-1})	47.74			48.61		
Whole pattern GR (Tk ha^{-1})	429940			318570		
Whole pattern TVC (Tk ha^{-1})	279897			233620		
Whole pattern GM (Tk ha^{-1})	150100			84950		
MBCR	2.41					

Price of output (Tk kg^{-1}): Alternate cropping pattern: rice: 27.50, rice straw: 6.00, mustard: 90.00
Existing cropping pattern:v Bororice: 30.00, Aman: 25.00, rice straw: 6.00Price of input (Tk kg^{-1}): Urea- 16.00, DAP-15.00, MoP-15.00, Gypsum-10.00, Boron-250.00, Zn-200.00, GR= Gross return, GM= Gross margin

Conclusion

The rice equivalent yield was increased 35% in Boro-T. Aman-Mustard cropping pattern over existing pattern through inclusion of new crop and varieties. The MBCR (2.41) of alternate pattern over existing cropping pattern was also promising. However, it is the results of one year (one cycle), for concrete decisions, the trial is needed to be repeated for next one year/cycle.

DEVELOPMENT OF EXISTING CROPPING PATTERN MUSTARD-SESAME-T. AMAN AT FARIDPUR

A. F. M. R. QUDDUS AND S. AHMED

Abstract

A trial was conducted at FSRD site, Faridpur started during Kharif I 2021 with sesame to improve the existing cropping pattern: Mustard-Sesame-T.Aman to increase yield and economic return. The trial field belongs to the agro-ecological zone (AEZ # 12) of Low Ganges River Floodplain Soil. Mustard-Sesame -T.Aman VAR. BARI Sarisha-18, BARI Til-4 and BRRI dhan75 were given as the improved variety whereas, the varieties of the same cropping pattern are BARI Sarisha-14, local and Binadhan-7. The crop cycle was started with the sesame at Kharif- I season. The product yield of different three crops in improved cropping pattern of sesame, T. Aman and mustard was 1.59, 5.21 and 1.83 t ha^{-1} while in existing pattern 1.41, 4.29, 1.37 t ha^{-1}, respectively. REY was found to increase 21% over existing cropping sequence. Existing cropping pattern required an average 283 days field duration and improved cropping pattern required 292 days (excluding seedling age of rice) to complete the cycle. The production efficiency was increased near about 18.29 % over existing cropping sequence. The higher gross return (Tk.443372 ha^{-1}) and gross margin (Tk. 220412

ha^{-1}) were obtained in improved Mustard-Sesame-T.Aman cropping pattern and lower gross return (Tk151443 ha^{-1}) was found in existing cropping pattern. The MBCR of improved cropping pattern was 8.20 over existing cropping pattern.

Introduction

In Faridpur district, about 13.5 thousand hectares of land comprising 9% of cultivable area is under oil based cropping pattern like Mustard-Jute-Fallow and Groundnut-Fallow-Fallow. In recent years, price of oil is increasing as a result oil crop area is increasing. During 2019-20, 2020-21 and 2021-22 mustard area was 8300 , 8800 and 8900 ha, respectively. Farmers normally cultivate Mustard, sesame and T. Aman with their local variety/cultivar like BARI Sarisha-14, local black coated seed of sesame and Binadhan-7, respectively. BARI and BRRI has developed BARI Sarisha-18 & BARI Til-4 and BRRI dhan75 can be easily fit in the farmers existing cropping pattern: Mustard-Sesame-T.Aman cropping pattern. This improved pattern is undoubtedly being highly productive and economically profitable. Hence, the trial was conducted to improve the existing cropping pattern, increase yield and economic return through rice-based cropping system.

Materials and Methods

The trial was conducted at FSRD site, Faridpur started during Kharif I. The trial field belongs to the agro-ecological zone(AEZ# 12) of Low Ganges River Floodplain Soil). Mustard-Sesame - T.Aman var. BARI Sarisha-18, BARI Til-4 and BRRI dhan75 were given as the improved variety whereas, the varieties of the same cropping pattern were BARI Sarisha-14, local and Binadhan-7. Three farmers have been selected as dispersed replications covering a total of 100 decimals of land. The crop cycle was started with the sesame at Kharif- I season. The crop management practices from first cycle of improved and existing cropping pattern are shown in Table 1.

Data on yield along with other parameters were collected and subjected to mathematical analysis. Agronomic performance like field duration, production efficiency and rice equivalent yield of cropping patterns were calculated. Cost and return analysis was done on the basis of prevailing market price of the commodities for gross return and marginal benefit cost ratio (MBCR). Production efficiency value in terms of kg ha^{-1}/day was calculated by total main product in a cropping pattern divided by total duration of crops in that pattern (Tomar and Tiwari, 1990).

Table 1. Crop management practices followed in Mustard-Sesame- T.Aman cropping pattern and existing cropping pattern at the FSRD site, Faridpur during 2021-22.

Parameters	Improved Cropping Pattern			Existing Cropping Pattern		
Crop	Sesame	T.Aman	Mustard	Sesame	T.Aman	Mustard
Variety	BARI Til-4	BRRI dhan75	BARI Sarisha-18	Local	BRRI dhan39	BARI Sarisha-14
Fertilizer dose (kg ha^{-1})	$N_{100}P_{40}K_{40}S_{20}Zn_3B_2$	$N_{80}P_{16}K_{40}S_9Zn_1B_0$	$N_{120}P_{36}K_{40}S_{15}Zn_2B_1$	$N_{37}P_{20}K_{25}S_{15}Zn_0B_{1.7}$	$N_{120}P_{25}K40S_{22}Zn_2B_1$	$N_{120}P_{36}K_{40}S_{15}Zn_2B_1$
Date of sowing	22-23 Mar. 21	22 Jul. 21	25 Nov. 21	22 Mar. 21	22 Jul. 21	25 Nov. 21
Date of planting	--	12 Aug 2021	--	--	11 Aug 2021	--
Date of harvesting	17-21 Jun. 21 (87-90 DAS)	16 Nov. 21 (96 DAT)	8 Mar. 22 (103 DAS)	21 Jun. 2021 (91 DAS)	17 Nov. 21 (98 DAT)	24 Feb. 22 (91 DAS)
Field duration (days)	88-91	97	104	92	99	92
Turnaround time (days)	--	51-55	8	--	50	7

Result and Discussions

Yield performance: Yield performance of improved cropping pattern and existing pattern were presented in Table 2. The product yield in improved cropping pattern of sesame, T.Aman and mustard was1.59, 5.21 and 1.83 t ha^{-1} while in existing pattern 1.41, 4.29, 1.37 t ha^{-1}, respectively (Table2). Improved cropping pattern gave higher rice equivalent yield (REY) (17.73 tha^{-1}) against existing cropping pattern (14.60 tha^{-1}). Higher rice equivalent yield was obtained in improved cropping pattern due to introduction of new varieties. REY was found to increase 21% over existing cropping sequence. Existing cropping pattern required in an average 283 days field duration and improved cropping pattern required 292 days (excluding seedling age of rice) to complete the cycle. The production efficiency was increased near about 18.30 % over existing cropping sequence.

Cost and return: The details of economic analysis of cropping patters are presented in Table 2. Economics of system productivity of three crop sequences revealed that the gross return was different for different cropping patterns. The higher gross return (Tk .443372 ha^{-1}) and gross margin (Tk.220412 ha^{-1}) were obtained in improved Mustard-Sesame-T.Aman cropping pattern and lower gross return (Tk.151443 ha^{-1}) was found in existing cropping pattern. The MBCR of improved cropping pattern was 8.20 over existing cropping pattern.

Farmer's opinion

Farmers were happy to get higher income from improved cropping pattern over existing cropping pattern.

Table 2. Yield and economics of improved and farmer's existing cropping pattern at Faridpur during 2021-22.

Parameters	improved cropping pattern			Existing cropping pattern		
Crop	Sesame	T. Aman	Mustard	Sesame	T. Aman	Mustard
Grain/seed yield (t ha^{-1})	1.59	5.21	1.83	1.41	4.29	1.37
Straw/Stover yield/(t ha^{-1})	--	4.34	3.02	--	3.61	1.64
Gross return ($Tkha^{-1}$)	111860	156290	175222	105900	128910	130013
TVC ($Tkha^{-1}$)	64470	99410	59080	58640	100660	54080
Gross margin ($Tkha^{-1}$)	47390	56880	116142	47260	28250	75933
REY for individual crop	4.47	6.25	7.01	4.24	5.16	5.2
Whole pattern REY (t ha^{-1})	17.73			14.6		
PE (kg $ha^{-1}day^{-1}$)	29.55			24.98		
Whole pattern GR (Tk ha^{-1})	443372			364823		
Whole pattern TVC (Tk ha^{-1})	222960			213380		
Whole pattern GM (Tk ha^{-1})	220412			151443		
MBCR	4.45					

Price (Tk kg^{-1}): Improved pattern: Sesame: 70/-, rice: 25/-, rice straw: 6/-, Mustard: 92.50, stover: 2/-
Existing pattern**:** Sesame: 75/-, rice:25/-, rice straw:6/- Mustard:92.50 and stover:2/-

Conclusion

The rice equivalent yield and production efficiency was increased 21 and 18% from the Mustard-Sesame-T.Aman cropping pattern through inclusion of new varieties. The MBCR (8.20) of improved pattern over existing cropping pattern was also promising. However, it is the results of one year (one cycle), for concrete decision, the trial is needed to be repeated for next one year.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN SUNFLOWER-JUTE-T. AMAN AGAINST EXISTING CROPPING PATTERN LENTIL-JUTE-T. AMAN AT FARIDPUR

S. AHMED AND A. F. M. R. QUDDUS

Abstract

A trial was conducted at the FSRD site, Faridpur started during Kharif I 2021 with alternate cropping pattern Sunflower-Jute-T.Aman against existing cropping pattern Lentil-Jute-T.Aman to increase yield and economic return through rice based cropping system. The trial field belongs to the agro-ecological zone (AEZ # 12) of Low Ganges River Floodplain Soil Sunflower-Jute -T.Aman var. BARI Surjomukhi-2, JRO 524 and BRRI dhan75 were given as the improved variety in the alternate pattern whereas, the varieties of the existing cropping pattern were BARI Masur-8, JRO 524 and Binadhan-7. The crop cycle was started with the jute at Kharif I season. The product yield in alternate cropping pattern of jute, T.Aman and sunflower was 2.96, 5.30, 2.15 t ha^{-1} while in existing pattern 2.80, 4.65, 1.58 t ha^{-1}, respectively. REY was found to increase 20% over existing cropping sequence. Existing cropping pattern required in an average 323 days field duration and alternate cropping pattern required 325 days (excluding seedling age of rice) to complete the cycle. The production efficiency was increased near about 15% % over existing cropping pattern. The higher gross return (Tk.609790 ha^{-1}) and gross margin (Tk.281712 ha^{-1}) were obtained in alternate Sunflower-Jute-T.Aman cropping pattern and lower gross return (Tk. 509690 ha^{-1}) was found in existing cropping pattern Lentil-Jute-T.Aman. The MBCR of alternate cropping pattern was 3.35 over existing cropping pattern.

Introduction

In Faridpur district, about 13.5 thousand hectares of land comprising 9% of cultivable area is under oil based cropping pattern like Mustard-Jute-Fallow and Groundnut-Fallow-Fallow. In recent years, price of oil is increasing as a result oil crop area is increasing. About 23% areas is under pulse based cropping pattern (grass pea, black gram and lentil). In some places of Faridpur, Sunflower is cultivating instead of pulse and about 32 ha of land during 2021-22 are under Sunflower-Jute-T.Aman cropping pattern. Farmers normally cultivate lentil, jute and T.Aman with their local HYV variety/cultivar like BARI Masur-3, JRO-524 and Binadhan-7. BARI and BRRI has developed BARI Surjomukhi-2 and BRRI dhan75 can be easily fit in the farmers existing cropping pattern: Lentil-Jute-T.Aman cropping pattern. This alternate pattern is undoubtedly being highly productive and economically profitable. Hence, the trial was conducted with alternate cropping pattern Sunflower-Jute-T.Aman against existing cropping pattern Lentil-Jute-T.Aman to increase yield and economic return through rice based cropping system.

Materials and Methods

On-farm trial was conducted at the FSRD site, Faridpur started during KharifI 2021with alternate cropping pattern Sunflower-Jute-T.Aman against existing cropping pattern Lentil-Jute-T.Aman to increase yield and economic return through rice based cropping system. The trial field belongs to the agro-ecological zone (AEZ # 12) of Low Ganges River Floodplain Soil Sunflower-Jute-T. Aman var. BARI Surjomukhi-2, JRO 524 and BRRI dhan75 were given as the improved variety in the alternate pattern whereas, the varieties of the existing cropping pattern were BARI Masur-3, JRO 524 and Binadhan-7. Three farmers have been selected as dispersed replications covering a total of 100 decimals of land. The crop cycle was started with the jute for alternate and existing cropping pattern at Kharif I season. In rabi season, lentil was alternated with sunflower crop.

The crop management practices from first cycle of alternate cropping pattern are stated in Table 1. Data on yield along with other parameters were collected and subjected to mathematical analysis. Agronomic performance like field duration, production efficiency and rice equivalent yield of cropping patterns were calculated. Cost and return analysis were done on the basis of prevailing market price of the commodities for gross return and marginal benefit cost ratio

(MBCR).Production efficiency value in terms of kg ha^{-1}/day was calculated by total main product in a cropping pattern divided by total duration of crops in that pattern (Tomar and Tiwari, 1990).

Table 1. Crop management practices followed in alternate cropping pattern Jute-T.Aman-Sunflower and existing cropping pattern Jute-T.Aman-Lentil at the FSRD site Faridpur during 2021-22

Parameters	Alternate cropping Pattern			Existing cropping pattern		
Crop	Jute	T.Aman	Sunflower	Jute	T.Aman	Lentil
Variety	JRO-524	BRRI dhan75	BARI Surjomukhi-2	JRO-524	Binadhan-7	BARI Masur-3
Seed rate (kg ha^{-1})	7	50	10	7	50	40
Fertilizer dose (kg ha^{-1})	$N_{50}P_{30}K_{50}$	$N_{80}P_{16}K_{40}S_9Zn_1B_0$	$N_{87}P_{34}K_{80}S_{29}Zn_4B_2$	$N_{95}P_{20}K_{50}$	$N_{120}P_{25}K_{40}S_{22}Zn_2B_1$	$N_{36}P_{20}K_{35}S_0Zn_{1.8}B_1$
Date of sowing	02 Apr. 2021	19 July 2021	27 Nov. 2021	02 Apr. 2021	19 July 2021	24 Nov. 2021
Date of planting	--	08 Aug. 021	--	--	07 Aug.2021	--
Date of harvesting	20 July 2021	6 Nov. 2021	27 Mar 2022	17 July 2021	14 Nov.2021	20 Feb. 2022
Field duration (days)	110	91	124	107	99	117
Turnaround time (days)	--	18	20	--	20	9

Result and Discussions

Yield performance: Yield performance in alternate cropping pattern and existing pattern were presented in Table 2. The product yield of different three crops in alternate cropping pattern of jute, T.Aman and sunflower was2.96, 5.30, 2.15t ha^{-1} while in existing pattern 2.80, 4.65, 1.58 t ha^{-1}, respectively (Table 2). Alternatecropping pattern gave higher rice equivalent yield (REY) (24.39t ha^{-1}/yr.) against existing cropping pattern (20.39t ha^{-1}/yr.). Higher rice equivalent yield was obtained in alternate cropping pattern due to introduction of new crop (sunflower) and varieties. REY was found to increase 20% over existing cropping sequence. Existing cropping pattern required in an average 323 days field duration and alternate cropping pattern required 325 days (excluding seedling age of rice) to complete the cycle. The production efficiency was increased near about 15%%over existing cropping pattern. Result indicated that long durated sunflower (var.BARI Surjamukhi-2) could easily be fitted in the existing cropping pattern.

Cost and return: The details of economic analysis of cropping patters are presented in Table 2. Economics of system productivity of three crop sequences revealed that the gross return was different for different cropping patterns. The higher gross return (Tk.609790 ha^{-1}) and gross margin (Tk.281712 ha^{-1}) were obtained in alternate Sunflower-Jute-T. Aman cropping pattern and lower gross return (Tk. 509690 ha^{-1}) was found in existing cropping pattern: Lentil-Jute-T. Aman. The MBCR of alternate cropping pattern was 3.35 over existing cropping pattern.

Farmers were happy to get higher income from alternate cropping pattern over existing cropping pattern.

Table 2. Yield and economic performance of improved cropping pattern Jute-T.Aman-Sunflower and existing cropping pattern Jute-T.Aman-Lentil at the FSRD site Faridpur, 2021-22

Parameters	Alternate cropping pattern			Existing cropping pattern		
Crop	Jute	T.Aman	Sunflower	Jute	T.Aman	Lentil
Grain/Fibre yield (t ha^{-1})	2.96	5.3	2.15	2.80	4.65	1.58
Straw/Stover/stick yield/(t ha^{-1})	4.67	4.33	--	4.58	3.97	0.92
Gross return (Tk ha^{-1})	236010	158480	215300	223740	140070	145880
TVC (Tk ha^{-1})	137670	99410	90998	138406	100660	59158
Gross margin (Tk ha^{-1})	98340	59070	124302	85334	39410	86722

Parameters	Alternate cropping pattern			Existing cropping pattern		
Crop	Jute	T.Aman	Sunflower	Jute	T.Aman	Lentil
REY for individual crop	9.44	6.34	8.61	8.95	5.60	5.84
Whole pattern REY (t ha^{-1})	24.39			20.39		
PE (kg$ha^{-1}day^{-1}$)	32.04			27.96		
Whole pattern GR (Tk ha^{-1})	609790			509690		
Whole pattern TVC (Tk ha^{-1})	328078			298224		
Whole pattern GM (Tk ha^{-1})	281712			211466		
MBCR	3.35					

Price of output (Tk kg^{-1}): Jute: 75.00, stick: 3.00, rice: 25.00, rice straw: 6.00, Sunflower: 100 , lentil: 90.00, stover: 4.00

Conclusion

The rice equivalent yield and production efficiency was increased 20 and 15%, respectively in Sunflower-Jute-T.Aman rice cropping pattern over existing pattern through inclusion of new crop and varieties. The MBCR (3.35) of alternate pattern over existing cropping pattern was also promising. However, it is the results of one year result, for concrete decisions the trial is needed to be repeated for next one year.

DEVELOPMENT OF MUSTARD-SESAME-T. AMAN CROPPING PATTERN AGAINST BORO-FALLOW-T. AMAN IN ACTIVE BRAHMAPUTRA JAMUNA FLOODPLAIN OF GAIBANDHA

M. J. ALAM AND A. A. MAHMUD

Abstract

The experiment was conducted at Kamolpur, Saghata, Gaibandha under On-Farm Research Division during 2021-22 to increase the cropping intensity and productivity by introducing short duration mustard in rice-based cropping patterns. Alternate cropping patterns were agronomically and economically profitable than the existing patterns. The system productivity based on rice equivalent yield (RYE) in the alternate cropping pattern was 18.18 t ha^{-1}, which was 58% higher than that of the existing cropping pattern (11.51 t ha^{-1}). The gross return from the alternate cropping pattern was Tk. 363600 ha^{-1}, 58% more compared to the existing cropping pattern with a value of Tk. 230200 ha^{-1}. Similarly, the higher gross margin was recorded from the alternate cropping pattern (Tk. 123600 ha^{-1}) or 70% higher than the existing cropping pattern (Tk. 72700 ha^{-1}). Finally, the marginal benefit-cost ratio (MBCR) of the whole cropping pattern was 1.62 over the existing cropping pattern. Replacement of Boro rice, as well as the inclusion of oilseed crops (sesame and mustard) in the existing cropping system using modern improved varieties, has resulted in increased productivity and profitability.

Introduction

Bangladesh must spend a huge amount of foreign exchange on the import of edible oil and oilseeds to meet the growing demand of the population. Due to inadequate domestic production in recent times, Bangladesh is dependent on imports to meet the demand for oil. However, the area under rapeseed and mustard has started increasing since 2010 (Miah et al., 2014). Recently, the Government of Bangladesh has given due importance to the research and development of oilseed crops to achieve self-sufficiency in edible oil. BARI and BINA have released several improved varieties of different oil crops (mustard, groundnut, sesame, soybean, linseed) and the adoption rate of these improved varieties at the field level is more encouraging (Miah et al., 2015b; Miah et al., 2015c) and positive effects as well as saving foreign exchange for the country (Miah et al., 2015a). Therefore, there is a need to increase per unit production by increasing yield thorough cropping system intensification. These could be achieved by improving the existing cropping pattern including the short duration of Aman rice, mustard, sesame etc. in the existing cropping pattern. Considering this, the existing crop cropping pattern (Boro-Fallow-T. Aman) was improved with an alternate cropping pattern (Mustard-Sesame-T.Aman) to increase the cropping intensity and productivity by integrating short-term mustard in rice-based cropping patterns.

Materials and Methods

The experiment was conducted at Saghata, Gaibandha of the On-Farm Research Division (OFRD), BARI, Gaibandha during 2021-22. A three crop-based alternative cropping pattern Sesame-T. Aman-Mustrad cropping pattern with their existing Boro-Fallow-T. Aman cropping pattern was tested. The plot size was 1 ha. Recommended fertilizer package (FRG, 2018) along with the application methods were done to support the normal growth of the crops. Agronomic performance like field duration and rice equivalent yield of cropping patterns was calculated. Economic analysis was done on the basis of the prevailing market price of the commodities. Details of the crop management of existing and alternate cropping patterns are shown in Table 1.

Results and Discussion

Yield and System productivity: In 2021-22, Boro and T. Aman rice yield were 5.51 and 5.29 t ha^{-1} in the existing (Boro-Fallow-T. Aman) cropping pattern. On the contrary, the yield of sesame, T. Aman, and mustard was 1.35, 4.79, and 1.87 t ha^{-1} in, respectively in the alternate (Sesame-T. Aman-Mustard) cropping pattern. In terms of system rice equivalent yield (REY) the higher value was observed in the alternate cropping pattern (18.18 t ha^{-1}), 58% more than that of the existing cropping pattern (11.51 t ha^{-1}). The reason was mainly due to the inclusion of sesame and mustard in the existing cropping pattern instead of Boro rice which plays a crucial role in increasing the total system yield.

Cost and return analysis: The gross return from the alternative cropping pattern was Tk. 363600 ha^{-1}, which was 58% higher than the existing cropping pattern (Tk. 230200 ha^{-1}). Similarly, a higher gross margin has been recorded from the alternative cropping pattern (Tk. 143600 ha^{-1}) which is 97% more than the existing cropping pattern (Tk. 72700 ha^{-1}). Finally, the marginal benefit-cost ratio (MBCR) of the whole cropping pattern was 2.13 over the existing cropping pattern. Due to high market prices of sesame and mustard, gross return, as well as gross margin, was found higher in the alternative crop pattern.

Farmers' opinion

At first the farmers were confused about growing of three crops a year on their land. However, now they are very much encouraged to grow three crop-based patterns which may encourage them to increase productivity and profitability.

Table 1. Details of the crop management of existing and alternate cropping patterns at Saghata, Gaibandha during 2021-22

Observations	Existing cropping pattern			Alternate cropping pattern		
Crop	Boro	Fallow	T. Aman	Sesame	T.aman	Mustard
Variety	BRRI dhan28	-	GutiSwarna	BARI Til-4	BRRIdhan87	BARI Sarisha-14
Spacing (cm)	20 x 15	-	20 x 15	30 x5	20 x 15	Row to row 30 cm
	-	-	-			
Fertilizer dose (NPKSZnB kg ha^{-1})	120-20-45-15-1-0	-	135-25-20-8-0-0	50-30-25-20-1-1	80-20-50-10-1-1	100-30-40-25-1-1
Date of sowing/ transplanting	20-25 January	-	15-20 July	15-20 Feb. 2021	15-20 July 2021	2-4 November 2021
Harvesting date	1-5 May	-	18-23 November	20-25 May 2021	25-26 October 2021	20-25 January 2022
Field duration	100	-	125	98	102	80
Turnaround time	75	-	65	50	8	27

Table 2. Yield and cost and return analysis of existing and alternate cropping patterns at Saghata, Gaibandha during 2021-2022

Observations	Existing cropping pattern			Alternate cropping pattern		
Crop	Boro	Fallow	T. Aman	Sesame	T.aman	Mustard
Grain/ seed yield (tha^{-1})	5.51	-	5.29	1.35	4.79	1.87
Straw or stover yield (tha^{-1})	7.55	-	6.65	-	6.11	-
Whole pattern REY (tha^{-1})	11.51			18.18		
Whole pattern GR (Tk. ha^{-1})	230200			363600		
Whole pattern TVC (Tk. ha^{-1})	157500			220000		
Whole pattern GM (Tk. ha^{-1})	72700			143600		
MBCR	2.13					

*Price (Tk. kg^{-1}): Urea- 16, TSP- 25, MP- 15, Gypsum- 9, Zinc Sulphate- 130, Boric acid- 140, Rice grain- 20, Rice straw- 1.0, Sesame- 100 and Mustard -75; REY: rice equivalent yield, MBCR: marginal benefit cost ratio.

Conclusion

In economic point of view, improved cropping pattern including oilseed crop mustard and sesame were suitable and profitable practice than the farmers existing cropping pattern. Therefore, this cropping pattern with high yielding varieties of sesame (BARI Til-4) and Mustard (BARI Sairsha-14) could be recommended for large scale extension in the farmer's field at flood prone areas of Gaibanda.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN CAULIFLOWER+ KNOLKHOL-RELAYED POINTED GOURD-T. AUS RICE AGAINST MUSTARD-BORO-FALLOW CROPPING PATTERN

M. K. SHAHADAT, M. H. RASHID, M.K. ISLAM, M. M. RAHMAN AND T. S. MUNMUN

Abstract

An on-farm trial was conducted at MLT site, Satkhira under AEZ-13 to increase cropping intensity and productivity through a four crop-based cropping pattern (T. Aus - Cauliflower + Knolkhol - Relay Pointed Gourd) instead of farmers existing practice of Mustard-Boro-T. Aman. It was observed that four-crop pattern produced the higher rice equivalent yield (REY) (15.59 t ha^{-1}) than farmers practice (12.65 t ha^{-1}). Likewise, production efficiency was also higher in four-crop pattern (113.82 kg ha^{-1}day^{-1}) than farmers practice (70.26 kg ha^{-1}day^{-1}). Four-crop pattern produced higher gross return (Tk. 311880 ha^{-1}) and gross margin (Tk. 163500 ha^{-1}).

Introduction

BARI is trying to convert mono crop land into double-crop land, likewise, double crop to triple crop and triple crop to four crop lands. Three major crop cropping patterns in Satkhira are Boro-Fallow-T. Aman (70500 ha, 51.49%), Boro-Aus-T. Aman (6250 ha, 4.56%) and Mustard-Jute-T. Aman (1900 ha, 1.39%), Mustard-Boro-T. Aman (1500 ha, 1.10%) (DAE, 2021). A number of farmers are shifting from their conventional pattern, Mustard-Boro-T. Aman to Late T. Aus - early cole crops- Relay Pointed gourd pattern. They usually intercrop cauliflower with Knolkhol then before final harvest of these winter crops followed relay pointed gourd for early summer harvest. Farmers can easily cultivate early winter crops like cauliflower, cabbage, kholkhol etc. for earning higher profit. When winter crops are harvested at the beginning of the rabi season, farmers could relay pointed gourd in the same field so that they can harvest pointed gourd at early summer when market price is relatively higher. So, the experiment was conducted in order to get higher market price and system productivity in the existing T. Aman - Mustard - Boro cropping pattern of Satkhira district.

Materials and Methods

On-farm trial of four-crop based cropping pattern has been conducted at farmers' field of Multi-Location Testing Site (MLTs), Satkhira. The four-crop sequence: T. Aus - Cauliflower + Knolkhol - Relay pointed gourd has been introduced against farmers' existing sequence of Mustard- Boro - T. Aman in order to increase cropping intensity, productivity and higher economic return. The trial started from intercropping of cauliflower and knolkhol. There were six farmers having a unit plot size of 33 decimal land per farmer involved with the trial. All the agronomic managements including sowing/transplanting, harvesting, fertilizer, irrigation, weeding etc. were followed according to standard methods (Azad et al., 2017). Recommended fertilizer package (BARC, 2018) along with the prescribed application methods were followed for all the crops. Pest management and other intercultural management practices were done as and when necessary. For economic comparison between two crop sequences, the yield of all crops was converted into price equivalent yield of rice based on the existing market price of individual crops (Ahlawat and Sharma, 1993).

Data on the yield of various crops in sequences were recorded and converted to ton per hectare. The data of farmer's practice was recorded from adjacent farmers' plots. Total system productivity was calculated as the summation of individual (component) crop yield of each cropping cycle. The productivity of crop sequences was compared by calculating their economic rice equivalent yield (REY) using formula given by Ahlawat and Sharma (1993), where

Results and Discussion

Agronomic management, field duration and turnover time: Agronomic management practices involved variety selection, sowing time selection, seed sowing, transplanting, fertilizer and irrigation application, weeding, thinning, disease and pest control etc. Table 1 represents the agronomic management practices followed in both farmer's pattern and four crop-based pattern. Short duration and high yielding varieties were cultivated , *viz*. mustard- BARI Sarisha-14, Boro rice- BRRI dhan28, cauliflower- Local HYV, Kholkhol- Quick Star and pointed gourd-Kanai Banshi.

In existing pattern field duration of mustard and Boro were 81 and 99 days, respectively (180 days) and turn over period between mustard and boro rice was 9. On the other hand, in the improved pattern, field duration of cauliflower and Knolkhol intercrop was 66-71 days, respectively. Where pointed gourd was relayed 20 days before final harvest of knolkhol (Table 1). Harvest of pointed gourd started from 10 March 2022 and continued on till date.

Grain and by-product yield, rice equivalent yield (REY), production and land use efficiency: Both in existing and four-crop pattern rice equivalent yield of mustard, boro, jute and T. Aman were calculated based on their respective yield and existing market price. In the existing pattern rice equivalent yield of mustard and boro were 6.58, 6.07 t ha^{-1}, respectively. Where, the whole pattern REY, production efficiency for existing and improved pattern were 70.26 Kg ha^{-1} day^{-1} (180 days), 113.82 kg ha^{-1} day^{-1} (161 days), respectively. The production efficiency of existing and improved pattern were 49.32 and 37.53%, respectively (Table 2).

Farmers' opinion

Farmers are satisfied with higher return from the four crop based improved pattern. Also expressed have many challenges for cultivating 4 crops in a year at the same land due to uncertain whether events, lack of irrigation water, lack of seeds, labor and credit etc.

Table 1. Agronomic management practices of the crops for existing patterns and four crop based pattern at the MLT site, Satkhira during 2021-2022

Parameters	**Existing cropping pattern**			**Improved pattern**			
Crop	Mustard	Boro	T. Aman	Cauliflower + Knolkhol		Pointed gourd	T. Aus
Variety	BARI Sarisha-14	BRRI dhan28	-	Local (HYV)	Quick Star	Local (Kanai Banshi)	-
Spacing (cm x cm)	30 cm row	20 x15	-	60 cm X 50 cm	30 cm X 20 cm	-	-
Unit plot size (deci)	33	33	-	33	33	33	-
Date of sowing	5 Nov. 21	20 Dec. 21	-	1 Sept. 21	15 Sept. 21	-	-
Seedling age (days)	-	45	-	34	35	-	-
Date of transplanting	-	3Feb. 22	-	5 Oct. 21	20 Oct. 21	10 Dec. 21	-
Fertilizer dose (kg ha-1 N-P-K-S-Zn-B)	90-27-60-15-5-2-0	138-20-83-21-4-0	-	70-30-60-18-0-0.5	70-30-60-18-0-0.5	-	-
Fertilizer application	Basal	Basal & top dress	-	Basal & top dress	Basal & top dress	-	-
Spray	2	4	-	-	-	-	-
Irrigation	2	11	-	4	4	-	-
Harvest date	25-Jan-22	13-May-22	-	10-Dec-21	30-Dec-21	10-Mar-22	-
Field duration (days)	81	99	-	66	71	90	-
Turnaround time (days)	-	9	-	-	-	-	-

Table 2: Average yield and production efficiency of the crops for the existing and four crops based cropping patterns at the MLT site, Satkhira during 2021-2022

Parameters	Existing cropping pattern			Improved cropping pattern			
	Mustard	Boro	T. Aman	Cauliflower +Knolkhol		Pointed gourd	T. Aus
Grain Yield (t ha^{-1})	1.52	5.42	-	24.26	23.56	-	-
By-product yield (t ha^{-1})	2.39	6.48	-	0	0	-	-
R EY (t $ha^{-1}yr^{-1}$)	6.58	6.07	-	9.704	5.89	-	-
Total RE (t $ha^{-1}yr^{-1}$)	12.65			15.59			
Production efficiency (kg ha^{-1} day^{-1})	70.26			113.82			
Land use efficiency (%)	49.32			37.53			

Conclusion

So far, the improved four-crop pattern produced higher yield and income over existing pattern. The final productivity and economic return will be calculated after completing of one cycle.

PERFORMANCE OF SWEET GOURD-KENAF-FALLOW CROPPING PATTERN AGAINST EXISTING CROPPING PATTERN IN HAOR AREAS OF KISHOREGANJ

M. MOHIUDDIN

Abstract

The experiment was conducted in Old Meghna Estuarine Floodplain Soils under the Agro-Ecological Zone (AEZ# 19) at Nunir haor, under the Multi-location Testing Site, Nikli, Kishoreganj, for 2021-22. Two crops pattern: Sweet gourd -Kenaf-Fallow was tested over the existing single crop pattern (Boro rice) after flood water receded. Results showed that the highest rice equivalent yield (14.75 t ha^{-1}) was obtained from two crops pattern. The highest average gross return and gross margin of the two crops pattern were obtained Tk.295010 and Tk. 150190 ha^{-1} which were 98 and 138 % higher over farmers' pattern. Farmers' practice gave the lower gross return (Tk. 148800 ha^{-1}). The marginal benefit cost ratio (MBCR) was found 2.47 which indicated the superiority of two crops pattern over the farmers' existing pattern.

Introduction

The present cropping intensity of Nikli Upazillas of Kishoreganj is only about 112% which is very low where country's cropping intensity 195%. After flood water receded 15-20% land in haor areas is suitable for crop cultivation in last week of September or first week of October. At that time, farmers are waiting for cultivating Boro rice by irrigation with deep tube well up to third week of December to first mid- January. As a result a vast area remains fallow for a long time (about 80 to 90 days) before Boro rice cultivation. So, there is an opportunity to increase cropping intensity and crop productivity. The farmers' of Nikli, Goroi traditionally grow local variety Sweet gourd for vegetable purpose. Introduce a new crop, Sweet gourd in cropping pattern would increase the total productivity. If the farmers' show Sweet gourd seeds by last week of September or first week of October then it will be harvested at mid- January to last week of January. After harvesting of Sweet gourd farmers can easily grow Jute (Kenaf) in its proper growing time which will not be affected by flash flood. Farmers will bear additional cost of Boro rice cultivation and other expanses from income of Sweet gourd and fulfill their nutritional need. The present study was undertaken to develop two crop-based cropping patterns for haor areas and increase cropping intensity, productivity and income of the farmers

Materials and Methods

The study was carried out in 2021-22 at farmer's field, at Nunir haor, Nikli, Kishoreganj (located in Agro Ecological Zone-19) under Old Meghna Estuarine Floodplain Soils. This trial was conducted to derive the economic consequences of two cropping patterns viz. IP: improved pattern (Sweet gourd -Kenaf-Fallow) and FP: farmer's pattern (Fallow-Boro rice-Fallow) through incorporation of high yielding varieties with improved management practices. In the improved pattern, Sweet gourd var. hybrid Dhaka-1 and Kenaf- HC 95were introduced against fallow period and Boro rice var. BRRI dhan29 was used in farmer's pattern, respectively. The agronomic parameters and cultural operation for crop production under improved and farmer's practices are presented in Table 1. All field operation and management practices of both farmer's and improved pattern were closely monitored and the data were recorded for agro-economic performance.

Agronomic performance viz. land use efficiency, production efficiency, rice equivalent yield and benefit cost ratio of cropping patterns were calculated. Land use efficiency is worked out by taking total duration of individual crop in a sequence divided by 365 days (Tomer and Tiwari, 1990). It is calculated by following formula:

Table 1. Agronomic practices of improved cropping pattern Sweet gourd-Kenaf-Fallow and farmers' existing pattern Fallow- Boro--Fallow during 2021-22

Parameter	Improved Pattern (IP)		Farmers' Pattern (FP)
	Sweet gourd	Kenaf	Boro rice
Variety	Hybrid Dhaka-1	HC-95	BRRI dhan29
Sowing/transplanting	30 October 2021	05 March 2022	02 January 2022
Seed rate (kg ha^{-1})	5	15	50
Planting method	Line	Broadcast	Line
Spacing	2m × 2m	Continuous	20cm × 15cm
Seedling/hill	2-3	-	3-4
Fertilizer dose (NPKSZnB kg ha^{-1})	81-35-75-18-5-02	115-40-63-14-0-0	140-18-53-08-03-02

Parameter	Improved Pattern (IP)		Farmers' Pattern (FP)
	Sweet gourd	Kenaf	Boro rice
Weeding (no.)	Four times	Twice at 15-20 and 35-40 DAS	Twice at 15-20 and 35-40 DAT
Irrigation (no.)	5 times	Two times	Several times
Insect/ pest control	IPM	IPM	Chemical
Harvesting time	10- 20 February 2022	09 June 2022	17 April, 2022
Field duration (day)	115	96	106

Results and Discussions

Grain and By-product Yield: Results of improved cropping pattern Sweet gourd-Kenaf-Fallow and the farmer's existing pattern Fallow-Boro rice-Fallow have been presented in Table 2. After first years of the study, the result revealed that fruit yield of sweet gourd (hybrid Dhaka-1) and Kenaf were 1.88 and 2.18 t ha^{-1}, respectively. Grain yield of boro rice in farmers pattern was 7.24 t ha^{-1}. Jute stick yield was found 4.14 t ha^{-1} in first year.

Rice equivalent yield: The mean rice equivalent yield revealed that improved cropping pattern produced higher rice equivalent yield (14.75 t ha^{-1}) over farmers' (7.44 t ha^{-1}) pattern (Table 2). Inclusion of high yielding sweet gourd and Kenaf variety and improve management practices in the improved pattern influenced to increase rice equivalent yield and total productivity increased by 98% compared to farmers' practice. Lower rice equivalent yield was obtained in the farmers' pattern due to traditional management practices.

Production efficiency: Maximum production efficiency (99.18) in terms of kg ha^{-1}/day was obtained from improved cropping pattern followed by farmers pattern (Table 2). The higher production efficiency in two crops pattern might be due to inclusion of high yielding sweet gourd and Kenaf varieties and improved management practices. Similar trend were noted by Nazrul et al. (2013) and Khan et al. (2006).

Land utilization index (LUI): Land utilization index (LUI) is the effective use of land in a cropping year which mostly depends on individual crop duration. It indicated that improved pattern used the land for 58% period of the year, whereas farmers' pattern for 41% period of the year (Table 2). The higher land utilization index in improved pattern because this pattern occupied the field for longest duration (211 days), whereas farmers' pattern occupied the field for 106 days of the year.

Cost and return analysis: The MBCR of improved pattern and rice-based farmers' existing pattern are presented in Table 2. From the economic point of view, the gross return of improved cropping pattern (Tk. 295010 ha^{-1}) showed its superiority by 98% over farmers' existing pattern (Tk.148800 ha^{-1}). The production cost of the improved pattern (Tk. 144820 ha^{-1}) was higher than farmers' pattern (Tk. 85670 ha^{-1}) due to inclusion of sweet gourd and improves management due to extra cost of inputs of the production. The gross margin was substantially higher in the improved pattern (Tk. 150190 ha^{-1}) than farmers' pattern (Tk. 63130 ha^{-1}). The higher gross margin of the improved pattern (138%) was achieved mainly higher yield advantages of the component crops. The mean marginal benefit cost ratio (MBCR) was found 2.47 which indicated the superiority of the improved cropping pattern over the farmers' pattern. The marginal benefit cost ratio (MBCR) also showed that inclusion of sweet gourd and Kenaf in the existing pattern might be profitable and acceptable to the farmers.

Table 2. Yield and cost and return analysis of alternate cropping pattern Sweet gourd-Kenaf-Fallow cropping pattern and existing cropping pattern Fallow-Boro-Fallow at Nikli, Kishoregonj during 2020-21

Observations	Alternate cropping pattern			Existing cropping pattern		
Crop	Sweet gourd	Kenaf	Fallow	Fallow	Boro	Fallow
Grain yield (t ha^{-1})	18.75	2.18	-	-	7.24	-
Straw yield (t ha^{-1})	-	4.14	-	-	4.00	-
Whole pattern REY (t ha^{-1})	14.76			7.44		
PE (kg ha^{-1}day^{-1})	99.18			47.95		
LUI (%)	57.81			41.37		
Whole pattern GR (Tk. ha^{-1})	295010			148800		
Whole patternTVC (Tk. ha^{-1})	144820			85670		
Whole pattern GM (Tk. ha^{-1})	150190			63130		
MBCR	2.47					

Conclusion: It was first year study, final results and recommendation will be given after two years of the study.

IMPROVEMENT OF LENTIL-SESAME-T. AMAN CROPPING PATTERN IN KUSHTIA

J. A. MAHMUD

Abstract

An experiment was conducted at Kushtia sadder Upazillas during 2021-2022 to increase cropping intensity and productivity thorough improved cropping pattern Lentil-Sesame-T.Aman with latest varieties. The varieties: Lentil (BARI Masur-6), Sesame (local), T.Aman (BRRI dhan39) were replaced by Lentil (BARI Masur-8)-Sesame (BARI Til-4)-T.Aman (BRRI dhan75) rice. Gross return and gross margin (Tk. 409663 ha^{-1} and Tk. 244013 ha^{-1}) were higher in improved cropping patter where existing cropping pattern were Tk. 354413 ha^{-1} and Tk. 197863 ha^{-1}.

Introduction

Lentil-Sesame -T.Aman is one of the important cropping patterns in Kushtia. Most of the farmers cultivate BARI Masur-3/6 of lentil, local/BARI Til-3 of sesame and BRRI dhan39 of T.Aman variety which are comparatively lower yielder and susceptible to pests. Recently BARI and BRRI developed new lentil, sesame and T.Aman variety. Replacing the local cultivars with the modern varieties such as BARI Masur-8 for lentil, BARI Til-4 for sesame and BRRI dhan-75 for T.Aman may contribute to 10-20% higher yield over the existing pattern. Hence, the experiment was undertaken in this consideration.

Materials and Methods

The experiment was conducted at farmer's field of Kushtia during 2021-22. The existing three crop sequence T.Aman-Lentil-Sesame has been improved through replacing variety of crops to increase productivity and income of the farmers'. The trial started from T.Aman rice in 2021 and continuing to 2022 involving six farmers' having a unit plot size of 33 decimal land per farmer. The experiment was laid out in RCB design with 6 dispersed replications. The varieties Lentil (BARI Masur-6)-Sesame (Local)-T.Aman (BRRI dhan39) were replaced by Lentil (BARI Masur-8)-Sesame (BARI Til-4)-T.Aman (BRRI dhan75) rice. All agronomic management practices are shown in Table 1. Recommended fertilizer package (FRG, 2018) along with prescribed application methods were followed for all the crops. Pest management and other intercultural management practices were done properly. For cost and return analysis yield of all crops was converted into rice equivalent yield on the prevailing market price of individual crop.

Data on the yield of different crops in patterns were recorded and converted into tonne per hectare. The data of farmers' practice was recorded from adjacent farmers' plots. Total system productivity was calculated as the summation of the individual (component) crop yield of each cropping cycle.

Table 1. Details of the crop management of Improved and existing cropping pattern at Kushtia during 2021-22

Parameters	Improved Cropping Pattern			Existing Cropping Pattern		
Crop	T.Aman	Lentil	Sesame	T.Aman	Lentil	Sesame
Variety	BRRI dhan75	BARI Masur-8	BARI Til-4	BRRI dhan39	BARI Masur-6	Local
Spacing	20 cm× 15 cm	Broadcast	Broadcast	20 cm× 15 cm	Broadcast	Broadcast
Fertilizer dose (NPKSZnB kg ha^{-1})	115-27-44-13-1-0	21-17-17.5-9.36-0-1	55-28-22.5-19-1.8-1.7-0	115-27-44-13-1-0	20-17-17.5-9-0-1	50-25-20-15-0-0
Date of sowing/ transplanting	3-4 Aug. 2021	23-25 Nov. 2021	22-25 Mar. 2022	25-30 Jul. 2021	20-24 Nov. 2021	12-15 Mar. 2022
Weeding (no.)	2	1	1	2	1	1
Date of harvesting	30 Oct. 2021	15-17 Mar. 2022	16-18 Jun. 2022	03-05 Nov. 2021	7-9 Mar. 2022	15-17 Jun. 2022

Results and Discussion

Yield and economic performance of improved and existing cropping patterns during 2021-22 are presented in Table 2.

The yield of T.Aman rice, lentil and sesame were recorded as 4.85, 1.90 and 1.20 t ha^{-1} with rice equivalent yield (REY) 12.20 t ha^{-1} in the improved cropping pattern whereas 4.25,1.60 and 1.05 t ha^{-1} yield of T.Aman rice, lentil and sesame with REY 10.52 t ha^{-1} were recorded in the existing cropping pattern during 2021-22.. The REY was 16 % higher over existing pattern due to replacing variety of crops and improved management practices.

In whole pattern gross return and gross margin were higher in improvement cropping pattern were Tk. 409663 ha^{-1} and Tk. 244013 ha^{-1} than the existing cropping pattern were Tk. 354413 ha^{-1} and Tk. 197863 ha^{-1}, respectively. The MBCR was 6.07 in improved cropping pattern over existing pattern which indicated the superiority of the improved pattern.

Farmers' opinion

Farmers were satisfied with new improved crop varieties. Gross return of improved varieties was more profitable than that of existing varieties. Farmers are interested to grow these new crop varieties instead of older one.

Table 2. Crop performance of improved and existing cropping pattern cropping pattern T.Aman-Lentil- Sesame at Kushtia during 2021-22

Parameters	Improved Cropping Pattern			Existing Cropping Pattern		
Crop	T.Aman	Lentil	Sesame	T.Aman	Lentil	Sesame
Grain/seed (t ha^{-1})	4.85	1.90	1.20	4.25	1.60	1.05
Straw yield (t ha^{-1})	3.87	1.75	1.15	3.45	1.62	1.12
Whole pattern REY(t ha^{-1})	12.20			10.52		
Whole pattern GR (Tk ha^{-1})	409663			354413		
Whole pattern TVC (Tk ha^{-1})	165650			156550		
Whole pattern GM (Tk ha^{-1})	244013			197863		
MBCR	6.07					

Unit Price (Tk kg^{-1}): Lentil: 80.00, Til : 65.00, T.Aman rice: 31.25 and Straw: 5.00
REY= Rice Equivalent Yield, GR=Gross Return, GM=Gross Margin and VC= Total Variable Cost

Conclusion

From the experimentation, cultivation of improved cropping pattern: T.Aman (var. BRRI dhan75)-Lentil (var. BARI Masur-8)-Sesame (var. BARI Til-4) is more profitable than that of existing pattern due to replacing variety of crops with management of crops. By practicing the improved cropping pattern, rice equivalent yield was 16% increased over existing pattern. Thus, the cultivation of improved cropping pattern would help to increase total production and enhance farmers' income.

IMPROVEMENT OF CROPPING PATTERN BORO–FALLOW-MUSTARD AT MANIKGANJ

M. R. AMIN

Abstract

The trial was conducted at Shibaloya Upazila of Manikganj district during 2021-2022 cropping season to increase cropping intensity and productivity through inclusion of mustard in farmers existing cropping systems. Improved cropping pattern: Boro rice (var. BRRI dhan89) – Fallow - Mustard var. (BARI Sarisha-14) against farmers existing Boro rice (var. BRRI dhan29) – Fallow - Mustard (var. Tori-7) cropping pattern. were evaluated. The yield of different crops in alternate cropping pattern were 7.37 t ha^{-1} in BRRI dhan89, and 1.43 t ha^{-1} BARI Sarisha-14 while that in the existing pattern of 7.09 t ha^{-1} in BRRI dhan29, and 0.87 t ha-1 in Tori-7, respectively. The higher gross return (Tk. 312695 ha^{-1}) and gross margin (Tk. 120105 ha^{-1}) were obtained in improved cropping pattern: Boro rice (BRRI dhan89) – Fallow - Mustard (BARI Sarisha-14) and in existing pattern gross return (Tk.262371 ha^{-1}) and gross margin (Tk. 68036 ha^{-1}). The MBCR of improved cropping pattern (11.60) was 18.51% higher over existing cropping pattern.

Introduction

Oilseed crops play an important role in Bangladesh Agriculture. Mustard is leading oilseed crop covered about 80% of the total oilseed area and contributing to more than 60% of the total oilseed production in Bangladesh. The acreage of rapeseed and mustard in Manikganj district was 37126 acres and total production was 15216 metric ton during 2018-2019 (BBS, 2019). . The yield of local varieties is very low and 868 kg ha^{-1} on an average while BARI developed improved varieties provide yield ranged from 1500 to 2500 kg ha^{-1} under different agro-ecological zones and climate variations. Oilseed Research Centre of BARI released a good number of improved varieties of mustard with high yield potential. The production area of BARI Sarisha-14 is increasing day by day due to its higher yield potentiality and higher market price of mustard oil. Farmers generally choose a crop and its variety considering the field duration of the crop to fit well in the existing cropping pattern to get higher yield and economic return. The experiment was undertaken to fit short duration and high yielding mustard variety to fit in the existing cropping pattern to increase production of oilseed crops and farmers income.

Materials and Methods

The experiment was conducted in the farmer's field at Shibaloya Upazillas of Manikganj during 2021-2022. The trial was carried out in three farmers' field in 06 bighas of land. The crop management practices used in existing and alternate cropping patterns are shown in Table 1. The experimental field was fertilized in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Half of urea and all TSP, MoP, Gypsum, Zinc and Boron were applied during final land preparation. The remaining half of urea was top dressed at 30 DAS during flowering stage of crop. Plant protection measures such as irrigation, weeding and pesticides application were done as and when required. Rovral @ 2 gm L^{-1} water was sprayed to control *Alterneria*leaf spot disease. Rice stem borer was observed in the field and Desis @ 2ml L^{-1} water sprayed to control this insect at the beginning of infestation. Data on yield and yield contributing characters was recorded.

Table 1.The crop management practices of existing and alternate cropping pattern at Shibaloya, Manikganj during 2021-22

Improved Cropping Pattern (Boro- Fallow-Mustard)				**Existing CP (Boro-Fallow-Mustard)**		
Observations	**Boro**	**Fallow**	**Mustard**	**Boro**	**Fallow**	**Mustard**
Variety	BRRI dhan89	-	BARI Sarisha-14	BRRI dhan-29	-	Tori-7
Spacing	25cm x 15cm	-	Broadcast	25cm x 15cm	-	Broadcast
Fertilizer dose NPKSZnB (kg ha^{-1})	115-18-75-20-2.6-1.27	-	104-33-45-20-1.6-1.27	115-18-75-20-2.6-1.27	-	104-33-45-20-1.6-1.27
Sowing/planting date	25-27 February, 2021	-	02-08 November, 2021	16-18 July, 2021	-	05-11 November, 2021
Field duration (days)	110	-	90	115	-	85
Harvesting time	14-18 June, 2021	-	28 January – 04 February, 2022	14 November, 2021	-	30 January – 6 February, 2022
Intercultural operation	Irrigation: 20, Weeding:1	-	Irrigation: Nil, Weeding: Nil	Irrigation: 20, Weeding:1	-	Irrigation: Nil. Weeding: Nil

Results and Discussion

Yield performance: The results of the present study have been presented in Table 2. The yield performance revealed that Boro (BRRI dhan-89) – Fallow – Mustard (BARI Sarisha-14) cropping pattern under improved practices gave higher grain yield of Boro rice (7.37 t ha^{-1}) and Mustard (1.43 t ha^{-1}) than existing pattern of Boro rice (BRRI dhan-29) – Mustard (Tori-7) were 7.09 t ha^{-1} in BRRI dhan-29 rice and 0.87 t ha^{-1} Tori-7, respectively. On an average, the yield of Boro rice and mustard in improved cropping pattern increased by 3.9, and 64.36%, respectively over the farmer's existing cropping pattern because of inclusion of high yielding mustard and rice variety with improved management practices.

Field duration: Farmers existing cropping pattern: Boro rice (BRRI dhan29) – Fallow – Mustard (Tori-7) required on an average 189 days field duration and alternative cropping pattern Boro rice (BRRI dhan89) – Mustard (BARI Sarisha-14) required 200 days (excluding seedling age of Boro rice grown in separate seedbed) to complete the cycle. The rest period of the year the land remains inundated due to flood.

In farmers existing cropping pattern (Boro– Fallow – Mustard) used local variety of mustard (Tori-7) which is a short duration variety which helps to grow BRRI dhan29 in longer field duration (115 days). Meanwhile in the improved cropping pattern: BARI Sarisha-14 (90 days) required 5 more days to get maturity than Tori-7 (85 days) but Boro rice var. BRRIdhan89 (110 days) got maturity 05 days earlier than BRRI dhan29 (115 days).

Cost and return: The details cost and return analysis of cropping pattern is presented in Table 2. The higher gross return (Tk.314240 ha^{-1}) and gross margin (Tk. 119105 ha^{-1}) were obtained in improved cropping pattern: Boro rice (BRRI dhan89) –Fallow- Mustard (BARI Sarisha-14) cropping pattern while lower gross return (Tk. 293348 ha^{-1}) and gross margin (Tk. 100013 ha^{-1}) in existing cropping pattern: Boro rice (BRRI dhan29)–Fallow- Mustard (Tori-7). Thus, considering the whole pattern analysis, the improved cropping pattern was found economically profitable with higher production of mustard j.

Farmers opined that rice var. BRRI dhan89 is a high yielding rice for Boro season with shor field duration compared to BRRI dhan29.Mustard var. BARI Sarisha-14 is an excellent variety of mustard with higher yield potentiality.

Table 2. Yield and economics of alternate and farmer's existing cropping pattern at Shibaloya, Manikganj during 2021-22

Parameters	Improved Cropping Pattern			Existing Cropping Pattern		
Crop	Boro rice	Fallow	Mustard	Boro rice	Fallow	Mustard
Grain /seed yield (t ha^{-1})	7.37	-	1.43	7.10	-	1.08
Straw yield (t ha^{-1})	6.90	-	2.15	6.67	-	1.62
Gross return (Tk. ha^{-1})	198135	-	116105	190748	-	102600
TVC (Tk. ha^{-1})	153060	-	42075	153060	-	40275
Gross margin (Tk. ha^{-1})	45075	-	75030	37688	-	30348
Whole pattern REY (t ha^{-1})	11.58			10.77		
Whole pattern GR(Tk. ha^{-1})	314240			293348		
Whole pattern TVC (Tk. ha^{-1})	195135			193335		
Whole pattern GM (Tk. ha^{-1})	119105			100013		
MBCR	11.60					

Price (Tk. kg^{-1}): Urea-16.00, TSP-22.00, MoP-15.00, Gypsum-15.00, Boron-500.00, Zn-230.00, Rovral-4400.00 & Labor cost (Tk. labor^{-1}day^{-1}): 400.00, Price of Boro rice: Tk. 25.00 kg^{-1} and straw: Tk. 2.00 $kg^{-1}$and Mustard: Tk. 80.00 kg^{-1} and stover: Tk. 1.00 kg^{-1}

Conclusion

The result showed that improved cropping pattern with mustard was found suitable and profitable practice than the farmers existing cropping pattern. Therefore, this cropping pattern with mustard (BARI Sarisha-14) could be suitable in the farmer's field at flood prone areas of Manikganj. This is first year trial, recommendation will be given after completion of two years result.

IMPROVEMENT OF MUSTARD-SESAME-T. AMAN RICE CROPPING PATTERN AT MANIKGANJ

M. R. AMIN

Abstract

The trial was conducted at Sadar Upazila of Manikganj district during 2021-2022 cropping season to increase cropping intensity and productivity through inclusion of high yielding mustard in farmers existing cropping pattern. Sesame (BARI Til-4) – T. Aman (BRRI dhan-75) – Mustard (BARI Sarisha-14) against farmers existing Sesame (Local variety) – T. Aman (BRRI dhan-49) – Mustard (Tori-7) cropping pattern were evaluated. The yield of different crops in alternate cropping patterns were 1.36 t ha^{-1} in sesame, 4.52 t ha^{-1} in BRRI dhan75 rice and 1.45 t ha^{-1} BARI Sarisha-14 while that in the existing pattern were 0.99 t ha^{-1} in sesame, 4.20 t ha^{-1} in BRRI dhan49 and 0.89 t ha^{-1} in Tori-7, respectively. The higher gross return (Tk. 329490 ha^{-1}) and gross margin (Tk. 161850 ha^{-1}) were obtained in alternate cropping and in existing pattern gross return (Tk.250855 ha^{-1}) and gross margin (Tk. 89215 ha^{-1}). The MBCR was found 13.11 which indicated the superiority of the improved pattern.

Introduction

Oilseed crops play an important role in Bangladesh Agriculture. Mustard is leading oilseed crop covered about 80% of the total oilseed area and contributing to more than 60% of the total oilseed production in Bangladesh. The acreage of rapeseed and mustard in Manikganj district was 37126 acres and total production was 15216 metric ton during 2018-2019 (BBS, 2019). Sesame contains 42.45 %oil and 20% protein. Oilseed Research Centre of BARI released a good number of improved varieties of mustard and several number of sesames with high yield potential. Farmers generally choose a crop and its variety considering the field duration of the crop to fit well in the existing cropping pattern to get higher yield and economic return. Manikganj is one of the important mustard and sesame growing area in Bangladesh. The experiment was undertaken to fit short duration and high yielding mustard variety to fit in the existing cropping pattern and to increase production of oilseed crops and farmers income

Materials and Methods

The experiment was conducted at in the farmer's field at sadder Upazillas of Manikganj during 2020-2021. The trial was carried out in three farmer's field in 06 bighas of land. The crop management practices used in existing and alternate cropping pattern is shown in Table 1. The experimental field was fertilized in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Half of urea and all TSP, MoP, Gypsum, Zinc and Boron were applied during final land preparation. The remaining half of urea was top dressed at 30 DAS during flowering stage of crop. Plant protection measures such as irrigation, weeding and pesticides application were done as and when required. Data on yield and yield contributing characters was recorded.

The crop sesame was slightly infested by Jute hairy caterpillar and Karate @ 2ml L^{-1} water sprayed to control this insect. Stem borer was observed in the T. Aman rice field and Desis @ 2ml L^{-1} water sprayed to control this insect at the beginning of infestation. Rovral @ 2 gm L^{-1} water was sprayed to control *Alterneria* leaf spot disease in mustard.

Table 1. Crop management practices of existing and alternate cropping pattern at Manikganj during 2021-22

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Sesame	T. Aman	Mustard	Sesame	T. Aman	Mustard
Variety	BARI Til-4	BRRI dhan75	BARI Sarisha-14	Local	BRRI dhan49	Tori-7
Fertilizer dose NPKSZnB kg ha^{-1}	55-30-25-20-2-1.7	90-15-35-12-2-1	104-33-45-20-1.6-1.27	55-30-25-20-2-1.7	90-15-35-12-2-1	104-33-45-20-1.6-1.27
Sowing/planting date	16-22 Mar. 2021	15-18 Jul. 2021	07 to 10 Nov. 2021	15-23 Mar. 2021	15- 20 July, 2021	07 to 15 Nov. 2021
Harvesting time	8-14 Jun., 2021	11 to 13 Oct. 2021	30 Jan. to 06 Feb.2022	10-20 June, 2021	25 Oct. to 05 Nov.2021	28 Jan. to 05 Feb. 2022
Field duration	85	89	88	85	105	80

Results and Discussion

Yield performance: The results of the present study have been presented in Table 2. The yield performance revealed that cropping pattern under improved practices gave higher seed yield in sesame (1.36 t ha^{-1}), T. Aman rice (4.52 t ha^{-1}) and Mustard (1.45 t ha^{-1}) than existing pattern of were 0.988 t ha^{-1} in sesame, 4.20 t ha^{-1}in BRRI dhan-49 rice and 0.95 t ha^{-1} Tori-7, respectively. On an average, the yield of sesame, T. Aman rice and mustard in improved cropping pattern increased by 37.76, 7.61, and 52.63 %, respectively over the farmer's existing cropping pattern because of inclusion of high yielding varieties of oilseeds (sesame and mustard) and rice with r improved management practices.

Field duration: Farmers existing cropping pattern required on average 262 days field duration and alternative cropping pattern required 270 days to complete the cycle

Cost and return: Cost and return analysis of cropping pattern are presented in Table 2. The higher gross return (Tk. 329490 ha^{-1}) and gross margin (Tk. 161850 ha^{-1}) were obtained in alternate cropping pattern : Sesame (BARI Til-4) – T. Aman (BRRI dhan75) – Mustard (BARI Sarisha-14) cropping pattern while lower gross return (Tk. 250855 ha^{-1}) and gross margin (Tk. 89215 ha^{-1}) in existing cropping pattern. MBCR was found 13.11 which indicated that improved cropping pattern was economically profitable with higher production of oilseeds in the farmer's field at Manikganj.

Farmers' opinion

Farmers opined that BARI Til-4 is a high yielding variety of sesame having 8 rows of seed in each pod but there are 4 rows of seed in local variety. The colour of seed in BRRI Til-4 is reddish brown and market price is slightly lower than black seed coat of local variety. BRRI dhan-75 is a high yielding aromatic rice variety with shorter field duration than BRRI dhan49. BARI Sarisha-14 is an excellent variety of mustard with higher yield potentiality.

Table 2. Yield and economics of alternate and farmer's existing cropping pattern at Manikganj during 2021-22

Parameters	Alternate Cropping Pattern			Existing Cropping Pattern		
Crop	Sesame	T. Aman	Mustard	Sesame	T. Aman	Mustard
Grain yield (t ha^{-1})	1.36	4.52	1.45	0.99	4.20	0.89
Straw yield (t ha^{-1})	2.52	5.11	2.50	2.05	4.45	1.80
Gross return (Tk. ha^{-1})	87770	123220	118500	63795	113900	73160
TVC (Tk. ha^{-1})	44325	75240	42075	44325	81240	42075
Gross margin (Tk. ha^{-1})	43445	47980	76425	19470	32660	31085
Whole pattern REY (t ha^{-1})	12.77			9.93		
Whole pattern GR (Tk. ha^{-1})	329490			250855		
Whole pattern TVC (Tk. ha^{-1})	167640			161640		
Whole pattern GM (Tk. ha^{-1})	161850			89215		
MBCR	13.11					

Price of output (Tk. kg^{-1}): Price of Sesame: 62.50, straw: 1.00, Price of T. Aman rice: 25.00 and straw: 2.00and Price of Mustard: 80.00 and straw: 1.00

Conclusion

From the result showed that in improved cropping pattern including two oilseed crops was suitable and profitable practice than the farmers existing cropping pattern. Therefore, this cropping pattern with high yielding varieties of sesame (var. BARI Til-4) and mustard (var. BARI Sarisha-14) is found suitable in the flood free or less flood affected medium highland of Manikganj district. This is first year trial, recommendation will be given after completion of two years result.

DEVELOPMENT OF FIVE CROPS BASED CROPPING PATTERN AGAINST FARMERS CROPPING PATTERN

N. SULTANA AND M.M. ZAMAN

Abstract

The experiment was conducted at Mymensingh sadar Upazila under On-Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh during 2020-2021 to evaluate agroeconomic performance and to increase cropping intensity and productivity of five crops based pattern and farmers' existing three crops based cropping pattern. Five crops based cropping patter (Garden pea-Red amaranth-Jute leaf-Kangkong-T. Aman) against farmers' existing cropping pattern (Potato-Jute leaf-T. Aman) were tested. The highest rice equivalent yield (44.82 t ha^{-1}) was obtained from 5 crop based cropping pattern. The improved pattern provided 117% higher gross return with marginal benefit cost ratio of 4.89, which suggested that inclusion of garden pea and kangkong with improved management practice in the existing pattern might be profitable to the farmers.

Introduction

In Mymensingh region, farmers mostly followed vegetables-vegetables-rice cropping pattern in medium highland. It covered anareas around less than 10 % of cultivable land area (DAE, 2014). Based on the farmers demand, it is high time to insert two more short duration vegetable to the existing three crops pattern it would be more productive and viable for this area. The average cropping intensity in Bangladesh is 191% and the country is losing 1% cultivable land every year for high population pressure and other purposes. Ensuring food security of increased population the country needs to be increased food production by increasing cropping intensity. So, there is a great scope of increasing cropping intensity as well as crop productivity here in Mymensingh as that of total country. Bangladesh Agricultural Research Institute has developed some 4-crops based cropping patterns by inclusion of vegetable which already been disseminated at the farmers' field. Following the modern technologies, cropping intensity may increase up to 400% or more. Oilseed, tuber crops, pulses and vegetables are the vital group of crops which are mostly grown in rabi season but area of those crops decreased due to increased irrigated boro rice. Development of short duration varieties of rice, mustard, potato, pulses and vegetables have opportunities created to accommodate five crops in the same piece of land in a year. Considering the above facts, a trial on Garden pea-Red amaranth-Jute leaf-Kangkong-T.Aman was conducted at farmer's field in Mymensingh.

Materials and Methods

The trial was conducted during 2020-2021. The experimental site belongs to tropical monsoon climate with high rainfall. Maximum rainfall was received during the months of April to September. The annual rainfall of the study period was 1854 mm. Mean annual minimum and maximum temperature was 21.18 and 29.58^{o}C, respectively. Monthly maximum, minimum and mean air temperature (^{o}C), total rainfall (mm) and relative humidity (%) have been presented in Table 1.

Rice stem borer, rice bug, rice brown plant hopper, rice hispa and sheath blight were observed sporadically in some plots of T. Aman rice field. Furadan 5G @ 10 kg ha^{-1} was applied during final land preparation and Virtako 40WG @ 1.5 g10L^{-1} water was sprayed twice at 10 days interval for controlling stem borer. Dursban @ 2mlL^{-1} and Marshal 2 mlL^{-1} water were sprayed at 55 and 65 DAT for controlling other insects. Folicur @0.5mlL^{-1}water was sprayed to control sheath blight disease. No other remarkable pests were observed in all other crops during the growing period.

Table 1. Agronomic parameters of five crop based cropping pattern and farmers' existing pattern at Mymensingh during 2020-2021

Parameters	Five crop based pattern (IP)					Farmers' pattern (FP)		
	Garden pea	Red amaranth	Jute leaf	Kangkong	T.Aman	Potato	Jute leaf	T.Aman
Variety	BARI Motorshuti-3	BARI Lalshak-1	Local	BARI Gimakolmi-1	BRRI dhan49	Local (Challisha)	Local	BRRI dhan49
Sowing/ Transplanting	10-15 Dec. 20	22thFeb. 21	25th Mar.-1stApr. 21	15th May. 21	02 Aug. 21	20thNov. 20	25-30 Feb. 21	25thJul. 21
Spacing (Row)	30 cm	Broadcast	Broadcast	30	20cm×15cm	20cm x 10cm	Broadcast	20cm×20cm
Seedling age (days)	-		-	-	25-30		-	30-40
Fertilizer (kg NPKSZn ha^{-1})	217-750-200-0-0 along with 10-12 t ha^{-1} CD	92-20-75-0-0 along with 10 t CD ha^{-1}	69-25-50-0-0-0 Along with 5 t ha^{-1} CD	65-20-50-0-0	92-25-50-11-3.5	161-44-150-22-0	58-20-38-0-0 along with 5 t ha^{-1} CD	95-23-15-6-0
Irrigation	-		-	-	5-7	-	-	5-7
Insect-pest/	IPM		IPM	IPM	IPM	Chemical	-	Chemical
Harvesting	12-15thFeb. 21	25th Mar. 21	1st to 5thMay. 21	20 June to 25 July 2021	14 to 18th Nov, 2021	29Jan, 2021	10thApril, 2021	10 to 15th Nov. 2021
TAT (days)	26	7	6	10	7	7	30	105
Field duration (days)	66	31	35	70	108	70	40	112

Results and Discussions

Grain/leaf yield of crops and by-products: After one year study of 5-crops based cropping pattern (Garden pea-Red amaranth-Jute leaf-Kangkong-T. Aman (IP) and farmer's existing pattern (Potato-Jute leaf-T. Aman (FP) have been presented in Table 3. It revealed that the yields of garden pea, red amaranth, jute leaf and kangkong were 8.0 and 11.0, 15.0 and 30.3 t ha^{-1}, respectively. On the contrary, the grain and straw yield of T. Aman rice in improved and existing cropping pattern was 4.3 and 3.8 tha^{-1}, respectively. The grain and straw yield of T. Aman rice (4.1 and 3.5 tha^{-1}, respectively) in farmers practice was lower due variation of management practices.

Field Duration:. The field duration of farmers' cropping pattern (Potato-Jute leaf-T. Aman) was 222 days, whereas in improved cropping pattern (Garden pea-Red amaranth-Jute leaf-Kangkong-T. Aman) was 310 days (excluding seedling age of rice) to complete the cycle (Table 2).

Rice equivalent yield: Five crops based cropping pattern produced higher rice equivalent yield (44.82 tha^{-1}yr^{-1}) over farmers' (20.50 tha^{-1}yr^{-1}) existing cropping pattern (Table 4). Inclusion of high value crop garden pea in rabi and kangkong in kharif season in existing cropping pattern increased REY by 119 % over farmers' practice. These results are in agreement with Mondal *et al.* (2015).

Production efficiency: Maximum production efficiency (221.29 kgha^{-1}day^{-1}) was obtained from five crops based pattern and minimum (126.57 kgha^{-1}day^{-1}) in farmers' practice (Table 4). The higher production efficiency in 5-crops based cropping pattern might be due to inclusion of high value crop garden pea and kangkong as well as improved management practices. Similar trend were also noted by Nazrul *et al.* (2013) and Khan *et al.* (2006).

Land Utilization Index (LUI):. Land utilization index indicated that 5-crops based cropping pattern used the land for 90% period of the year, whereas farmers' pattern used the land for 61% period of the year (Table 4). The higher land use efficiency in five crops based pattern because this pattern occupied the field for longest duration (310 days), whereas the farmers' pattern, 222 days of a year.

Cost and return analysis: Gross return of five crops based improved pattern was Tk1128100 ha^{-1} which was more than 117 % higher over farmers' pattern (Table 5). Farmers' pattern gave the lowest gross return TK171665 ha^{-1}. Total variable cost was higher in improved pattern (Tk. 296000 ha^{-1}) might be due to additional inputs and management cost of component crops. The gross margin was substantially higher in the improved pattern (Tk. 832100 ha^{-1}) over farmers' pattern (Tk. 347835 ha^{-1}). The higher gross margin of the improved pattern was achieved mainly higher yield advantages of the component crops. The marginal benefit cost ratio (MBCR) was found 4.89 which indicated the superiority of the improved pattern over the farmers' pattern. These results are supported by Mondal *et al.*, (2015).

Farmers' opinion

Farmers' opined that cultivation of 5-crops in a year increased crop productivity undoubtedly but it is needed the proper schedule to establish the crops in time. The high value crop garden pea is most promising because of higher market price and kangkong could be harvest during a longer period of growing season.

Table 2. Yields, production efficiency and land utilization index of crops and cost and return analysis of improved and farmers cropping patterns at Mymensingh, during 2020-21.

Parameters	Alternate Cropping Pattern					Existing Cropping Pattern		
Crop	Garden pea	Red amaranth	Jute leaf	Kangkong	T.Aman	Potato	Jute leaf	T.Aman
Grain yield (t ha^{-1})	8.0	11.0	15.0	30.3	4.3	10.0	14.0	4.1
Straw yield (t ha^{-1})	-	-	-	-	3.8	-	-	3.5
Rice equivalent yield (t ha^{-1}yr^{-1})	44.82					20.50		

Parameters	Alternate Cropping Pattern					Existing Cropping Pattern		
Crop	Garden pea	Red amaranth	Jute leaf	Kangkong	T.Aman	Potato	Jute leaf	T.Aman
Production efficiency (kg zha^{-1}day^{-1})	221.29					126.57		
Land utilization index (%)	84.93					60.82		
Whole pattern gross return (Tk. ha^{-1})	1128100					519500		
Whole pattern TVC (Tk. ha^{-1})	296000					171665		
Whole pattern GM (Tk. ha^{-1})	832100					347835		
MBCR	4.89					-		

Price (Tk. kg^{-1}): Garden pea=40, Red amaranth=15, Jute leaf=15, Kangkong=10 and T.aman=25
Price of input and output (Tk. kg^{-1}): Urea: 16.00, TSP: 22.00, MoP: 15.00, Gypsum: 10.00, Zinc sulphate: 180.00, Boric acid: 220.00
Price (Tk. kg^{-1}): Garden pea=40, Red amaranth=15, Jute leaf=15, Kangkong=10 and T.aman=25 and Straw=2

Appendix Table 1. Monthly air temperature, total rainfall and relative humidity in the experimental area of Mymensingh

Months	Air temperature (°C)			Rainfall (mm)	Relative humidity (%)
	Maximum	Minimum	Mean		
January	22.75	13.99	18.37	0	83
February	26.44	16.03	21.24	0	77
March	31.11	19.98	25.55	33.00	76*=
April	30.45	21.44	25.95	268.10	79
May	30.08	23.51	26.80	437.70	83
June	31.28	25.95	28.62	301.39	85
July	32.41	26.82	29.62	305.9	85
August	32.54	26.95	29.75	214.70	84
September	31.78	26.00	28.89	143.90	84
October	30.92	22.56	26.74	95.10	85
November	29.28	17.41	23.35	36.20	82
December	25.96	13.52	19.74	17.70	80
Yearly average	29.58	21.18	25.39	154.47	82

Conclusion

A high value garden pea and leafy vegetable kangkong could easily be grown in between farmer existing pattern. Cultivation of five crops would be created employment generation for male and female labors and increased crop productivity by increasing cropping intensity.

DEVELOPMENT OF MUSTARD-SUMMER VEGETABLES-JUTE CROPPING PATTERN AGAINST MUSTARD-FALLOW-JUTE CROPPING PATTERN

N. SULTANA AND M.M. ZAMAN

Abstract

The experiment was conducted at Netrokona Sadar, Upazila, Mymensingh under On Farm Research Division, Bangladesh Agricultural Research Institute, during 2020-2021 to study the comparative agro economic performance of three crops based pattern and farmers' existing two crops based cropping pattern for increasing cropping intensity and productivity. Three crops based cropping patter (Mustard-Summer vegetables-Jute) against farmers' existing cropping pattern (Mustard-Fallow-Jute) were tested. The highest jute equivalent yield (6.3 t ha^{-1}) was obtained from 3 crops based cropping pattern. Gross return of the improved pattern was Tk.514000 ha^{-1} which was 119 % higher over farmers' pattern. The marginal benefit cost ratio (MBCR) was found 3.70; which expressed that inclusion of summer vegetables with improved production practices in the existing pattern might be profitable and acceptable to the farmers.

Introduction

One of the major cropping pattern Mustard-Fallow-Jute is practiced by farmers' in some pocket areas in Netrakona district of Bangladesh. Generally, farmers of this region cultivated local mustard followed by jute. This pattern covered a very few areas where irrigation facilities are inadequate. The cultivation of short duration vegetable after mustard harvested might be utilized fallow land to increase the cropping intensity and crop productivity. Red amaranth is a short duration vegetable crop which could be introduced without hampering the existing cropping sequence. On the other hand, the productivity of existing pattern is low due to local varieties and poor management practices. However, introducing modern variety and improved technology of mustard and jute offered the opportunity to overcome the situation. Different cropping patterns are available in Bangladesh and abroad (Azad *et al*., 1982, Soni and Kaur, 1984, Malavia *et al*., 1986, Khan *et al*., 2005, Khan *et al*., 2006 and Nazrul *et al*., 2013) but a small efforts have been made for the evaluation of improved technologies of Mustard-Red amaranth-Jute cropping pattern. The study was therefore, initiated with a view to find out the agro-economic feasibility of an improved package of technologies over the existing farmers' cropping pattern.

Materials and Methods

The trial was conducted to increase cropping intensity and productivity by incorporating high value red amaranth in the existing cropping system (mustard-vegetable-jute) during 2020-2021. The experimental site belongs to tropical monsoon climate with high rainfall. Agronomic performance like field duration, land utilization index, production efficiency and rice equivalent yield of cropping patterns were calculated. The crop was free from remarkable insect and pests were in all other crops during the growing period. In mustard there was alternaria leaf spot disease which was controlled by spraying with Rovral wp @ 2g L^{-1} water at three to four times in 7 days interval.

Table 1. Agronomic management of three crops based cropping pattern and farmers' existing pattern at Mymensingh during 2020-2021

Parameters	Three crop based pattern (IP)			Farmers' pattern (FP)		
	Mustard	Read amaranth	Jute	Mustard	Fallow	Jute
Variety	BARI Sarisha-14	BARI Lalshak-1	HC95	Tori-7	-	Local kenaf
Sowing/ transplanting	15-18 Nov. 20	23-25 Feb. 21	6-8 Apr. 21	18-20 Nov. 20	-	28-30 Mar. 21
Spacing	Broadcast	Broadcast	Broadcast	Broadcast	-	Broadcast
Fertilizer (kg NPKSZnB ha^{-1})	115-34-42-27-0-2	92-20-75-0-0-0 along with 10 t CD ha^{-1}	78-34-63-23-2-0	161-44-150-22-0-0	-	92-25-38-18-0-0
Insect-pest/ Rodent control	IPM	IPM	IPM	Chemical	-	Chemical
Harvesting time	4-6 Feb. 21	27-29 Mar. 21	25-27 Jul. 21	3-5 Feb. 21	-	13-15 Jul. 21
TAT (days)	116	20	8	119	-	54
Field duration (days)	80	32	109	75	-	103

Results and Discussions

Grain/leaf yields of crops and by-product: Mustard-Summer Vegetables-Jute (IP) and farmer's existing pattern Mustard-Fallow-Jute (FP) have been presented in Table 2. From the result it revealed that the higher seed yield of mustard (1.5 t ha^{-1}) and fiber yield of jute (3.2 t ha^{-1}) was recorded in improved pattern might be due to introduction of new variety and improved management practices. A short duration vegetable *viz.* red amaranth can be grown after harvest of mustard with 8.0 t ha^{-1} of marketable leaf yield, which provided economic support to the farmers (Table 2).

Field duration: The farmers' cropping pattern Mustard-Fallow-Jute has needed 178 days for total crop production in a year whereas in improved cropping pattern Mustard-Summer Vegetables-Jute required 221 days to complete the cycle (Table 1). Result indicated that in existing pattern, mustard to jute production 54 days remains fallow the land, in this period a short duration vegetable crop such as red amaranth (only 30-35 days to be harvested) could easily be fitted in cropping pattern. Similar trend was also observed by Mondal *et al*. (2015).

Jute equivalent yield: Three crops based cropping pattern produced higher jute equivalent yield (6.3 tha^{-1}yr^{-1}) over farmers' (4.1 tha^{-1}yr^{-1}) existing cropping pattern (Table 2). Inclusion of improved production technology like as variety and an extra crop in existing cropping pattern (Mustard-Fallow-Jute) increased JEY by 54 %. These results are in agreement with Mondal *et al*. (2015).

Production efficiency: Maximum production efficiency (57.47 kgha^{-1}day^{-1}) was obtained from three crops based pattern and minimum (15.00 kgha^{-1}day^{-1}) in farmers' practice (Table 2). The higher production efficiency was observed in 3-crops based cropping pattern might be due to inclusion of high yielding variety and as well as a short duration vegetable crop. Similar trend were also noted by Nazrul *et al*. (2013) and Khan *et al*. (2006).

Land utilization index (LUI): LUI indicated that 3-crops based cropping pattern used the land for 61% period of the year, whereas farmers' pattern used the land for 49% period of the year (Table 2). The higher land use efficiency was observed in three crops based cropping pattern because this pattern occupied the field for longest duration (221 days), whereas the farmers' pattern for 178 days of a year.

Cost and return analysis: Economic analysis revealed that gross return of improved pattern was Tk. 514000 ha^{-1} which was more than 119% higher over farmers' pattern (Table 2). Farmers' pattern gave the lowest gross return Tk. 233950 ha^{-1}. Total variable cost was higher in improved pattern (Tk.155985 ha^{-1}) might be due to inclusion high yielding component crops and those of improved production technology in the pattern. The gross margin was substantially higher in the improved pattern (Tk. 358015ha^{-1}) than in farmers' pattern (Tk.153485 ha^{-1}). The higher gross margin of the improved pattern was achieved mainly higher yield advantages of the component crops. The marginal benefit cost ratio (MBCR) was found 3.70 which indicated the superiority of the improved pattern over the farmers' pattern.

Farmers' opinion

Farmers opined that cultivation of 3-crops in a year increased crop productivity undoubtedly but it is needed the proper schedule to establish the crops in time.

Table 2. Yields, production efficiency and land utilization index of crops and cost and return analysis of improved and farmers cropping patterns at Mymensingh, during 2020-2021

Parameters	Alternate Cropping Pattern			Existing Cropping Pattern		
Crop	Mustard	Red amaranth	Jute	Mustard	Fallow	Jute
Grain yield (t ha^{-1})	1.5	8.0	3.2	0.8	-	1.87
Straw yield (t ha^{-1})	1.0	-	2.7	0.7	-	2.2
Jute equivalent yield (t ha^{-1}yr^{-1})	6.3			4.1		
Production efficiency (kgha^{-1}day^{-1})	57.47			15.00		
Land utilization index (%)	60.55			48.77		
Whole pattern gross return (Tk. ha^{-1})	514000			233950		
Whole pattern TVC (Tk. ha^{-1})	155985			80465		
Whole pattern GM (Tk. ha^{-1})	358015			135485		
MBCR	3.70			-		

Price of input and output (Tk kg^{-1}): Urea: 16.00, TSP: 22.00, MoP: 15.00, Gypsum: 10.00, Zinc sulphate: 180.00, Boric acid: 220.00
Price (Tk kg^{-1}): Mustard=75,Red amaranth=15, Jute= 75, Stover= 1 and Jute stick= 15
Price of input and output (Tk. kg^{-1}): Urea: 16.00, TSP: 22.00, MoP: 15.00, Gypsum: 10.00, Zinc sulphate: 180.00, Boric acid: 220.00
Price (Tk. kg^{-1}): Mustard: 75, Red amaranth: 15, Jute: 75, Stover:1 and Jute stick: 15

Conclusion

A short duration vegetable crop could easily be grown in between farmer existing pattern: Mustard-Fallow-Jute crops. Cultivation of three crops instead of two crops would create employment generation for male and female labors and increased crop productivity by increasing cropping intensity might be applied this pattern where irrigation facilities is inadequate in kharif-I season.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN VEGETABLE-BORO-T. AMAN RICE AGAINST VEGETABLE-FALLOW - T. AMAN

MD. ASADUZZAMAN

Abstract

The experiment was conducted at OFRD, BARI, Shibpur, Narsingdi during three consecutive years of 2018-19, 2019-2020 and 2020-2021 to improve the existing cropping pattern by inclusion of vegetable and to increase crop yield with farmers income. On an average, alternate cropping pattern: Cauliflower (var. 770) - Boro (var. BRRI dhan50) - T. Aman (var. BRRI dhan57) gave higher rice equivalent yield of 20.82, gross margin (Tk. 136500 ha^{-1}) against the existing pattern Cauliflower (var. Snow white) - Fallow-T. Aman (var. BRRI dhan39).

Introduction

Farmers at Narsingdi followed different types of cropping patterns. Vegetable-Fallow- T. Aman is one of the important cropping pattern practice by the farmers. Horticulture Research Centre, BARI has developed a number of short duration high yielding cauliflower varieties. It needs to popularize among the farmers by fitting this cauliflower variety in the existing cropping pattern *viz.* Vegetable- Fallow-T. Aman rice as e alternate cropping pattern : Vegetable - Boro - T. Aman.As such, the trial was conducted to evaluate the new cropping pattern to the farmers for higher yield and profit.

Materials and Methods

The trial was conducted at OFRD, BARI, Shibpur, Narsingdi during three consecutive years2018-19, 2019-2020 and 2020-2021. Unit plot size was 800m^2. The improved cropping pattern was cauliflower (Var. 770) - Boro (BRRI dhan50)-T. Aman (var. BRRI dhan57) against existing cropping pattern: cauliflower (var. Snow white)-Fallow - T. Aman (var. BRRI dhan39). Agronomic practices and fertilizer doses are given in Table 1. Necessary irrigation, intercultural operations and pest management practices were done as and when necessary. Data on yield and yield contributing characters and economics were recorded and analyzed .

Results and Discussion

Crop management and yield performance of the pattern: The details of crop management under improved cropping pattern and farmers existing pattern are shown in Table 1. Field duration of cropping pattern comprises on the individual crop duration. Farmers' cropping pattern: Vegetable-Fallow-T. Aman rice has needed 205 days field duration while total field duration of three crops pattern: cauliflower –Boro-T. Aman rice has needed 280 days (excluding seedling age of rice) to complete the cycle . Average grain yield of Boro rice in the alternate cropping pattern were 5.54 t ha^{-1}. The curd yield (41.14 t ha^{-1}) of cauliflower and BRRI dhan57 of 4.45t ha^{-1}, in alternate cropping pattern whereas curd yield of cauliflower var. Snow white and rice var. BRRI dhan39 were 42.57 and 4.26t ha^{-1} in the existing pattern.

Rice equivalent yield: Improved cropping pattern produced higher rice equivalent yield (20.82 t ha^{-1} yr^{-1}) over farmers' existing cropping pattern (14.90 t ha^{-1} yr^{-1}). Inclusion of Boro rice in existing cropping pattern increased REY 39.80 % compared to farmers' practice (Table 1)

Cost and return: Gross return of improved cropping pattern was Tk.419960 ha^{-1} which was more than 36 .32% higher over farmers' pattern. Farmers' pattern gave the lower gross return TK. 308050 ha^{-1}. Total variable cost was higher in improved pattern (TK. 283460 ha^{-1}) might be due to inclusion of Boro rice in the pattern. The gross margin was substantially higher in the alternate pattern Tk.136500 ha^{-1} than farmers' pattern (TK.105080 ha^{-1}). The higher gross margin of the alternate pattern was achieved mainly due to inclusion of Boro rice as a component crop.

Farmers opinion

Farmers were highly satisfied due to higher return from alternate cropping pattern Cauliflower (Var. 770) - Boro (var. BRRIdhan50) - T. Aman (var. BRRIdhan57) against existing pattern.

Table 1: Agronomic management practices for crops grown under existing and alternate cropping patterns at Shibpur, Narsingdi, 2018-2021(Average of three years).

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern		
Crop	Cauliflower	Fallow	T. Aman	Cauliflower	Boro	T. Aman
Variety	Snow white	-	BRRI dhan39	Var. 770	BRRI dhan50	BRRI dhan57
Spacing(cm)	60×45	-	20×15	30×5	20×15	20×15
Seedling age (days)	25	-	30-35	25	40-45	20-25
Transplanting days	05-10 Nov. 20	-	1-10 Jul. 21	10-15 Nov. 20	20-25 Jan. 21	20-25 Jul. 21
Fertilizer dose (kg ha^{-1} N-P-K-S-Zn and B)	120-40-100-0-0	-	130-20-30-12-0-2.5	138-40-125-1.2-0.7-0	130-22-35-10-0-2.5	130-20-30-12- 0- 2.5
Fertilizer application	Basal & Top dress	-	Basal & Top dress	Basal & Top dress	Basal & Top dress	Basal & Top dress
Intercultural operation	-	-	2 Weeding	2 Weeding	2 Weeding	2 Weeding
Harvesting date	3-18 Feb. 21		20-25 Oct. 21	10-15 Jan. 21	10-15 May 21	25-30 Oct. 21
Field duration (seedling to seed)	90-100		107-112	62-68	110-115	95-100
Turnaround time (days)	T. Aman to Vegetable 11	-	Vegetable to T.Aman 130-135	T. Aman to Vegetable 15	Vegetable to Boro 5	Boro to T.Aman 60-65
Yield (t ha^{-1}) 2018-19	43.4	-	4.12	40.00	5.45	4.64
Yield (t ha^{-1}) 2019-20	42.2	-	4.41	41.00	5.52	4.48
Yield (t ha^{-1}) 2019-20	42.1	-	4.25	42.4	5.64	4.41
Average	42.57		4.26	41.14	5.54	4.45
Rice equivalent yield (t ha^{-1})	14.90			20.82		
Gross margin (Tk. ha^{-1})	82850	-	22230	75700	35010	25790
Total variable cost (Tk. ha^{-1})	130000	-	72970	130000	80250	73210
Gross return (Tk. ha^{-1})	212850	-	95200	205700	115260	99000
Whole pattern Gross margin (Tk. ha^{-1})	105080			136500		
MBCR						

Price (Tk. kg^{-1}) : Boro Rice sold-19, T. Aman Rice sold -20, Rice straw-3.00, Cauliflower- 5

Conclusion

The results of three years studied revealed that alternate cropping pattern: Cauliflower (Var. 770) - Boro (var. BRRI dhan50) - T. Aman (var. BRRI dhan57) was more productive and remunarative compared to existing pattern. So, it could be suggested for large scale production in medium highlands of Narsingdi.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN POTATO-OKRA-T. AMAN RICE AGAINST CABBAGE-FALLOW-T. AMAN

MD. ASADUZZAMAN

Abstract

The experiment was conducted at OFRD, BARI, Shibpur, Narsingdi during 2020-21 to improve the existing cropping pattern by inclusion of vegetable with the increase crop yield and farmers income. Alternate cropping pattern: Potato (var. BARI Alu-40)-Okra (var. BARI Derosh-2) - T. Aman (var. BRRI dhan71) gave higher rice equivalent yield (36.30 t ha^{-1}), gross margin (Tk. 385340 ha^{-1}) against the existing pattern Cabbage (var. Atlas 70) - Fallow-T. Aman (var. BRRI dhan49).

N.B. MBCR TO BE GIVEN

Introduction

Farmers at Narsingdi practicing different types of cropping pattern. Vegetable-Fallow – T. Aman is one of the important cropping patterns practicing by the farmers. Ensuring food security of increased population, the country needs to be increased production by increasing cropping intensity. Tuber Research Centre of BARI has developed several high yielding potato varieties. It needs to popularize among the farmers by fitting potato in the existing cropping pattern: Vegetable- Fallow – T. Aman. The alternate cropping pattern was Vegetable - Vegetable – T. Aman. The trial was conducted to evaluate the new cropping pattern among the farmers for higher yield and productivity.

Materials and Methods

The trial was conducted at OFRD, BARI, Shibpur, Narsingdi during 2020-21. The unit plot size was 600 m^2. The improved cropping pattern was potato (Var. BARI Alu-40) – ladys finger (var. BARI Derosh-2) –T. Aman (var. BRRI dhan71) against existing cropping pattern; Cabbage (var Atlas 70)-Fallow – T. Aman (var. BRRI dhan49). Agronomic practices and fertilizer doses are given in Table 1. Necessary irrigation, intercultural operations and pest management practices were done as and when necessary. Data on yield and yield contributing characters and economics were recorded and analyzed.

Results and Discussion

Crop management and yield performance of the pattern: The details of crop management under improved cropping pattern and farmers existing pattern are shown in Table 1. Field duration of farmers' cropping pattern: Vegetable-Fallow-T. Aman rice has needed 202 days field duration. Against three crops pattern: Potato-–lady's finger-T. Aman rice has needed 295 days (excluding seedling age of rice) to completed the one cycle The yield of Okrain the alternate cropping pattern was 14.5 t ha^{-1} whereas tuber yield of potato (var. BARI ALu-40) and grain yield of rice var. BRRI dhan71 was 35.3 and 4.56 t ha^{-1}. The head yield of cabbage (var. Atlas70) and grain yield of rice var. BRRI dhan49 were 48.4 and 4.10 t ha^{-1} in existing pattern.

Rice equivalent yield: Improved cropping pattern produced higher rice equivalent yield (36.3 t ha^{-1} yr^{-1}) over farmers' existing cropping pattern (16.2 tha^{-1} yr^{-1}). Inclusion of Okravar. BARI Derosh-2 in existing cropping pattern increased REY 36.30% compared to farmers' practice (Table 1).

Cost and return: Gross return of improved cropping pattern was Tk.735900 ha^{-1}, which was more than 45.38 % higher over farmers' pattern with lower gross return (Tk..334000 ha^{-1}). Total variable cost was higher in improved pattern (TK.350560 ha^{-1}) might be due to inclusion of BARI Derosh-2 in the pattern. The gross margin was substantially higher in the alternate pattern Tk.385340 ha^{-1} than farmers' pattern (Tk.167460 ha^{-1}). The higher gross margin of the alternate pattern was achieved mainly due to inclusion of Okra(var. BARI Derosh-2) as a component crop.

Farmers opinion

Farmers were highly satisfied to see the higher returns in alternate cropping pattern: Potato (var. BARI Alu40) – Okra(var. BARI derosh-2) - T. Aman (var. BRRIdhan71) against existing pattern cabbage (var. Atlas70)- Fallow-T. Aman (var. BRRIdhan49) due to higher yield as well as return .

Table 1: Agronomic management practices of the crops for the existing and alternate cropping patterns at Shibpur, Narsingdi during 2020-2021

Parameters	Existing Cropping Pattern			Alternate Cropping Pattern		
Crop	Cabbage	Fallow	T. Aman	Potato	Lady's finger	T. Aman
Variety	Atlas70	-	BRRI dhan49	BARI Alu-40	BARI Derosh-2	BRRI dhan71
Spacing(cm)	60×45	-	20×15	60×25	50×40	20×15
Seedling age (days)	25	-	30-35	-	-	25-30
Transplanting days	10-15 Nov. 20	-	1-15 Jul. 21	25-30 Nov. 20	10-15 Mar. 21	20-25 Jul. 21
Fertilizer dose (kg ha^{-1} N-P-K-S-Zn and B)	180-45-60-0-0	-	130-20-30-12-0-2.5	135-30-90-10-2-1	90-30-60-15-2-1.4	130-20-30-12- 0-2.5
Fertilizer application	Basal & Top dress	-	Basal & Top dress	Basal & Top dress	Basal & Top dress	Basal & Top dress
Intercultural operation	-	-	2 Weeding	2 Weeding	2 Weeding	2 Weeding
Harvesting date	10-15 Feb.21		20-30 Oct. 21	25-28 Feb. 21	05-10 Jul. 21	20-25 Oct. 21
Field duration (seedling to seed)	90 -92		105-110	90-95	110-115	85-90
Turnaround time (days)	15-20	-	140-145	35	10	15
Yield (t ha^{-1}) 2020-21	48.4	-	4.10	35.30	14.5	4.24
Rice Equivalent Yield (t ha^{-1})	16.20			36.3		
Gross margin (Tk. ha^{-1})	150000	-	17460	244950	121250	19140
Total variable cost (Tk. ha^{-1})	92000	-	74360	178650	96250	75660
Gross return (Tk. ha^{-1})	242000	-	92000	423600	217500	94800
Whole pattern Gross margin (Tk. ha^{-1})	167460			385340		
MBCR						

Price (Tk. kg^{-1}): Potato-12 T. Aman rice sold -20, Rice straw-3.00, Cabbage-5, Derosh-15

Conclusion

The result concluded that yield as well as returns from alternate cropping pattern Potato (var.BARI Alu-40)-Okra (var. BARI Derosh-2)-T. Aman (var. BRRI dhan71) was higher than existing pattern in the study area.

DEVELOPMENT OF ALTERNATIVE CROPPING PATTERN MUSTARD-T.AUS-T.AMAN RICE AGAINST FALLOW- BORO- T.AMAN CROPPING PATTERN IN RAJSHAHI REGION

M. S. RAHMAN, M. M. ANWAR, M. N. A. SIDDQUIE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

A field trial was conducted at the farmers' field of Paba, Rajshahi during 2020-2021and 2021-2022 to develop Mustard- T. Aus- T. Aman cropping pattern. There were two treatments i.e, T_1: Existing Cropping pattern: Fallow- Boro-(var. BRRI dhan-28)- T.aman (var. Sharna) and T_2: Alternate Cropping pattern: Mustard (var. BARI Sarisha-18)- T.aus (var. BRRI dhan82). T.aman (var. BRRI dhan87). Higher Rice Equivalent yield (14.25 t ha^{-1}) and gross margin (Tk. 284394 ha^{-1}) were obtained from alternate cropping pattern over existing cropping pattern (11.13 t ha^{-1}, Tk. 215640 ha^{-1}). During 2021-2022, in improved cropping pattern, yield of

Mustard, T.Aus and T.aman rice were 2.05, 4.5 and 5.1 t ha^{-1} while in existing pattern, grain yield of Boro and T. Aman rice were 5.81 and 4.76 t ha^{-1}, respectively. Improved cropping pattern gave higher rice equivalent yield (15.04 t ha^{-1}) against existing cropping pattern (10.87 t ha^{-1}). Total gross return and gross margin of improved cropping pattern were Tk. 438540 ha^{-1} and Tk. 231413 ha^{-1} whereas in existing cropping pattern Tk. 318690 ha^{-1} and Tk. 152037 ha^{-1}, respectively and MBCR was 2.96 due to introduction of new crops and varieties.

Introduction

Boro rice-T.Aman rice is one of the major existing cropping patterns at Paba upazila of Rajshahi district.. Generally, farmers of the upazila are cultivated T. Aman rice followed by Boro rice and a long period (around 90 days) remains fallow after T. Aman rice harvest which could be utilized by inclusion of a suitable Kharif-1 crop viz., T. Aus rice. The area is comparatively high and there is scarcity of irrigation water to cultivate Boro rice after harvest of T. Aman rice. In this context, T. Aus rice might be a promising crop for cultivation in rainfed condition. Besides, mustard var. BARI Sarisha-18 is a new variety with crop duration 100 days, seed yield of 2-2.5 t ha^{-1} and low erusic acid. This cropping pattern require minimum water so increase cropping intensity as well as productivity and profitability can be possible. With this view in mind, the experiment was undertaken to increase productivity and income of farmers of AEZ-11.

Materials and Methods

The experiment was conducted at Paba, Rajshahi during 2020-21 and 2021-2022 in High Ganges River Floodplain (AEZ-11) to develop Mustard- T. Aus -T. Aman cropping pattern. The experiment was laid out in a randomized complete block design with six dispersed replications. There were two treatments i.e, T_1: Existing Cropping pattern: Fallow-Boro (var. BRRI dhan-28)-T. Aman (var. Sharna) and T_2: Alternate Cropping pattern: Mustard (var. BARI Sarisha-18)- T.*aus* (var. BRRI dhan-82) - T. Aman (var. BRRI dhan87). During 2021-2022, BRRI dhan48 and BRRI dhan75 were used instead of BRRI dhan82 and BRRI dhan87, respectively. All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management etc. are presented in Table 1 and for 2021-2022 in Table 2. Recommended fertilizer package (BARC, 2018) along with the application methods were done to support the normal growth of the crops.

In mustard field, Rovral@2 gm L^{-1} was applied for controlling alterneria blight of mustard. In T.aus and T. Aman, stem borer and sheath blight was observed in some plots. Folicur @ 0.5 ml/L was sprayed to control sheath blight and Virtako 40 WG @ 1.5g/10 L for stem borer.

For economic comparison between two crop sequences, the yield of all crops was converted into price equivalent yield based on prevailing market price of individual crops. The economic indices i.e., gross return, gross margin, and marginal benefit cost ratio (MBCR) were also calculated on the basis of prevailing market price of the commodities. Relevant data were taken and computed.

Table 1. Details of cultural practices adopted for different crops in field experiments in 2020-2021

Crop	Variety	Seed rate (kg ha^{-1})	Spacing (cm^2)	Sowing/ transplant	Harvest	Fertilizer Nutrient (kg ha^{-1})					
						N	P	K	S	Zn	B
Mustard	BARI Sarisha-18	7	Broadcast	11-15 Nov.2020	21 -25 Feb. 21	126	35	46	29	2.5	2
T.Aus	BRRI dhan82	35	20 x 15	16-17 Mar. 20	14-16 Jun. 20	76	11	38	6.4	-	-
T. Aman rice	BRRI dhan87	35	20 x 15	15-20 Jul. 20	25-30 Oct. 20	90	10	25	12	1	-

Table 2. Details of cultural practices adopted for different crops in field experiments in 2021-2022

Crop	Variety	Seed rate (kg ha^{-1})	Spacing (cm^2)	Sowing/ transplant	Harvest	Fertilizer nutrient (kg ha^{-1})					
						N	P	K	S	Zn	B
Mustard	BARI Sarisha-18	7	Broadcast	15 Nov. 21	28 Feb.22	126	35	46	29	2.5	2
T. Aus	BRRI dhan48	35	20 x 15	25 Mar. 21	19 Jul. 21	76	11	38	6.4	-	-
T. Aman	BRRI dhan75	35	20 x 15	24 Jul. 21	3 Nov. 21	90	10	25	12	1	-

Results and Discussion

Yield, cost and return of improved pattern and existing pattern during 2020-21 are presented in Table 3. In improved cropping pattern, yield of Mustard, T. Aus and T. Aman *rice* were 1.91, 4.75 and 5.2 t ha^{-1} while in existing pattern, grain yield of Boro and T. Aman rice were 5.68 and 5.02 t ha^{-1}, respectively. Improved cropping pattern gave higher rice equivalent yield (REY) (14.25 t ha^{-1}) against existing cropping pattern (11.33 t ha^{-1}). Total gross return and gross margin of improved cropping pattern were Tk. 443830 ha^{-1} and Tk. 284394 ha^{-1} whereas in existing cropping pattern those were Tk. 349840 ha^{-1} and Tk. 215640 ha^{-1}, respectively and MBCR was 3.72. Higher gross return and gross margin were obtained in improved cropping pattern due to introduction of new crops and varieties with management practices

Again, yield, cost and return of improved pattern and existing pattern during 2021-22 are presented in Table 4. In improved cropping pattern, yield of Mustard, T. Aus and T. Aman *rice* were 2.05, 4.5 and 5.1 t ha^{-1} while in existing pattern, yield of Boro and T. Aman rice were 5.81 and 4.76 t ha^{-1}, respectively. Improved cropping pattern gave higher rice equivalent yield (REY) (15.04 t ha^{-1}) against existing cropping pattern (10.87 t ha^{-1}). Total gross return and gross margin of improved cropping pattern were Tk. 438540 ha^{-1} and Tk. 231413 ha^{-1} whereas in existing cropping pattern those were Tk. 318690 ha^{-1} and Tk. 152037 ha^{-1}, respectively and MBCR was 2.96. Higher gross return and gross margin were obtained in improved cropping pattern due to intensification of cropping and introduction of new crops and varieties.

Farmers obtained diversified way in alternate pattern due to inclusion of high demand, high income and stable market price gaining mustard and T. Aus crop in the system instead of Boro rice in existing pattern.

Table 3. Yield, economic analysis of existing and improved cropping pattern in 2020-2021

Observations	**Improved pattern**			**Existing pattern**		
Crop	**Mustard**	**T. Aus**	**T. Aman**	**Boro**	**Fallow**	**T. Aman**
Seed /grain yield (t ha^{-1})	1.91	4.75	5.2	5.68	-	5.02
Straw yield (t ha^{-1})	3.5	5.10	5.34	5.81	-	5.31
Gross return (Tk. ha^{-1})	133700	148650	161480	193640	-	156200
Total variable cost (Tk. ha^{-1})	52976	57550	48910	85100	-	49100
Gross margin (Tk. ha^{-1})	80724	91100	112570	108540	-	107100
W. Pattern REY (t ha^{-1})	14.25			11.33		
W. Pattern gross return (Tk. ha^{-1})	443830			349840		
W. Pattern TVC (Tk. ha^{-1})	159436			134200		
W. Pattern gross margin (Tk. ha^{-1})	284394			215640		
MBCR	3.72					

Price of output (Tk.kg^{-1}): T. Aman- 29, straw- 2, Mustard- 70, T. Aus rice- 27 and straw- 4, Boro rice- 30 and straw- 4

Table 4. Yield, cost and return analysis of existing and alternate cropping pattern in 2021-2022

Observation	Improved pattern			Existing pattern		
Crop	Mustard	T. Aus	T. Aman	Boro	Fallow	T. Aman
Seed /grain yield (t ha^{-1})	2.05	4.5	5.1	5.81	-	4.76
Straw yield (t ha^{-1})	3.78	5.30	5.56	6.34	-	5.30
Gross return (Tk. ha^{-1})	179120	115700	143720	193850	-	124840
Total variable cost (Tk. ha^{-1})	64319	69971	72837	96234	-	70419
Gross margin (Tk. ha^{-1})	114801	45729	70883	97616	-	54421
W. Pattern REY (t ha^{-1})	15.04			10.87		
W. Pattern gross return (Tk. ha^{-1})	438540			318690		
W. Pattern TVC (Tk. ha^{-1})	207127			166653		
W. Pattern gross margin (Tk. ha^{-1})	231413			152037		
MBCR	2.96					

Price of output (Tk. kg^{-1}): T. Aman- 26, T. Aman (Shorna)- 24, straw-2, Mustard- 80, T. Aus rice- 21 and straw- 4, Boro rice- 29, straw- 4

DEVELOPMENT OF ALTERNATIVE CROPPING PATTERN ONION/BRINJAL- T.AMAN RICE AGAINST ONION- JUTE- T.AMAN CROPPING PATTERN IN RAJSHAHI REGION

M. S. RAHMAN, M. M. ANWAR, M. N. A. SIDDQUIE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

A field trial was conducted at the farmers' field of Puthia, Rajshahi during 2021-2022 to develop Onion/Brinjal -T. Aman cropping pattern. There were two treatments i.e, T_1: Existing Cropping pattern: onion (var. BARI Peaj1-Jute var. (Nabin)-T. Aman (var. BRRI dhan75) and T_2: Alternate Cropping pattern: Onion (var. BARI Peaj-1)/Brinjal var. (Rangila) - T. Aman (var. BRRI dhan75). Higher Rice Equivalent yield (66.7 t ha^{-1}) and gross margin (Tk. 1282347 ha^{-1}), were obtained from alternate cropping pattern over existing cropping pattern (43.1 t ha^{-1}, Tk. 774658 ha^{-1}), respectively and MBCR was 6.58 due to introduction of new crops and varieties.

Introduction

Jute is now in a problem of rotting due to lack of water in the Puthia Upazila, Rajshahi. Sometimes, jute has to be rotten in the kennel with mud. Due to decompose of jute in this dirty water, the color of the jute is not expected to be golden. Because of this, jute is being sold at low price in the market. Brinjal is an important vegetable for its commercial and nutritional value in Bangladesh. Again Brinjal relay onion cultivation is developed technology of BARI. So, introduction of brinjal as relay crop instead of jute can make the pattern (Onion/Brinjal-T. Aman rice) more profitable than existing one. With view in mind, this trial was undertaken.

Materials and Methods

The experiment was conducted at Puthia, Rajshahi during 2021-2022 in High Ganges River Floodplain (AEZ-11) to develop Onion/Brinjal -T. Aman cropping pattern. The experiment was laid out in a randomized complete block design with six dispersed replications. There were two treatments i.e, T_1: Existing Cropping pattern: onion (var. var. BARI Peaj-1-Jute (var. Nabin)-T. Aman (var. BRRI dhan75) and T_2: Alternate Cropping pattern: Onion (var. BARI Peaj-1)/Brinjal (var. Rangila) - T. Aman (var. BRRI dhan75). Brinjal seedlings were transplanted in field as relay with onion, minimum one month before onion harvest. All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management etc. are presented for 2021-2022 in Table 1. Recommended fertilizer package (BARC, 2018) along with the application methods were done to support the normal growth of the crops. In onion field, Rovral@2 gm L^{-1} + Ridomil@ 2 gm L^{-1} was applied for controlling purple blotch of onion. In T. Aman, stem borer and sheath blight was observed in some plots. Folicur @ 0.5 ml/L was sprayed to control sheath blight and Virtako 40 WG @ 1.5g/10 L for stem borer. For economic comparison between two crop sequences, the yield of all crops was converted into price equivalent yield on the basis of prevailing market price of individual crops. The economic indices i.e. gross return, gross margin, and marginal benefit cost ratio (MBCR) were also calculated on the basis of prevailing market price of the commodities. Relevant data were taken and computed.

Table 1. Details of cultural practices adopted for different crops in field experiments in 2021-2022

Crop	Variety	Seed rate (kg ha^{-1})	Spacing (cm^2)	Sowing/ transplant	Harvest	Fertilizer (kg ha^{-1})					
						N	P	K	S	Zn	B
Onion*	BARI Piaj-1	7	10 ×6	01Jan. 21	24 -26 Mar. 21	120	45	125	18	2.5	1.2
Brinjal*	Rangila	0.15	1m×0.8m	25 Feb. 21	15-16 Jun. 21	175	30	125	16	4	2
Jute	Nabin	7	Broadcast	30 Mar. 21	5 Aug. 21	111	10	42	13	-	-
T. Aman rice	BRRI dhan75	35	20 x 15	20 Jul.-10 Aug. 21	25-30 Nov. 21	90	10	35	12	1	-

*Cowdung @5 tha^{-1} was added with chemical fertilizers.

Results and Discussion

Yield, cost and return of improved pattern and existing pattern during 2021-2022 are presented in Table 3. In improved cropping pattern, yield of onion, Brinjal and T. Aman *rice* were 26.1, 33.42 and 4.45 t ha^{-1} while in existing pattern, yield of Onion, Jute and T. Aman rice were 25.8, 2.83 and 4.62 t ha^{-1}, respectively. Improved cropping pattern gave higher rice equivalent yield (REY) (66.7 t ha^{-1}) against existing cropping pattern (43.1 t ha^{-1}). Total gross return and gross margin of improved cropping pattern were Tk. 1744840 ha^{-1} and Tk. 1282347 ha^{-1}, respectively; whereas in existing cropping pattern those were Tk. 1146140 ha^{-1} and Tk. 774658 ha^{-1}, respectively and MBCR was 6.58. Higher gross return and gross margin were obtained in improved cropping pattern due to introduction of high value vegetables crop and varieties.

Table 3. Yield, cost and return analysis of existing and alternate cropping pattern in 2021-2022

Observation	Improved pattern			Existing pattern		
Crop	**Onion/Brinjal**		**T. Aman**	**Onion**	**Jute**	**T. Aman**
Bulb /grain/fibre/ fruit yield (t ha^{-1})	26.1	33.42	4.45	25.8	2.83	4.62
Straw yield (t ha^{-1})	3.5	5.10	5.34	5.81	3.64	5.52
Gross return (Tk. ha^{-1})	783000	835500	126340	774000	240960	131180
Total variable cost (Tk. ha^{-1})	211249	180929	70315	193024	107493	70965
Gross margin (Tk. ha^{-1})	571751	654571	56025	580976	133467	60215
W. Pattern REY (t ha^{-1})	66.7			43.1		
W. Pattern gross return (Tk. ha^{-1})	1744840			1146140		
W. Pattern TVC (Tk. ha^{-1})	462493			371482		
W. Pattern gross margin (Tk. ha^{-1})	1282347			774658		
MBCR	6.58					

Price of output (Tk. kg^{-1}): Onion- 30 , T. Aman- 26, straw- 2, Jute- 80 and Jute stick- 4, Brinjal- 25

DEVELOPMENT OF MECHANIZATION PACKAGE FOR FOUR CROPS BASED CROPPING PATTERN

M. S. H. MOLLA, M. Z. FERDOUS, M. A. A. H. TALUKDER AND S.M.A.H.M. KAMAL

Abstract

Four crop-based improved cropping pattern was tested under mechanization package against farmer's traditional practice at FSRD site, OFRD, BARI, Ajoddhapur, Rangpur, during 2020-21 and 2021-22 (partial) to develop mechanization package for four crops-based cropping pattern and to reduce turnaround time. The results exposed that all component crops of potato/sweet gourd-jute-T. Aman cropping pattern showed under mechanization system could be established more successfully with short duration crop varieties than farmers' practice. The rice equivalent yield (REY), crop productivity and profitability were higher in mechanization system than farmers' traditional practice. Use of improved planting and

harvesting machineries in all component crops production system, helped in timely planting, and harvesting, which reduced the turnaround time vice versa increased the field duration of crops. The reduction of production cost and increment of yield under mechanization system was enhanced total productivity and profitability.

Introduction

Bangladesh is an overpopulated and predominately an agricultural country. To meet up the food requirements of the ever-growing population of the country, sufficient foods need to be produced from per unit of land. To achieve food sufficiency, there is no other better option than to increase production per unit of land as well as cropping intensity and faster mechanization may well contribute in regard. Replacing the traditional inefficient agricultural tools, efficient mechanization must be introduced and extended. The government has already attributed due importance to agricultural mechanization in the National Agricultural Policy. The researchers of BARI and other organizations have already developed some mechanization tools, and some are under process e.g. planters, seeders, weeders, harvesters, winnowers, processors etc. but all have limited uses at farmers level. Mechanization is an important tool for profitable and competitive agriculture. Without mechanization it will not be possible to maintain multiple cropping patterns, which need quick land preparation, planting, weeding, harvesting, processing etc. (MoA, 2009). On-Farm Research Division of BARI has already developed some promising four crops-based cropping patterns at farmer's level in a limited scale. For large scale expansion, it is utmost need to mechanize focusing timely sowing/planting, harvesting, processing etc. for all the component crops. The present study was undertaken to develop mechanization package for four crops-based cropping pattern and to assess the crop productivity by reducing the turnaround time.

Materials and Methods

The experiment on mechanization for four crops-based cropping patterns were conducted at FSRD site, Ajoddhapur, Rangpur under On-Farm Research Division, BARI, Rangpur during 2020-21 and 2021-22 (partial) to develop mechanization package for four crops-based cropping pattern and to assess the crop productivity by reducing the turnaround time. Two production packages i.e., Mechanization system and farmers traditional practice were imposed on four crops based improved cropping pattern potato/sweet gourd-jute-T. Aman. The special mechanization tools were for potato (Planter & Harvester), for sweet gourd (Pit maker), for jute (Seeder), for T. Aman (Rice Transplanter & Reaper) etc. Two production packages were incorporated in each farmer plot, and it was replicated in three farmer's field.

The details of the varieties used, and cultural operations adopted in different crops under the production packages are given in Table 1. The fertilizers dose for different crops were used as per Fertilizer Recommendation Guide, 2018 (BARC, 2018). The sources of nutrients were urea for N, TSP for P, M_0P for K, Gypsum for S, Zinc sulphate for Zn and Boric acid for B. For Rabi crops all inorganic fertilizers except urea and MoP were applied to land and mixed with soil at the time of final land preparation and urea and MoP were used as top dressed in 2-3 splits. No extra fertilizer was used for sweet gourd production. In case of T. Aman rice, all the fertilizers except urea were applied as basal. Urea was applied as top dressing in three equal splits at 10, 25 and 40 days after transplanting. Aphid was observed in Potato field and it was sprayed with Asataf @ 2 g L^{-1} water during 30 days after planting. For controlling late blight disease of potato, Dithane M-45 @ 4 g L^{-1} water was applied 5 times starting from 30 DAP and continued up to 70 DAP at an interval of 10 days. In T. Aman rice, Vittaco was applied @ 80 gm ha^{-1} to control stem borer and Folicure was sprayed @ 2 ml L^{-1} at 65 DAT for controlling leaf blight. Pheromone trap was used in sweet gourd to control the fruit fly.All the crops were harvested at maturity from five spots with an area of 6.0 m^2 each. Data on yield of various crops in sequences were recorded and converted to ton per hectare. Total system productivity was calculated as summation of individual (component) crop yield of each cropping cycle. The productivity of crop sequences was compared by calculating their economic rice equivalent yield (REY) using formula given by Ahlawat and Sharma (1993).

Table 1. The details of the varieties used, and other cultural operations adopted in different crops under the four crops-base cropping pattern

Treat	Crop	Variety	Spacing (cm^2)	Date of planting/Sowing	Date of harvesting	Rate of fertilizer application (kg ha^{-1})						
						N	P	K	S	Zn	B	CD
Mechanize	Potato	BARI Alu-25	60× 25	18-19 Nov.	16-18 Feb.	135	30	110	22	2	1	5000
	Sweet gourd	BARI Hybrid Mistikumra-1 (Relay)	180×200	21-23 Nov.	2-6 April	0	0	0	0	0	0	0
	Jute	BJRI Toshapat-8	20× Continuous	09-10 April	23-24 July	90	6	50	16	0	0	0
	T. Aman	Binadhan-17	20× 15	07-08 Aug.	5-6 Nov.	90	6	33	4	1	0	0
Farmer practice	Potato	BARI Alu-25	50× 20	20-24 Nov.	15-18 Feb.	135	30	110	22	2	1	5000
	Sweet gourd	BARI Hybrid Mistikumra-1 (Relay)	180×200	23-28 Nov.	1-6 April	0	0	0	0	0	0	0
	Jute	BJRI Toshapat-8	Broadcast	10-15 April	19-24 July	90	6	50	16	0	0	0
	T. Aman	Binadhan-17	25× 25	07-10 Aug.	4-10 Nov.	90	6	33	4	1	0	0

Results and Discussion

The average field performance, yield and economic performance of four crops-based cropping pattern during 2020-21 are presented in Table 2.

Field performance: The total turnaround time of the four crops-based cropping pattern was 33 days in mechanization system and 41 days in farmers traditional practice system. It showed that about one week turnaround time could be minimized through mechanization in planting and harvesting system. It also helped to remain the crop in the field relatively more time (about one week) for proper maturing or harvesting in mechanization system, which triggering to increase yield.

Yield performance: Crop yield of potato, sweet gourd, jute, and T. Aman were recorded as 29.20, 27.36, 2.87 and 4.52 t ha^{-1}, respectively with whole pattern rice equivalent yield (REY) 40.08 t ha^{-1} in mechanization system whereas 26.80, 26.28, 2.54 and 4.20 t ha^{-1} respectively with whole pattern REY 37.48 t ha^{-1} were recorded in farmers traditional practice system.

Production efficiency: Maximum production efficiency (120.72 kg $ha^{-1}day^{-1}$) was obtained from mechanization system and minimum (115.67 kg $ha^{-1}day^{-1}$) was obtained from farmers traditional practice system. The higher production efficiency in mechanization system might be due to timely planting and more field duration of the component crops.

Land Use Efficiency (LUE): Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. The LUE indicated that mechanization system used the land for 90.96% period of the year, whereas farmers traditional practice system used the land for 88.77% period of the year. The land uses efficiency in mechanization system was higher because this system occupied the field for longest duration (332 days), whereas the farmers traditional practice system occupied the field for 324 days of a year.

Cost and return analysis: Total gross return and gross margin of mechanization system were Tk. 801570 ha^{-1} and Tk. 513326 ha^{-1}, respectively whereas in farmers traditional practice system these were Tk. 749510 ha^{-1} and Tk. 436422 ha^{-1}, respectively. The whole pattern MBCR was 2.10.

Farmers opined that the machineries used for the cropping pattern were very useful and these needs to make available with low price.

Table 2. The average crop performance of four crops-base cropping pattern under mechanization system and farmers traditional practice system at FSRD site Ajoddhapur, Rangpur during 2017-18 to 2019-20

Parameter	Mechanization				Farmers' Practice			
Crop	Potato	Sweet gourd	Jute	T. Aman	Potato	Sweet gourd	Jute	T. Aman
Field duration	88	50 (138-88) (88 days relay time excluded)	105	89	86	48 (134-86) (86 days relay time excluded)	100	90
Turnaround time	12	Relay (0)	6	15	14	Relay (0)	9	18
Crop yield (t ha^{-1})	29.20	27.36	2.87	4.52	26.80	26.28	2.54	4.20
Straw/stover yield (t ha^{-1})	-	-	4.78	4.98	-	-	4.72	4.65
REY (t ha^{-1})	11.68	16.42	6.22	5.77	10.72	15.77	5.63	5.36
Whole pattern REY	40.08				37.48			
Gross return (Tk. ha^{-1})	233600	328320	124350	115300	214400	315360	112500	107250
Total variable cost (Tk. ha^{-1})	153316	35822	52311	46795	158252	42430	57420	54986
Gross margin (Tk. ha^{-1})	80284	292498	72039	68505	56148	272930	55080	52264
GM (Tk. ha^{-1})	513326				436422			
PE (kg ha^{-1}day^{-1})	120.72				115.67			
LUE (%)	90.96				88.77			
MBCR	2.10				-			

Price (Tk. kg^{-1}): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, Rice grain-20, Rice straw-05, Jute fiber-35, Jute stick-5, Potato-08 and sweet gourd-12 REY: rice equivalent yield, MBCR: marginal benefit cost ratio, GM: gross margin

Conclusion

From the above discussion it is clear that cultivation of crops intensively suitable under mechanization system. However, it needs to continue another year for a conclusion on its suitability and profitability.

IMPROVEMENT OF OILSEED CROPS BASED CROPPING PATTERN IN RANGPUR

M. S. H. MOLLA, M. Z. FERDOUS, M. A.-A. H. TALUKDER AND S.M.A.H.M. KAMAL

Abstract

Oilseed-based alternative cropping patterns were tested against farmers traditional practiced at stable char land of Bongram, Chilmari, Kurigram under On-Farm Research Division, BARI, Rangpur during 2020-21 and 2021-22 (partial) to find out the profitable cropping pattern including mustard var. BARI Sarisha-18 and sunflower var. BARI Surjamukhi-3. Two alternative cropping patterns (CP) i.e. CP_1: Sunflower-Proso millet-T. Aman and CP_2: Mustard (var. BARI Sarisha-18)- Jute-T. Aman were tested against existing cropping pattern Mustard (var. BARI Sarisha-14)-Proso millet-T. Aman. The results showed that the rice equivalent yield (REY) was higher in CP_2 (18.33 t ha^{-1}) and CP_1 (15.29 t ha^{-1}) than existing pattern (12.54 t ha^{-1}). The maximum gross margin was calculated in CP2 (Tk. 212681 ha^{-1}) followed by CP_1 (Tk. 187011 ha^{-1}). The maximum production efficiency and MBCR was also found in CP_2 followed by CP_1 and minimum in existing cropping pattern.

Introduction

Everybody needs a small amount of fat in their diet for healthy functioning. Oils and fats supply calories and essential fats and help human body to absorb fat-soluble vitamins such as A, D, E and K. The type of fat is just as important for health as the total amount of fat consumed. To avoid "bad" cholesterol (LDL), canola type mustard oil (var. BARI Sarisha-18), and sunflower oil (var. BARI Surjamukhi-3) may be helpful. Because it contains very low cholesterol. So, it needs to promote these types of crops varieties and also needs to fit in the cropping pattern for sustainability. From the above views, the present study was undertaken at stable charland area to develop suitable and profitable cropping pattern including healthy oilseed crops.

Materials and Methods

The experiment onoilseed crops-based cropping pattern was conducted at Char Bongram, Chilmari, Kurigram under On-Farm Research Division, BARI, Rangpur during 2020-21 and 2021-22 (partial) to find out the profitable cropping pattern including relatively safe mustard var. BARI Sarisha-18 and sunflower var. BARI Surjamukhi-3. Two alternative cropping pattern (CP) i.e. CP1: Sunflower (var. BARI Surjamukhi-3)-Proso millet (var. BARI Cheena-1)-T. Aman (var. BRRI dhan87) and CP2: Mustard var. (BARI Sarisha-18)-Jute (var. BJRI Toshapat-8)-T. Aman (var. BRRI dhan87) were tested against existing cropping pattern Mustard (var.BARI Sarisha-14)-Proso millet (Local)-T. Aman (Local). Three cropping patterns were incorporated in each farmer plot, and replicated in three farmers' field. The details of the varieties used, and cultural operations adopted in different crops under the production packages are given in Table 1. The fertilizers dose for different crops were used as per Fertilizer Recommendation Guide 2018 (BARC, 2018). The sources of nutrients were urea for N, TSP for P, M_0P for K, Gypsum for S, Zinc sulphate for Zn and Boric acid for B. All the crops were harvested at maturity from five spots with an area of 6.0 m^2 each. Data on yield of various crops in sequences were recorded and converted to ton per hectare. Total system productivity was calculated as summation of individual (component) crop yield of each cropping cycle. The productivity of crop sequences was compared by calculating their economic rice equivalent yield (REY) using formula given by Ahlawat and Sharma (1993).

Table 1**.** The details of the varieties used, sowing and harvesting time of different crops under the cropping patterns

Parameter	Existing pattern			Alternative pattern 1 (CP_1)			Alternative pattern 2 (CP_2)		
Crop	Mustard	Proso millet	B. Aman	Sunflower	Proso millet	T. Aman	Mustard	Jute	T. Aman
Variety	BARI Sarisha-14	Local	Local (Gainja)	BARI Surjamukhi-3	BARI Cheena-1	BRRI dhan87	BARI Sarisha-18	BJRI Toshapat-8	BRRI dhan87
Sowing date	23 Nov.	26 Mar.	20 Jul.	23 Nov.	03 Apr.	30 Jul.	23 Nov.	04 Apr.	01 Aug.
Harvesting date	17 Feb.	08 Jun.	14 Nov.	05 Mar.	15 Jun.	04 Nov.	03 Mar.	20 Jul.	05 Nov.

Results and Discussion

The average field performance, yield and economic performance of oilseed crops-based cropping patterns during 2020-21 are presented in Table 2.

Yield performance: Crop yield of mustard, proso millet and B. Aman were recorded as 1.30, 1.15 and 4.45 t ha^{-1}, respectively with whole pattern rice equivalent yield (REY) 12.54 t ha^{-1} in existing cropping pattern. The crop yield of sunflower, proso millet and T. Aman were recorded as 1.41, 1.38 and 5.45 t ha^{-1}, respectively with whole pattern REY 15.29 t ha^{-1} in CP_1. The crop yield of mustard, jute and T. Aman were recorded as 1.68, 2.15 and 5.41 t ha^{-1}, respectively with whole pattern REY 18.33 t ha^{-1} in CP_2. It was found that maximum REY was obtained from CP_2 (18.33 t ha^{-1}).

Production efficiency: Maximum production efficiency (60.50 kg $ha^{-1}day^{-1}$) was obtained from CP_2 and minimum (45.58 kg $ha^{-1}day^{-1}$) was obtained from farmers existing pattern. The higher production efficiency in CP_2 might be due to higher yield and higher market price.

Land Use Efficiency (LUE): Land use efficiency is the effective use of land in a cropping year, which mostly depends on crop duration. The LUE indicated that CP_2 used the land for 83.01% period of the year, whereas farmers existing pattern used the land for 75.34% period of the year.

Cost and return analysis: The gross margin of CP_1 and CP_2 were Tk. 187011 ha^{-1} and Tk. 212681 ha^{-1}, respectively whereas in farmers existing pattern (Tk. 160198 ha^{-1}). The whole pattern MBCR was 1.95 in CP_1 and 1.83 in CP_2.

Farmers' opinion

Farmers opined that canola type mustard var. BARI Sarisha-18 is relatively long duration but it can be easily fitted in a profitable cropping pattern Mustard-Jute-T. Aman.

Table 2. The average crop performance of oilseed crops-based cropping patterns at Char Bongram, Chilmari, Kurigram during the year of 2020-21

Parameter	Existing pattern			Alternative pattern 1 (CP_1)			Alternative pattern 2 (CP_2)		
Crop	Mustard	Proso millet	B. Aman	Sunflower	Proso millet	T. Aman	Mustard	Jute	T. Aman
Field duration	86	72	117	102	72	96	100	107	96
Turnaround time	37	44	9	29	44	22	32	12	18
Crop yield (t ha^{-1})	1.30	1.15	4.45	1.41	1.38	5.45	1.68	2.15	5.41
Straw/stover yield (t ha^{-1})	1.40	-	4.81	-	-	5.80	1.80	5.25	5.82
REY (t ha^{-1})	4.30	2.59	5.65	5.29	3.11	6.90	6.39	5.08	6.87
Whole pattern REY (t ha^{-1})	12.54			15.29			18.33		
Gross return (Tk. ha^{-1})	85900	51750	113050	105750	62100	138000	127800	101500	137300
Total variable cost (Tk. ha^{-1})	39527	26585	24390	46265	26585	45989	42355	65575	45989
Gross margin (Tk. ha^{-1})	46373	25165	88660	59485	35515	92011	85445	35925	91311
GM (Tk. ha^{-1})	160198			187011			212681		
Production efficiency (kg ha^{-1}day^{-1})	45.58			56.64			60.50		
Land use efficiency (%)	75.34			73.97			83.01		
MBCR (over existing pattern)	-			1.95			1.83		

Price (Tk. kg^{-1}): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, Rice grain-20, Rice straw-05, Jute fiber-35, Jute stick-5, Mustard seed (BARI Sarisha-14)-65, Mustard seed (BARI Sarisha-18)-75, Mustard stover-01, Proso millet-45 and Sunflower-75 REY: rice equivalent yield, MBCR: marginal benefit cost ratio, GM: gross margin

Conclusion

From the above discussion it can be concluded that sunflower var. BARI Surjamukhi-3 and mustard var. BARI Sarisha-18 can be successfully fitted in existing cropping pattern as healthy oilseed crop. However, it needs to continue for another year for recommendations.

DEVELOPMENT OF Zn FORTIFIED CROPS BASED CROPPING PATTERN

S.M.A.H. M. KAMAL, M. Z. FERDOUS, M. S. H. MOLLA AND M. A. H. TALUKDER

Abstract

A field trail was conducted at char Bongram, Ranigonj, Chilmari, Kurigram, OFRD, and Rangpur during Rabi season 2020-21 to find out the feasibility of fitting Zn enriched and or medicinal crops in cropping pattern and increase Zn availability in food system. The highest rice grain equivalent yield (11848 kgha^{-1}) was produced by T_1 whereas 8106 kg ha^{-1} was obtained from existing cropping pattern. The gross margin and marginal benefit cost ratio of T_1 and T_2 cropping pattern were Tk. 202650 ha^{-1} and 3.68 and Tk. 29410 ha^{-1} and 2.77, respectively. So, the Lentil (var. BARI Masur-8) -T. Aus (var. BRRI dhan-48)-T. Aman rice (var. Bina dhan-20) cropping sequence was better in char land condition in Rangpur.

Introduction

Zinc deficiency is one of the most prevalent nutritional deficiencies in the world. Zinc-rich foods play an important role in boosting immunity and preventing infections. Zinc is an essential micronutrient that regulates cell health and survival and it can produce disease-fighting cells such as white blood cells. Clinical nutritionist and dietician, Avni Kaul says, "Zinc is crucial for the normal development and functioning of our cells and immune system. It helps to decrease the levels of harmful chemicals for the body such as cytokines. In another case, Maideen, N.M.P. (2020) was found that Black cumin (Nigella sativa) has antiviral, antioxidant, anti-inflammatory, immunomodulatory, bronchodilatory, antihistaminic, antitussive activities related to causative organism and signs and symptoms of COVID-19. Besides of these, BARI, BRRI and BINA has developed a good number of crops varieties which have medicinal value (var. BARI Kalojira-1) and Zn nutritional enrichment (var. BARI Mosur-8; var. BRRI dhan 62 and Binadhan-20). The objectives was to find out the feasibility of fitting Zn enriched and or medicinal crops in cropping pattern and increase Zn availability in food system under corona pandemic

Materials and Methods

The experiment was conducted at char Bongram, Ranigonj, Chilmari, Kurigram under OFRD, Rangpur during rabi season of 2020-21 to find out the feasibility of fitting Zn enriched and or medicinal crops in cropping pattern and increase Zn availability in food system under corona pandemic. The experimental site represents the agro-ecological zone (AEZ-3) recognized as "Tista Mender Flood Plain Soil". The design was followed with RCB with three dispersed replications. The treatments were two cropping patterns viz. i) T_1: Lentil (var. BARI Masur-8) -T. Aus (var. BRRI dhan-48)-T. Aman rice (Bina dhan-20) and ii) T_2: Existing cropping pattern grass pea (BARI Khasari-3-Local)-Proso millet (Local) + T. Aman rice (Ganngia -Local). The experiment was started 23 November 2021 and crop was harvested after maturity. Weeding, irrigation and spraying were done as required. Fertilizers were used to follow by BARI Krishi Projukti Handbook, 2019. Data were taken on different growth parameters like plant height, tuber/plant, tuber weight/plant, and crop yield. Only crop yields were considered to analysis.

Results and Discussions

Lentil (var. BARI Masur-8) -T. Aus (var. BRRI dhan-48)-T. Aman rice (var. Bina dhan-20) cropping pattern performed better and produced 11848 kg ha^{-1} of T. Aman rice equivalent yield (REY). On the contrary, existing cropping pattern (T_2) gave 8106 kg ha^{-1} of REY. The gross margin and benefit cost ratio of T_1 and T_2 cropping pattern were Tk. 202650 ha^{-1} and 3.68 and Tk. 29410 ha^{-1} and 2.77, respectively (Table1). Zinc fortified crops based cropping pattern was given an extra Tk. 86240 ha^{-1} than existing cropping pattern (T_2).

Farmer's opinion

Zinc fortified crop variety under improved cropping pattern's gave higher yields than local varieties.

Table 1: Yield and economic returns of crops grown under improve and existing cropping pattern at Kurigram during 2020-21

Cropping pattern	Crops	Yield (kg ha^{-1})	REY (kg ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})	MBCR
Improved pattern: Lentil (BARI Masur-8) -T. Aus (BRRI dhan48)-T. Aman rice (Bina dhan-20)	Lentil	1630	11848	296200	80550/-	215650	
	T. Aus	3850					
	T. Aman	3890					
Existing pattern: Grass pea (BARI Khasari-3-Local)-Proso millet (Local) + T. Aman rice (Ganngia - Local)	Grass pea	1270	8106	202650	73240/-	129410	
	Prooso millet	1150					
	T. Aman	3750					

Price (Tk. kg^{-1}): BARI Musur - 63, Grass pea: 45, Prooso millet: 45, BRRI dhan48: 25 and T. Aman rice local & Binadhan-20: 25

Conclusion

Zinc fortified crops based cropping pattern (T_1) was given extra Tk. 86240 ha^{-1} than existing cropping pattern. The improved cropping pattern found agronomically suitable and economically viable.

INCREASE OF CROPPING INTENSITY THROUGH ADOPTION OF SHORT DURATION MUSTARD VARIETIES IN RICE BASED CROPPING SYSTEM

M.S. RAHMAN, M. M. RAHAMAN AND A.K.M.Z. NOOR

Abstract

The experiment was conducted at farmers filed at FSRD, Tarakandi, Sherpur during 2021-2022 to evaluate the comparative agronomic performance of existing cropping pattern Fallow- Boro-T. Aman rice and improved cropping pattern Mustard- Boro-T. Aman rice by introducing a short duration mustard (var. BARI Sarisha-14) after harvest of T. Aman rice. The higher rice equivalent yield (17.47 t ha^{-1}) was obtained from improved cropping pattern, which was 58.81% higher over farmers existing pattern. At the same time improved cropping pattern: Mustard- Boro-T. Aman rice gave higher gross return (Tk. 425878 ha^{-1}) and gross margin (Tk. 176976 ha^{-1}) which was 59.86 and 108 % higher over farmer's pattern. Farmers practice gave the lower gross return (Tk. 266400 ha^{-1}) and gross margin (Tk. 85048 ha^{-1}).

N.B. MBCR TO BE GIVEN

Introduction

Farmers at Sherpur areas practicing different types of cropping patterns. Fallow-Boro-T. Aman rice is one of the important cropping patterns. Oilseed Research Centre, BARI has developed several short duration high yielding mustard varieties. It is a good option to popularize these varieties to the farmers by fitting mustard in the existing cropping pattern. So, short duration mustard to be popularized as new variety in Mustard-Boro-T. Aman rice among the farmers. With this view in mind, the trial was undertaken.

Materials and Methods

The experiment was conducted at farmer's field under FSRD site, Tarakandi, Sherpur during the year of 2021-22. The experiment was laid out in a randomized complete block design with three dispersed replications. The unit plot size was 150 m^2. Recommended fertilizer package (BARC, 2018) and application methods were followed to support the normal growth of the crops. All field operations and management practices were closely monitored, and data were recorded and presented in Table 1. The collected data were averaged and presented in tabular form. Agronomic performance like field duration, and rice equivalent yield of cropping patterns were calculated. For comparison between crop sequences the yield of every crop was converted into rice equivalent yield (REY) on the basis of prevailing market price of individual crop (Ahlawat and Sharma, 1993). The marginal benefit cost ratio (MBCR) was computed as CIMMYT, 1988.

Results and Discussion

Crop management and yield performance of the pattern: The details of crop management under improved cropping pattern and farmers existing pattern are shown in Table 1. Existing cropping pattern: Fallow-Boro-T. Aman rice has needed 200 days field duration while in improved pattern (Mustard- Boro-T. Aman rice) needed 277 days (excluding seedling age of rice) to complete the cycle (Table1). Average grain yield of BARI Sarisha-14 in the alternate cropping pattern was 1.72 t ha^{-1}. The grain yield of hybrid rice viz. Tej gold and Dhani gold was 6.10 and 6.14 t ha^{-1}, respectively in alternate cropping pattern. The grain yield of rice var. BRRI dhan-28 and Dhani Gold (hybrid) was 5.20 and 5.8 t ha^{-1} in existing pattern.

Rice equivalent yield: Improved cropping pattern produced higher rice equivalent yield (17.47 t ha $^{-1}$yr $^{-1}$) over farmers' existing cropping pattern (11.0 t ha^{-1}yr^{-1}). Inclusion of mustard in existing cropping pattern has increased REY 58 % compared to farmers' practice (Table 1).

Cost and return: Gross return of improved cropping pattern was Tk. 425878 ha^{-1} which was 59.86 % higher over farmers' pattern (Tk. 266400 ha $^{-1}$). Total variable cost was higher in improved pattern (Tk. 248902 ha^{-1}) might be due to inclusion of mustard in the pattern. The gross margin was substantially higher in the alternate pattern Tk. 176976 ha^{-1} than farmers' pattern (Tk.85048 ha^{-1}). The higher gross margin of the alternate pattern was achieved mainly due to inclusion of mustard as a component crop.

Farmers were highly satisfied to see the higher returns of alternate cropping pattern (Mustard-Boro-T.Aman rice) against existing pattern (Fallow-Boro-T. Aman rice) due to its higher yield and gross return.

Conclusion

From the above result it should be concluded that alternate cropping pattern (Boro var. Tejgold) - T.aman (var. Dhani Gold)- Mustar (var. BARISarisha 14) was more productive and remunerative compared to existing pattern.

Table 1. Agronomic parameters of alternate cropping pattern and existing cropping pattern at Tarakandi, Sherpur during 2021-22

Parameter	Alternate cropping pattern			Existing cropping pattern		
	Boro	T. Aman	Mustard	Fallow	Boro	T. Aman
Variety	Tej gold (Hybrid)	Dhani gold (Hybrid)	BARI Sarisha-14	-	BRRI dhan28	Dhani gold (Hybrid)
Sowing/transplanting	04-06 Feb., 2021	30-31 July, 2021	8-13 Nov., 2021	-	20-30 Jan., 2021	25-30 July, 2021
Seed rate (kg ha^{-1})	50	50	7	-	50	50
Planting method	Line	Line	Broadcast	-	Line	Line
Spacing	20 cm x 15 cm	20cm x 15cm	-	-	20cm x 15cm	20cm x 15cm
Seedling age (days)	35	30	-	-	35-40	30
Seedlings hill^{-1}	2	2	-	-	-	2
Fertilizer dose (kg N-P-K-S-Zn-B ha^{-1})	139-21-75-20-2.5-2.5	139-21-75-20-0-2.5	103-32-40-24-1.6-1.7	-	139-21-75-20-2.5-2.5	139-21-75-20-0-2.5
Fertilizer application	Basal & top dress	Basal & top dress	Basal & top dress	-	Basal & top dress	Basal & top dress
Weeding (no.)	Once at 25 DAS	Once at 30 DAS	Once at 22 DAS	-	Once at 25 DAS	Once at 30 DAS
Irrigation (no.)	40	3	-	-	40	3
Insect and disease control	Chemical	Chemical	Chemical	-	Chemical	Chemical
Harvesting time	16-18 May. 21	31 Oct.-3 Nov. 21	26-29 Jan. 22	-	10-15 May 21	31 Oct.-3 Nov. 21
Grain yield (t ha^{-1})	6.10	6.14	1.72	-	5.20	5.80
By product yield (t ha^{-1})	6.79	6.27	1.95	-	6.5	6.27
Field duration (days)	105	92	80	-	105	95
REY (t ha^{-1}yr^{-1})	17.47			11.0		
Gross return (Tk. ha^{-1})	425878			266400		
TVC (Tk. ha^{-1})	248902			181352		
Gross Margin(Tk. ha^{-1})	176976			85048		
BCR/MBCR				/		

Unit price (Tk. kg^{-1}): Boro rice-22, T.Aman rice-6, Mustard-50, Rice straw-3, Mustard straw-2

IMPROVEMENT OF FALLOW-BORO-T. AMAN RICE CROPPING PATTERN THROUGH INCLUSION OF MUSTARD AND IMPROVEMENT MANGEMENT

M.S. RAHMAN, M. M. RAHAMAN AND A.K.M.Z. NOOR

Abstract

The experiment was conducted at farmer's field under Multilocation Testing (MLT) site, Boushi, Sarishabari, Jamalpur during 2021-2022 to evaluate the comparative agronomic performance of existing cropping pattern: Fallow-Boro-T. Aman rice and improved cropping pattern: Mustard- Boro-T. Aman rice by introducing a short duration mustard (var. BARI Sarisha-14) after T. Aman rice harvest. The higher rice equivalent yield (14.85 t ha^{-1}) was obtained from improved cropping pattern which was 48.5% higher over farmers existing pattern. It also gave higher gross return (Tk. 413400 ha^{-1}) and gross margin (Tk. 136018 ha^{-1}). Farmers practice gave the lower gross return (Tk. 249400 ha^{-1}) and gross margin (Tk. 44326 ha^{-1}).

Introduction

Farmers at Jamalpur region followed different types of cropping pattern. Fallow-Boro-T. Aman rice is one of the important cropping Patterns. Oilseed Research Centre, BARI has developed a number of short duration high yielding mustard varieties. It needs to popularize among the farmers by fitting mustard in the existing cropping pattern: Fallow-Boro-T. Aman rice. The alternate cropping pattern was Mustard -Boro-T. Aman rice. The trial was conducted to find out the performance of improved cropping pattern for higher productivity and profit.

Materials and Methods

The experiment was conducted at Multilocation Testing site (MLT), Boushi, Sarishabari, Jamalpur under On-Farm Research Division, Bangladesh Agricultural Research Institute, Sherpur during the year of 2021-22. The experiment was laid out in a randomized complete block design with two dispersed replications. The unit plot size was 1.5 ha. Two cropping pattern viz. alternate cropping pattern (Mustard-Boro-T. Aman rice) and farmers' cropping pattern (Fallow-Boro-T. Aman rice) were the treatment variables of the experiment. Recommended fertilizer package (BARC, 2018) and method of application were done to support the normal growth of the crops. All field operations and management practices were closely monitored and data were recorded and presented in Table 1. The collected data were averaged and presented in tabular form. Agronomic performance like field duration, and rice equivalent yield of cropping patterns were calculated. For comparison between crop sequences the yield of every crop was converted into rice equivalent yield on the basis of prevailing market price of individual crop (Ahlawat and Sharma, 1993). Production efficiency (kg ha^{-1} day^{-1}) and marginal benefit cost ratio (MBCR) was computed as CIMMYT, 1988.

Results and Discussion

The details of crop management under improved cropping pattern and farmers existing pattern are shown in Table 1. Farmers' cropping pattern (Fallow- Boro-T. Aman rice) was needed 201 days field duration while improved cropping pattern: Mustard-Boro-T. Aman rice has needed 284 days (excluding seedling age of rice) to complete the cycle (Table1). Average grain yield of mustard var. BARI Sarisha-14 in the alternate cropping pattern was 1.59 t ha^{-1}. The grain yield of BRRI dhan-89 and BRRI dhan-49 was 5.6 and 4.8 t ha^{-1} in alternate cropping pattern but BRRI dhan28 and Hori dhan produced 5.20 and 4.8 t ha^{-1} of rice grain yields in existing pattern.

Rice equivalent yield: Improved cropping pattern produced higher rice equivalent yield (14.85 t $ha^{-1}yr^{-1}$) over farmers' existing cropping pattern (10.0 t $ha^{-1}yr^{-1}$) Inclusion of mustard in existing cropping pattern increased REY 48.5 % compared to farmers' practice (Table 1).

Cost and return analysis: Gross return of improved cropping pattern was Tk. 413400 ha^{-1} which was more than 65.75 % higher over farmers' pattern. Farmers' pattern gave the lower gross return Tk.249400 ha^{-1}. Total variable cost was higher in improved pattern (Tk. 277382 ha^{-1})

might be due to inclusion of mustard in the pattern. The gross margin (Tk. 136018 ha^{-1}) was substantially higher in the alternate pattern than farmers' pattern (Tk. 44326 ha^{-1}). The higher gross margin of the alternate pattern was achieved mainly due to inclusion of mustard as a component crop

Farmer's opinion

Farmers were highly satisfied to see the higher returns of alternate cropping pattern Mustard-Boro-T.Aman rice against existing pattern Fallow-Boro-T. Aman rice due to higher yield as well as gross return of the improved pattern. They also opined that this pattern would be expanded in this area.

Table-1. Agronomic parameters of alternate cropping pattern and existing cropping pattern at Boushi, Jamalpur during 2021-22

Parameter	Alternate cropping pattern			Existing cropping pattern		
	Boro	T. Aman	Mustard	Fallow	Boro	T. Aman
Variety	BRRI dhan89	BRRI dhan-49	BARI Sarisha-14	-	BRRI dhan28	Hori dhan
Sowing/transplanting	20 Jan.21	30- Jul.21	8-13 Nov.21	-	20-30 Jan.21	25-30 Jul.21
Seed rate (kg ha^{-1})	40	40	40	-	40	40
Planting method	Line	Line	Broadcast	-	Line	Line
Spacing (Row x hill)	20 cm x 15 cm	20cm x 15cm	-	-	20cm x 15cm	20cm x 15cm
Seedling age (days)	35	30	-	-	35-40	30
Seedling hill^{-1}	2	2	-	-	-	2
Fertilizer dose (kg N-P-K-S-Zn-B ha^{-1})	139-21-75-20-2.5-2.5	79-17-50-18-3.5-0	103-32-40-24-1.6-1.7	-	139-21-75-20-2.5-2.5	139-21-75-20-0-2.5
Fertilizer application	Basal & top dress	Basal & top dress	Basal & top dress	-	Basal & top dress	Basal & top dress
Weeding (no.)	Once at 25 DAS	Once at 30 DAS	Once at 22 DAS	-	Once at 25 DAS	Once at 30 DAS
Irrigation (no.)	40	3	-	-	40	3
Insect and disease control	Chemical	Chemical	Chemical	-	Chemical	Chemical
Harvesting time	10 May 21	31 Oct.-3 Nov. 21	26-29 Jan. 22	-	10-15 May 21	31 Oct.-3 Nov. 21
Grain yield (t ha^{-1})	5.6	4.8	1.59	-	5.20	4.8
By product yield (t ha^{-1})	7.9	6.9	2.8	-	6.5	6.20
Field duration (days)	110	90	84	-	105	96
REY (t ha^{-1}yr^{-1})	14.85			10.0		
Gross return (Tk. ha^{-1})	4,13,400			2,49,400		
TVC (Tk. ha^{-1})	277382			205074		
Gross Margin (Tk. ha^{-1})	136018			44,326		
MBCR						

Unit price (Tk.kg^{-1}): Boro rice- 25, T.Aman rice-25, Mustard-70, Rice straw boro- 2, Rice straw aman- 3, Mustard-2

Conclusion

Improved cropping pattern (Mustard var. BARI Sarisha 14 –Boro (var. BRRI dhan89)-T. Aman rice (var. BRRI dhan49) was more productive and remunerative compared to existing pattern.

IMPROVEMENT OF FALLOW-T. AUS-T. AMAN RICE CROPPING PATTERN THROUGH INCLUSION OF MUSTARD IN SYLHET REGION

M. I. NAZRUL

Abstract

An experiment was executed at multilocation testing (MLT) site, Moulvibazar during 2020-22 to find out the performance of improved cropping pattern and to increase the productivity and income of the farmers. The experimental design was RCB with six (6) dispersed replications. The existing cropping patter (EP): Fallow-T. Aus-T. Aman rice and improved cropping pattern (IP): Mustard-T. Aus-T. Aman rice, respectively has been tested. T. Aus rice var. BRRI dhan48 and T.aman rice var. Binadhan-16 o were used . The improved pattern (IP) provided 16.74 t ha^{-1} of T. Aman rice equivalent yield which was almost 69 % higher than that of existing pattern. Similarly, higher mean gross margin (Tk. 385020 ha^{-1}) with marginal benefit cost ratio (2.17) was obtained over existing pattern. It's also revealed that 35 % extra cost provided an ample scope of considerable improvement of the productivity with the inclusion of modern mustard and T. Aman rice variety in improved pattern.

Introduction

In Sylhet region, Fallow-T. Aus-T. Aman rice, Fallow-Jute-T. Aman rice and Boro-Fallow-T. Aman rice, Fallow-Fallow- T. Aman rice, etc. are the dominant cropping patterns widely followed by farmers. They cultivate rice mainly in rain -feed condition. Some farmers transplant T. Aus being dependent on rainfall, its seeds are sown during early monsoon (early May). This delayed transplantation of T. Aus that causes late cultivation and harvesting of T. Aman rice. Due to late harvesting of T. Aman, all rabi crops are not possible to be grown. The soils under these cropping pattern areas are generally heavy clay loams to clays and the top soil quickly becomes dry and hard after the harvest of T. Aman crop. In Sylhet region, more than 40% land remains fallow for a long time (December-May) after the harvest of T. Aman rice due to moisture stress up to Kharif-I season as such farmers of this region cultivated Sesame/Jute/T. Aus rice following the existing cropping pattern (Fallow-T.aus- T. Aman rice) under rainfed condition.

Shaheb and Nazrul (2012) reported that mustard varieties can be grown well in fallow land of Sylhet where mustardvar. BARI Sarisha-14 and BARI Sarisha-17 could be more suitable and produced higher seed yield. To enhance the crop production through utilization of fallow land in Sylhet region, the mustard-rice, potato-rice and chickpea-rice based cropping patterns have been developed (Nazrul, 2019; Nazrul et al., 2013; Nazrul and Shaheb, 2012; Shaheb et al., 2011). A number of reports on different cropping pattern are available in Bangladesh that an additional crop could be introduced without much changes or replacing the existing ones for considerable increases of productivity as well as profitability of the farmers (Azad et al. 1992; Khan et al., 2005 and Nazrul et al., 2013, Kamrozzaman *et al.*, 2015). But, little effort has been made for on-farm evaluation of the improved technologies of Mustard-T. Aus-T. Aman rice cropping pattern in Sylhet area. The present trial was therefore, initiated to increase productivity and economic return through improved package of technologies over the farmer's existing practices.

Materials and Methods

An experiment was executed at multiplication testing (MLT) site, Moulvibazar, during 2020-2022 to see the performance of improved cropping pattern and to increase the productivity and income of the farmers. The experimental design was RCB with six (6) dispersed replications. The existing cropping patter (EP): Fallow-T. Aus-T. Aman rice and improved cropping pattern (IP): Mustard-T. Aus - T. Aman rice, respectively was tested. The area covered by 1200 m^2 in each replication. The details crop management practices for mustard, T. Aus and T. Aman rice under both the patterns during 2020-2022 are presented in Table 1. Seed/grain yield of mustard, T. Aus and T. Aman rice was measured plot wise and converted into T. Aman rice equivalent yield. All data were then analyzed following MS excel package. T. Aman rice equivalent yield was calculated on the basis of the prevailing market price of individual crop.

Table 1. Management practices followed in improved and existing cropping patterns at MLT site, Moulvibazar, 2020-2022 (Average)

Observation/	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Fallow	T. Aus	T. Aman
Variety	BARI Sarisha-14	BRRI dhan48	Binadhan-16	-	BRRI dhan48	Binadhan-7
Date of sowing/ transplanting	29-11-20	23-04-21	02-08-21	-	16-04-21	01-08-21
Seed rate (kg ha^{-1})	7.5	26	26	-	26	26
Spacing (cm)	-	20 x 15	20 x 15	-	20 x 15	20 x 15
Fertilizer dose (N-P-K-S-Zn-B, $kgha^{-1}$)	115-30-43-27-18-1.7	134-53-83-60-0-0	150-53-83-60-0-0	-	134-53-83-60-0-0	165-60-105-86-0-0
Date of harvesting	08-02-21	27-07-20	03-11-21	-	25-07-21	18-11-21
Field duration (days)	85	90	105	-	90	110
Turnaround time (days)	75	05	05	135	10	10

Results and Discussions

Yield of rice and mustard: In rice, the average yield of T. Aus and T. Aman was varied from 3.89-5.42 t ha^{-1}. In mustard var. BARI Sarisha-14 was produced 1.41 t ha^{-1} of average seed yield in improved cropping pattern (IP), whereas lands remain fallow in EP at that period. The variety of T. Aus and T. Aman rice gave higher grain yields under the existing cropping pattern, which might be due to use of improved rice variety. The highest average grain yields 5.05 and 6.55 t ha^{-1} was obtained from T. Aus and T. Aman rice, respectively under improved cropping pattern.

T. Aman rice equivalent yield: The total productivity of the cropping sequence was ascertained by the rice equivalent yield (REY) which varied under cropping sequences. In an average of two years result revealed that the highest REY (16.74 t ha^{-1}) was recorded from IP as compared to EP (9.88 t ha^{-1}). Inclusion of mustard as new crop and modern variety of T. Aman rice in IP, ultimately increased REY 69 % as compared to EP. Similarly gross return, gross margin and MBCR was highest in improved cropping pattern.

Table 2. Yield and economic analysis of improved and existing cropping pattern at MLT site, Moulvibazar, 2020-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T.Aus	T.Aman	Fallow	T.Aus	T.Aman
Seed/grain yield (tha^{-1})	1.39	4.50	5.42	-	4.49	3.89
Straw yield (tha^{-1})	1.41	5.40	6.5	-	5.50	4.8
REY	5.14	5.05	6.55	-	5.16	4.72
Total REY	16.74			9.88		
Gross return (Tk. ha^{-1})	118220	116150	150650	-	118680	108560
Total variable cost (Tk. ha^{-1})	49000	68000	80000	-	68000	78000
Gross margin (Tk. ha^{-1})	33100	41800	70650	-	23060	30670
Total Gross return (Tk. ha^{-1})	385020			227240		
Total variable cost (Tk. ha^{-1})	197000			146000		
Total Gross margin (Tk. ha^{-1})	145550			53730		
MBCR	2.71					

Unit price (TK.kg^{-1}): Mustard grain-85, Mustard straw-2, Rice straw-4, T. Aus-21, T. Aman-23

Conclusion

From the findings it can be concluded that improved pattern is profitable in respect of REY, gross margin and marginal benefit cost ratio.

VALIDATION OF FOUR CROP-BASED CROPPING PATTERN MUSTARD-VEGETABLES-T. AUS-T. AMAN RICE AGAINST FARMERS EXISTING CROPPING PATTERN

M. I. NAZRUL

Abstract

A field trial was conducted at the multi-locational testing (MLT) site, Moulvibazar under on-farm research division (OFRD) of Bangladesh Agricultural Research Institute (BARI), Sylhet to evaluate the comparative agronomic performance and economic return of four crops based cropping patterns. The cropping patterns were as viz. CP_1: Fallow-T. Aus (var. BRRI dhan48)-T. Aman (var. BRRI dhan49) as control; CP_2: Mustard green (var. . Local laishak) - T. Aus (var. BRRI dhan48)-T. Aman (var. BRRI dhan49); CP_3: Mustard green (var. Local Laishak)-Patshak (var. BJRI deshipatshak-1)-T. Aus (var. BRRI dhan48)-T. Aman (var. BRRI dhan49) and CP_4: Mustard green (var. Local Laishak)-Data shak (var. BARI Datashak-1)-T. Aus (var. BRRI dhan48)-T. Aman (var. BRRI dhan49). The results showed that four crops could be grown successfully one after another in a sequence in the field. The maximum rice equivalent yield (REY) of 39.46 t ha^{-1} was obtained from the cropping pattern CP_3 (Mustard green-Patshak-T. Aus-T. Aman) and it was followed by CP_4 (35.58 tha^{-1}) and CP_2 (29.56 tha^{-1}) during two years of crops cycle. The highest gross margin Tk. 606860 ha^{-1}) was also obtained from CP_3 followed by CP_4 (Tk. 511490 ha^{-1}). The highest MBCR (5.92) was found in the same crop sequence (CP_3). Based on overall yield performance, economic benefit and climatic situation of Sylhet region it may be concluded that CP_3 was the best pattern compared to others,

Introduction

The main challenge of the new millennium is to increase per unit yield by at least 50% through manipulating the limited land resource. Increasing the crop production through high cropping intensity and productivity is the most logical way to raise the total production. However, in order to produce more food within a limited area, two, most important options to be adopted are *i*) to increase the cropping intensity by producing three or more crops over the same piece of land in a year, and *ii*) to increase the production efficiency of the individual crop by using optimum management practices.It is well fitted that short duration leafy vegetables are the important group of crops which are mostly grown in rabi (winter) seasons in Bangladesh. The areas of oilseeds and pulses in rabi seasons are decreasing because of increasing cultivation of short duration high value leafy vegetable in medium high land to medium low land. Undoubtedly, potential adoption of pulse, oil seed, and vegetables in Fallow-T. Aus-T. Aman rice cropping system would increase crop productivity, generate employment and additional income for the rural poor by utilizing fallow.. However, the benefit of incorporation of extra crops in the rice-based cropping pattern will largely depends on the selection of suitable crop varieties and adoption of appropriate agronomic practices. The present experiment was therefore, undertaken to study the economic feasibility of growing four crops in a year in a piece of land by incorporating mustard, vegetables, transplanted aus and aman rice in the existing two or three crops based pattern.

Materials and Methods

The field experiment was conducted at the multi-locational testing (MLT) site, Moulvibazar under on-farm research (OFRD) of Bangladesh Agricultural Research Institute (BARI), Sylhet (AEZ 20) during two consecutive years of 2020-21 and 2021-22. Soils analysis report of the experimental field is presented in Table 1. Four cropping patterns were CP_1: Fallow-T. Aus rice-T. Aman rice, CP_2: Mustard green-T. Aus rice -T. Aman rice and CP_3: Mustard green-Patshak-T.aus rice-T. Aman rice & CP_4: Mustard green-Data shak-T.aus rice-T.aman rice. The experiment was laid out in a Randomized Complete Block (RCB) design with 4 dispersed replications. The unit plot size 8 m x 5 m. As per treatment mustard greenleaf (laishak) was grown during *Rabi* season. Fertilizer management and intercultural operations like weeding, mulching etc, were done according to Nazrul et al. (2018). The seeds of mustard green were sown on 8-10 November, 2020. The leaves of mustard green was harvested from 25 November to 15 January and mustard was harvested on 20-24 February, 2021. Seed yield and straw yields were taken from the whole plot. The seeds of jute (var. BJRI deshipatshak-1) was sown on 3-5 March during Kharif-I season and fertilizer management and intercultural operations were done according to Monirul Islam *et al.* (2018). Jute (patshak) was harvested on 11-13 April, 2021. Patshak was harvested at 6-8 cm height from soil surface and remaining part of the jute plant was incorporated with soil. Biomass weight of harvested jute was taken from the entire plot. Data shak (var. BARI Datashak-1) was the second crop of CP_4. Fertilizers management and intercultural operation like weeding, mulching, etc. were done according to Mondal *et al*. (2009). The seeds of data shak were broadcasted on 3-5 March both in CP_4. The datashak was harvested on 18-20 April in both years and yield was taken from whole plot. T. Aus rice was the next crop of the sequence. Fertilizers management and intercultural operations were done according to Haque *et al*. (2011). Twenty days old seedlings of BRRI dhan48 were transplanted with 20 cm x 15 cm spacing on 18-20 March, 2021 in CP_1 and CP_2 and 22-24 March in CP_3 and CP_4. T. Aus rice was harvested on 6-8 July in CP_1 and on 14-18 July in CP_3 and CP_4, respectively. Rice was harvested at 30 cm height from soil surface and the remaining part of the rice plant was incorporated with soil. Grain yield and straw yield were taken from the whole plot. Transplanted aman (T. Aman) rice was grown during the Kharif II season and it was the last crop of the sequence. Fertilizers management and intercultural operations like weeding, mulching etc. were done according to Rahman et al. (2008). Seedlings were grown in seedbed in a separate plot. 25 days old seedlings of BRRI dhan49 was transplanted with 20 cm x 15 cm spacing on 20-23 July, 2020. T. Aman rice was harvested on 4-6 November, 2020. Rice was harvested at 30 cm height from soil surface and remaining part of the rice plant was incorporated with soil. Grain and straw yields were taken from whole plot. Microsoft Excel was used to measure the average of two years data of treatments.

Table 1. Initial soil properties of the experimental field under MLT site, Moulvibazar, 2020-21

Sample	pH	OM (%)	Total N (%)	K	P	S	Zn	B
				meq. 100g^{-1} soil		µg^{-1} soil		
Value	5.53	0.99	0.06	0.16	11.32	8.31	1.27	0.56
Critical	-	-	0.12	0.12	10.00	10.00	0.60	0.20
Interpretation	Acidic	Low	Very low	Low	Low	Low	Medium	Optimum

Results and Discussions

Results presented in Table 2 showed that the harvested leaves, seeds and straw yields of mustard green (Laishak) were 16.60, 1.20 & 2.37 t ha^{-1} in CP_2, 15.57, 1.14 & 2.47 t ha^{-1} in CP_3 and 14.69, 1.25 & 2.27 t ha^{-1} in CP_4, respectively.

In case of cropping pattern 3, the component crop BJRI deshipatshak-1 gave 10.67 t ha^{-1} of leaf yield; whereas, 8.39 t ha^{-1} fresh biomass yield was produced by BARI Datashak-1 under the propping pattern 4. In case of transplanted aus rice, grain and straw yields of 3.80 & 3.90 t ha^{-1}, 3.71 & 3.86 t ha^{-1}, 3.82 & 3.89 t ha^{-1} and 3.71 & 3.84 t ha^{-1} was obtained from the crop sequences of CP_1, CP_2, CP_3 and CP_4, respectively. On the contrary, the transplanted aman rice produced grain and straw yields of 4.35 & 4.50 t ha^{-1}, 4.10 & 4.25 t ha^{-1}, 4.04 & 4.21 t ha^{-1} and 4.00 & 4.16 t ha^{-1} under crop sequences of CP_1, CP_2, CP_3 and CP_4, respectively. Total productivity of different cropping sequence was determined by rice equivalent yield (REY) which was calculated from yields of component crops. Rice equivalent yield was different under different cropping sequence (Table 3). The maximum REY (39.46 tha^{-1}) was recorded from the cropping sequence: Mustard green-Patshak-T. Aus rice-T. Aman rice, which was followed by Mustard green-Data shak-T. Aus rice-T. Aman rice (35.58 tha^{-1}). The lowest REY (8.19 tha^{-1}) was obtained from the cropping sequence Fallow-T. Aus rice-T. Aman rice. Inclusion of datashak and patshak during kharif-I season in CP_3 and CP_4 which resulted increased REY 382 to 334 % compared to farmers pattern CP_1. On the other hand, four crops patterns CP_3 and CP_4 increased 33.49 and 20.37 % higher REY compared to three crops pattern (CP_2).

Cost and return analysis

Economics of cropping system productivity of four cropping sequence showed that the gross return was different in each cropping patterns (Table 3). The maximum gross return (Tk. 907580 ha^{-1}) was recorded from CP$_3$ (Mustard green-Patshak-T. Aus rice-T. Aman rice) followed by CP$_4$ (Mustard green-Data shak-T. Aus rice-T. Aman rice) and CP$_2$ (Mustard green-T. Aus rice -T. Aman rice). Fallow-T. Aus rice-T. Aman rice (control) cropping pattern gave the lowest gross return (Tk. 188370 ha^{-1}). Total variable cost was also lower in CP$_1$ (Tk. 86000 ha^{-1}). The highest total variable cost (Tk. 306850 ha^{-1}) was recorded from CP$_4$ might be due to higher cost of seeds and management inputs. The highest gross margin was obtained from CP$_3$ (Tk. 606860 ha^{-1}) followed by CP$_4$ (Tk. 511490 ha^{-1}) and CP$_2$ (Tk. 448330 ha^{-1}). Cropping pattern 1 gave the lowest gross margin (Tk. 102370 ha^{-1}). The highest marginal benefit cost ratio (MBCR) was found in CP$_3$ (5.92) followed by CP$_4$ (4.99) and CP$_2$ (4.38).

Table 2. Performance of different crops under four cropping patterns during 2020-2022 at MLT site, Moulvibazar

Crop	Cropping pattern 1			Cropping pattern 2		
	Fallow	T. Aus	T. Aman	Mustard green	T. Aus	T. Aman
Variety	-	BRRI dhan48	BRRI dhan49	local	BRRI dhan48	BRRI dhan49
Sowing/ Transplanting	-	18-20 Mar	16-18 June	8-10 Nov	18-20 Mar	16-18 June
Crop duration (Days)	-	85	110	105	85	110
Date of Harvest	-	6-8 July	29-31 Oct	21-23 Feb	6-8 July	29-31 Oct
Leaf yield (t ha^{-1})	-	-	-	16.60	-	-
Grain/seed yield (t ha^{-1})	-	3.80	4.35	1.20	3.71	4.10
Straw yield (t ha^{-1})	-	3.90	4.50	2.37	3.86	4.25

Table 2. Continuation

Crop	Cropping pattern 3				Cropping pattern 4			
	Mustard green	Patshak	T. Aus	T. Aman	Mustard green	Datashak	T. Aus	T. Aman
Variety	local	BJRI patshak-1	BRRI dhan48	BRRI dhan49	local	BARI Data Shak-1	BRRI dhan48	BRRI dhan49
Sowing/ Transplanting	12-14 Nov	3-5 Mar	22-24 Mar	21-23 June	15-15 Nov	3-5 Mar	21-24 April	20-25 July
Crop duration(Days)	105	40	85	110	105	40	85	110
Date of Harvest	24-27 Feb	11-13 Apr	12-14 July	4-6 Nov	26-28 Feb	18-20 Apr	16-18 July	8-10 Nov
Leaf yield (t ha^{-1})	15.57	10.67	-	-	14.69	8.39	-	-
Grain/seed yield (t ha^{-1})	1.14	-	3.82	4.04	1.25	-	3.74	4.00
Straw yield (t ha^{-1})	2.47	-	3.89	4.21	2.27	-	3.84	4.16

Table 3. Rice equivalent yield, cost and return of four cropping patterns during 2020-22 at MLT site, Moulvibazar

Patterns	REY (t ha^{-1})	Gross return (Tk.ha^{-1})	Toal Variable cost (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})	MBCR
CP$_1$	8.19	188370	86000	102370	-
CP$_2$	29.56	679880	231550	448330	4.38
CP$_3$	39.46	907580	300720	606860	5.92
CP$_4$	35.58	818340	306850	511490	4.99

Market price (Tk. Kg^{-1}): T. Aman (seed-55, non-seed-23 & straw-1), T. Aus: (seed-55, non-seed-21 & straw-1), Mustard green: (leaf-25, seed-90, non seed-65 & straw-3), Jute: (leaf-24 & seed-130), Data Shak: (leaf-22 & seed-250), Urea-16, TSP-22, MoP-15.

Conclusion

Four crops based three cropping patterns such as CP_3: Mustard green (var. Local Laishak)-Patshak (var. BJRI deshipatshak-1)-T. Aus (var. BRRI dhan48)-T. Aman (var. BRRI dhan49) and CP_4: Mustard green (var. Local laishak)-Data shak (var. BARI Datashak-1)-T. Aus (var. BRRI dhan48) -T. Aman (BRRI dhan49) are agronomical feasible and economically profitable compared to the existing cropping pattern viz. Fallow-T. Aus (var. BRRI dhan48)-T. Aman (var. BRRI dhan49). However, CP_3 was found the most profitable one. Growing of four crops in a year in same piece of land, increase cropping intensity and productivity. More employment opportunity for male and female labors to be be created and at the same time due to increased production of rice and vegetable, the food and nutritional requirement could be ascertained for the farmers.

IMPROVEMENT OF EXISTING CROPPING PATTERN MUSTARD-T. AUS-T. AMAN RICE THROUGH INCLUSION OF MODERN VARIETIES IN SYLHET REGION

M. I. NAZRUL

Abstract

The trial was conducted at the farmer's field in Sylhet under AEZ 20 during 2020-2021 to compare the productivity and profitability of cropping patterns viz. improved pattern (IP): Mustard (var. BARI Sarisha-18-T. Aus (var. BRRI dhan48)-T. Aman rice (var. BRRI dhan75) by introducing high yielding varieties of mustard and rice in existing pattern (EP): Mustard (var. BARI Sarisha-14-T. Aus (var. BRRI dhan48)-T. Aman rice (var. Binadhan-7). The experiment was laid out in randomized complete block design with six dispersed replications. Results showed that the improved pattern with management practices provided 24 % higher rice equivalent yield (REY) than existing pattern. Similarly, the highest mean gross margin (Tk. 224430 ha^{-1}) with marginal benefit cost ratio (1.49) was obtained over existing pattern. Results revealed that 4.41 % extra cost provides an ample scope of considerable improvement of the productivity with the inclusion of modern mustard and T. Aman rice varieties in improved pattern.

Introduction

At present fallow - T. Aus - T. Aman followed by mustard - T. Aus - T. Aman rice cropping sequences are widely followed by farmers under rainfed condition in medium high land to medium low land in Sylhet region. Nazrul (2019) reported that inclusion of short duration mustard in fallow period preceding T. Aus-T. Aman rice cropping can be practice by the farmers for higher crops yield and productivity in that region. Transplantation of aus rice is being dependent on rainfall, which sown during early monsoon (early May). This delayed transplantation of T. Aus rice that causes late cultivation and harvesting of T. Aman rice, which hampered timely cultivation of rabi crops. The soils under these cropping pattern areas are generally heavy silty clay loams to clays and the top soil quickly becomes dry and hard after the harvest of T. Aman rice. In Eastern Surma Kushiara Floodplain of Sylhet region, a vast area remains fallow for a long time after the harvest of T. Aman rice due to moisture stress up to next season for cultivation of T. Aus rice following the existing cropping pattern (Fallow-T. Aus-T. Aman rice). However, the yields of rice are very low compared to other regions of the country. Generally, rainfall starts in February and prevails up to November in each year that offers an excellent opportunity for the production of short duration pulse and oilseed crops before T. Aus rice. Shaheb and Nazrul (2012) reported that mustard varieties can be grown well in fallow land of Sylhet where var. BARI Sarisha-14 and BARI Sarisha-17 could be more suitable and produced higher seed yield. To enhance the crop production through utilization of fallow land in Sylhet region, the potato-rice and chickpea - rice based cropping patterns have been developed (Nazrul *et al.,* 2013; Nazrul and Shaheb, 2012; Shaheb *et al.,* 2011). A number of reports on different cropping pattern are available in Bangladesh that an additional crop could be introduced without much changes or replacing the existing ones for considerable increases of productivity as well as profitability of the farmers (Azad *et al.* 1992; Khan *et al.,* 2005 and Nazrul *et al.,* 2013, Kamrozzaman *et al*., 2015*).* But, little effort has been made for on-farm evaluation of the improved technologies of Mustard-T. Aus-T. Aman rice cropping pattern in Sylhet area. The present study was therefore, initiated to increase productivity through of an improved package of technologies over the farmer's existing practices.

Materials and Methods

The trial was conducted at the farmer's field in Sylhet under AEZ 20 during 2020-21. Improved pattern (IP): Mustard (var. BARI Sarisha-18)-T. Aus (var. BRRI dhan48)-T. Aman rice (var. BRRI dhan75) by introducing high yielding varieties of mustard and rice in existing pattern (EP): Mustard (var. BARI Sarisha-14)-T. Aus (var. BRRI dhan48)-T. Aman ric (var. Binadhan-7) were tested in the trial. The experiment was laid out in randomized complete block design with six dispersed replications.

Average monthly total rainfalls, along with maximum and minimum average temperatures during the study period are presented in fig. 1. The highest amount of average monthly rainfall occurred in June followed by July and May, whereas lowest amount of rainfall occurred in January followed by November and December. Rainfall increases gradually from the month of January to June and then decreases.

The initial status of N (0.07%), P (7.59 µg/soil), K (0.18 meq/100g soil), S (10.80 µg/soil), B (0.34 µg/soil) and Zn (1.27 µg/soil) was very low, low, low, low, medium and medium, respectively. Two plots of 500 m^2 were selected for each replication. One plot was under the improved pattern and the other assigned for farmer's pattern.

Table 1. Management practices followed in improved and existing cropping pattern at FSRD site, Kamalbazer, Sylhet during 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Mustard	T. Aus	T. Aman
Variety	BARI Sarisha-18	BRRI dhan48	BRRI dhan75	BARI Sarisha-14	BRRI dhan48	Binadhan-7
Date of sowing/ transplanting	15-11-20	23-04-21	02-08-21	29-11-20	16-04-21	01-08-21
Seed rate (kg ha^{-1})	7.5	26	26	7.5	26	26
Spacing (cm)	-	20 x 15	20 x 15	-	20 x 15	20 x 15
Fertilizer dose (N-P-K-S-Zn-B, $kgha^{-1}$)	115-30-43-27-18-1.7	134-53-83-60-0-0	150-53-83-60-0-0	115-30-43-27-18-1.7	134-53-83-60-0-0	165-60-105-86-0-0
Date of harvesting	10-02-21	27-07-20	03-11-21	08-02-21	25-07-21	18-11-21
Field duration (days)	95	90	95	85	90	110
Turnaround time (days)	70	05	10	75	3	2

Results and Discussions

Yield of rice and mustard: In rice, the average yield of T. Aus and T. Aman was varied from 3.89-4.65 t ha^{-1}. In mustard, the variety BARI Sarisha-18 was produced 2.10 t ha^{-1} of seed yield in IP, whereas 1.39 t ha^{-1} by BARI Sarisha-14 in EP. The variety of T. Aus and T. Aman rice was given higher grain yields under the IP, it might be due to use of improved rice variety. The highest average yield of T. Aus (4.50 tha^{-1}) and T. Aman (4.65 tha^{-1}) rice was recorded from IP.

T. Aman rice equivalent yield: Total productivity of the cropping pattern was ascertained by the rice equivalent yield (REY) it was calculated from the yields of component crops. REY was varied under different cropping sequence. Average of two years of data revealed that the highest REY (18.61 t ha^{-1}) was recorded from IP as compared to EP (15.02 t ha^{-1}). Inclusion of new mustard variety and modern variety of T. Aman rice in IP increased REY 24 % as compared to EP. Similarly, the highest mean gross margin (Tk. 224430 ha^{-1}) with marginal benefit cost ratio (1.49) was obtained over existing pattern. It was found that 4.41 % extra cost provides an ample scope of considerable improvement of the productivity with the inclusion of modern mustard and T. Aman rice in improved pattern.

Farmers' opinion

Farmers opined that the mustard var. BARI Sarisha-14 can be replaced by BARI Sarisha-18 in Mustard- T. Aus- T. Aman rice cropping pattern for higher yield and economic return.

Table 2: Yield and economic analysis of improved and existing cropping pattern at FSRD site, Kamalbazer, Sylhet during 2019-2022 (Average)

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T. Aus	T. Aman	Mustard	T. Aus	T. Aman
Variety	BARI Sarisha-18	BRRI dhan48	BRRI dhan75	BARI Sarisha-14	BRRI dhan48	Binadhan-7
Seed/grain yield (tha^{-1})	2.10	4.50	4.65	1.39	4.49	3.89
Straw yield (tha^{-1})	2.25	5.40	5.5	1.41	5.50	4.8
REY	7.75	5.05	5.61	5.14	5.16	4.72
Total REY	18.61			15.02		
Gross return (Tk. ha^{-1})	182850	116150	129030	118220	118680	108560
Total variable cost (Tk. ha^{-1})	55600	68000	80000	49000	68000	78000
Gross margin (Tk. ha^{-1})	65370	41800	48950	33100	23060	30670
Total Gross return (Tk. ha^{-1})	428030			345460		
Total variable cost (Tk. ha^{-1})	203600			195000		
Total Gross margin (Tk. ha^{-1})	224430			150460		
MBCR	1.49					

Unit price (TK.kg^{-1}) Mustard=85.00, Mustard Straw = 2.00, Rice Straw= 4.00, T.Aus=21.00, T.Aman = 23.00

Conclusion

Results revealed that improved pattern is more productiv, and remunerative for medium high land under Eastern Surma Kushiyara Floodplain (AEZ 20). So, farmers of commanding area could follow Mustard (var. BARI Sarisha-18)-T. Aus (var. BRRI dhan48)-T. Aman rice (var. BRRI dhan75) cropping pattern for higher productivity and profitability. Mustard straw could be utilized as fuel instead of cowdung in rural area.

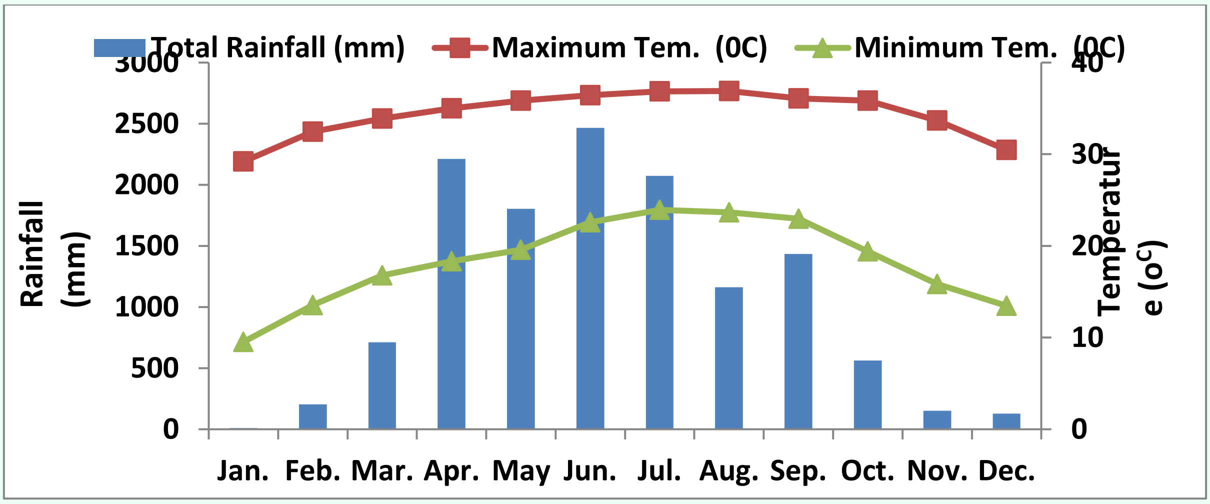

Fig. 1. Average of three years monthly total rainfall (mm), maximum and minimum air temperatures during study period (Source: Metrological Department, Sylhet)

ENHANCEMENT OF MUSTARD PRODUCTION THROUGH INCLUSION IN FALLOW-BORO-T. AMAN RICE CROPPING PATTERN

M.A.H. KHAN, T. TASMIMA, M.M. RAHMAN AND S. ROY

Abstract

On-farm trial was conducted at FSRD site Atia, MLT site Ghatail, Madhupur and Dhanbari to increase cropping intensity and productivity through inclusion of mustard in fallow period at farmers existing practice of Fallow-Boro-T. Aman. Variety of each crop were BARI Sarisha-14, BRRI dhan29 and BRRI dhan49, respectively. It was observed that three crop patterns produced higher rice equivalent yield (REY) (14.34, 16.47, 16.61 and 17.46 t ha^{-1}), respectively which was 40, 48, 48 and 52% higher than farmers' practice . Cost-benefit analysis over four locations in Tangail district showed that improved pattern gave higher gross return (Tk. 364950 ha^{-1}) and gross margin (Tk. 196004 ha^{-1}) which were 46.95 and 75.50 % higher compared to that of existing pattern with only 23.63% . The marginal benefit-cost ratio of the three crop patterns over the existing pattern was 2.64, which indicates the profitability of the cropping pattern.

Introduction

BARI is trying to convert mono crop land into double-crop land, likewise, double crop to triple crop and triple crop to four crop land. The major crop cropping patterns in Tangail district are Fallow- Boro- T. Aman. After harvest of T. Aman and before planting of Boro the land remains fallow around 3 months. Some of the farmers are growing for short duration crops in that time. Mustard is a high value crop which can be easily grown in between two crops. So, the trial was conducted to improve the existing cropping patterns, and thereby increasing cropping intensity, productivity and economic return.

Materials and Methods

On-farm trial of three-crop based crop sequence was conducted at farmers' field of FSRD site, MLT site, Tangail during 2020-21. Three-crop sequence: Mustard-Boro-T. Aman has been introduced against farmers' existing sequence of Fallow- Boro-T. Aman to increase cropping intensity and productivity. The trial was done involving six cooperative farmers having a unit plot size of 33 decimal land per farmer. All agronomic activities including sowing/transplanting, harvesting, fertilizer, irrigation, weeding etc. were followed according to standard methods (Azad et al., 2017). Recommended fertilizer package (BARC, 2012 and BARC, 2018) along with prescribed application methods were followed for all the crops. Pest management and other intercultural management practices were done as and when necessary. In Boro and T. Aman, stem borer and sheath blight was observed in some plots. Folicur @ 0.5 ml/L was sprayed to control sheath blight and Virtako 40 WG @ 1.5g/10 L for stem borer. In Mustard, Alternaria blight was observed in some plots, Rovral @ 2g/L water was sprayed at early stage for controlling the disease at 7 days interval. For economic comparison between two crop sequences, the yield of all crops was converted into price equivalent yield of boro rice based on the prevailing market price of individual crops (Ahlawat and Sharma, 1993). Data on the yield of various crops in sequences were recorded and converted to ton per hectare. The data of farmer's practice was recorded from adjacent farmers' plots. Total system productivity was calculated as the summation of individual (component) crop yield of each cropping cycle.

Table 1. Crop management practices of the crops for existing patterns and improved patterns at different location of Tangail during 2020-21

Parameters	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	Boro	T. Aman	Mustard	Boro	T. Aman
Variety	-	BRRI dhan29	BRRI dhan49	BARI Sarisha-14	BRRI dhan29	BRRI dhan49
Date of transplanting	-	17 Jan-04 Feb	10 Jun-24Jul	01 -20 Nov	27 Jan-15 Feb	12 Jun-15 Jul

Parameters	Existing cropping pattern			Improved cropping pattern		
Seed rate (kg ha^{-1})	-	40	40	7	40	40
Spacing (cm)	-	20 x15	20 x15	Broadcasting	20 x15	20 x15
Fertilizer dose (kg ha-^{1} N-P-K-S-Zn-B)	-	138-15-30-0-2.6-0	74-12-42-10-3-0	90-34-42-26-1.7-1.7	138-15-60-15-3-0	70-15-35-8-4-0
Date of harvesting (range)	-	15 May-1 Jun	26 Oct-22 Nov.	22 Jan-08 Feb	18 May -12 Jun	05 Oct-14 Nov
Field duration (days)	-	114-123	116-118	81-85	100-115	113-120
Turnaround time (days)	-	68-72	25-53	6-25	5-7	24-32

Results and Discussion

Crop management, field duration and turnaround time: Similar agronomic management practices were followed in both farmers practice and improved cropping pattern practices. However, the difference in the improved pattern is the inclusion of mustard against fallow period. Crop field duration of Mustard, *Boro* and T. Aman rice under improved cropping pattern at different location of Tangail, Mustard (var. BARI Sarisha-14)- *Boro* (var. BRRI dhan29)-T. Aman rice (var. BRRI dhan49) were 81-85, 100-115 and 113-120 days, respectively while, in existing cropping pattern Fallow- *Boro* (var. BRRI dhan29)-T. Aman rice (var. BRRI dhan49) were 114-123 and 116-118 days for *Boro* and T. Aman, respectively. Turnaround time for improved and existing cropping pattern were 35-64 and 93-125 days, respectively.

Grain and by-product yield, rice equivalent yield (REY): FSRD site, Atia, the existing pattern, rice equivalent yield of Boro and T. Aman were 6.95 and 3.30 t ha^{-1}, respectively while the whole pattern REY was 10.25 t ha^{-1}. On the other hand, in the improved cropping pattern REY of Mustard, Boro and T. Aman were 2.94, 6.60 and 4.80 t ha^{-1}, respectively. The cumulative REY of the whole pattern was 14.34 t ha^{-1} . (Table 2). At MLT site, Ghatail, in the existing pattern rice equivalent yield of Boro and T. Aman were 6.75 and 4.40 t ha^{-1}, respectivelywhere, the whole pattern REY was 11.15 t ha^{-1}. On the other hand, in the improved cropping pattern REY of Mustard, Boro and T. Aman were 4.82, 6.75 and 4.90 t ha^{-1}, respectively. The cumulative REY of the whole pattern were 16.47 t ha^{-1} . (Table 3). At MLT site, Madhupur, in the existing pattern rice equivalent yield of Boro and T. Aman were 6.50 and 4.75 t ha^{-1}, respectively where, the whole pattern REY was 11.25 t ha^{-1}. On the other hand, in the improved cropping pattern REY of Mustard, Boro and T. Aman were 4.15, 7.50 and 4.96 t ha^{-1}, respectively. The cumulative REY of the whole pattern were 16.61 t ha^{-1} . (Table 4). At MLT site, Dhanbari, in the existing pattern rice equivalent yield of Boro and T. Aman were 6.80 and 4.70 t ha^{-1}, respectivelywhere, the whole pattern REY was 11.50 t ha^{-1}. On the other hand, in the improved cropping pattern REY of Mustard, Boro and T. Aman were 5.66, 7.00 and 4.80 t ha^{-1}, respectively. The cumulative REY of the whole pattern were 17.46 t ha^{-1} . (Table 5).

Cost and return analysis: In Improved cropping pattern, average gross return, total variable cost and gross margin of three crop pattern were Tk. 364950, Tk. 168945, Tk. 196004 per hectare, respectively while gross return, total variable cost and gross margin of existing cropping pattern were Tk. 248343, Tk. 136659, Tk. 111684 per hectare, respectively (Table 6). The MBCR was found 2.64, which indicates the profitability of three crop-based, improved pattern over the farmers ‘existing patterns.

Farmers’ opinion

Boro and T. Aman rice yield increased to some extend due to balanced fertilization and management practice and they obtained additional yield of mustard. Farmer were satisfied with higher seed yield of mustard and economic return than existing pattern. Several amounts of seed have been stored by the farmers for growing mustard in the next year.

Table 2. Yield of existing and improved cropping pattern at FSRD site, Atia, Tangail, 2020-21

Parameters	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	Boro	T. Aman	Mustard	Boro	T. Aman
Seed/grain yield (t ha^{-1})	-	6.95	3.30	1.47	4.60	4.80
Straw yield (t ha^{-1})	-	4.15	3.20	2.22	5.73	4.15
Rice equivalent yield (t ha^{-1})	-	6.95	3.30	2.94	6.60	4.80
Whole pattern REY (t ha^{-1})	10.25			14.34		

Unit price (Tk. kg^{-1}): Mustard-60, Boro-30, T. Aman-27.5, and Stover-2.00, straw-4 and straw-5.00

Table 3. Yield of existing and improved cropping pattern at MLT site, Ghatail, Tangail, 2020-21

Parameters	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	Boro	T. Aman	Mustard	Boro	T. Aman
Seed/grain yield (t ha^{-1})	-	6.75	4.40	1.55	6.75	4.90
Straw yield (t ha^{-1})	-	5.75	5.1	3.73	5.84	4.60
Rice equivalent yield (t ha^{-1})	-	6.75	4.40	4.82	6.75	4.90
Whole pattern REY (t ha^{-1})	11.15			16.47		

Unit price (Tk. kg^{-1}): Mustard-70, Boro-22.5, T. Aman-22.5, and stover-2.00, straw-2 and straw-2.00

Table 4. Yield of existing and improved cropping pattern at MLT site, Madhupur, Tangail during 2020-21

Parameters	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	Boro	T. Aman	Mustard	Boro	T. Aman
Seed/grain yield (t ha^{-1})	-	6.50	4.75	1.38	7.50	4.96
Straw yield (t ha^{-1})	-	6.20	4.50	2,30	6.00	4.56
Rice equivalent yield (t ha^{-1})	-	6.50	4.75	4.15	7.50	4.96
Whole pattern REY (t ha^{-1})	11.25			16.61		

Unit price (Tk. kg^{-1}): Mustard =70, Boro- 18.75, T. Aman-25, and stover-2, straw- 4 and straw- 5

Table 5. Yield of existing and improved cropping pattern at MLT site, Dhanbari, Tangail, 2020-21

Parameters	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	Boro	T. Aman	Mustard	Boro	T. Aman
Seed/grain yield (t ha^{-1})	-	5.80	3.70	1.65	7.00	4.00
Straw yield (t ha^{-1})	-	6.40	4.30	2.30	6.80	4.80
Rice equivalent yield (t ha^{-1})	-	6.80	4.70	5.66	7.00	4.80
Whole pattern REY (t ha^{-1})	11.50			17.46		

Unit price (Tk. kg^{-1}): Mustard-70, Boro-18.75, T. Aman-25, and stover-2.00, straw-4 and straw-5.00

Table 6. Average rice equivalent yield and cost-return analysis of Existing and Improved cropping patterns at Tangail district during 2020-21

Site	Pattern	Rice equivalent yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
FSRD site, Atia	Existing	10.25	230625	124140	139485	2.31
	Improved	14.34	322650	151945	170705	
MLT site, Ghatail	Existing	11.15	250875	153390	97485	3.23
	Improved	16.47	370575	201720	168855	
MLT site, Madhupur	Existing	11.25	253125	134710	118415	2.76
	Improved	16.61	373725	166808	206917	
MLT site, Dhanbari	Existing	11.50	258750	134399	124351	2.28
	Improved	17.46	392850	175310	217540	
Average	Existing	11.04	248343	136659	111684	
	Improved	16.22	364950	168945	196004	

Average price (Tk. kg^{-1}): Boro-22.50

Conclusion

Based on the yield, cost and economic return, Mustard-Boro-T. Aman rice cropping pattern is more profitable than existing cropping pattern. The final conclusion can be drawn after completion of the 2nd cycle.

IMPROVEMENT OF EXISTING CROPPING PATTERN LENTIL- JUTE-T. AMAN RICE THROUGH VARIETY REPLACEMENT

M.A.H. KHAN, T. TASMIMA, M.M. RAHMAN AND S. ROY

Abstract

The trial was conducted at the farmers' field of FSRD site, Atia, Tangail to evaluate the agro-economic performance of Lentil (var. BARI Mosur-8)-Jute var. (BJRI Toshapat-8)-T. Aman rice (Hybrid Arize-7006) cropping pattern against farmers' existing pattern Lentil (Local)-Jute (0-9897)-T. Aman rice (var. BR11) through incorporation of modern high yielding varieties and improved management practices during 2020-21. Two cropping pattern viz., improved pattern and existing pattern were the treatments variables. The experiment was laid out in randomized complete block design with six dispersed replications in farme. Mean data showed that the improved management practices for Lentil- Jute- T. Aman rice cropping pattern provided higher rice equivalent yield (21.85 t ha^{-1}) over existing cropping pattern (15.39 t ha^{-1}). Average gross return Tk. 594910 ha^{-1} and gross margin Tk. 308651 ha^{-1} of improved pattern were 44.35 and 74.96 % higher, respectively compared to that of farmers' pattern with only 21 % extra cost. The marginal benefit cost ratio 3.62 which indicated the superiority of improved cropping pattern over existing cropping pattern.

Introduction

Lentil- Jute-T. Aman is an important cropping pattern at FSRD site, Atia, Tangail. This cropping pattern acquires 100 ha area of total cultivable land. In this cropping pattern, farmers use old crop varieties whose are poor yielding and susceptible to different pest. As such new and high yielding crop varieties in Lentil-Jute-T. Aman cropping pattern is needed for the improvement of the existing cropping pattern for higher yield and economic return. The study was therefore, initiated with a view to improve the existing cropping pattern by inclusion new crop varieties and to increase crop yields and economic return of farmers.

Materials and Methods

The experiment was conducted at the farmers' field of Farming System Research and Development site under On-Farm Research Division, Bangladesh Agricultural Research Institute, Tangail during 2020 - 2021. The experiment was laid out in a randomized complete block design with six dispersed replications. Two cropping patterns viz., improved pattern and farmers' existing pattern were the treatments variables of the experiment. The unit plot size was 1000-1200 Sq.m. In the improved pattern, Lentil var. BARI Mosur-8,Jute var. BJRI Tossa pat-8 and T.Aman rice var. Hybrid Arize-7006 was used.. Lentil was the first crop of the sequence and it was grown during *rabi* season. In improved pattern, BARI Mosur-8 was seeded as broadcast at @ 35.0 kg ha^{-1} during 09-10 December 2020 and harvested during 17-20 March 2021. Jute was the second crop of the sequence, and it was grown during *Kharif* season. In improved pattern, BJRI Toshapat-8 was seeded as broadcast at @ 7.5 kg ha^{-1} during 24-25 April 2021 and harvested during 25-29 Jul. 2021. T. Aman rice was the third crop of the sequence. Seedlings of rice were grown in adjacent plot and transplanting was done with 25-30 days old seedlings of T. Aman rice var. Hybrid Arize-7006 were transplanted with 20 cm × 15 cm during 02-04 August 2021. Fertilizer management and intercultural operations like weeding, mulching, irrigation, and pest management were done according to BRRI (2013). T. Aman rice was harvested during 20-24 November 2021. T. Aman rice plant was harvested at 15 cm from soil surface and remaining parts of the plants was incorporated in soil. In T. Aman, stem borer was observed in some plots. Virtako 40 WG @ 1.5g/10 L was sprayed for controlling stem borer. In Lentil, Root rot was observed in some plots, Emister top @ 0.5 ml/L water was sprayed at early stage for controlling the disease.

Table 1. Crop managements of improved and existing cropping pattern at FSRD site Atia, Tangail

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Lentil	Jute	T. Aman	Lentil	Jute	T. Aman
Varity	Local	0-9897	BR-11	BARI Masur-8	BJRI Toshapat-8	Hybrid Arize-7006
Date of sowing/ Transplanting	15-16 Dec. 2019	20-21 Apr. 2020	29-31 Jul. 2020	9-10 Dec. 2020	24-25 Apr. 2021	2- 4 Aug. 2021
Seed rate ((kg ha^{-1})	40	8	40	35	7.5	15
Spacing (cm)	Broadcast	Broadcast	20×15	Broadcast	Broadcast	20×20
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	10-12-10-0-0-0	35-15-37-14-0-0	69-15-28-14-0-0	18-16-15-9-0-1.7	92-10-30-17-4-0	76-18-28-10-4-0
Date of harvesting (range)	12-15 Mar. 2020	18-22 Jul. 2020	28-30 Nov. 2020	17-20 Mar. 2021	25-29 Jul. 2021	20-24 Nov. 2021
Field duration(days)	85-86	88-89	120-121	97-98	91-92	110-111
Turned around time (days)	16-17	38-39	9-12	12-14	37-38	16-18

Results and Discussion

Crop management: Crop management practices include date of sowing/transplanting, date of harvesting, fertilizer dose used, irrigation, weeding and application of pesticides etc. of improved and existing cropping pattern are shown in Table 1. The mean crop field duration of Lentil, Jute and T. Aman rice under improved cropping pattern Lentil (BARI Mosur-8)-Jute (BJRI Toshapat-8)-T. Aman rice (Hybrid Arize-7006) were 97-98, 91-92 and 110-111 days, respectively while, in existing cropping pattern Lentil (Local)-Jute (0-9897)-T. Aman rice (BR11) were 85-86, 88-89 and 120-121 days for Mustard, Jute and T. Aman, respectively. Total field duration of improved cropping pattern and existing cropping pattern were 300-301 and 295-296 days, respectively. Turnaround times for improved and existing cropping pattern were 69-70 and 66-67 days, respectively.

Grain/Seed and By-product yield: Results of the study have been presented in Table 2. Yield of Lentil seed (var. BARI Mosur-8), Jute fiber (var. BJRI Toshapat-8) and T. Aman rice (Hybrid Arize-7006) of improved cropping patterns were 1.75, 3.57 and 4.84 tha^{-1} respectively, whereas stover, stick and straw yields were 0.63, 2.98 and 4.32 tha^{-1}, respectively, while, in existing cropping pattern yield of Lentil seed (Local), Jute fiber (0-9897) and T. Aman rice (BR11) were 0.95, 2.95 and 3.15 tha^{-1} respectively, whereas stover, stick and straw yield were 0.42, 2.30 and 2.56 tha^{-1}, respectively.

Rice equivalent yield (REY): Total productivity of improved and existing cropping patterns was evaluated in terms of rice equivalent yield (REY) and it was calculated from yield of component crops. Improved cropping pattern produced higher mean rice equivalent yield (21.85 $tha^{-1}yr^{-1}$) over existing (15.39 $tha^{-1}yr^{-1}$) pattern (Table 2) which increased rice equivalent yield of 41 % compared to farmers' one. Lower rice equivalent yield was obtained in the existing pattern due to variety and traditional management practices.

Cost and return analysis: Profitability analysis was done on the basis of prevailing market price during the crop season. Improved cropping pattern showed its superiority over existing cropping pattern. The study revealed that mean gross return of the improved and existing pattern was Tk. 594910 and Tk. 412140, respectively (Table. 2). The mean gross return of improved cropping pattern was 44.35 % higher than farmers' existing pattern. The mean total variable cost of the improved and existing cropping pattern was Tk. 286259 and Tk. 235723 ha^{-1}, respectively. Gross margin (Tk. 308651 ha^{-1}) was calculated at improved pattern over existing cropping pattern (Tk. 176417 ha^{-1}). The mean MBCR was found 3.62 which indicated the superiority of improved cropping pattern over existing cropping pattern.

Farmers' opinion

In improved cropping pattern yield increased to some extend due to varietal changes, balanced fertilization and management practice. Considering the higher yield farmer preferred the improved pattern.

Table 2. Yield and Economic analysis of improved and existing cropping pattern at FSRD site Atia, Tangail during the year of 2020-21

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Lentil	Jute	T. Aman	Lentil	Jute	T. Aman
Seed/fibre/grain yield (t ha^{-1})	0.95	2.95	3.15	1.75	3.57	4.84
Stover / stick /straw yield (t ha^{-1})	0.42	2.30	2.56	0.63	2.98	4.32
Rice equivalent yield (t ha^{-1})	3.42	8.85	3.15	6.30	10.71	4.84
Whole pattern REY (t ha^{-1})	15.39			21.85		
Gross return (Tk. ha^{-1})	86340	234250	91550	158760	297550	138600
Total variable cost (Tk. ha^{-1})	40315	147223	48185	50763	165213	70283
Gross margin (Tk. ha^{-1})	46025	87027	43365	107997	132337	68317
Whole pattern gross margin (Tk. ha^{-1})	176417			308651		
MBCR	3.62					

Unit price (Tk. kg^{-1}): Lentil- 90, Jute- 75, T. Aman- 25, and stover- 2.00, stick- 10 and straw- 5.00

Conclusion

The total crop productivity (in terms of REY) and profitability of improved cropping pattern Lentil (var. BARI Mosur-8)-Jute (var.BJRI Toshapat-8)-T. Aman rice (Hybrid Arize-7006) showed much higher than that of existing cropping pattern Lentil (Local)-Jute (0-9897)-T. Aman rice (var.BR-11) due to replacing varieties and management practices. This is one year result, final conclusion could be drawn after completion of 2nd cycle of the pattern.

IMPROVEMENT OF EXISTING CROPPING PATTERN WHEAT- JUTE-T. AMAN RICE THROUGH VARIETY REPLACEMENT

M.A.H. KHAN, T. TASMIMA, M.M.RAHMAN AND S.ROY

Abstract

The trial was conducted at the farmers' field of FSRD site Atia, Tangail to evaluate the agro-economic performance of wheat (var. BARI Gom-32)-Jute (var. BJRI Toshapat-8)-T. Aman rice (Hybrid Arize-7006) cropping pattern against farmers' existing cropping pattern wheat (Local)-Jute (0-9897)-T. Aman rice (BR11) through incorporation of modern high yielding varieties and improved management practices during 2020-21. Two cropping pattern viz., improved pattern and existing pattern were the treatments variables. The experiment was laid out in randomized complete block design with six dispersed replications in farmers' condition. Mean data showed that the improved management practices and changing varieties for Wheat- Jute-T. Aman rice cropping pattern provided higher rice equivalent yield (20.44 t ha^{-1}) over existing cropping pattern (15.64 tha^{-1}). Average gross return Tk. 562250 ha^{-1} and gross margin Tk. 265500 ha^{-1} of improved pattern were 30.36 and 45.48 % higher, respectively compared to that of existing pattern with only 19.27 % extra cost. The marginal benefit cost ratio 2.73 which indicated the superiority of improved cropping pattern over existing cropping pattern.

Introduction

Wheat- Jute-T. Aman is an important cropping pattern at FSRD site, Atia, Tangail. This cropping pattern acquires 400 ha area of total cultivable land. In this cropping pattern farmers use old crop varieties whose are poor yielding ability and susceptible to different pest. Due to above reasons new and high yielding crop varieties in Wheat- Jute-T. Aman cropping pattern is needed.

Therefore, a trial was conducted for the improvement of the existing cropping pattern for higher yield and economic return.

Materials and Methods

The experiment was conducted at the farmers' field of Farming System Research and Development site under On-Farm Research Division, Bangladesh Agricultural Research Institute, Tangail during 2020 to 2021. The experiment was laid out in a randomized complete block design with six dispersed replications. Two cropping pattern viz., improved pattern and farmers' existing pattern were the treatments variables of the experiment. The unit plot size was 1000-1200 m^2. In the improved pattern, wheat var. BARI Gom-32 was introduced against local wheat, Jute var. BJRI Tossa pat-8 was used against 0-9897 and T. Aman rice var. Hybrid Arize-7006 was used against 0-9897 variety. Wheat was the first crop of the sequence and it was grown during *rabi* season. In improved pattern, BARI Gom-32 was seeded as broadcast at @ 120 kg ha^{-1} during 29-30 November 2020 and harvested during 17-20 March 2021. Jute was the second crop of the sequence and it was grown during *Kharif* season. In improved pattern, BJRI Toshapat-8 was seeded as broadcast at @ 7.5 kg ha^{-1} during 15-16 April 2021 and harvested during 8-11 August 2021. T. Aman rice was the third crop of the sequence. Seedlings of rice were grown in adjacent plot and transplanting was done with 25-30 days old seedlings of T. Aman rice var. Hybrid Arize-7006 were transplanted with 20 cm × 15 cm during 12- 14 August 2021. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to BRRI (2013). T. Aman rice was harvested during 19-21 November 2021. T. Aman rice plant was harvested at 15 cm from soil surface and remaining parts of the plants was incorporated in soil. In T. Aman, stem borer was observed in some plots. Virtako 40 WG @ 1.5g/10 L water was sprayed at 7 days interval for controlling stem borer.

Results and Discussion

Crop management: Crop management practices include date of sowing/transplanting, date of harvesting; fertilizer dose used, irrigation, weeding and application of pesticides etc. of improved and existing cropping pattern are shown in Table 1. The mean crop field duration of Wheat, Jute and T. Aman rice under improved cropping pattern Wheat (BARI Gom-32)-Jute (BJRI Toshapat-8)-T. Aman rice (Hybrid Arize-7006) were 107-108, 115-116 and 99-100 days, respectively while, in existing cropping pattern Wheat (Local)-Jute (0-9897)-T. Aman rice (BR11) were 105-106, 107-108 and 105-106 days for Wheat, Jute and T. Aman, respectively. Total field duration of improved cropping pattern and existing cropping pattern were 323-324 and 319-320 days, respectively. Turnaround times for improved and existing cropping pattern were 44-45 and 41-42 days, respectively.

Grain/Seed and By-product yield: Results of the study have been presented in Table 2. Yield of Wheat grain (BARI Gom-32), Jute fibre (BJRI Toshapat-8) and T. Aman rice (Hybrid Arize-7006) of improved cropping patterns were 4.20, 3.90 and 4.50 tha^{-1} respectively, whereas straw, stick and straw yield were 3.00, 2.90 and 4.25 tha^{-1}, respectively, while, in existing cropping pattern yield of Wheat seed (Local), Jute fibre (0-9897) and T. Aman rice (BR -11) were 3.40, 2.82 and 3.10 tha^{-1} respectively, whereas straw, stick and straw yield were 2.80, 2.20 and 2.54 tha^{-1}, respectively.

Rice equivalent yield (REY): Total productivity of improved and existing cropping patterns was evaluated in terms of rice equivalent yield (REY) and it was calculated from yield of component crops. Improved cropping pattern produced higher mean rice equivalent yield (20.44 $tha^{-1}yr^{-1}$) over existing (15.64 $tha^{-1}yr^{-1}$) pattern (Table 2) which increased rice equivalent yield of 30.70 % compared to existing one. Lower rice equivalent yield was obtained in the existing pattern due to variety and traditional management practices.

Cost and return analysis: Profitability analysis was done on the basis of prevailing market price during the crop season. Improved cropping pattern showed its superiority over existing cropping pattern. The study revealed that mean gross return of the improved and existing pattern was Tk.

562250 and Tk. 431300, respectively (Table. 2) The mean gross return of improved cropping pattern was 30.36 % higher than existing cropping pattern. The mean total variable cost of the improved and existing cropping pattern was Tk. 296750 and Tk. 248800 ha^{-1}, respectively. Gross margin (Tk. 265500 ha^{-1}) was calculated at improved pattern over existing cropping pattern (Tk. 182500 ha^{-1}). The mean MBCR was found 2.73 which indicated the superiority of improved cropping pattern over existing cropping pattern.

Farmers' opinion

In improved cropping pattern, yield increased to some extend due to varietal changes, balanced fertilization and management practice. Considering the higher yield farmer preferred the improved pattern.

Table 1. Crop managements of improved and existing cropping pattern at FSRD site, Atia, Tangail

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Wheat	Jute	T. Aman	Wheat	Jute	T. Aman
Varity	BARI Gom-25	0-9897	BR11	BARI Gom-32	BJRI Toshapat-8	Hybrid Arize-7006
Date of sowing/ Transplanting	29-30 Nov. 2019	20-21 Apr. 2020	7-8 Aug. 2020	29-30 Nov. 2020	15-16 Apr. 2021	12- 14 Aug. 2021
Seed rate ((kg ha^{-1})	125	8	40	120	7.5	15
Spacing (cm)	Broadcast	Broadcast	20×15	Broadcast	Broadcast	20×20
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	92-32-22-21-0-0	35-15-37-14-0-0	69-15-28-14-0-0	80-30-55-22-4-1	92-10-30-17-4-0	76-18-28-10-4-0
Date of harvesting (range)	15-16 Mar. 2020	1-2 Aug. 2020	20-21 Nov. 2020	17-20 Mar. 2021	8-11Aug. 2021	19-21 Nov. 2021
Field duration(days)	105-106	107-108	105-106	107-108	115-116	99-100
Turned around time (days)	9-10	26-27	6-7	11-12	29-30	4-5

Table 2. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Atia, Tangail during the year of 2020-21

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Wheat	Jute	T. Aman	Wheat	Jute	T. Aman
Seed/grain yield (t ha^{-1})	3.40	2.82	3.10	4.20	3.50	4.90
Straw/stick yield (t ha^{-1})	2.80	2.20	2.54	3.00	2.90	4.25
Rice equivalent yield (t ha^{-1})	4.08	8.46	3.10	5.04	10.50	4.90
Whole pattern REY (t ha^{-1})	15.64			20.44		
Gross return (Tk. ha^{-1})	107600	233500	90200	132000	291500	138750
Total variable cost (Tk. ha^{-1})	56250	145300	47250	63400	164600	68750
Gross margin (Tk. ha^{-1})	51350	88200	42950	68600	126900	70000
Whole pattern gross margin (Tk. ha^{-1})	182500			265500		
MBCR	2.73					

Unit price (Tk. kg^{-1}): Wheat-30, Jute-75, T.aman- 25 and straw-2.00, stick-10 and straw-5.00

Conclusion

The total crop productivity (in terms of REY) and profitability of improved cropping pattern; Wheat (BARI Gom-32)-Jute (BJRI Toshapat-8)-T. Aman rice (Hybrid Arize-7006) were higher than existing cropping pattern: Wheat (Local)-Jute (0-9897)-T. Aman rice (BR-11) due to replacing of HYV BARI Gom-32, BJRI Toshapat-8 and Hybrid Arize-7006 varieties. Thus, improved cropping pattern: Wheat (BARI Gom-32)-Jute (BJRI Toshapat-8)-T. Aman rice (Hybrid Arize-7006) is economically viable and agronomically suitable. The recommendation could be drowned after completion of the 2nd cycle.

IMPROVEMENT OF EXISTING CROPPING PATTERN WHEAT- SESAME -T. AMAN RICE THROUGH VARIETY REPLACEMENT

M.A.H. KHAN, T. TASMIMA, M.M.RAHMAN AND S.ROY

Abstract

The trial was conducted at the farmers' field of FSRD site, Atia, Tangail to evaluate the agro-economic performance of Wheat (var.BARI Gom-32)-Sesame (var. BARI Til-4)-T. Aman rice (Hybrid Arize-7006) cropping pattern against farmers' existing cropping pattern: Wheat (var. BARI Gom-32)-Sesame (Local)-T. Aman rice (var. BR11) through replacing of modern high yielding varieties and improved management practices for crop production during 2020 and 2021. Two cropping patterns viz., improved pattern and existing pattern were the treatments variables of the experiment. The experiment was laid out in randomized complete block design with six dispersed replications in farmers' condition. Mean data showed that the improved management practices with changing varieties of Wheat-Sesame-T. Aman rice cropping pattern provided higher rice equivalent yield (13.16 t ha^{-1}) over existing cropping pattern (9.36 t ha^{-1}). Average gross return Tk. 368650 ha^{-1} and gross margin Tk. 199424 ha^{-1} of improved pattern were 46 and 65 % higher, respectively compared to that of existing pattern with only 28.25 % extra cost. The marginal benefit cost ratio 3.12 which indicated the superiority of improved cropping pattern over existing cropping pattern.

Introduction

Wheat- Sesame-T. Aman is an important existing cropping pattern at FSRD site, Atia, Tangail. This cropping pattern acquires 250 ha area of total cultivable land. In this cropping pattern farmers use old crop varieties whose are poor yielding and susceptible to different pest. As such to introduce new and high yielding crop varieties in Wheat- Sesame-T. Aman cropping pattern is required. Therefore, a trial may be conducted for the improvement of the existing cropping pattern for higher yield and economic return.

Materials and Methods

The experiment was conducted at the farmers' field of Farming System Research and Development site under On-Farm Research Division, Bangladesh Agricultural Research Institute, Tangail during 2020 to 2021. The experiment was laid out in a randomized complete block design with six dispersed replications. Two cropping pattern viz., improved pattern and farmers' existing cropping pattern were the treatments variables of the experiment. The unit plot size was 1000-1200 m^2. In the improved pattern, Sesame var. BARI Til-4 was used against local Til and T.Aman rice var. Hybrid Arize-7006 was used against BR-11 variety. Wheat was the first crop of the sequence in both pattern and it was grown during *rabi* season. In improved pattern, BARI Gom-32 was seeded as broadcast at @ 120 kg ha^{-1} during 29-30 November 2020 and harvested during 15-17 March 2021. Sesame was the second crop of the sequence and it was grown during *Kharif* season. In improved pattern, BARI Til-11 was seeded as broadcast at @ 7.5 kg ha^{-1} during 22-23 April 2021 and harvested during 14-16 July 2021. T. Aman rice was the third crop of the sequence. Seedlings of rice were grown in adjacent plot and transplanting was done with 25-30 days old seedlings of T. Aman rice var. Hybrid Arize-7006 were transplanted with 20×20 cm during 5- 7 August 2021. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to BRRI (2013). T. Aman rice was harvested during 16-19 November 2021. T. Aman rice plant was harvested at 15 cm from soil surface and remaining parts of the plants was incorporated in soil. In T. Aman rice, stem borer was observed in some plots. Virtako 40 WG @ 1.5g/10 L water was sprayed at 7 days interval for controlling stem borer.

Results and Discussion

Crop management: Crop management practices include date of sowing/transplanting, date of harvesting, fertilizer dose used, irrigation, weeding and application of pesticides etc. of improved and existing cropping pattern are shown in Table 1. The mean crop field duration of Wheat, Sesame and T. Aman rice under improved cropping pattern Wheat (BARI Gom-32)-Sesame (BARI Til-4)-T. Aman rice (Hybrid Arize-7006) were 106-107, 83-84 and 103-104 days, respectively while, in existing cropping pattern Wheat (BARI Gom-32)- Sesame (Local)-T. Aman rice (BR-11) were 115-116, 81-82 and 115-116 days for Wheat, Sesame and T. Aman, respectively. Total field duration of improved cropping pattern and existing cropping pattern were 292-295 and 311-314 days, respectively. Turnaround times for improved and existing cropping pattern were 73-76 and 54-57 days, respectively.

Grain/Seed and By-product yield: Results of the study have been presented in Table 2. Yield of Wheat seed (BARI Gom-32), Sesame (BARI Til-4) and T. Aman rice (Hybrid Arize-7006) of improved cropping patterns were 4.40, 1.32 and 4.72 tha^{-1} respectively, whereas straw, stover and straw yield were 3.50, 1.40 and 3.45 tha^{-1}, respectively, while, in existing cropping pattern yield of Wheat seed (BARI Gom-32), Sesame (Local) and T. Aman rice (BR11) were 3.30, .90 and 3.24 tha^{-1} respectively, whereas straw, stover and straw yield were 2.90, 1.20 and 2.30 tha^{-1}, respectively.

Rice equivalent yield (REY): Total productivity of improved and existing cropping patterns was evaluated in terms of rice equivalent yield (REY) and it was calculated from yield of component crops. Improved cropping pattern produced higher mean rice equivalent yield (13.16 t ha^{-1}) over existing (9.36 t ha^{-1}) pattern which increased rice equivalent yield of 40% compared to existing one (Table 2). Lower rice equivalent yield was obtained in the existing pattern due to variety and traditional management practices.

Cost benefit analysis: Profitability analysis was done on the basis of prevailing market price during the crop season. Improved cropping pattern showed its superiority over existing cropping pattern. The study revealed that mean gross return of the improved and existing pattern was Tk. 368650 and Tk. 252500, respectively (Table. 2) The mean gross return of improved cropping pattern was 46 % higher than existing cropping pattern. The mean total variable cost of the improved and existing cropping pattern was Tk. 169226 and Tk. 131955 ha^{-1}, respectively. Gross margin (Tk. 199424 ha^{-1}) was calculated at improved pattern over existing cropping pattern (Tk. 120545 ha^{-1}). The mean MBCR was found 3.12 which indicated the superiority of improved cropping pattern over existing cropping pattern.

Farmers' opinion

Farmers reacted positively and were satisfied with higher yield of improved cropping pattern to some extend due to varietal changes, balanced fertilization and management practice. Considering the higher yield farmer preferred the improved pattern.

Table 1. Crop managements of improved and existing cropping pattern at FSRD site, Atia, Tangail

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Wheat	Sesame	T. Aman	Wheat	Sesame	T. Aman
Varity	BARI Gom-32	Local	BR11	BARI Gom-32	BARI Til-4	Hybrid Arize-7006
Date of sowing/ Transplanting	1-2 Dec. 2019	25-26 Apr. 2020	29-31 Jul. 2020	29-30 Nov. 2020	22-23 Apr. 2021	5- 7 Aug. 2021
Seed rate ((kg ha^{-1})	125	8	40	120	7.5	15
Spacing (cm)	Broadcast	Broadcast	20×15	Broadcast	Broadcast	20×20
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	92-32-22-21-0-0	40-17-35-15-0-0	69-15-28-14-0-0	80-30-55-22-4-1	53-28-22-10-2-2	76-18-28-10-4-0
Date of harvesting (range)	25-27 Mar. 2020	15-17 Jul. 2020	22-25 Nov. 2020	15-17 Mar. 2021	14-16 Jul. 2021	16-19 Nov. 2021
Field duration (day)	115-116	81-82	115-116	106-107	83-84	103-104
Turned around time (day)	9-10	30-31	15-16	14-15	37-38	22-23

Table 2. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Atia, Tangail during the year of 2020-21

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Wheat	Sesame	T. Aman	Wheat	Sesame	T. Aman
Seed/grain yield (t ha^{-1})	3.30	0.90	3.24	4.40	1.32	4.72
Straw yield (t ha^{-1})	2.90	1.20	2.30	3.50	1.40	3.45
Rice equivalent yield (t ha^{-1})	3.96	2.16	3.24	5.28	3.16	4.72
Whole pattern REY (t ha^{-1})	9.36			13.16		
Gross return (Tk. ha^{-1})	104800	55200	92500	140200	93200	135250
Total variable cost (Tk. ha^{-1})	52385	24450	55120	66535	30738	71953
Gross margin (Tk. ha^{-1})	52415	30750	37380	73665	62462	63297
Whole pattern gross margin (Tk. ha^{-1})	120545			199424		
MBCR	3.12					

Unit price (Tk. kg^{-1}): Wheat-30, Til -60, T.aman-25 and straw-2.00, stover-1.00, straw-5.00

Conclusion

The total crop productivity (in terms of REY) and profitability of improved cropping pattern Wheat (BARI Gom-32)-Sesame (BARI Til-4)-T. Aman rice (Hybrid Arize-7006) were much higher than that of existing pattern Wheat (BARI Gom-32)- Sesame (Local)-T. Aman rice (BR-11) due to replacement of BARI Til-4 and Hybrid Arize-7006 varieties. Thus, improved cropping pattern Wheat (BARI Gom-32)-Sesame (BARI Til-4)-T. Aman rice (Hybrid Arize-7006) is economically viable and agronomically suitable. For conformation, the experiment could be repeated further one year study.

DEVELOPMENT OF GARDEN PEA-BORO-T. AMAN RICE CROPPING PATTERN AGAINST T. AMAN-FALLOW-BORO CROPPING PATTERN

M.A.H. KHAN, T. TASMIMA, M.M.RAHMAN AND S.ROY

Abstract

The experiment was conducted at the farmers' field of FSRD site, Atia, Tangail to evaluate the agro-economic performance of T. Aman (Hybrid Arize-7006)-Garden Pea (var. BARI Matarsuti-3)-Boro rice (var. BRRI dhan29) cropping pattern against farmers' existing cropping pattern T. Aman rice (var. BR11)-Fallow- Boro rice (var. BRRI dhan29) through incorporation of modern high yielding varieties and improved management practices during 2020 and 2021. Two cropping patterns viz., improved pattern and existing pattern were the treatments variables of the experiment. The experiment was laid out in randomized complete block design with six dispersed replications. Mean data showed that the improved management practices for T. Aman-Garden pea-Boro rice cropping pattern provided higher rice equivalent yield (16.70 t $ha^{-1}yr.^{-1}$) over existing cropping pattern (10.05 t $ha^{-1}yr^{-1}$). Average gross return Tk. 477300 ha^{-1} and gross margin Tk. 190750 ha^{-1} of improved pattern were 63.68% and 100% higher, respectively compared to that of existing pattern with only 46.02 % extra cost. The marginal benefit cost ratio 2.06 which indicated the superiority of improved cropping pattern over existing cropping pattern.

Introduction

Boro-T. Aman is one of the dominant cropping patterns at Tangail. After harvest of T. Aman and before planting of Boro the land remains fallow around 3 months. Some of the farmers are growing short duration vegetables in that time. Garden Pea is a high value crop which can be easily grown in between two crops. Farmers sell green pods as vegetable and the plants are used as fodder or green manure which improves the soil health. In this context, the experiment is therefore undertaken to study the feasibility of growing garden pea as vegetable crop during fallow period for higher yield & economic return.

Materials and Methods

The experiment was conducted at the farmers' field of Farming System Research and Development site under On-Farm Research Division, Bangladesh Agricultural Research Institute, Tangail during 2020 to 2021. The experiment was laid out in a randomized complete block design with six dispersed replications. Two cropping patterns viz., improved pattern and farmers' existing cropping pattern were the treatments variables of the experiment. The unit plot size was 1000-1200 m^2. In the improved pattern, T. Aman var. Hybrid Arize-7006 was used against rice var. BR11 and Garden pea var. BARI Matarsuti-3 was used in fallow land. T. Aman was the first crop of the sequence in both pattern and it was grown during *kharif-2* season. In improved pattern, Seedlings of T. Aman rice were grown in adjacent plot and transplanting was done with 25-30 days old seedlings of T. Aman rice var. Hybrid Arize-7006 were transplanted with 20×20 cm during 12-14 August 2021. T. Aman rice was harvested during 20-23 November 2021. T. Aman rice plant was harvested at 15 cm from soil surface and remaining parts of the plants was incorporated in soil. Garden pea was the second crop of the pattern and it was grown during *rabi* season. In improved pattern, BARI Matarsuti-3 was seeded as line at @ 225 kg ha^{-1} with 30×15 cm during 1-2 December 2020 and harvested during 30 January 2021 and 6 February 2021. Boro rice was the third crop of the sequence. Seedlings of rice were grown in adjacent plot and transplanting was done with 25-30 days old seedlings of Boro rice var. BRII dhan29 were transplanted with 20×20 cm during 11-13 February 2021 and it was harvested during 30-31 May 2021. Fertilizer management and intercultural operations like weeding, mulching, irrigation and pest management were done according to BRRI (2013). In Boro and T. Aman rice stem borer and sheath blight was observed in some plots. Folicur @ 0.5 ml/L water was sprayed to control sheath blight and Virtako 40 WG @ 1.5g/10 L water was sprayed to control stem borer.

Table 1. Crop managements of improved and existing cropping pattern at FSRD site, Atia, Tangail

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	Boro	T. Aman	Garden pea	Boro	T. Aman
Variety	-	BRRI dhan29	BR11	BARI Matarsuti-3	BRRI dhan29	Hybrid Arize-7006
Date of sowing/ Transplanting	-	29-31 Jan. 2021	20-22 Jul. 2020	1-2 Dec. 2020	11- 13 Feb. 2021	12-14 Aug. 2021
Seed rate ((kg ha^{-1})	-	40	40	225	40	15
Spacing (cm)	-	20×15	20×15	30×15	20×20	20×20
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	-	105-30-100-27-3-0	69-15-28-14-0-0	18-16-15-9-0-1.7	105-30-100-27-3-0	76-18-28-10-4-0
Date of harvesting (range)	-	14-17 May. 2021	1-3 Nov. 2020	30Jan.2021 6 Feb.2021	30-31 May. 2021	20-23 Nov. 2021
Field duration(days)	-	104-105	103-104	67-68	109-110	100-101
Turned around time (days)	-	90-91	67-68	10-11	5-6	71-72

Results and Discussion

Crop management: Crop management practices include date of sowing/transplanting, date of harvesting, fertilizer dose used, irrigation, weeding and application of pesticides etc. of improved and existing cropping pattern are shown in Table 1. The mean crop field duration of T. Aman, Garden Pea and Boro rice under improved cropping pattern T. Aman (Hybrid Arize-7006)-Garden Pea (BARI Matarsuti-3)- Boro rice (BRRI dhan29) were 100-101, 67-68 and 109-110 days, respectively while, in existing cropping pattern T. Aman (BR11)- Fallow- Boro rice (BRRI dhan29) were 103-104 and 104-105 days for T. Aman and Boro rice respectively. Total field duration of improved cropping pattern and existing cropping pattern were 277-280 and 207-209 days, respectively. Turnaround times for improved and existing cropping pattern were 86-89 and 157-159 days, respectively.

Grain/Seed and By-product yield: Results of the study have been presented in Table 2. Yield of T. Aman (Hybrid Arize-7006), Garden Pea (BARI Matarsuti-3) and Boro rice (BRII Dhan29) of improved cropping patterns were 3.55, 5.2 and 7.48 tha^{-1} respectively, whereas straw, stover and straw yield were 2.94, 0 and 4.05 tha^{-1}, respectively, while, in existing cropping pattern yield of Boro rice (BRRI dhan29) and T. Aman (BR11) were 7.10 tha^{-1} and 2.95, respectively, whereas straw yield were 3.95 tha^{-1} 2.15, and , respectively.

Rice equivalent yield (REY): Total productivity of improved and existing cropping patterns was evaluated in terms of rice equivalent yield (REY) and it was calculated from yield of component crops. Improved cropping pattern produced higher mean rice equivalent yield (16.70 t ha^{-11}) over existing (10.05 t ha^{-1}) pattern which increased rice equivalent yield of 66.17% compared to existing one (Table 2). Lower rice equivalent yield was obtained in the existing pattern due to traditional variety, fallow period and low management practices.

Cost benefit analysis

Profitability analysis was done on the basis of prevailing market price during the crop season. Improved cropping pattern showed its superiority over existing cropping pattern. The study revealed that mean gross return of the improved and existing pattern was Tk. 477300 and Tk. 291600, respectively which was 63.68% higher than existing cropping pattern (Table. 2). MBCR was found 2.06 which indicated the superiority of improved cropping pattern over existing cropping pattern.

Farmers' opinion

Farmer preferred the improved pattern due to higher yield as well as return. They reacted positively and satisfied with the high value crop garden pea in between two rice.

Table 2. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Atia, Tangail during 2020-21

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	Fallow	Boro	T. Aman	Garden pea	Boro	T. Aman
Seed/grain yield (t ha^{-1})	-	7.10	2.95	5.2	7.48	3.55
Straw/stover yield (t ha^{-1})	-	6.95	2.15	-	6.05	2.94
Rice equivalent yield (t ha^{-1})	-	7.10	2.95	5.67	7.48	3.55
Whole pattern REY (t ha^{-1})	10.05			16.70		
Gross return (Tk. ha^{-1})	-	207100	84500	156000	217850	103450
Total variable cost (Tk. ha^{-1})	-	152753	43482	67280	154915	64355
Gross margin (Tk. ha^{-1})	-	54347	41018	88720	62935	39095
Whole pattern gross marginTk. ha^{-1})	95365			190750		
MBCR	2.06					

Unit price (Tk. kg^{-1}): T. Aman- 25, Garden pea- 30, Boro dhan- 27.5 and straw- 5.00, stover-0.00, straw- 3.00

Conclusion

The total crop productivity (in terms of REY) and profitability of improved cropping pattern T. Aman (Hybrid Arize-7006)- Garden Pea (var. BARI Matarsuti-3)- Boro rice (var. BRRI dhan29) were higher than existing pattern T. Aman (var. BR11)- Fallow- Boro rice (var. BRRI dhan29). Thus, improved cropping pattern T. Aman (Hybrid Arize-7006)- Garden Pea (var. BARI Matarsuti-3)- Boro rice (var. BRRI dhan29) is agronomically suitable and economically viable technology. For conformation, the experiment would be repeated further one year.

DEVELOPMENT OF ALTERNATE CROPPING PATTERN WHEAT-JUTE-T. AMAN AGAINST FARMERS EXISTING FALLOW-JUTE-T. AMAN PATTERN IN GOPALGANJ REGION

M M HOWLADER

Abstract

The experiment was conducted at the MLT site, Tungipara, Sader and Moksedpur under Gopalganj district and Najirpur under Pirojpur district during 2020-`21 and 2021-22 to improve the productivity and profitability of existing cropping pattern Fallow-Jute-T. Aman by new cropping pattern. It was found that improved cropping pattern wheat-jute-T. Aman gave highest rice equivalent yield (REY) (22.39 t ha^{-1}) where farmers practice gave (16.57 t ha^{-1}). Also the improved cropping pattern Wheat-Jute-T. Aman gave highest gross return (Tk. 559750 ha^{-1}), gross margin (Tk. 204418 ha^{-1}) and the MBCR was 2.02.

Introduction

In order to mitigate the food demand it is necessary to intensify the crop production through introducing new crop in cropping pattern. The main challenge of the new millennium is to increase per unit yield at least 50% through manipulating the limited land resource. Gopalganj mainly a low laying area and water receding period is here very late that's why farmers cannot sow mustard and vegetables in early *rabi* season and there main cropping pattern is Fallow-Jute-T. Aman. There is a good opportunity to introduce wheat which can supplement grain demand of this district. BARI Gom 30 is a heat tolerant, blast resistant and also a late variety. So, it easily introduce in existing pattern cropping pattern. Considering the above facts an alternate cropping pattern Wheat-Jute-T. Aman was designed and conducted against farmers existing Fallow-Jute-T.aman cropping pattern.

Materials and Methods

An experiment was conducted at Tungipara, Sadar and Muksudpur under Gopalganj district and Nazirpur under Pirojpur district during 2020-`21 and 2021-22. Alternate cropping pattern Wheat-Jute-T. Aman was tested against farmers' existing pattern Fallow-Jute-T.aman. The experiment was carried 3 locations having an area of 33 decimal each location. All agronomic activities including sowing/transplanting, harvesting, spacing, fertilizer management etc. are presented in Table 1.

Table 1. Agronomic management practices and rice equivalent yield of the crops for the existing (Fallow-Jute-T. Aman) and alternate cropping pattern (Wheat-Jute-T. Aman) at different MLT site, Gopalganj during 2020-21.

Parameters	Existing cropping pattern			Alternate cropping pattern		
Crop	Fallow	Jute	T. Aman	Wheat	Jute	T.Aman
Variety	-	JRO-524	BRRI dhan87	BARI Gom-30	JRO-524	BRRI dhan87
Spacing	-	Broadcast	20 cm x 15 cm	30 cm row	Broadcast	20 cm x 15 cm
Unit plot size (decimal)		33	33	33	33	33
Seedling age (days)	-	-	30	-	-	30
Date of sowing/ transplanting	-	18-29/3/21	4-11/8/21	31 /11/2020-03/12/2020	22-29/3/21	4-11/8/21
Fertilizer dose (kg ha^{-1} N-P-K-S-Zn-B)	-	90-15-75-24-4-0	77-12-42-10-3-0	120-24-90-15-2.6-1.4	90-15-75-24-4-0	77-12-42-10-3-0
Fertilizer application	-	Basal and top dress	Basal and top dress	Basal & top dress	Basal and top dress	Basal and top dress
Intercultural operation		Weeding-2 Irrigation-1	Weeding-2	Weeding-2 Irrigation-2	Weeding-2 Irrigation-1	Weeding-2
Date of harvesting	-	22-29/7/21	07-16/11/21	15-21/3 /21	22-29/7/21	07-16/11/21
Field duration (days)	-	120-124	93-95	106-111	120-124	93-95
Turnaround time (day)	-	-	107	-	7	12
Grain Yield (t ha^{-1})	-	3.60	5.09	4.12	3.75	5.15

Parameters	Existing cropping pattern			Alternate cropping pattern		
Crop	Fallow	Jute	T. Aman	Wheat	Jute	T.Aman
Straw Yield (t ha^{-1})	-	7.50	5.75	5.30	7.50	5.84
REY (t ha^{-1})	-	10.56	6.01	5.36	10.95	6.08
Total REY(t ha^{-1})	16.57			22.39		

Result and Discussion

Economic analysis: Economic analysis shows that IP gave highest gross return (Tk. 559750) and gross margin (Tk. 204418) whereas FP gave gross return and gross margin Tk. 414250 and Tk. 130855, respectively. The marginal benefit cost ratio (MBCR) was found 2.02 which indicates improved pattern is profitable than farmers practice (Table 2).

Farmers' opinion

Farmers and their neighbors were happy to obtain higher income from alternate cropping pattern over existing cropping pattern**.**

Table 2. Rice equivalent yield and cost benefit analysis of farmers and improved cropping patterns pattern (Wheat-Jute-T. Aman) at different MLT site, Gopalganj, 2020-21.

Pattern	REY (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
Existing pattern (FP)	16.57	414250	283395	130855	2.02
Improved pattern (IP)	22.39	559750	355332	204418	

Price (Tk. kg^{-1}): T. Aman = 25.00, Wheat = 30.00, Jute= 65.00, Rice straw = 4.00, Jute stalk = 4.00, Wheat straw = 2.00.

Conclusion

The research findings indicated that Wheat-Jute-T. Aman cropping pattern is applicable in some areas of Gopalganj regions and it can be easily fitted against the existing pattern with higher benefit. It is the first year result, for further conformation the experiment need to be repeated in the next year.

IMPROVEMENT OF T. AMAN - MUSTARD-BORO RICE CROPPING PATTERN

M R ALAM AND M MONIRUZZAMAN

Abstract

The program was carried out at the farmers' field during 2021-22 to improve T. Aman-Mustard-Boro rice cropping pattern against T. Aman-Fallow-Boro rice at FSRD site, Ganggarampur, Pabna. The program was implemented in five farmer's field. Crop yield of T. aman, Mustard and Boro rice were recorded as 5.65, 1.63 and 6.45 t ha^{-1}, respectively with rice equivalent yield (REY) 21.76 t ha^{-1} in the improved cropping pattern whereas REY 14.25 t ha^{-1} were recorded in the existing cropping pattern. The gross margin was higher in improved cropping pattern than existing attern due to addition of Mustard.

Introduction

Rice based cropping pattern is the major cropping pattern in Bangladesh agriculture. (Haque, 1998). More than 60% of the total cropped areas covered by T. Aman-Fallow-Boro rice cropping pattern in Bangladesh. About 2.4 mha crop land is occupying by this cropping pattern in Bangladesh (Ladha *et al.,* 2003; Dawe *et al.,* 2004; Bhuiyan *et al.,* 2004). Rice is the staple food and the economy mainly depends on rice production. In self-sufficiency of rice, the dominant cropping pattern T. Aman (wet season rice)-Fallow-Boro (dry season rice) plays an important role which covers about 1.8 million hectares (about 22% of the total land) of land (Elahi *et al.,* 1999). Bangladesh Rice Research Institute (BRRI) has recommended the T. Aman- Mustard-Boro cropping pattern for the irrigated ecosystem (BARC, 2001; Khan *et al.,* 2004) with the inclusion of 70-75 days local mustard variety (Tori 7) in the transition period between T. Aman and Boro rice. But the farmers harvest poor yield from local var. Tori-7 that can be increased manifold by introducing high yielding varieties (Alam and Rahman, 2006; Basak *et al.,* 2007). Bangladesh Agricultural Research Institute (BARI) has developed high yielding yellow seeded mustard (Brassica campestris) varieties, BARI Sarisha-17 whose yield potential is higher than Tori-7. T. Aman-Fallow-Boro crop sequence can be shifting easily possible by inclusion of these mustard varieties with higher economic return.

Materials and Methods

The production program was conducted at the farmers' field condition at FSRD site, Ganggarampur during 2021-22. Mustard BARI Sarisha-17 variety was included in existing cropping pattern T. Aman-Fallow–Boro rice to develop T. Aman-Mustard-Boro rice cropping pattern. The program was implemented in 1 ha land with 5 farmers. Some fields were partially infested with aphid and *Alternaria* blight disease. Insecticide Malathoin and fungicide Rovral 50 WP were applied three times at 7 days interval in the infected fields. Data of existing patterns were collected from neighbor farmer's practiced land of each location. Economic analysis was done on the basis of prevailing local market price of the commodities. Productivity of different cropping systems was compared in terms of rice equivalent yield (REY). The REY was calculated on the basis of average market price of T. Aman and Boro rice. The details of the crop management for the cropping pattern have been presented in Table 1.

Table 1. Crop management practices in alternate cropping pattern and existing cropping pattern at FSRD site, Ganggarampur, Pabna during 2021-22

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	T. Aman	Fallow	Boro	T. Aman	Mustard	Boro
Variety	Swarna	-	BRRI dhan29	BRRI dhan49	BARI Sarisha-17	BRRI dhan58
Spacing	20 cm ×15 cm	-	20 cm × 15 cm	20 cm × 15 cm	Broadcast	20 cm × 15 cm
Fertilizer dose (N-P-K-S-Zn-B Kg ha^{-1})	102-62-20-08-0-0	-	136-50-20-08-0-0	90-10-35-12-1-0	80.6-26-23.5-10-1.6-0.5	150-20-65-18-1.3-0
Date of sowing/ transplanting	20-30/07/21	-	20-25/01/22	16-20/07/11	10-15/11/21	1-3/03/22
Harvesting date	10-15/11/21	-	25-30/05/22	25-30/10/19	10-15/02/22	10-15/06/22

Results and discussion

Grain yield in the developed cropping pattern were 5.65, 1.63 and 6.45 t ha^{-1} for T. Aman, Mustard and Boro rice, respectively with rice equivalent yield 21.76 t ha^{-1}. Besides, the yield in the existing pattern were 5.27 and 6.11 for T. Aman and Boro rice, respectively with 14.25 t ha^{-1} REY.

Cost and Return analysis: Total gross margin of the improved pattern were Tk.333100 ha^{-1} whereas in existing pattern it was Tk. 206225 ha^{-1}. Marginal benefit cost ratio in improved cropping pattern was 2.8 over existing pattern (Table 2).

Farmers' opinion

Farmers were highly impressed with the high yielding, more oil containing and short duration mustard variety BARI Sarisha-17 that can be easily fitted in between T. Aman and Boro in Pabna region. From the cost and return, it is revealed that farmers can earn a good cash from mustard before Boro cultivation.

Table 3. Performance of crops in improved cropping pattern (T. Aman-Mustard-Boro) and the existing pattern T. Aman-Fallow-Boro at FSRD site, Ganggarampur, Pabna during 2021-22

Observation	Existing cropping pattern			Improved cropping pattern		
Crop	T. Aman	Fallow	Boro	T. Aman	Mustard	Boro
Variety	Swarna	-	BRRI dhan29	BRRI dhan49 & Swarna	BARI Sarisha-17	BRRI dhan58
Field duration	112-115	-	124-130	102-107	88-92	102-107
Turnaround time	55	-	70	25	15	20
Grain or seed yield (t ha^{-1})	5.27	-	6.11	5.65	1.63	6.45
Straw or stover yield (t ha^{-1})	6.74	-	8.31	6.62	2.70	8.55
REY (t ha^{-1})	14.25			21.76		
Gross return (Tk. ha^{-1})	373975			571250		
Total variable cost (Tk. ha^{-1})	167750			238150		
Whole pattern GM (Tk. ha^{-1})	206225			333100		
MBCR (Whole pattern)	-			2.8		

Price (Tk kg^{-1}): T. Aman rice=23.75; Boro rice= 28.75; Av. Rice price= 26.25; Rice straw= 5; Mustard seed= 100; Mustard stover= 1.

Conclusion

Short duration with high yielding mustard variety BARI Sarisha-17 can easily be grown during the fallow period between T. Aman and Boro. It will help to increase productivity and minimize the shortage of edible oil for the increasing population of Bangladesh.

B. Intercropping

INTERCROPPING OF SOYBEAN WITH MAIZE IN BHOLA

G. N. HASAN AND M. R.H. ANIK

Abstract

A field trial was conducted at Bhola sadar and Daulatkhan during the rabi season of 2020-21 and 2021-22 at the farmer's field under AEZ-18 to verify the agro-economic performance of intercropping of Soybean with Maize and to ensure the maximum utilization of the land for higher yield, and economic return. The experiment was laid out in Randomized Complete Block Design.. Four treatments combination of different seed rate of mustard and cowpea viz., $T_{1=}$ Sole maize, $T_{2=}$ Sole Soybean, $T_{3=}$ Two row maize (60cm x 25cm) with 2 row Soybean (30cm x 6cm), $T_{4=}$ Paired row maize (120cm x 25cm) with 4 row Soybean (30cm x 6cm). Maize var. was BARI Hybrid Maize-16 and BARI Soybean-6. In case of maize no. of cobs plant^{-1}, 1000-grain wt. (g) of maize was significantly influenced by intercrop combination in two consecutive years. Plant population was higher (7.13cm & 6.87 cm) in T_1 treatments followed by T_3 treatments (7.13cm & 6.87cm) and lower plant population was from T_4 treatments (6.38cm & 6.12cm) due to paired row maize combination.. The maximum no. of grains cob^{-1} (545 & 558) was recorded from T_1 followed by T_4 (536 & 539) and the lowest (518 & 496) from T_3 treatment in 2021 & 2022 ,respectively. The highest maize grain yield (7.83 & 7.92 t ha-1) was obtained from sole maize whereas Seed yield (1.72 & 1.82 t ha-1) of sole soybean was significantly higher and lowest yield (1.30 & 1.25 t ha-1) from T_3 treatment in 2021 & 2022, respectively. The highest Maize Equivalent Yield 9.41 t ha-1 and 9.63 t ha-1 was recorded from T_3 intercropped combination in two consecutive years (Table 3a & 3b). In T_4 treatment, the LER was higher 1.80 & 1.71 and LER was lower 1.67 & 1.60 from T3 treatment in both years.

Introduction

Cereal and legume intercropping is recognized as a common cropping system by the small scale farmers in developing countries (Tsubo and Mukhala, 2003). Intercropped legumes fix most of their N from the atmosphere and not compete with cereals for N resources (Vesterager et al., 2008). Cereal-grain legume intercropping has potential to address the soil nutrient depletion on smallholder farms (Sanginga and Woomer, 2009). Soybean is the most important protein source for feed farm animals (that in turn yields animal protein for human consumption. Among the legumes, the soybean is valued for its high (38–45%) protein content as well as its high (approximately 20%) oil content. Maize is a very popular grain crop among all cereals over the world as well as Bangladesh. Day by day cultivation of maize is increasing at Bhola because of high profit. At present near about 3000 ha area are occupied under maize cultivation in Bhola that was only 140 ha by the year of 2010. On the other hand, at the same period the area under soybean in Bhola was 1415 ha and it was increased by 7572 ha in 2019 (Source-DAE-Bhola). Both of those crops are grown at Rabi season in the region. But farmers cultivate this crop singly. It can be possible to intercrop with these crops for several benefits. Intercropping has shown potential as a land-use efficient and sustainable agricultural practice (Li et al. 2014; Brooker et al. 2015), which is as well the main model to increase the land use efficiency in both traditional and modern agriculture. Therefore, the present study was undertaken to verify the agro-economic performance of intercropping of Soybean with Maize with the following objectives-

1. To find out the appropriate intercrop combination for higher yield and economic return.
2. To investigate yield, yield components and Land Equivalent Ratio of intercropped maize and Soybean.

Materials and Methods

The experiment was conducted at Bhola sadar under Bhola district during the *rabi* season of 2020-21 and 2021-22 at the farmer's field under AEZ-18. The design of the experiment was Randomized Complete Block with five dispersed replications. Four treatments combination viz., $T_{1=}$ Sole maize, $T_{2=}$ Sole Soybean, $T_{3=}$ Two row maize (60cm x 25cm) with 2 row Soybean (30cm x 6cm), $T_{4=}$ Pair row maize (120cm x 25cm) with 4 row Soybean (30cm x 6cm) were tested. Maize var. was BARI Hybrid Butta-16 and Soybean var. was BARI Soybean-6. Unit plot size was 8m × 5m. Fertilizer dose for intercropping was 100-30-35-18-2 kg ha^{-1} N-P-K-S-Zn, respectively in the form of urea, TSP, MOP, gypsum and $ZnSO_4$ respectively. As the crop was cultivated in rainfed condition all fertilizers were applied during final land preparation except urea. Both Mazie and Soybean seeds were sown in line sowing method. Sowing date of both soybean and Maize was 07-20 January, 2021 & 2022 and harvesting date of Soybean was 21-30 April 2021& 2022. For controlling Soybean hairy caterpillar, nitro 505 EC @ 2ml Lit^{-1} water was sprayed once. Leaf roller was controlled by spraying of Sevin 20EC @ 2 ml Lit^{-1} water twice after 10 days interval. Maize was harvested 10-18 May 2021 & 2022. Standard cultural practices were done as and when necessary. Data were collected plot wise and analyzed statistically using Crop Stat analytical package.

Result and Discussions

Yield and yield attributes: From the results it is revealed that no. of cobs plant-1, cob length (cm) of maize was not significantly influenced among the treatments by intercrop combination.. In case of plant population between T_1 (7.13) and T_3 (7.10) have no significant difference but statistically deference than T4 treatment (6.28). Cob length was higher in T_1 followed by T_4 . Significant number of grains per cob was found where no. of grains cob^{-1} (545 & 558) was recorded from T_1 followed by T_4 (536 & 539) and the lowest (518 & 496) from T_3 treatment in 2021 & 2022 respectively. The highest maize grain yield (7.83 & 7.92 t ha^{-1}) was obtained from sole maize in both the years (Table 1a & 1b).

The highest number of pods $plant^{-1}$ was obtained from sole soybean.e. See rain yield (1.72 & 1.82 t ha^{-1}) of sole soybean was significantly higher and lowest soybean grain yield (1.28 and 1.25 t ha^{-1}) from T3 treatment during 2020-21 and 2021-22, respectively.

The highest Maize Equivalent Yield 9.41 and 9.63 t ha^{-1} was recorded from T_4 intercropped combination followed by T_3 treatment and the lowest from sole Soybean (Table 3a) in both the consecutive year.

Land equivalent ratio (LER): In T_3 treatment, the LER was 1.67 in 2021 but it was 1.60 in the year 2022. On the other hand, in T_4 treatment, the LER was 1.80 in 2021 but it was 1.71 in the year 2022. Growing maize and soybean in intercropping under rainfed condition resulted in higher LER (Table 4) when grown as T_3 and T_4 indicting beneficial association between the two.

Cost and Return

Cost and return analysis revealed that highest gross return (Tk. 235250,and Tk. 288900 ha^{-1}) was obtained from T_4 treatment followed by T_3 treatment. In case of gross margin, the highest (Tk. 148150 ha^{-1}) was from T_3 treatment in 2020-21 but it was higher (Tk. 190700 ha^{-1}) from T_4 treatment in 2021-22.

Farmer's opinion

Maize with soybean intercropped was found as a profitable practice at Bhola region but different intercultural operations like weeding and fertilization is difficult. But they could earn more income easily without hampering the main crop (Maize).

Table 1a. Yield and yield contributing characters of **Maize** under intercrop combinations at Bhola during the year of 2020-21

Treatments	Plant m^{-2} (no.)	Cobs plant^{-1} (no.)	Cob length (cm)	Grains cob^{-1} (no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})
T_1= Sole maize	7.13	1.20	24.50	545	348	7.83
T_2= Sole Soybean	-	-	-	-	-	-
T_3= 2 row soybean +2 row maize	7.10	1.12	22.34	518	336	7.34
T_4= 4 row soybean + pair row maize	6.28	1.16	23.18	536	340	6.85
CV (%)	10.43	9.62	7.26	13.17	8.44	10.26
LSD (0.05)	0.69	NS	1.97	5.61	4.37	0.76

Table 1b. Yield and yield contributing characters of **Maize** under intercrop combinations at Bhola during the year of 2021-22

Treatments	Plant m^{-2} (no.)	Cobs plant^{-1} (no.)	Cob length (cm)	Grains cob^{-1} (no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})
T_1= Sole maize	6.87	1.23	25.29	558	356	7.92
T_2= Sole Soybean	-	-	-	-	-	-
T_3= 2 row soybean +2 row maize	6.84	1.10	21.65	496	338	7.23
T_4= 4 row soybean + pair row maize	6.12	1.15	24.26	539	343	6.89
CV (%)	12.36	8.75	7.68	11.78	9.72	12.26
LSD (0.05)	0.62	NS	2.62	6.27	5.62	0.89

Table 2a. Yield and yield contributing characters of **Soybean** under intercrop combinations at Bhola during the year of 2020-21.

Treatments	Plant m^{-2} (no.)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (No.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)	Seed yield ($t\ ha^{-1}$)
T_1= Sole maize	-	-	-	-	-	-
T_2= Sole Soybean	58.34	4.82	52.23	2.54	61.34	1.72
T_3= 2 row soybean +2 row maize	54.76	3.55	43.96	2.47	58.12	1.28
T_4= 4 row soybean + pair row maize	46.72	4.53	48.78	2.50	60.23	1.60
CV (%)	10.32	8.36	11.60	9.27	7.42	8.45
LSD (0.05)	3.27	0.23	2.74	NS	NS	0.09

Table 2b. Yield and yield contributing characters of **Soybean** under intercrop combinations at Bhola during the year of 2021-22.

Treatments	Plant m^{-2} (no.)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (No.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)	Seed yield ($t\ ha^{-1}$)
T_1= Sole maize	-	-	-	-	-	-
T_2= Sole Soybean	56.82	4.78	53.46	2.68	61.25	1.82
T_3= 2 row soybean +2 row maize	52.31	3.30	41.17	2.46	60.10	1.25
T_4= 4 row soybean + pair row maize	43.35	4.60	49.62	2.52	61.18	1.56
CV (%)	12.36	7.39	10.61	8.27	7.42	7.68
LSD (0.05)	4.02	0.14	6.13	0.18	NS	0.19

Table 3a. Maize Equivalent yield of Maize Soybean intercrops at Bhola during 2020-21.

Treatments	Maize Equivalent Yield ($t\ ha^{-1}$)	Gross return ($Tk\ ha^{-1}$)	Total variable cost ($Tk\ ha^{-1}$)	Gross margin ($Tk\ ha^{-1}$)
T_1= Sole maize	7.83	195750	78350	117400
T_2= Sole Soybean	2.75	68750	42175	26575
T_3= 2 row soybean +2 row maize	9.38	234500	86350	148150
T_4= 4 row soybean + pair row maize	9.41	235250	88350	146900

Price of output: ($Tk.\ Kg^{-1}$): Maize- 25; Soybean- 40

Table 3b. Maize Equivalent yield of Maize Soybean intercrops at Bhola during 2021-22.

Treatments	Maize Equivalent Yield ($t\ ha^{-1}$)	Gross return ($Tk\ ha^{-1}$)	Total variable cost ($Tk\ ha^{-1}$)	Gross margin ($Tk\ ha^{-1}$)
T_1= Sole maize	7.92	237600	88750	148850
T_2= Sole Soybean	3.34	100200	45350	54850
T_3= 2 row soybean +2 row maize	9.21	276300	92600	183700
T_4= 4 row soybean + pair row maize	9.63	288900	98200	190700

Price of output: ($Tk.\ Kg^{-1}$): Maize- 30; Soybean- 55

Table 4. Land Equivalent Ratio (LER) of crops grown alone and mixed with each other with and without compost application.

Crop Stands	LER (2020-21)	LER (2021-22)
T_1= Sole maize	1.00	1.00
T_2= Sole Soybean	1.00	1.00
T_3= 2 row soybean +2 row maize	1.67	1.60
T_4= 4 row soybean + pair row maize	1.80	1.71

Conclusion

Considering the yield and return it can be concluded that intercropping of four rows soybean with two rows maize performed better than other treatment combinations in terms of higher MEY, Gross return and LER in both the years. From the result of this experimentation, it is evident that, intercropping is more profitable than the sole cropping and risk of cultivation of one crop can be reduced by mixed/ inter cropping.

INTERCROPPING OF SHORT DURATION WINTER VEGETABLES WITH SWEET GOURD IN HILL VALLEYS OF BANDARBAN

MOHAMMAD TANHARUL ISLAM

Abstract

A field experiment on intercropping of five winter leafy vegetables viz. radish, chinese cabbage (batishak), red amaranth, spinach and bushbean with sweet gourd was conducted at farmer's field of hill valleys of Bandarban hill district during rabi season of 2021-22 to evaluate the performance of sweet gourd production, to increase land use efficiency and to find out best intercrop combination. Five intercrop combinations such as T_1= Sweet gourd + radish (leaf), T_2= Sweet gourd + chinese cabbage, T_3= Sweet gourd + red amaranth, T_4= Sweet gourd + spinach and T_5= Sweet gourd + bushbean were used as treatments and sole sweet gourd were used in the experiment as control (T_0). Intercropping short duration winter vegetables with pumpkin influenced pumpkin yield and increased system. Treatment, T_3= Sweet gourd + red amaranth, T_5= Sweet gourd + bushbean and T_2= Sweet gourd + chinese spinach intercropping combinations performed better than sole sweet gourd. However, the results indicating that highest sweet gourd equivalent yield (40.13), gross return (802600 Tk. ha^{-1}), gross margin (604600 Tk. ha^{-1}) and BCR (4.05) was obtained from treatment T_3which indicating that this intercropping system might be suitable for higher crop productivity, better land and time utilization as well as economic return for the hilly areas of Bandarban.

Introduction

Crop productivity may increase by cultivating short duration crop like radish (leaf), Chinese cabbage (leaf), red amaranth (leaf), spinach (leaf) and bushbean with sweet gourd. Sweet gourd is a popular vegetable grown extensively throughout the tropical and subtropical countries (Hossain *et al*. 2015). This crop is appreciated by consumers because their fruits, tender stems, leaves and even flowers can be used as vegetables. Further, fruits of sweet gourd are used as vegetables both at immature (green) and mature (ripe) stage (Hossain *et al*. 2015). It is rich in carbohydrate and minerals and a cheaper source of vitamins, especially carotenoid pigments, which play a major role in nutrition in the form of pro vitamin A, antioxidants, when used at ripening stage (Dutta *et al*. 2006). It is a long duration (typically takes 95 to 120 days to mature, depending on variety and climate) and wider spacing crop (generally sown in rows on 1.8-3.0 m wider bed with wider plant spacing varying from 0.8-2.0 m depending on the vigor of the variety of sweet gourd grown) (Napier 2009). That is why there is a great scope to cultivate short duration leafy vegetables in the inter-row space of pumpkin to utilize the land and other resources to the maximum extent. It was observed that up to 40 days the canopy of the sweet gourd cannot cover the whole plot. Leafy vegetables on the other hand are an important constituent of fresh vegetables which can be grown with minimum investment and by growing leafy vegetables a grower can market his product more quickly than other types of vegetables as these vegetables can be harvested within 35-40 days (Biswas 2015). These nutritious vegetables are actually a source of minerals, vitamins and fibers. Therefore, to utilize the land intensively this experiment was conducted to find out suitable intercrop combination with sweet gourd for higher productivity and maximum economic return.

Materials and Methods

The experiment was laid out at bikricchara hill valleys of Bandarban in a randomized complete block design with 2 m × 2 m plots replicated thrice. Five crop combinations along with sole sweet gourd (i.e., six treatments all together) were evaluated: T_1= sweet gourd + radish (leaf), T_2= sweet gourd + chinese cabbage (Batishak), T_3= sweet gourd + red amaranth, T_4= sweet gourd + spinach and T_5= sweet gourd + bushbean. Sole sweet gourd was also cultivated as control (T_0).

Seeds of sweet gourd (*Cucurbita maxima var*. BARI mistikumra-2), radish (*Raphanussativus var*. BARI Mula-1), chinese cabbage (Brassica rapa var. Hybrid chinese cabbage), red amaranth (*Amaranthusgangeticus var.* BARI Lalshak-1), spinach (*Spinaciaoleracea var*. BARI palongshak-1) and bushbean (*Phaseolus vulgaris* var. BARI Bushbean-2) were sown on 15 November, 2021 (rabi/winter season).

For sweet gourd, pits of 50 cm × 50 cm × 45 cm size were dug at a spacing of 2 m × 2 m. Sweet gourd seeds were directly sown in pits (2 seeds per pit and 1 plant was allowed to grow) whereas leafy vegetables seeds were sown following broadcasting method and bushbean were sown maintaining 30 cm × 15 cm row-row and plant-plant spacing. Intercrop seeds were sown in the whole plot excluding pit areas and therefore the approximate intercropped areas were 95%. Seeds of all crops were treated with a recommended fungicide, Bavistin at 2 g /L before sowing to control disease organisms, such as bacterial spot, fusarium root rot and damping-off disease, which may be on the seed surface. The crop was fertilized with N, P, K, S, Zn, B and cowdung at 69, 35, 75, 18, 3, 2 kg ha^{-1} and 10 t ha^{-1}, respectively. The sources of N, P, K, S, Zn and B were urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum, zinc sulphate and boric acid, respectively. Entire amount of cowdung, TSP, gypsum, zinc sulphate, boric acid and one third (1/3) of MOP were applied during pit making (5 days prior to seed sowing of pumpkin). Total amount of Urea and rest of MoP were applied in four equal installments for at 15, 35, 55, and 75 days after seed sowing in pit at ring method. An additional 46 kg ha^{-1} N was top dressed only on leafy vegetables at their early vegetative stage at 15 days after sowing. Hand weeding was done for all plots as per requirement to control weed infestation especially before top dress and split application of fertilizer. Three irrigations were provided in the experimental field with ground water at 15, 35 and 55 days after sowing (DAS). Insect pest and disease infestations were generally low for most of the seasons during the experimental years. However, sex pheromone trap (Cuelure) was used to control shoot and fruit borers. Chemical protection measures were also taken against powdery and downy mildew diseases by spraying sulphur fungicide, Thiovit 80 WP at 2 g /L. Radish (leaf), chinese cabbage, red amaranth, spinach and bushbean were harvested manually at 25-33 DAS and bushbean was harvested at 64-66 DAS in 2022. Harvesting of sweet gourd was done at 113-120 DAS on March, 2022. Data on yield and yield contributing characters were recorded plot wise. Plot yields were then converted to tons per hectare.

Results and Discussion

Yield components of sweet gourd: Fruit plant^{-1}, fruit length, fruit breadth, average fruit weight was influenced by intercropping system (Table 1). Highest fruit plant^{-1} was obtained from T_2= Sweet gourd + chinese spinach combination (3.83) where lowest result from T_1= Sweet gourd + radish leaf (2.44). Highest fruit length was obtained from T_0= Sole sweet gourd (15 cm) while lowest was found from T_1= Sweet gourd + radish (13.54 cm).Sole sweet gourd showed highest fruit breadth (22.84 cm) and average fruit weight (3.09 kg) over all other treatments. Lowest average fruit weight (2.43) was obtained from T_2= Sweet gourd + radish (leaf) combination.

Crop Yield and Sweet gourd equivalent yield (SEY): The highest fruit yield ha^{-1} (17.08 t) was recorded in sole sweet gourd. The lowest fruit yield ha^{-1} (9.60 t) was found in T_1= Sweet gourd + radish (leaf) crop combination. Highest vegetable yield plot^{-1} and ha^{-1} (11.07 kg and 19.83 t) were found in treatment T_1 followed by T_2 (19.71 t) and lowest (11.53 t) was found from T_4= Sweet gourd + spinach combination. Highest SEY (40.13) was found from treatment T_3 followed by T_5 (38) and T_2 (36.04) crop combination. Lowest SEY (27.07) was found from T_4 crop combination.

Cost and return analysis

Cost and return analysis revealed that highest gross return (802600 Tk. ha^{-1}), gross margin (604600 Tk. ha^{-1}) and BCR (4.05) was obtained from intercrop combination T_3= Sweet gourd + red amaranth followed by T_5= Sweet gourd + bushbean (760000 Tk. ha^{-1}, 567000 Tk. ha^{-1} and 3.94 respectively) and T_2= Sweet gourd + chinese spinach (720800 Tk. ha^{-1}, 523600 Tk. ha^{-1} and 3.66 respectively). Lowest gross return (588600 Tk. ha^{-1}), gross margin (390900 Tk. ha^{-1}) and BCR (2.98) was obtained from treatment T_1. Sole Sweet gourd was found least profitable.

Farmers' opinion

Farmers in these areas could grow red amaranth, bushbean and chinese spinach as intercrop with sweet gourd because of high profitability over sole sweet gourd and other intercrop cultivation.

Table 1. Fruit number, fruit length, fruit breadth and fruit weight of sweet gourd as influenced by vegetables intercropping, 2021-22

Intercrop combinations	Fruits $plant^{-1}$	Fruit length (cm)	Fruit breadth (cm)	Average fruit weight (kg)
T_0= Sweet gourd (sole)	3.44	15	22.84	3.09
T_1= Sweet gourd + radish (leaf)	2.44	13.54	20.69	2.43
T_2= Sweet gourd + chinese spinach	3.83	14.29	22.25	2.71
T_3= Sweet gourd + red amaranth	3.33	14.82	22.04	3.08
T_4= Sweet gourd + spinach	3.33	14.95	21.71	2.95
T_5= Sweet gourd + bushbean	3.22	14.61	21.53	2.80
CV (%)	16.9	4.56	2.88	9.04
$LSD_{(0.05)}$	0.43	0.54	0.51	0.21

Table 2. Individual crop yield and sweet gourd equivalent yield (SEY) in sweet gourd-vegetables intercropping system for the crop year 2021-22

Intercrop combinations	Fruit Yield (t ha^{-1})	Vegetable yield (t ha^{-1})	SEY (t ha^{-1})
T_0= Sweet gourd (sole)	17.08	-	17.08
T_1= Sweet gourd + radish (leaf)	9.60	19.83	29.43
T_2= Sweet gourd + chinese spinach	16.34	19.71	36.04
T_3= Sweet gourd + red amaranth	16.38	15.83	40.13
T_4= Sweet gourd + spinach	15.55	11.53	27.07
T_5= Sweet gourd + bushbean	14.24	13.58	38
CV (%)	14.86	14.71	11.06
$LSD_{(0.05)}$	1.80	1.61	2.57

Table 3. Cost and return analysis of sweet gourd-vegetables intercropping system for the crop year 2021-22

Intercrop combinations	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
T_0= Sweet gourd (sole)	341600	193800	147800	1.76
T_1= Sweet gourd + radish (leaf)	588600	197700	390900	2.98
T_2= Sweet gourd + chinese spinach	720800	197200	523600	3.66
T_3= Sweet gourd + red amaranth	802600	198000	604600	4.05
T_4= Sweet gourd + spinach	541400	197000	344400	2.75
T_5= Sweet gourd + bushbean	760000	193000	567000	3.94

Selling price (Tk kg^{-1}): Sweet gourd: 20, radish leaf: 20, chinese cabbage: 20, red amaranth: 30, spinach: 20 and bushbean: 35.

INTERCROPPING OF BLACK CUMIN WITH GROUNDNUT AT SANGU RIVERBANK OF BANDARBAN HILL DISTRICT

MOHAMMAD TANHARUL ISLAM

Abstract

The experiment was carried out at the farmers' field of On-Farm Research Division, BARI, Bandarban during the rabi season, 2021-22 to find out the suitable intercropping system for increasing crop productivity and profitability of black cumin with groundnut intercropping system. The treatments were: T_1=sole groundnut, T_2=sole black cumin, T_3= one row of black cumin in between two rows of groundnut and T_4= two rows of black cumin in between two rows of groundnut. Treatments were arranged in a randomized complete block design with three replications. Between intercropped treatments, single row of black cumin within paired rows of groundnut (T_3) showed higher groundnut equivalent yield (3331.12 kg ha^{-1}), highest land equivalent ratio (1.43), gross return (Tk. 199867 ha^{-1}), gross margin (Tk. 149367 ha^{-1}) and benefit cost ratio (3.96) over the respective sole groundnut crop (T_1), sole black cumin (T_2) and Two rows of black cumin in between two rows of groundnut (T_4). The result showed that groundnut + black cumin (single row) intercrop system was most productive and profitable than sole groundnut cultivation in Bandarban region.

Introduction

Intercropping is widely practiced by many farmers in the tropics. Intercropping gives a greater stability of yield over monoculture (Willey and Reddy, 1981). Besides, intercropping ensures greater resource use efficiency (Herrara and Harwood, 1974; Poathick and Malla, 1979). The black cumin (*Nigella sativa* L.), an important source for a spice and in pharmaceutical industries, is one of the most important medicinal minor spice plants in Bangladesh. Seed of black cumin contain about 21% protein, 35% carbohydrates and 35-38% plant fats and oils. It contains all essential amino acids and rich source of vitamins and minerals. Total cultivable area of Bangladesh is 14.86 million hectares. Black cumin is an annual plant, originally grown in arid and semi-arid regions. On the other hand, groundnut is the third major oil crop in Bangladesh in area and production. It contains maximum oil content. Groundnuts are a popular source of food throughout the world, consumed either as peanut butter or crushed and used for groundnut oil or simply consumed as a confectionary snack. Groundnuts are cultivated in the tropical and subtropical regions of the world on sandy soils. In Bandarban district, it is grown in the river bank of Sangu during rabi season where farmers normally grow groundnut as sole crop. The cropping intensity of this area is 150%. An extra crop may be introduced as intercrop and cropping intensity may be increased. That is why this experiment was taken to evaluate the performance of intercropping black cumin with groundnut.

Materials and Methods

The experiment was conducted in a farmer's field of sangu river bank in Bandarban during the rabi season, 2021-22. Four treatments viz. T_1: Sole groundnut, T_2: Sole black cumin, T_3: Groundnut + Black cumin (single row) and T_4: Groundnut + Black cumin (double row) were used.. The trial was laid out in randomized complete block design (RCBD) with three replications. The unit plot size was 5 m × 4.5 m. Local Groundnut (var. Tridana Badam) and Black cumin (var. BARI Black cumin-1) were used.. For groundnut, spacing was 40 cm × 15 cm and in between two line of groundnut, black cumin seed were sown maintaining 10 cm distance from each other for single line. For double row of black cumin (T_4), 15 cm line-line and 10 cm plant-plant distance were maintained. Both groundnut and black cumin seeds were sown on 13 November, 2021. Fertilizers were applied @ 15-35-20-15 kg N-P-K-S ha^{-1} for groundnut. All fertilizers were applied as basal at the time of final land preparation in the form of urea, triple super phosphate, muriate of potash and gypsum respectively. Two times weeding and earthing up were done. The component crop was harvested on 12-14 March, 2022 and groundnut was harvested on 04 April, 2022. At harvest, the yield and yield attributes were recorded and analyzed statistically. Groundnut equivalent yield, LER and economic analysis were done for each treatment on a hectare basis considering the farm rate of crop. Groundnut equivalent yield (GEY) was calculated by converting the yield of black cumin to the yield of groundnut. Index of yield was calculated by the following formula: (Index of yield= Intercrop yield/Sole crop yield × 100). Land equivalent ratio (LER) was computed according to Shaner et al. (1982) as follows: LER= yield of sole groundnut/ yield of intercrop groundnut + yield of sole black cumin / yield of intercrop black cumin.

Results and Discussion

Yield of groundnut and black cumin was significantly differing from one another in each treatment. Yield of sole groundnut and sole black cumin was higher due to no intercrop competition. Treatment T_3: Groundnut + Black cumin (single row) showed highest GEY (3331.12 kg ha^{-1}) and lowest GEY (1632.78 kg ha^{-1}) from Sole black cumin. Highest LER (1.43) was found from treatment T_3.Crop Index of yield for both sole groundnut and black cumin was 100 but in T_3: Groundnut + Black cumin (single row), groundnut index of yield was 87.32 and for black cumin 56.41 i.e., yield reduced 12.68 and 34.49 % In T_4 treatment: Groundnut + Black cumin (double row), the index of yield for groundnut and black cumin was 69.93 and 51.38 i.e., yield reduced 30.07 and 48.62 % , respectively.

Highest gross return, gross marginand BCR was found from T_3 (199867 Tk. ha^{-1}, 149367 Tk. ha^{-1} and 3.96) over sole groundnut cultivation (T_1) (165600 Tk. ha^{-1}, 118100 Tk. ha^{-1} and 3.49) and T_4: Groundnut + Black cumin (double row) was not profitable (166133 Tk. ha^{-1}, 114133 Tk. ha^{-1} and 3.19) than sole groundnut cultivation. Lowest gross return, gross margin and BCR was found from Sole black cumin (97967 Tk. ha^{-1}, 49167 Tk. ha^{-1} and 2.01).

Farmer's opinion

Groundnut + Black cumin (single row) was found to be more profitable practice with high economic return. Therefore, this intercropping system could help to meet up the medicinal spice crop requirement of the family without hampering the main crop.

Table 1. Yield, groundnut equivalent yield (GEY) and LER of Groundnut-Black cumin intercropping system in Bandarban during the year of 2021-2022

Treatments	Yield (kg ha^{-1})		GEY (kg ha^{-1})	LER	Index of yield (%)	
	Groundnut	Black cumin			Groundnut	Black cumin
T_1= Sole groundnut	2760	-	2760	1.00	100	-
T_2= Sole black cumin	-	979.67	1632.78	1.00	-	100
T_3: Groundnut + Black cumin (single row)	2410	552.67	3331.12	1.43	87.32	56.41
T_4: Groundnut + Black cumin (double row)	1930	503.33	2768.88	1.21	69.93	51.38
CV (%)	4.07	1.27	-	-	-	-
LSD $_{(0.05)}$	0.079	7.04	-	-	-	-

LER= Land equivalent ratio

Table 2. Cost-benefit analysis of Groundnut-Black cumin intercropping system in Bandarban during the year of 2021-2022

Treatments	Gross return (Tk ha^{-1})	TC (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
T_1= Sole groundnut	165600	47500	118100	3.49
T_2= Sole black cumin	97967	48800	49167	2.01
T_3: Groundnut + Black cumin (single row)	199867	50500	149367	3.96
T_4: Groundnut + Black cumin (double row)	166133	52000	114133	3.19

Selling price (Tk kg^{-1}): Groundnut: 60, black cumin: 100.

INTERCROPPING OF VEGETABLES, SPICES AND RED AMARANTH WITH CHEWING TYPE SUGARCANE

AFM RUHUL QUDDUS AND SELIM AHMED

Abstract

A trial was carried out at the FSRD site, Sholakundu, Faridpur of AEZ-12 during the two consecutive *rab*i 2020-21 and 2021-22 to find out suitable profitable intercrop combinations with chewing type sugarcane and to intensify use of land for growing vegetables and spices crops. . Four treatments *viz* T_1: red amaranth (Lalshak) in between four rows of onion bulb, T_2: red amaranth in between three rows of coriander (leaf purpose), T_3: red amaranth in between three rows of radish, and T_4: red amaranth and radish in between four rows of onion bulb (farmer's practice). It was laid out in RCB design with six compact replications. BARI Piaz-1, BARI Lalshak-1, BARI Mula-1, BARI Dhonia-2 and Gendari (local) were used as planting materials for onion, red amaranth, radish, coriander and sugarcane, respectively. The highest cane yield was calculated from T_2 (81.87 t ha^{-1}) where red amaranth & coriander leaf were intercropped and the lowest from farmer's practice; T_4 (79.60 t ha^{-1}).The highest average OEY (10.23 t ha^{-1}) was calculated from T_1 followed by T_4 (8.14 t ha^{-1}). The lowest average OEY was found from T_3 (5.64 t ha^{-1}) where red amaranth was sown in between two rows of radish. The highest GM with sugarcane and intercrop was found from T_1 (Tk 587624 ha^{-1}) followed by T_2 (Tk. 523852 ha^{-1}). The lowest GM was observed in T_4 (Tk 499617 ha^{-1}).

Introduction

Sugarcane (*Saccharum officinarum L.*) is the second cash cum-industrial crop in Bangladesh. It is a long duration crop for cultivation which needs about 12-13 months from transplanting to harvest. It is a wide spacing crop usually planted at 80 to 120 cm row to row spacing depending on varietal purpose. There is a little scope of increasing area under sugarcane due to heavy competition for food, fiber, oilseed, pulses etc. Therefore, the only alternative left is to increase the vertical production of sugarcane and sugar by finding out the efficient agronomic management practices. In recent years, several changes in cropping system been observed. The sole cropping has been shifted to intercropping system which has proved to be productive. Intercropping of different vegetables and spices is possible in sugarcane field. Because, in sugarcane, the wide space of inter-row 90 cm available between 2 rows of sugarcane, long duration for bud sprouting, initial slow rate of growth and its ability to compensate for any loss of tillers due to intercrop competition have helped in successful intercropping (Islam and Islam, 2018). Again, sugarcane's efficient root system helps to tap plant nutrients and moisture from the soil deep layers allowing the intercrops to feed at the top layer of soil. Thus, intercropping of different vegetables and spices are getting popularity day by day. In Faridpur, about 2500-3000 ha of land use for sugarcane. As a one-year crop, farmers cultivate different crops (onion bulb, black cumin, coriander leaf), vegetables (tomato, radish, lalshak) using ridge up-to 2-3 months after sugarcane planting. Farmers plant sugarcane in furrow and grow intercrops in ridge for 3-4 months, then, farmers breakdown the ridge and its soil is used to fill the furrow for mechanical support of the sugarcane. Farmers normally use different combination of intercrops but yet studied that which one is more productive and economically suitable. Hence, the trial was conducted to find out suitable intercropping combination of different vegetable and spices with sugarcane for increasing farmer's income as well as production.

Materials and Method

The experiment was carried out at the FSRD site, Faridpur of AEZ-12, during the two consecutive *rab*i 2020-21 and 2021-22 to find out suitable profitable intercrop combinations with chewing type sugarcane and to intensify use of land for growing vegetables and spices crops.. Four treatments *viz* T_1: red amaranth (Lalshak) in between four rows of onion bulb, T_2: red amaranth in between three rows of coriander (leaf purpose), T_3: red amaranth in between three rows of radish, and T_4: red amaranth and radish in between four rows of onion bulb. It was laid out in RCB design with six compact replications. BARI Piaz-1, BARI Lalshak-1, BARI Mula-1, BARI Dhonia-2 and Gendari (local) were used as planting materials of onion, red amaranth, radish, coriander and sugarcane, respectively. The unit plot size was 10.5 m^2 (7m ×1.5m). Planting system of sugarcane, red amaranth, radish, oriander and onion bulb was 1.5 m x 0.1 m, broadcast, 30 cm x 10 cm, 25 cm x continuous and 25 cm x 10 cm, respectively. Seed of intercrops was sown for red amaranth @ 3 kg ha^{-1} (75% for all treatment except T_4; 50%), coriander @ 18 kg ha^{-1}, radish@ 5 kg ha^{-1} (100% for T_3 and 75% for T_4) and onion bulb @ 750 kg ha^{-1}. The sugarcane (100% of recommended dose; RD), red amaranth (50% of RD), radish, coriander and onion bulb (75% of RD each) were fertilized with 230-100-750-45-4-2 kg ha^{-1}, 50-12-10-5-0-0 kg ha^{-1}, 135-45-60-14-2-0 kg ha^{-1}, 75-30-22-11-1.5-0 kg $ha^{-1}$and 105-45-45-22-2-1 kg ha^{-1} N-P-K-S-Zn-B, respectively in the form of urea, DAP, MOP, gypsum, zinc sulphate and boric acid, respectively. For sugarcane cultivation, half of N & K and all of P, S, Zn, B was applied in trench and mixed thoroughly with the soil before planting of sugarcane. Remaining N and K was applied as top dress at tillering stage (120-150 DAP) under moist soil condition. For onion, all of P, S, Zn and B, and half of N and K was applied as basal during final land preparation. Remaining N and K was applied in two equal splits at 20 DAT and 48 DAT under moist soil condition and mixed thoroughly with the soil. For intercrops, all fertilizers except N were applied during final land preparation and N was applied as top dress at 20 DAS. Sugarcane settlings were transplanted in trenches at 15 cm plant to plant spacing during 28 October, 2020. Intercrops of vegetables and spices were sown on 28 October 2021 and 4 November, 2020. For sugarcane, 3 times irrigation, weeding & spading, fungicide application and 6 times insecticides were applied. Irrigation was applied to intercrops at immediately after sowing, 20 DAS/DAT and 48 DAT (onion intercrop). Two times weeding of intercrop was done at 20 DAS/DAT and 46 DAT. Different fungicides (Rovral at 22-29 DAT and Amister top at 53-56 DAT for controlling onion disease) were sprayed. Coriander, radish, red amaranth and onion bulb were harvested at 38 , 44 , 28 DAS and 90 DAT. Chewing type sugarcane was harvested on 27 September 2021. The yield of intercrop was calculated in ton per hectare considering from 5 m^2 sample plot. Collected data of onion equivalent yield were analysed statistically with the help of R programme and mean separation was done by DMRT. Gross return and margin were performed considering the prevailing price of intercrops at the harvesting period in the local market. Two years average data was prepared.

Results and Discussion

Intercrop: Red amaranth was common intercrop in all the treatments. Table 3, 4 and 5 stated the yield of intercrops during 2021-22, 2020-21 and average of two years, respectively. The highest average leaf yield (2.65 t ha^{-1}) of red amaranth was calculated from T_1 treatment where red amaranth (Lalshak) was cultivated in between four rows of onion bulb followed by T_2 (2.29 t ha^{-1}). The lowest average red amaranth leaf yield (0.97 t ha^{-1}) was obtained from farmer's practice; T_4 treatment where radish and onion were present. The onion was present in T_1 and T_4 treatment as intercrop. The higher average yield of onion was found with red amaranth (8.21 t ha^{-1}) and the lower average yield (4.01 t ha^{-1}) from T_4 where red amaranth and radish were cultivated in between four rows of onion bulb resulting higher intercrop competition. In case of radish cultivation as intercrop, higher average radish yield was obtained from T_3 treatment (18.76 t ha^{-1}) where red amaranth exists. But, in T_4 treatment, due to higher competition with three crops, like red amaranth and onion, radish was showed lower average yield (13.72 t ha^{-1}). The Onion Equivalent Yield (OEY) differ among the intercrop combination (Table 6, 7 and 8). Year wise OEY and respective cost & return was comparatively higher in 2021-22 season than that of 2020-21 due to might be higher yield obtaining from intercrops. The highest average OEY (10.23 t ha^{-1}) was calculated from T_1 followed by T_4 (8.14 t ha^{-1}). The lowest average OEY was found from T_3 (5.64 t ha^{-1}) where red amaranth was sown in between two rows of radish.

Considering average cost and return analysis from Table 8, it is revealed that the higher variable cost (VC) was calculated from those treatments where onion bulb was planted (T_1 and T_4). The highest average gross return (GR) was calculated from T_1 (Tk 306750 ha^{-1}) and the lowest from T_3 (Tk. 169050 ha^{-1}) due to lowest OEY. The highest average gross margin (GM) was found from

T_1 (Tk 183387 ha^{-1}) followed by T_2 (Tk. 134615 ha^{-1}). The lowest average GM was observed in T_4 (Tk 97880 ha^{-1}).

Sugarcane: Sugarcane yield and yield contributing characters was stated in Table 1. Single cane weight was ranged between 1.57 (T_3, T_4) to 1.62 (T_2). The highest cane yield was calculated from T_2 (81.87 t ha^{-1}) and lowest from farmer's practice; T_4 (79.60 t ha^{-1}). In case of cost and return (Table 2), the maximum gross margin (Tk. 409862 ha^{-1}) was calculated from T_3 treatment for getting highest number of cane ha^{-1} (51333) followed by T_1 (Tk. 404237 ha^{-1}). The lowest gross margin was observed from farmer's practice (Tk. 401737 ha^{-1}).

Sugarcane with intercrop: Cost and return of sugarcane with Onion Equivalent Yield was stated in Table 9. The highest GR was calculated from T_1 (Tk. 1019112 ha^{-1}) followed by T_4 (Tk. 940112 ha^{-1}) and increase percentage was 8.40. The lowest GR obtained from T_3 (Tk. 887712 ha^{-1}). Onion based intercrop showed higher VC. VC was highest in farmer's practice;T_4. The highest GM was found from T_1 (Tk 587624 ha^{-1}) followed by T_2 (Tk. 523852 ha^{-1}). The lowest GM was observed in T_4 (Tk 499617 ha^{-1}).

Farmers' opinion

Farmers were interested to cultivate intercrop of red amaranth (Lalshak) in between four rows of onion bulb and in between two rows of coriander (leaf purpose) due to get higher gross margin.

Table 1. Sugarcane yield and yield contributing characters at the FSRD site, Faridpur 2020-21

Treatment	Cane m^{-2} (nos.)	Cane ha^{-1} (nos.)	Single cane weight (kg)	Cane yield (t ha^{-1})
T_1 (Red amaranth+Onion bulb)	5.08 a	50883.33 a	1.59 ab	81.00 a
T_2 (Red amaranth+Coriander leaf)	4.97 a	50016.67 a	1.62 a	81.87 a
T_3 (Red amaranth+Radish)	5.13 a	51333.33 a	1.57 b	80.69 a
T_4 (Red amaranth+Radish+Onion bulb)	5.07 a	50683.33 a	1.57 b	79.60 a
CV (%)	5.58	5.47	2.68	4.99

T_1: Red amaranth (Lalshak) in between four rows of onion bulb, T_2: red amaranth in between three rows of coriander (leaf purpose), T_3: red amaranth in between three rows of radish, and T_4: red amaranth and radish in between four rows of onion bulb.

Table 2. Sugarcane yield and cost & return at the FSRD site, Faridpur during 2020-21

Treatment	Yield ha^{-1}		GR (Tk ha^{-1})	VC (Tk ha^{-1})	GM (Tk ha^{-1})
	No. of cane	Weight			
T_1 (Red amaranth+Onion bulb)	50883	81.00	712362	308125	404237
T_2 (Red amaranth+Coriander leaf)	50016	81.87	695562	306325	389237
T_3 (Red amaranth+Radish)	51333	80.69	718662	308800	409862
T_4 (Red amaranth+Radish+Onion bulb)	50683	79.60	709262	307825	401737

T_1: Red amaranth (Lalshak) in between four rows of onion bulb, T_2: red amaranth in between three rows of coriander (leaf purpose), T_3: red amaranth in between three rows of radish, and T_4: red amaranth and radish in between four rows of onion bulb.
Input price: Seed (Tk kg^{-1}): Sugarcane cutting: 3.00/cutting, Fertilizer (Tk kg^{-1}): Urea-16, DAP-16, MoP- 15, Gypsum-10, Zn SO_4- 220, Boric acid- 240, **Out price** (Tk kg^{-1})**:** 14.00 Tk/cane

Table 5. Intercrop yield (t ha^{-1}) at the FSRD site, Faridpur (average of 2 years)

Treatment	Red amaranth (t ha^{-1})	Onion bulb (t ha^{-1})	Coriander (t ha^{-1})	Radish (t ha^{-1})
T_1 (Red amaranth+Onion bulb)	2.65	8.21	--	--
T_2 (Red amaranth+Coriander leaf)	2.29	--	2.95	--
T_3 (Red amaranth+Radish)	1.39	--	--	18.76
T_4 (Red amaranth+Radish+Onion bulb)	0.97	4.01	--	13.72

T_1: Red amaranth (Lalshak) in between four rows of onion bulb, T_2: red amaranth in between three rows of coriander (leaf purpose), T_3: red amaranth in between three rows of radish, and T_4: red amaranth and radish in between four rows of onion bulb.

Table 8. Average Onion Equivalent Yield (t ha^{-1}) and cost & return at the FSRD site, Faridpur (average of 2 years)

Treatment	Onion Equivalent Yield (t ha^{-1})	GR (Tk ha^{-1})	VC (Tk ha^{-1})	GM (Tk ha^{-1})
T_1 (Red amaranth+Onion bulb)	10.23	306750.00	123363.00	183387.00
T_2 (Red amaranth+Coriander leaf)	6.67	192275.00	57660.00	134615.00
T_3 (Red amaranth+Radish)	5.64	169050.00	64924.00	104126.00
T_4 (Red amaranth+Radish+Onion bulb)	8.14	230850.00	132970.00	97880.00

Input price: Seed (Tk kg^{-1}): Red amaranth: 800.00, coriander: 100.00, Radish: 500.00 and onion bulb: 100.00
Fertilizer (Tk kg^{-1}): Urea-16, DAP-16, MoP- 15, Gypsum-10, Zn SO_4- 200, Boric acid- 240,
Out price (Tk kg^{-1}): Red amaranth: 20.00, Onion bulb: 30.00, coriander: 45.00, radish: 5.00

Table 9. Cost & return of sugarcane with Onion Equivalent Yield (t ha^{-1}) at the FSRD site, Faridpur

Treatment	Cane yield (t ha^{-1})	Onion Equivalent Yield (t ha^{-1})	GR (Tk ha^{-1})	VC (Tk ha^{-1})	GM (Tk ha^{-1})
T_1	81.00	10.23	1019112	431488	587624
T_2	81.87	6.67	887837	363985	523852
T_3	80.69	5.64	887712	373724	513988
T_4	79.60	8.14	940112	440795	499617

Output price: Tk 14/cane

Conclusion

Cultivation of red amaranth (Lalshak) in between four rows of onion bulb followed by in between three rows of coriander (leaf purpose) was profitable as intercrop combination with chewing type sugarcane.

INTERCROPPING OF CAULIFLOWER WITH Bt. BRINJAL

KU AHAMMAD AND MH RAHMAN

Abstract

An experiment was carried out at MLT site Tularampur, Narailduring 2021-2022. There were four treatments, viz. T_1= 1 row cauliflower between 2 rows of brinjal, T_2= 2 row cauliflower between 2 rows of brinjal, T_3= 1 cauliflower between 2 brinjal plant along with line and T_4= Sole brinjal used t. The experiment was laid out in RCB with 3 replications. Cauliflower (var. White Snow) was intercropped with Bt. begun (var. BARI Bt. begun-4).Yield and yield contributing characters of of Bt. begun showed no significant difference due to intercropping. The maximum Bt. begun yield (25.9 t ha^{-1}) was produced from T_3 (1 cauliflower between 2 brinjal plant) followed byT_4 (Sole brinjal) and T_2 (2 row cauliflower between 2 rows of brinjal), and lowest (25.3 t ha^{-1}) from T_1 (1 row cauliflower between 2 rows of brinjal). The highest equivalent yield (49.8 t ha^{-1}) of Bt. begun was obtained from T_2 and lowest (25.46 t ha^{-1}) from T_4. The highest gross margin (1020417 Tk.ha^{-1}) and marginal benefit cost ratio (5.51) were found from T_2 (2 row cabbage between 2 rows of brinjal) and the lowest gross margin (430000 Tk.ha^{-1}) from T_4 (Sole Bt. begun).

Introduction

Brinjal is one of the major vegetable crops in Bangladesh grown round the year. The main growing season of this crop is winter and the farmers of Narail district cultivate it as a sole crop. BARI has released some Bt. brinjal varieties- BARI Bt. Begun-1, BARI Bt. Begun-2, BARI Bt. Begun-3 and BARI Bt. Begun-4. Among the varieties BARI Bt. Begun-4 is cultivated by some farmers of Narail district in winter season. At the time of marketing they get fewer prices for Bt.brinjal compared to local varieties. So, cauliflower intercropping with BARI Bt. Begun-4 may compensate the loss of Bt. begun cultivation as well as increase the total productivity and economic return. But no scientific study has been done in this regard earlier. Therefore, the present experiment was conducted to find out the performance of cauliflower as intercrop with brinjal in Narail district.

Materials and Methods

An experiment was carried out at MLT site Tularampur, Narailduring 2021-2022. There were four treatments viz. T_1= 1 row cauliflower between 2 rows of brinjal, T_2= 2 row cauliflower between 2 rows of brinjal, T_3= 1cauliflower between 2 brinjal plant along with lineand T_4= Sole brinjal used . The experiment was laid out in RCB with 3 replications. Cauliflower (var. White Snow) was intercropped with Bt. begun.The plot size of the experiment was 5m × 4m. Bt. begun and cauliflower were transplanted on 25 December 2021 maintaining the spacing according to the program as per treatments. Fertilizers were used @ 45-30-20-15-0.5-0.5 kg Urea, TSP, MoP, Gypsum, Zinc and Boron/bigha respectively and cow dung 1.5t/bigha. Cowdung and all fertilizers except urea were used as basal during final land preparation. Urea was applied in three installments after transplanting (DAT) of Bt. begun. Weeding, irrigation and other intercultural operations were done properly. Cauliflower was harvested during 05-10 March 2022 and Bt. begun was harvested from 12 March to 30April 2022. Data on yield and yield contributing characters were taken and statistically analyzed with MSTAT-C software.

Results and Discussion

Caulifloweryield showed significant difference due to intercropping with Bt. begun. The maximum card yield (48.7 t ha^{-1}) was produced from T_2 (2 row cauliflower between 2 rows of brinjal) followed byT_1 (24.5 t ha^{-1}), T_3 (12.1), in Table 1. Similarly the maximum equivalent yield (49.8 t ha^{-1}) of Bt. begun was obtained from T_2 followed byT_1 (37.6 t ha^{-1}), T_3 (31.9 t ha^{-1}) and T_4 (25.6 t ha^{-1}), in Table 2. The highest gross margin (1020417 Tk.ha^{-1}) and marginal benefit cost ratio (40) was found from T_2 (2 row cauliflower between 2 rows of brinjal) and the lowest gross margin (430000 Tk.ha^{-1}) from T_4 (Sole Bt. begun).

Farmers' opinion

Farmers were impressed with BARI Bt. begun-4 intercropping with cauliflower. They preferred 2 row cauliflower between 2 rows of brinjal intercropping system.

Table 1. Yield and yield contributing character of Bt. begun intercropping with cauliflower during 2021-2022

Treatment	Fruits/plant	Fruit wt. (kg)	Bt. Begun fruit yield (t ha^{-1})	Card yield (t ha^{-1})
T_1	10.8	242	25.3	24.5
T_2	10.6	246	25.5	48.7
T_3	12.0	229	25.9	12.1
T_4	11.1	244	25.6	0.0
F test	NS	NS	NS	**
CV (%)	9.35	7.01	11.49	4.30

T_1= 1 row Cauliflower between 2 rows of brinjal, T_2= 2 row Cauliflower between 2 rows of brinjal, T_3= 1 Cauliflower between 2 brinjal plant. T_4= Sole brinjal

Table 2. Cost and return analysis of Bt. begun intercropping with cauliflower during 2021-2022

Treatment	Bt. begun equivalent yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
T_1	37.6	939167	220000	719167	30
T_2	49.8	1245417	225000	1020417	40
T_3	31.9	797500	218000	579500	20
T_4	25.6	640000	210000	430000	0

Market price (Tk./kg): Bt. begun = 20, Cauliflower = 10

PERFORMANCE OF MUNGBEAN AND SESAME INTERCROPPING IN SOUTHERN DISTRICT OF BANGLADESH

K N ISLAM, M M ISLAM AND M S I KHAN

Abstract

The experiment was conducted at MLT site Kuakata, Patuakhali and MLT site Amtoli, Borguna during rabi season of 2021-22 to find out suitable intercrop combination in southern district and to increase the total crop productivity of the farmers. Four treatments namely: T_1 = 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast, T_2 = 100% mungbean in rows (30cm × 5 cm) + 25% sesame as broadcast, T_3 = Sole crop of mungbean in row (30 cm × 5 cm) (100% mungbean) and T_4 = Sole crop of sesame in row (30 cm x 5 cm) (100% sesame) were evaluated at each location. Sole mungbean and sesame gave higher yields than intercrop treatments in all the locations. Among the intercrop treatments, the highest seed yield of mungbean was obtained from T_2 treatment in all the locations while the lowest from T_1. On the other hand, sesame gave higher seed yield in T_1 treatment. Intercropping increased mungbean equivalent yield (MEY) and land equivalent ratio (LER) compared to sole cropping. Over the locations, the highest MEY (2.33 t ha^{-1}), LER (1.44) and BCR (1.87) was found in T_1 (100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast) treated plot which was also compared to the other intercropping and sole cropping system.

Introduction

Mungbean and sesame are essential food crops for cultivation and became the major component of protein diet (Choudhary *et al.*, 2011). Intercropping is the means of producing more food from limited area of land by cultivating multiple crops simultaneously. It ensures improved use of land, labor and resources. The system of intercropping not only improves the yield and returns but also reduces the risk of complete crop failure as compare to the sole cropping system (Rao and Singh, 1990). In addition to intercropping, used growth resources efficiently, suppressed weeds, disease and pest incidences (Paoline *et al.*, 1988). A few farmers are cultivating other crops as intercropping with mungbean. The southern districts of Bangladesh have problems in crop production such as hailstorm, cyclones, floods and soil salinity. The adoption of intercropping technology can increase the total crop productivity of the region by reducing the risk of crop failure. Therefore, the experiment was undertaken to find out suitable intercrop combination and to increase the total crop productivity by reducing the risk of crop failure.

Materials and Methods

The experiment was conducted at MLT site Kuakata, Patuakhali and MLT site Amtoli, Borguna during late rabi season of 2021-22. Four treatments namely: T_1= One row mungbean alternated with one row sesame (30 cm x 5 cm), T_2 = 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast, T_3 = Sole crop of mungbean in row (30 cm × 5 cm) (100% mungbean), T_4 = Sole crop of sesame in row (30 cm x 5 cm) (100% sesame) were evaluated at each location. Mungbean var. BARI Mungbean-6 and sesame var. BARI Til-4 were used as test crop. The experiment was laid out in RCB design with three dispersed replications. The unit plot size was 5 m x 4 m at Kuakata and Amtoli. Seeds were sown according to treatments on 1 February and 29 January at Kuakata and Amtoli, respectively. In sole mungbean and intercrop plots, the land was fertilized with N_{23}, P_{17} and $K_{17.5}$ kg ha^{-1} at the time of final land preparation. In sole sesame, fertilizers were applied at the rate of $N_{57.60}$, P_{30}, K_{25}, $S_{19.82}$, $Zn_{1.05}$ and $B_{1.70}$ kg ha^{-1}. All intercultural operations were done in proper time for better growth of the crop. The data were statistically analyzed and means were separated by critical difference (CD) values at 5% level of significance.

Results and Discussion

Mungbean and sesame yields were significantly influenced by intercropping (Table 1). At Kuakata, sole mungbean gave the highest seed yield (1.68 t ha^{-1}). In intercropping, T_2 gave higher yield of mungbean than that of T_1. Sole sesame gave the highest seed yield (1.33 t ha^{-1}). In intercropping, T_1 gave higher yield of sesame than that of T_2. Similar trend was found in Amtoli.

Intercropping increased mungbean equivalent yield (MEY) compared to sole cropping (Table 2). At Kuakata, the maximum MEY (2.33 t ha^{-1}) was found in T_1 treatment followed by T_2. Similar trend was found in Amtali. Results indicate that 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast would be suitable for higher total productivity. The highest LER (1.44) was obtained by 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast intercropping system. This result indicated that 44% of the yield of mungbean and sesame on intercrops in monocrops. Considering economic analysis, the highest gross margin and BCR were obtained Tk. 151450 and 1.87, respectively from 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast combination over other combination (Table-3).

Farmers' opinion

Farmers have shown their interest in crop production through intercropping where maximum use of land possible, increase in total crop production and reduction in risk of crop failure.

Table 1. Yield of mungbean and sesame as influenced by intercropping at different locations during Rabi season of 2021-22

Treatments	Seed yield (t ha^{-1})			
	Kuakata		Amtoli	
	Mungbean	Sesame	Mungbean	Sesame
T_1	1.41 b	0.80 b	1.42 b	0.78 b
T_2	1.56 ab	0.39 c	1.53 ab	0.36 c
T_3	1.68 a	-	1.69 a	-
T_4	-	1.33 a	-	1.31 a
CV (%)	4.15	1.94	5.49	3.85
$CD_{(0.05)}$	0.15	0.03	0.19	0.08

Means were separated by critical difference (CD) values at 5% level of significance. T_1= 100% mungbean in rows (30cm × 5 cm) + 50% sesame as broadcast, T_2 = 100% mungbean in rows (30cm × 5 cm) + 25% sesame as broadcast, T_3= Sole crop of mungbean in row (30 cm × 5 cm) (100% mungbean), T_4 = Sole crop of sesame in row (30 cm x 5 cm) (100% sesame)

Table 2. Mungbean equivalent yield (MEY) as influenced by intercropping over locations during Rabi season of 2021-22

Treatments	MEY (t ha^{-1})		Mean MEY (t ha^{-1})	LER		Mean LER
	Kuakata	Amtali		Kuakata	Amtali	
T_1	2.33	2.32	2.33	1.44	1.44	1.44
T_2	2.01	1.95	1.98	1.22	1.18	1.20
T_3	1.68	1.69	1.69	1.00	1.00	1.00
T_4	1.53	1.51	1.52	1.00	1.00	1.00

Table 3. Cost and return analysis of mungbean equivalent yield (MEY) as influenced by intercropping during rabi season of 2021-22

Treatments		Gross return (Tk ha^{-1})	TC (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
T_1		151450	80907	70543	1.87
T_2		128700	80747	47953	1.59
T_3		109850	80857	28993	1.36
T_4		98800	71440	27360	1.38

Selling Price: Mungbean= Tk. 65/ kg, Sesame= Tk. 75/kg

Conclusion

The findings showed that intercropping sesame with mungbean gave maximum productivity as well as economic returns than sole crop. Above results revealed that intercropping combination of 100% mungbean in rows (30 cm × 5 cm) + 50% sesame as broadcast would be suitable for maximum total productivity as well as economic return over sole crop.

INTERCROPPING OF SHORT DURATION VEGETABLES AND SPICES WITH BUSHBEAN IN SYLHET REGION

M. I. NAZRUL

Abstract

A field experiment was laid out during 2021-22 in winter season at MLT site, Moulvibazar. Four different intercropping combinations, T_1 = Bush bean (100%) + Radish (100%), T_2 = Bush bean (100%) + Carrot (100%), T_3 = Bush bean (100%) + Coriander (100%), T_4 = Bush bean (100%) + Chilli (100%) and T_5 = Bush bean sole (100%) were considered. The experiment was randomized complete block design with three dispersed replications. Highest bush bean equivalent yield (18.85 t ha^{-1}) was obtained from the combination of Bush bean + Chilli, whereas, the lowest yield (11.03 t ha^{-1}) from the Bush bean + Coriander. The highest gross return (Tk. 848250 ha^{-1}) and gross margin (Tk. 562750 ha^{-1}) was obtained from the combination of Bush bean + Chilliwhereas the lowest gross return (Tk. 212850 ha^{-1}) and gross margin (Tk. 62150 ha^{-1}) was obtained from Bush bean sole cultivation. Maximum percent increased of bush bean equivalent yield (298%) followed by Bush bean + Radish (276%); but the highest benefit ratio (3.04) was obtained from the inter crop combination of bush bean + radish.

Introduction

Intercropping is one of the techniques of vertical expansion of crop production that increases the total productivity per unit area than sole cropping. The cultivable land is decreasing day by day. So, attempts should be taken to cultivate more than one crop from limited land area. On the other hand, soil fertility is also reducing due to intensive cultivation of high yielding crop varieties and improper crop management. In Sylhet, especially bush beans are cultivated as sole crop in haor areas. But it can be cultivated with short dureted vegetable and spices as intercrop without hampering the main crop. Hence, the study has been conducted to find out suitable intercrop combination for increasing production and economic return.

Materials and Methods

The experiment was conducted at MLT site, Moulvibazer during the year 2021-22. Four intercrop combinations, T_1 = Bush bean (100%) + Radish (100%), T_2 = Bush bean (100%) + Carrot (100%), T_3 = Bush bean (100%) + Coriander (100%), T_4 = Bush bean (100%) + Chilli (100%) and T_5 = Bush bean sole (100%) were considered. The experiment was set up in randomized complete block design with three replications. The seed of bushbean were sown with maintaining the spacing of 30 cm × 15 cm. The sole crop of bush bean and intercropped treatments were fertilized with cow dung 5 t ha^{-1} and 93-40-75-10-4-2 kg ha^{-1} of N-P-K-S-Zn-B in the form of urea, triple super phosphate, and murate of potash, gypsum, zinc sulphate and boric acid, respectively. Half of urea and all other fertilizers and cowdung were used at final land preparation. Remaining N fertilizer was applied in top dress in two equal splits at 15 & 30 days after sowing. The seeds of bush bean and companion crop were sown during 24-30 November, 2020. Intercultural operations were done as and when necessary. There was no remarkable disease and pest attack. The companion crop was harvested on 10-15, January 2021 and bush bean harvested during 17-23 February, 2021. Data on yield components were collected from 10 plants selected at random in each plot and seed yield was recorded plot wise. The collected data were analyzed statistically using "STAR" software package and means were separated by LSD.

Results

Yield and yield attributes of bushbean: The yield and yield contributing characters were statistically different except plant height and number of seeds per pod. Maxium plant height (36.45 cm) was observed in case of bush bean grown as base crop. The highest pod length was obtained in sole bush bean (13.12 cm). The sole bush bean practice also provided the highest pod diameter (1.17 cm) and maximum pod weight (5.29 g) followed by bush bean + criander combination (5.09 g). On the other hand statistically similar number of pods per plant and weight of 100- seeds was produced by bush bean + chilli and sole bush bean cultivation practice. Among the intercropped combinations the maximum dry seed yield (4.73 t ha^{-1}) was recorded by bush bean sole followed by the combination of bush bean + coriander (4.51). The lowest seed yield (4.00 t ha^{-1}) was obtained from the combination of bush bean + carrot.

Companion crops yield: The average yields of componat crops viz. radish, carrot, coriander and chilli under intercrops was 30.47, 10.53, 3.67 and 8.15 t ha^{-1}, respectively (Table 2). Results showed that, among component crops, radish gave the highest root yield (30.47 t ha^{-1}) in intercropping system followed by carrot (10.53 t ha^{-1}).

Bushbean Equivalent Yield (BEY): Bushbean equivalent yield was expressed in total productivity of this system. Bush bean equivalent yields higher in all the intercrops that was ranged from 11.03-18.85 t ha^{-1} than sole crop of bush bean (4.73 t ha^{-1}). The highest bush bean equivalent yield (18.85 t ha^{-1}) was recorded in bush bean + chilli intercropped combination which was followed by bush bean + radish (17.80 t ha^{-1}) and bush bean + carrot (15.70 t ha^{-1}) and the total productivity also increase of 298, 276, 232 and 133 percent over sole bush bean (Table 2).

Cost benefit analysis

Intercrop combination of bush bean with vegetables and spices showed higher monetary return than sole crop (Table 3). The highest gross return (Tk. 848250 ha^{-1}) was recorded from bush bean + chilli intercrop combination which was more than 3 percent higher over sole bush bean. This intercropping combination also gave the higher gross margin (Tk. 562750 ha^{-1}) followed by bush bean + radish. Among the intercrop combinations, the lowest gross return (Tk. 212850 ha^{-1}) and gross margin (Tk. 62150 ha^{-1}) were obtained from bush bean as sole crop.

Farmer's opinions

Bush bean with short duration vegetable and spices (radish, carrot, coriander, chilli) was found a profitable practice. As such farmers can earn extra income easily without hampering the base crop (bush bean) and also boost up their family nutrition from companion crops.

Table 1. Yield and yield attributes of bush bean-based intercropping at MLT site, Moulvibazer 2021-22

Treatment	Plant height (cm)	Pod				Seeds pod^{-1}	100-seed wt.(g)	Seed yield (t ha^{-1})
		Length (cm)	Diameter (cm)	Plant^{-1}	Wt. (g)			
T_1: Bush bean + Radish	35.59	12.59	1.09	8.40	4.69	5.00	40.34	4.26
T_2: Bush bean + Carrot	35.30	12.10	1.10	8.76	4.60	5.15	39.00	4.00
T_3: Bush bean + Coriander	36.09	12.90	1.16	9.63	5.09	5.03	41.67	4.51
T_4: Bush bean + Chili	36.09	12.70	1.15	10.33	4.87	5.13	41.00	4.36
T_5: Bush bean sole	36.45	13.12	1.17	10.00	5.29	5.23	43.84	4.73
CV (%)	6.29	2.16	2.20	3.26	2.35	2.13	2.67	2.87
LSD $_{(0.05\%)}$	NS	1.33	2.45	2.45	1.28	NS	1.87	0.14

Table 2. Yield of companion crops and bush bean equivalent yield (BEY) under bush bean base intercropping system 2021-22

Treatments	Yield of companion crops (t ha^{-1})	BEY (t ha^{-1})	% increase of BEY over sole bush bean
T_1: Bush bean (100%) + Radish (100%)	30.47	17.80	276
T_2: Bush bean (100%) + Carrot (100%)	10.53	15.70	232
T_3: Bush bean (100%) + Coriander (100%)	3.67	11.03	133
T_4: Bush bean (100%) + Chilli (100%)	8.15	18.85	298
T_5: Bush bean sole (100%)	-	4.73	-

BEY: Bush bean equivalent yield

Table 3: Cost benefit analysis of bush bean base intercropping system during 2021-22.

Treatments	Gross return ($Tk.ha^{-1}$)	Total cost ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)	BCR
T_1: Bush bean (100%) + Radish (100%)	801000	263500	537500	3.04
T_2: Bush bean (100%) + Carrot (100%)	706500	265500	441000	2.66
T_3: Bush bean (100%) + Coriander (100%)	496350	268500	229850	1.85
T_4: Bush bean (100%) + Chilli (100%)	848250	285500	562750	2.97
T_5: Bush bean sole (100%)	212850	150700	62150	21.41

Price in Tk. Kg^{-1}: Bush bean: 45, Radish: 20, Carrot: 50, Coriander: 80and Chilli: 80

Conclusion: From the result it was found that intercrop combinations, bush bean + radish and bush bean + chilli could be profitable intercrop combination for haor farmers of Sylhet region.

INTERCROPPING OF CORIANDER WITH GROUNDNUT ON YIELD AND SYSTEM PRODUCTIVITY IN HAOR AREAS OF SYLHET

M. I. NAZRUL

Abstract

The trial was conducted at farmer's field during winter 2021-22 under MLT site, Moulvibazar. Six intercrop combinations viz. T_1: Groundnut sole, T_2: Coriander sole, T_3: Groundnut + coriander (100%), T_4: Groundnut + coriander (90%), T_5: Groundnut + coriander (80%) and T_6: Groundnut + coriander (70%) were considered as treatments. The groundnut var. BARI Chinabadamm-8 and Local coriander was used in this trial. The experiment was setup in randomized complete block design with three dispersed replications. Among the combinations, the highest pod yield (2.64 t ha^{-1}) of groundnut and green leaf yield of coriander (3.81 t ha^{-1}) was found in their respective sole crops. On the contrary, in intercrop situation the maximum yields of coriander leaf (3.44) and GEY (6.10 t ha^{-1}) was obtained from T_3 (groundnut+ 100% coriander) which was increased 131% over than sole groundnut. Intercrop combination (100% groundnut+ 100% coriander) also gave the maximum gross margin (Tk. 251000 ha^{-1}) with higher marginal rate of return (620) followed by T_4 (groundnut + 90 % coriander) combination. So, the combination of 100 % groundnut with 100 % coriander could be a good tool for escalating the yield and profit of haor farmers in Sylhet region.

Introduction

Groundnut (*Arachis hypogaea* L.) is the third most important legume crop in Bangladesh which grown on 31,579 ha of land and produces 56713 metric tons of nut with an average yield of 1.79 t ha-1 (BBS, 2015). Recently the area of groundnut is being decreased due to the competition with rabi crops like wheat, potato, Boro rice and mustard (Alom *et. al.,* 2009). Groundnut var. BARI Chinabadam-8 is successfully growing in haor areas of Sylhet during rabi season. At the same time farmers cultivating coriander alone and or with groundnut as intercrop.

Intercropping is recommended to be used in many parts of the world for food or fibers productions, because of its overall high productivity, effective control of pests and diseases, good ecological services and economic profitability. In practice, most intercropping systems involve only two crops, as inclusion of more crops results in higher labor costs. Mostly, intercropping is practiced with the aim of maximum plant competition rather than plant competition for maximum crop yield. Considering the benefits of intercropping system, the research has been undertaken to find out the suitable intercrop combination for increasing yield and economic return for the farmers in haor areas of Sylhet region.

Materials and Methods

The experiment was conducted at MLT site, Moulvibazer during the year 2021-22. Six intercrop combinations such as T_1: Groundnut sole, T_2: Coriander sole, T_3: Groundnut + coriander (100%), T_4: Groundnut + coriander (90%), T_5: Groundnut + coriander (80%) and T_6: Groundnut + coriander (70%) were considered as treatments. The groundnut var. BARI Chinabadamm-8 and local coriander was used . The experiment was setup in randomized complete block design with three dispersed replications. The seed of groundnut were sown with maintaining the spacing of 40 cm × 15 cm. The crop was fertilized as per fertilizer recommendation guide (FRG, 2018) BARC, Farm gate, Dhaka. The seeds of groundnut and coriander were sown on 15-18 December, 2020. Intercultural operations were done as and when necessary. There was no remarkable disease and pest attack. The coriander was harvested on 05 February 2021 and groundnut was harvested during 15-17 May, 2021. Data on yield components were collected from 10 plants selected at random in each plot and seed yield was recorded plot wise. The collected data were analyzed statistically using "STAR" software package and means were separated by LSD.

Results

Yield and yield attributes of groundnut: The yield and yield contributing characters of groundnut intercropped with coriander varied significantly except seeds per pod. The maximum pods per plant were obtained in sole groundnut (37.96) followed by T_5 (Groundnut + 80 % coriander) but the lowest pods per plant in T_3 (Groundnut + 100% coriander). The similar trend of results was observed in case of 100- kernel weight. Sole groundnut provided maximum 100-kernel weight (46.70 g), followed by T_6 (Groundnut + 70 % coriander). The maximum shelling percent (80.53%) of groundnut was found in T_1 (sole groundnut) followed by T_6 (73.07%). Sole groundnut (T_1) cultivation practice contributed the highest pod yield (2.64 t ha^{-1}) followed by T_6 (1.66 t ha^{-1}); but stastistically similar pod yiels were produce by T_4 and T_5 (1.60 t ha^{-1}) combinations.

Yield of coriander as companion crop: On an average, the yields of coriander was 3.81, 3.44, 3.07, 2.58, and 2.35 t ha^{-1} in the combinations of T_2, T_3, T_4, T_5, and T_6, respectively (Table 2). Results showed that T_2 (sole coriander) produced higher see yield (3.81 t ha^{-1}) of coriander followed by T_3, whereas the lower quantity of coriander leaves was produced by T_6 (groundnut + 70% coriander).

Groundnut Equivalent Yield (GEY): Eequivalent yield is expressed in total productivity of this system. Higher groundnut equivalent yields (5.08, 6.10, 5.69, 5.04 and 4.79 t ha^{-1}) were produced by T_2, T_3, T_4 and T_5 than sole groundnut (T_1). The maximum groundnut equivalent yield (6.10 t ha^{-1}) was recorded in T_3 (groundnut + 100 % coriander) followed by T_4 and T_5. The highest increment of total productivity (131%) was also found in T_3 (groundnut + 100 % coriander) over sole groundnut (Table 2).

Cost benefit analysis

Intercrop combination of groundnut with coriander showed higher monetary return than sole crop (Table 3). The highest gross return (Tk. 366000 ha^{-1}) was recorded from T_3 (groundnut + 100 % coriander) intercrop combination which was more than 131 percent higher over sole groundnut. This intercropping combination also gave the maximum gross margin (Tk. 251000 ha^{-1}) with MMR (620%) followed by T_4 (600 %).

Dominance analysis was employed to determine the most efficient marginal rate of return (MRR). Gross margin of different treatments were arranged in ascending order to identify the cost dominated. The un-dominated treatments were arranged (Table 3) and indicated gross margins, total variable cost (TVC) and marginal rate of return. The result shows that the highest MRR (620 %) was obtained from T_3 (groundnut + 100 % coriander) and signified that investment of an additional Tk.100 in the production process increase return as 620 % to the total benefit. The results showed that intercropping earn higher money return compared to sole crop.

Farmer's opinions

Farmers in Hakaluki haor areas are cultivating groundnut mostly as sole crop, now the practices make them familiar and experienced with profitable intercropping practice. As such farmers can earn extra income easily without hampering the main crops and also boost up their family nutrition.

Table 1. Pod yield and yield attributes of groundnut intercropped with coriander at farmer's field under MLT site, Moulvibazer during 2021-22

Treatment	Pods plant^{-1}	Seeds pod^{-1}	100 kernel wt.(g)	Shelling (%)	Pod yield (t ha^{-1})
T_1: Groundnut sole	37.96	2.00	46.70	80.53	2.64
T_2: Coriander sole	-	-	-	-	-
T_3: Groundnut + coriander (100%)	26.33	2.00	42.17	71.64	1.51
T_4: Groundnut + coriander (90%)	26.91	2.00	42.70	72.06	1.60
T_5: Groundnut + coriander (80%)	28.51	2.00	43.17	72.68	1.60
T_6: Groundnut + coriander (70%)	28.43	2.00	43.77	73.07	1.66
CV (%)	10.52	-	1.50	3.20	12.22
LSD $_{(0.05\%)}$	7.36	NS	1.25	5.59	0.52

Table 2. Yield of coriander and groundnut equivalent yield (GEY) in intercropping system 2021-22

Treatments	Yield of coriander (t ha^{-1})	Pod yield (t ha^{-1})	GEY (t ha^{-1})	% Increase of GEY over sole groundnut
T_1: Groundnut sole	-	2.64	2.64	-
T_2: Coriander sole	3.81	-	5.08	92
T_3: Groundnut + coriander (100%)	3.44	1.51	6.10	131
T_4: Groundnut + coriander (90%)	3.07	1.60	5.69	116
T_5: Groundnut + coriander (80%)	2.58	1.60	5.04	91
T_6: Groundnut + coriander (70%)	2.35	1.66	4.79	81

GEY: Groundnut equivalent yield; Price (Tk. Kg^{-1}): groundnut: 60.00, coriander: 80.00

Table 3. Marginal analysis of un-dominated groundnut-coriander intercropping system, 2021-22

Treatments	Gross return (Tk. ha^{-1})	MGM (Tk. ha^{-1})	TVC (Tk. ha^{-1})	MVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	
T_1	158400	-	81500	-	76900	
T_2	304800	-	73000	-	231800	
T_3	366000	207600	115000	33500	251000	
T_4	341400	183000	112000	30500	229400	
T_5	302400	144000	109000	27500	193400	
T_6	287400	129000	106000	24500	181400	

Price (Tk. Kg^{-1}): groundnut: 60.00, chilli: 80.00; MGM: marginal gross margin; TVC: total variable cost; MVC: marginal variable cost; MRR: marginal rate of return.

Conclusion

From the result it was found that intercrop combinations were better than sole crop in terms of yield and economic return. The treatment combination viz. 100% groundnut + 100 % coriander could be a suitable technology for haor farmers to boost up the production of groundnut and coriander with maximum profit.

INTERCROPPING OF ONION WITH GROUNDNUT AT THE CHARLAND OF TANGAIL

M. A. H. KHAN, S. ROY, T. TASMIMA, AND M. M. RAHMAN

Abstract

An experiment was conducted at the MLT site, Bhuapur during the Rabi season of 2020-21 and 2021-22 to find out a suitable intercrop combination of groundnut and onion to increase the productivity and income of farmers. Four treatments viz., T_1= Sole groundnut (100%), T_2= Sole onion (100%), T_3= One row of onion between two rows of groundnut, T_4= Two rows of onion between two rows of groundnut were considered. Both two crops generally yielded more when grown as a single crop compared with when groundnut was intercropped with onion. In intercropping groundnut with onion, groundnut yield was not significantly affected; however, onion yield was significantly reduced (4.36-45.23%). Groundnut equivalent yields were recorded higher from all intercrop treatments as compared to sole groundnut and sole onion production. Analysis of intercropping treatments revealed that two rows of onion in between one row of groundnut resulted in the highest groundnut equivalent yield (10.78 t ha^{-1}) as well as gross margin (Tk. 440155 ha^{-1}) and the lowest groundnut equivalent yield (1.90 t ha^{-1}) as well as gross margin (Tk. 57955 ha-1), were obtained from sole groundnut treatment.

Introduction

Intercropping is an important farming system to increase crop production by growing two or more crops simultaneously on the same piece of land. It is widely practiced in densely populated countries, particularly in the tropics like Bangladesh. The demand for onion is increasing with the rapidly growing world population which will become 9 billion in the year 2050. There is also a large gap between the demand and supply of onion in Bangladesh. Hence, a cropping system that can increase the rate of onion production and/or lower the cost of production will provide economic opportunity for farmers. Intercropping has been identified as a promising system that makes effective use of land and other resources (Remison, 1982) like water and soil nutrients and results in reduced cost of production (Bijay et al., 1978). Intercropping involving legumes has been found to be most useful as it improves soil fertility and gives better yields and economic returns (Lithourgidis *et al.,* 2011). The main effect of intercropping is because of the more efficient utilization of available resources and increased productivity compared with each sole crop (Mao *et al*., 2012). Yield is increased because growth resources such as light, water, and nutrients are more efficiently absorbed and converted to crop biomass by the intercropping over time and space as a result of differences in competitive ability for growth resources between the component crops. Intercropping provides high insurance against crop failure, especially in areas subject to extreme weather conditions such as char, drought, and flood and overall provides greater financial stability for farmers. Thus, if a single crop may often fail, farmers can reduce their risk for total crop failure by growing more than one crop in their fields. Onion is the main spices crop of Bangladesh. Groundnut (*Arachis hypogaea* L.) was selected as an intercrop because of its high nitrogen fixing activity. A wider spacing (40 cm x 15 cm) is maintained to grow groundnut. This spacing could be used as the inclusion of an additional crop as an intercrop in existing groundnut cultivation. Therefore, intercropping groundnut with onion might be a profitable practice for the use of land and nutrient resources and for the farmers' well-being. Hence, two crops can be grown using a single dose of nitrogenous fertilizer by reducing the cost of nitrogenous fertilizer up to 50%. Keeping this view in mind, the present study was undertaken to find out a suitable crop combination as an intercrop with groundnut for maximum land use efficiency and economic return.

Materials and Methods

The experiment was conducted at the MLT site Bhuapur, Tangail under AEZ # 8 during the Rabi season 2020-21 and 2021-22. The experiment was laid out following RCB design with five replications. The unit plot size was 8 m x 5 m. There were four treatments viz., T_1= Sole groundnut (100%), T_2= Sole onion (100%), T_3= One row of onion in between two rows of groundnut, T_4=

Two rows of onion in between two rows of groundnut. Spacing of groundnut was maintained at 40 cm × 15 cm and onion 15 cm x 10 cm. The plot was fertilized with 12-32-43-54-2 N-P-K-S-B ha^{-1} for sole and intercropping treatments. All fertilizers and 2/3rd of Urea were applied during final land preparation and the rest of Urea was top dressed at two equal installments in between two rows of onion. The groundnut var. BARI Chinabadam-9 and onion var. Taherpuri were used. Seeds of groundnut and onion were planted on 2 November, 2021. Intercultural operations were done properly for the normal growth and development of the crops. The crop was sprayed with Imitaf to control caterpillar and Rovral against fungal infection.The onion was harvested on 8 March, 2022, and the groundnut on 30 March, 2022. Data on yield and yield contributing attributes were recorded and analyzed with CropStat analytical package. The cost and return analysis were computed on the basis of the prevailing market price.

Results and Discussions

Effect of intercropping treatments and yield of onion: Insignificant differences between the intercropping treatments for all the parameters except in bulb yield (Table 1The growth of onion plants decreased significantly when groundnut was intercropped in onion due to competition for essential nutrients, moisture, light, soil space, and applied chemical fertilizer between two crops. Similarly, the maximum bulb weight was obtained when onion was grown alone probably due to better plant growth in terms of plant height and leaf number. Increased leaf number is possibly responsible for increased bulb size and weight. The bulb weight decreased greatly when groundnut was intercropped in onion probably due to reduced plant height and decreased leaf number. The maximum bulb yield recorded in onion when grown as a single crop was due to maximum plant height, the number of leaves, and bulb weight. A significant decrease (33.33-60%) occurred in bulb yield when groundnut was intercropped in onion probably due to a decrease in bulb weight in this intercropping treatment as there was the active competition between two crops for attaining essential nutrients for their growth.

Effect of intercropping treatments and yield of groundnut: Significant differences between intercropping treatments was not found except seed yield (Table 2). The maximum plant height (35.80 cm), number of effective pods per plant (15.89), 1000-kernel weight (548.36 g), and pod yield (1.90 t ha^{-1}) of groundnut were recorded as sole crop (Table 2). The maximum number of pods per plant (15.89) was recorded when groundnut was grown alone because of the maximum height of plants with maximum leaves and canopy. Enough leaves and green areas resulted in the increased rate of photosynthesis and the plant produced the maximum number of pods per plant. The seeds per pod, 1000- kernel weight, and pod yield were maximum when groundnut grown alone because of good vegetative growth which directly influences the yield. The maximum pod yield was recorded in the treatment where groundnut was grown alone. This increase in yield was directly related to an increase in plant height, the number of effective pods per plant, and the number of 1000-kernel weights. The highest number of effective pod $plant^{-1}$ was recorded in T_1 treatment (15.89) followed by T_3 (15.48) and T_4 (15.29). The highest nut yield (1.90 t ha^{-1}) was produced in T_1 treatment which might be due to a higher number of effective pods $plant^{-1}$ and higher thousand kernel weight (548.36 g). Due to intercropping, the yield of groundnut was decreased in T_3 and T_4 treatment (Table 2). The higher groundnut equivalent yields were recorded from all intercrop treatments as compared to the sole crop of groundnut. The highest groundnut equivalent yield (10 t ha^{-1}) was observed in sole onion (T_2) but the maximum gross return (Tk. 547200 ha^{-1}) and gross margin (Tk. 440155 ha^{-1}) were observed in T_3 treatment because of lower production cost compare to sole onion.

Farmers' opinion

Farmers are keen interest with a higher yield and gross margin of one row of onion in between two rows of groundnut intercropping system. They are interested in cultivating groundnut and onion as an intercropping system.

Table 1. Bulb yield and yield components of onion affected by intercropping with groundnut at MLT site Bhuapur, Tangail during the Rabi, 2020-21 and 2021-22 (Pooled)

Treatment	Days to maturity	Plant height (cm)	Individual bulb weight (g)	Bulb yield (t ha^{-1})
T_1	-	-	-	-
T_2	124	60.12	25	12
T_3	124	56.78	26	9
T_4	124	55.17	26	7.5
$LSD_{0.05}$	NS	4.20	3.02	2.09
CV (%)	00	6.90	8.01	13.2

T_1 = Sole groundnut (100%), T_2 = Sole onion (100%), T_3 = Groundnut (100%) + one row of onion between two rows of groundnut, and T_4 = Groundnut (100%) + two rows of onion between two rows of groundnut

Table 2. Pod yield and yield component of groundnut affected by intercropping with onion at MLT site Bhuapur, Tangail during the Rabi, 2020-21 and 2021-22 (Pooled)

Treatment	Plant height (cm)	Effective pod plant^{-1} (no.)	1000- kernel weight (g)	Pod yield (t ha^{-1})
T_1	35.80	15.89	548	1.90
T_2	-	-	-	-
T_3	35.68	15.48	524	1.62
T_4	35.20	15.29	504	1.34
$LSD_{0.05}$	NS	NS	NS	NS
CV (%)	5.90	6.60	6.40	8.02

T_1 = Sole groundnut (100%), T_2 = Sole onion (100%), T_3 = Groundnut (100%) + one row of onion in between two rows of groundnut, and T_4 = Groundnut (100%) + two rows of onion between two rows of groundnut

Table 3. Cost and return analysis of groundnut intercropping with the onion at MLT site Bhuapur, Tangail during the Rabi 2020-21 and 2021-22(Average)

Treatment	Groundnut equivalent yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
T_1	1.90	114000	56045	57955
T_2	10.00	600000	182250	417750
T_3	9.12	547200	107045	440155
T_4	7.59	455400	149045	306355

T_1 = Sole groundnut (100%), T_2 = Sole onion (100%), T_3 = Groundnut (100%) + one row of onion between two rows of groundnut, and T_4 = Groundnut (100%) + two rows of onion between two rows of groundnut, Onion: Tk. 50 kg^{-1}, Groundnut: Tk 60. kg^{-1}

Conclusion

From the results showed that groundnut could be successfully intercropped with onion without a significant reduction in the yield of groundnut. Farmers can earn better economic benefits by following the cultivation of one row of onion in between two rows of groundnut.

PERFORMANCE OF INTERCROPPING OF BLACK CUMIN WITH GROUNDNUT IN CHARLAND AREAS

M. A. H. KHAN, S. ROY, T. TASMIMA, M. M. RAHMAN

Abstract

An experiment was conducted at the MLT site, Bhuapur during the Rabi season of 2021-22 to find out the optimum row arrangement of black cumin for intercropping with groundnut for higher productivity and return. Four treatments viz., T_1= Sole groundnut (100%), T_2= One row of black cumin in between two rows of groundnut, T_3= Two rows of black cumin in between normal rows of groundnut, T_4= Sole black cumin (100%). Groundnut intercropping with black cumin makes effective use of land and other resources and results in reduced cost of production. Groundnut equivalent yields were recorded higher from all intercrop treatments as compared to sole groundnut and sole black cumin production. Analysis of intercropping treatments revealed that two rows of black cumin in between two rows of groundnut resulted in the highest groundnut equivalent yield (3.06 t ha^{-1}) as well as gross margin (Tk. 99398 ha^{-1}) and the lowest groundnut equivalent yield (1.43 t ha^{-1}) as well as gross margin (Tk. 29848 ha^{-1}), were obtained from sole groundnut treatment.

Introduction

An estimated 6.5 million people, around 5% of the Bangladeshi population live on the Charland's and of the total area of the country, 5% is Char, which comes to about a total area of approximately 7200 square kilometers. The achar dwellers mainly depend on agriculture and agriculture related activities. Groundnut (*Archis hypogea* L.) is the second important oilseed crop that covered a considerable area in Bangladesh and it is a long duration crop. On the other hand, black cumin is a very important and valuable spices crop which is usually grown as sole and in some cases as intercrop in farmers field in various Charland areas of Bangladesh. The spacing for groundnut cultivation is 40 cm X 15 cm. So, there is a scope to intercrop black cumin with groundnut. This might be economically profitable for the farmers. Hence this experiment was undertaken to find out the optimum row arrangement of black cumin for intercropping with groundnut for higher productivity and return.

Materials and methods

The experiment was conducted at the MLT site Bhuapur, Tangail under AEZ # 8 during the Rabi season 2021-22. The experiment was laid out following RCB design with five dispersed replications. The unit plot size was 5 m x 4 m. There were four treatments viz., T_1= Sole groundnut (100%), T_2= One row of black cumin in between two normal rows of groundnut, T_3= Two rows of black cumin in between two normal rows of groundnut, T_4= Sole black cumin (100%). Spacing of groundnut was maintained at 40 cm × 15 cm and black cumin (15 cm x 10 cm). The plot was fertilized with 45-36-75-30-2-1 kg NPKSB ha^{-1} for sole and intercropping treatments. ½ N and full quantity of other fertilizers was applied as basal. The remaining N was top dressed at the flowering stage and covered with soil followed by irrigation. The groundnut var. BARI Chinabadam-9 and black cumin (var. BARI Kalozira-1) was used. Seeds of groundnut and black cumin were planted on 3 November, 2021. Intercultural operations were done properly for the normal growth and development of the crops. The black cumin was harvested on 20 March, 2022, and the groundnut on 30 March, 2022. Data on yield and yield contributing attributes were recorded and analyzed with CropStat analytical package. The cost and return analysis were computed on the basis of the prevailing market price.

Results and discussions

Effect of intercropping treatments on yield and yield attributes of groundnut: There were no significant differences between intercropping treatments except yield. The highest plant height, number of effective pods $plant^{-1}$, and 1000 seed weight were observed in T_1 treatment (sole groundnut) which results in the highest yield (1.43 t ha^{-1}). A significant decrease (4.38-5.92%) occurred in pod yield when groundnut was intercropped with black cumin which may be due to decreased number of pods $plant^{-1}$ and 1000 seed weight. This may be occurred due to an active competition between two crops for attaining essential nutrients for their growth.

Effect of intercropping treatments on the yield of black cumin: There was a significant difference between intercropping treatments except plant height. The maximum plant height was observed in T_4 (35.90 cm) treatment whereas the lowest in T_2 (34.60 cm). The highest thousand seed weight (3 g) was found in the T_4 treatment which results in the maximum seed yield (0.51 t ha^{-1}) and the lowest in seed yield T_2 (0.29 t ha^{-1}) treatment (Table 2). The maximum seed yield was found in T_4 where black cumin was grown as the sole crop. The higher groundnut equivalent yields were recorded from all intercrop treatments as compared to sole groundnut.

The highest groundnut equivalent yield (3.06 t ha^{-1}) was observed in T_3 treatment as well as the highest gross return (Tk. 183600 ha^{-1}) and gross margin (Tk. 99,398 ha^{-1}) (Table 3).

Pest infestation: No remarkable pest incidence was observed during the cropping period.

Farmers' opinion

Intercropping groundnut with black cumin is a profitable technology. But the germination of black cumin is hampered in groundnut and black cumin intercropping. Farmers are less interested to follow this intercropping combination.

Table 1. Pod yield and yield components of groundnut affected by intercropping with black cumin at MLT site Bhuapur, Tangail during the rabi, 2021-22

Treatment	Plant height (cm)	Effective pod plant^{-1} (no.)	1000- seed weight (g)	Pod yield (t ha^{-1})
T_1	36.27	17.47	520.60	1.43
T_2	34.40	17.07	527.93	1.37
T_3	34.67	17.20	508.60	1.35
$LSD_{0.05}$	4.56	2.61	48.47	0.04
CV (%)	5.70	6.70	4.10	1.40

T_1= Sole groundnut (100%), T_2= One row of black cumin in between two rows of groundnut and T_3= Two rows of black cumin in between two rows of groundnut, T_4= Sole black cumin (100%)

Table 2. Seed yield and yield components of black cumin affected by intercropping with groundnut at MLT site Bhuapur, Tangail during the rabi, 2021-22

Treatment	Plant height (cm)	Effective pod plant^{-1} (no.)	1000- seed weight (g)	Pod yield (t ha^{-1})
T_2	34.60	10.40	2.83	0.29
T_3	35.33	8.43	2.80	0.41
T_4	35.90	9.47	3.00	0.51
$LSD_{0.05}$	5.70	0.63	0.15	0.03
CV (%)	7.10	2.90	2.30	3.60

T_1= Sole groundnut (100%), T_2= One row of black cumin in between two rows of groundnut and T_3= Two rows of black cumin in between two rows of groundnut, T_4= Sole black cumin (100%)

Table 3. Cost and return analysis of groundnut intercropping with black cumin at MLT site Bhupaur, Tangail during the rabi 2021-22

Treatment	Groundnut equivalent yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
T_1	1.43	85800	55952	29848
T_2	2.58	154800	79652	75148
T_3	3.06	183600	84202	99398
T_4	2.12	127200	43200	84000

Farm gate price: Black cumin: Tk. 250 kg^{-1}, Groundnut: Tk. 60 kg^{-1}

Conclusion

From the results showed that groundnut could be grown with black cumin. Farmers can earn better economic benefits by following the cultivation of two rows of black cumin in between two normal rows of groundnut.

PERFORMANCE OF INTERCROPPING GARLIC, ONION, FENUGREEK, BLACK CUMIN WITH GROUNDNUT IN CHARLAND AREAS

S. ROY, M. A. H. KHAN, M. M. RAHMAN, T. TASMIMA

Abstract

An experiment was conducted at the MLT site, Bhuapur during the rabi season of 2021-22 to find out the suitable intercrop combination of groundnut for higher productivity and profitability of Charland areas . Five treatments viz., T_1= Sole groundnut (100%), T_2= Two rows of black cumin in between two rows of groundnut, T_3= One row of fenugreek in between two rows of groundnut, T_4= One row of garlic in between two rows of groundnut, T_5= One row of onion in between two normal rows of groundnut. Analysis of intercropping treatments revealed that one row of onion in between one row of groundnut resulted the highest groundnut equivalent yield (9.48 t ha^{-1}) as well as gross margin (Tk. 450348 ha^{-1}) and the lowest groundnut equivalent yield (1.47 t ha^{-1}) as well as gross margin (Tk. 32248 ha^{-1}), were obtained from sole groundnut treatment.

Introduction

An estimated 6.5 million people, around 5% of the Bangladeshi population live on the Char land. Of the total land area of the country, 5% is Char, which comes to about a total area of approximately 7200 square kilometers. The Char dwellers mainly depend on agriculture and agriculture related activities. Groundnut (*Archis hypogea* L.) is the second important oilseed crop that covered a considerable area in Bangladesh and it is a long duration crop. On the other hand, black cumin, onion, garlic, and fenugreek are very important and valuable spices crop which is usually grown as sole and in some cases as intercrop in farmers field in various Charland areas of Bangladesh. The spacing for groundnut cultivation is 40 cm X 15 cm. So, there is a scope to intercrop black cumin, onion, garlic, and fenugreek with groundnut. This might be economically profitable for the farmers. Hence this experiment was undertaken to find out the suitable intercrop combination of groundnut for higher productivity and profitability of Charland areas stakeholders.

Materials and Methods

The experiment was conducted at the MLT site Bhuapur, Tangail under AEZ # 8 during the rabi season 2021-22. The experiment was laid out following RCB design with four replications. The unit plot size was 5 m x 4 m. There were five treatments viz., T_1= Sole groundnut (100%), T_2= Two rows of black cumin in between two rows of groundnut, T_3= One row of fenugreek in between two rows of groundnut, T_4= One row of garlic in between two rows of groundnut, T_5= One row of onion in between two rows of groundnut. Spacing of groundnut was maintained at 40 cm × 15 cm. The plot was fertilized with 45-36-75-30-2-1 kg N-P-K-S-Zn-B ha^{-1} for sole and intercropping treatments. All fertilizers and ½ N of Urea were applied during final land preparation and the rest of Urea was top dressed at flowering stage and covered with soil followed by irrigation. The variety of groundnut was BARI Chinabadam-9, black cumin (var. BARI Kalozira-1), fenugreek (var.BARI Methi-1), garlic (var. BARI Rashun-2), and onion (var. Taherpuri). Seeds of groundnut and onion were planted on 4 November, 2021. Intercultural operations were done properly for the normal growth and development of the crops. Imitaf was sprayed to control caterpillar and Rovral against fungal infection.The onion was harvested on 8 March, 2022, black cumin on 20 March, 2022, garlic on 29 March, 2022, fenugreek on 28 March, 2022 and the groundnut on 30 March, 2022. Data on yield and yield contributing attributes were recorded and analyzed with CropStat analytical package. The cost and return analysis were computed on the basis of the prevailing market price.

Results

There were significant differences between intercropping treatments except for the number of effective pods plant^{-1}. The maximum plant height (37.60 cm) was observed in T_5 treatment. The maximum thousand seed weight (547.60 g) and pod yield (1.47 t ha^{-1}) was found when groundnut is grown solely followed by T_5 (1.44 t ha^{-1}) treatment. The maximum groundnut equivalent yield was observed in T_5 (9.48 t ha^{-1}) whereas the lowest in T_1 (1.47 t ha^{-1}). In cost and return analysis, the maximum gross return (Tk. 568800 ha^{-1}) and gross margin (Tk. 450348 ha^{-1}) was observed in T_5 treatment. On the other hand, the lowest gross return (Tk. 568800 ha^{-1}) and gross margin (Tk. 450348 ha^{-1}) were found in T_1 treatment.

Farmers' opinion

Farmers are interested to grow onion, garlic with groundnut. But they are not willing to grow black cumin and fenugreek with groundnut as intercropping because of germination problem of black cumin and fenugreek.

Table 1. Podyield and yield components of groundnut affected by intercropping with black cumin, fenugreek, garlic, onion at MLT site Bhuapur, Tangail during the rabi, 2021-22

Treatment	Plant height (cm)	Effective pod plant^{-1} (no.)	1000 -seed weight (g)	Pod yield (t ha^{-1})
T_1	35.07	17.00	547.60	1.47
T_2	35.80	16.40	508.47	1.30
T_3	33.33	16.07	509.47	1.29
T_4	36.80	17.13	507.33	1.35
T_5	37.60	17.33	525.63	1.44
$LSD_{0.05}$	2.93	NS	25.95	0.14
CV (%)	4.40	5.10	2.70	5.60

Table 2. Yield of black cumin, fenugreek, garlic, and onion affected by different intercropping with groundnut and groundnut equivalent yield at MLT site Bhuapur, Tangail during the rabi, 2021-22

Treatment	Pod yield (t ha^{-1}) of groundnut	Seed yield of black cumin (t ha^{-1})	Seed yield of fenugreek (t ha^{-1})	Bulb yield of garlic (t ha^{-1})	Bulb yield of onion (t ha^{-1})	Groundnut equivalent yield (t ha^{-1})
T_1	1.47	-	-	-	-	1.47
T_2	1.30	0.29	-	-	-	2.51
T_3	1.29	-	0.38	-	-	1.93
T_4	1.35	-	-	2.83		3.71
T_5	1.44	-	-	-	8.04	9.48

Farm gate price (Tk. kg^{-1}): Groundnut: 60, Black cumin: 250, Fenugreek: 100, Garlic: 50, Onion: 60

Table 3. Cost and return analysis of groundnut intercropping with black cumin, fenugreek, garlic, and onion at MLT site Bhupaur, Tangail during the rabi 2021-22

Treatment	Gross return (Tk. ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
T_1	88200	55952	32248
T_2	80852	24900	55952
T_3	115800	78827	36973
T_4	222600	97022	125578
T_5	568800	118452	450348

T_1= Sole groundnut (100%), T_2= Two rows of black cumin in between two rows of groundnut, T_3= One row of fenugreek in between two rows of groundnut, T_4= One row of garlic in between two rows of groundnut and T_5= One row of onion in between two rows of groundnut

Conclusion

From the results showed that groundnut could be grown successfully intercropped with one row of onion without a significant reduction in groundnut yield. Farmers can earn better economic benefits by following the cultivation of one row onions in between two rows of groundnut.

INTERCROPPING OF SWEET GOURD WITH CABBAGE

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Abstract

The experiment was conducted at MLT site, Dhirashram, Gazipur sadar during rabi season of 2021-22 to evaluate the performance of sweet gourd as intercrop with varying plant population of cabbage and to increasing of farmers income. . Five treatments viz. T_1= Sole Sweet gourd (2 m × 2 m), T_2=Sole Cabbage (60 cm × 45 cm), T_3= Sweet gourd (2m × 2m) + Cabbage (60 cm × 45 cm), T_4= Sweet gourd 2m × 2m) + Cabbage (65 cm × 50cm) and T_5=Sweet gourd (2m × 2m) + Cabbage (70 cm × 55 cm) were tested. Sweet gourd var. BARI Mistikumra-2 and cabbage var. Autumn queen were tested with three replications. Cabbage equivalent yield (84 t ha^{-1}) in sweet gourd (2 m × 2 m) + Cabbage (65 cm × 50 cm) combination was higher than sole cabbage (60 cm × 40 cm). Maximum gross return was achieved in T_3 (Tk. 993500 ha^{-1}) followed by T_4 (Tk. 886600 ha^{-1}).

Introduction

Sweet gourd and cabbage are important vegetable in Bangladesh. Farmers of Gazipur normally cultivated it as mono crop. Some farmers intercrop it with winter vegetables haphazardly. Winter vegetables like cabbage, cauliflower and radish may be grown in association with sweet gourd. These winter vegetables are short duration and short stature vegetable. On the other hand, sweet gourd is comparatively long duration crop. Winter vegetables may be harvested before the commencement of competition with sweet gourd. Therefore, the experiment was conducted to evaluate the performance of sweet gourd as intercrop with cabbage as well as increasing farmer's income.

Materials and Methods

The experiment was conducted at MLT site Dhirashram in Gazipur Sadar during rabi season of 2021-2022 to evaluate the performance of sweet gourd as intercrop with varying plant populations of cabbage and to increasing of farmers income. Five treatments viz. T_1= Sole Sweet gourd (2 m × 2 m), T_2=Sole Cabbage (60 cm × 45 cm), T_3= Sweet gourd (2m × 2m) + Cabbage (60 cm × 45 cm), T_4= Sweet gourd 2m × 2m) + Cabbage (65 cm × 50cm) and T_5=Sweet gourd (2m × 2m) + Cabbage (70 cm × 55 cm) were tested. BARI Mistikumra-2 and Autumn queen variety were tested as sweet gourd and cabbage . The experiment was laid out in RCB design with 3 replications. The unit plot size was 6m × 6m.Cabbage were planted on 18 to 20 December and sweet gourd was transplanted before 15 of cabbage planted. Fertilizer @ 80-36-100-24-2-2 kg ha^{-1} of NPKSZnB +10 ton of cowdung were applied in sole sweet gourd. Chemical fertilizers were used in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. Fertilizer @ 100-51-91-18-2-3 kg ha^{-1} of NPKSznB + 10 ton cowdung per hectare were applied in cabbage for normal growth. Two hrard of urea and full dose of TSP, MoP, Zinc sulphate, boric acid and cowdung were applied at final land preparation and rest one third of urea as top dressed at 20 DAT. Cabbage were harvested on 13-30 March 2022 and sweet gourd was harvested on 30 March to 6 May 2022.Data on yield attributes were recorded and analyzed statistically through MSTAT.

Results and Discussion

Individual head weight and head yield of cabbage were significantly affected by the treatments (Table 1). It was observed that head length and head diameter of cabbage increasing where population plot^{-1} was lower than sole crop cabbage. Sweet gourd (2m × 2m) + cabbage (70cm × 55cm) gave the highest head length, head diameter and individual head weight due to wider spacing and less competition of different growth resources. Sole cabbage (60cm × 45cm) produced maximum yield (84 t ha^{-1}) which was followed by sweet gourd (2m × 2m) + cabbage (70cm × 55cm) (64.1 t ha^{-1}) due to plant population was higher and no inter competition of sweet gourd. In intercropping combinations, treatment, sweet gourd (2m × 2m) + cabbage (60cm ×

45cm) gave higher head yield (82.4 t ha^{-1}) due to cabbage population was same as sole crop cabbage. The lowest yield (64.1 t ha^{-1}) was obtained from sweet gourd (2m × 2m) + cabbage (70cm × 55cm) due to wider spacing and lower plant populations (99) and higher competition of natural resources.

The highest sweet gourd yield (14.5 t ha^{-1}) was obtained from sole crop but yields were poor due to heavy rainfall in experimental period (How much rainfall to be given). Among the intercrop situation, sweet gourd yield as lower than sole crop and when cabbage spacing was wider than sole cabbage spacing the sweet gourd yield were lower due to the combined effect of both the components (Table 2).

Higher equivalent yield indicates higher productivity and efficiency of intercropping systems. Cabbage equivalent yield, benefit cost analysis of sole and intercropping presented in Table 3. Cabbage equivalent yield (CEY) in T_4 intercropping systems (88.666 t ha^{-1}) were higher than sole cabbage (84 t ha^{-1}). Higher CEY in these combinations might be contributed by combined effect of both the components. Maximum gross return was calculated in sweet gourd (2m × 2m) + cabbage (60cm × 45cm) (Tk. 993500 ha^{-1}) which was followed by sole cabbage (Tk. 913000 ha^{-1}) and T_4 (Tk. 8866000 ha^{-1}) respectively. Gross margin was also higher in T_3 treatments which was followed by T_2, T_4 and T_5 treatments. The lowest gross margin was obtained from sole sweet gourd (Tk. 77500 ha^{-1}).

Farmers opinion

Farmers expressed their satisfaction with higher market price of cabbage and sweet gourd in sweet gourd (2m × 2m) + Cabbage (65 cm × 50cm) combination.

Conclusion

The overall results indicated that among the combinations, sweet gourd 2m × 2m) + Cabbage (65 cm × 50cm) combination was found suitable for total productivity and economic return.

Table 1. Yield and yield attributes of cabbage in cabbage + sweet gourd intercropping systems at Gazipur sadar during the rabi season of 2021-22.

Treatment	Plant populations m^{-2}	Head diameter (cm)	Head length (cm)	Individual head weight (kg)	Head yield (t ha^{-1})
T_1	-	-	-	-	-
T_2	130	62.2	18.3	2.04	84.00
T_3	130	63.2	16.3	2.12	82.00
T_4	120	66.8	20.1	2.74	75.10
T_5	99	71.1	21.63	3.00	64.13
LSD (0.05)		6.34	4.07	0.19	5.13
CV (%)		4.82	10.66	3.85	3.36

T_1= Sole Sweet gourd (2 m × 2 m), T_2=Sole Cabbage (60 cm × 45 cm), T_3= Sweet gourd (2m × 2m) + Cabbage (60 cm × 45 cm), T_4= Sweet gourd (2m × 2m) + Cabbage (65 cm × 50cm) and T_5=Sweet gourd (2m × 2m) + Cabbage (70 cm × 55 cm).

Table 2. Fruit yield and yield attributes of sweet gourd in cabbage + sweet gourd intercropping systems at Gazipur sadar during the rabi season of 2021-22.

Treatment	No. of fruits m^{-2}	Individual fruit weight (kg)	Fruit yield (t ha^{-1})
T_1	5.0	2.61	14.5
T_2	-	-	-
T_3	4.3	2.33	11.23
T_4	3.7	2.10	10.53
T_5	4.3	1.90	9.04
LSD (0.05)	1.10	0.22	2.71
CV (%)	12.76	14.88	11.98

Table 3. Equivalent yield of cabbage and cost and return analysis in sweet gourd cabbage intercropping systems at Gazipur sadar during the year of 2021-22.

Treatment	Cabbage equivalent yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
T_1	-	217500	140000	77500
T_2	-	913000	220000	693000
T_3	59.35	993500	290000	703500
T_4	88.66	886600	280000	606600
T_5	79.90	798950	275000	523950

C. Mixed Cropping

EFFECT OF SEED RATE OF MUSTARD AND COWPEA MIXED CROPPING IN BHOLA

G. N. HASAN AND M. R.H. ANIK

Abstract

A field trial was carried out at Daulatkhan and Bhola sadar during the rabi season of 2019-20,2021-21 and 2021-22 at the farmer's field under AEZ-18 to evaluate the performance of mixed cropping of cowpea with mustard and to ensure the maximum utilization of the land for higher yield and economic return. Four treatments combination of different seed rate of mustard and cowpea viz., T_1= Sole mustard (100%), T_2= (Mustard 100% + 20% cowpea), T_3= (Mustard 100% + 30% cowpea), T_4= (Mustard 100% + 40% cowpea) were tested. On average of 3 years, it is clearly found that siliqua plant-1 of mustard was statistically significant among the treatments. The highest number (78.58) of siliqua plant-1 was recorded from T_1 treatment and the lowest (67.31) from T_4 treatments. Number of seed per siliqua was also higher (23.91) in T_1 treatment but among the T_2, T_3 and T_4 treatments there was no significant differences. There was no statistical significance in case of 1000- seed weight among the treatments. The highest mustard seed yield (1.38 t ha-1) was observed in the sole followed by T_2 treatment (1.30 t ha-1) and the lowest yield (1.21 t ha-1) from T_4 treatment. In case of cowpea there was no significant difference in number of seeds per pod and 1000- seed weight. The plant population was significantly higher (7.85) in T_4 treatment followed by T_3 (6.23) and lower from T_2 (4.65) treatment.Similar trend was followed in number of pods per plant in T_4 (15.98) and lower in T_3 (11.87). The maximum cowpea yield (0.67 t ha^{-1}) was in T_4 treatment followed by T_3 treatment (0.49 t ha-1) and lowest (0.31t ha-1) in T_2 treatment. In three years average, the maximum mustard equivalent yield was found in T_4 (1673 kg ha-1) where 100% Mustard + 40% cowpea used followed by T_3 treatments (1609 kg ha-1) and T_2 treatment (1514 kg ha-1). The lowest mustard equivalent yield was found in sole mustard (1380 kg ha-1).

Introduction

Mixed cropping is the agricultural practice of growing two or more crops in the same piece of land area at the same time. It offers effective weed suppression, pest and disease control and use of soil resources under organic farming systems. Mixed cropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. Cowpea is a traditional crop in Bhola. Farmers of Bhola grow at least some cowpea for home consumption, beside commercial cultivation. Farmers like to utilize this fallow period using cowpea mixed with the main crop. More than 7000-hectare land is occupied by mustard in Bhola. Farmers use seed rate of both crops from their assumption. Therefore, the study was undertaken to verify the agro-economic performance of mixed cropping of cowpea with mustard and to ensure the maximum utilization of the land for higher yield and economic return in Bhola.

Materials and Methods

The experiment was conducted at Daulatkhan and Bhola sadar during the rabi season of 2019-20,2021-21 and 2021-22 at the farmer's field under AEZ-18. The design of the experiment was

Randomized Complete Block with four dispersed replications. Four treatment combination of different seed rate of mustard and cowpea viz., T_1= Sole mustard (100%), T_2= (Mustard 100% + 20% cowpea), T_3= (Mustard 100% + 30% cowpea), T_4= (Mustard 100% + 40% cowpea) were tested. Mustard var. BARI Sarisha-14 and cowpea var. BARI Felon-1 was used. . Unit plot size was 8m × 5m. Seed rate recommended 50 kg ha^{-1}. Fertilizer dose for mustard was applied. It was 100-30-35-18-2 kg ha^{-1} N-P-K-S-B, respectively in the form of Urea, TSP, MOP, Gypsum and Boric acid respectively. As the crop was cultivated in rainfed condition all fertilizers were applied during final land preparation. Both mustard and cowpea seeds were sown in broadcast system. Sowing and harvesting dates of three consecutive years were given in Table-1. Mustard duration was 81-86 days. For controlling mustard aphid, Malathion @2ml Lit^{-1} water was sprayed once. Alternaria leaf blight was controlled by spraying of Rovral @2 g Lit^{-1} water once. Standard cultural practices were done as and when necessary. Data were collected plot wise and analyzed statistically using Crop Stat analytical package.

Table 1. Crop management practices used in different locations during 2019-22 in Bhola district

Sowing time	Harvesting time
Sowing was 20-25 December, 2019	Mustard was 15-20 March, 2020 Cowpea was 22-26 April, 2020
Sowing was 17-25 December, 2020	Mustard was 10-16 March, 2021 Cowpea was 20-25 April, 2021
Sowing was 10-20 December, 2021	Mustard was 05-12 March, 2022 Cowpea was 12-30 April, 2022

Result and Discussions

Results of the study of average yield and yield contributing characters in three consecutive years from 2019-20 t0 2021-22 were presented on Table-2. In three years, average it is clearly found that no. of siliqua plant^{-1} of mustard was significant where highest number (78.58) of siliqua plant^{-1} from sole mustard and the lowest (67.31) from T_4 treatments. Number of seed per siliqua was also higher (23.91) in T_1 treatment but among T_2, T_3 and T_4 treatments there was no significant differences. There was no statistical significance in 1000- seed weight among the treatments. The highest mustard seed yield (1.38 t ha^{-1}) was observed in the sole mustard followed by T_2 treatment (1.30 t ha^{-1}) and the lowest mustard yield (1.21 t ha^{-1}) from T_4 treatment. In case of cowpea there was no significant difference in number of seeds per pod and 1000- seed weight. The plant population was significantly higher (7.85) in T_4 treatment followed by T_3 (6.23) and lower from T_2 (4.65) treatment. Number of pods per plant was significantly higher in T_4 (15.98) treatments and lower in T_3 (11.87). The maximum cowpea seed yield of 0.67 t ha^{-1} was observed in e T_4 treatment followed by T_3 treatment 0.49 t ha^{-1} and lowest 0.31t ha^{-1} in T_2 treatment.

Mustard Equivalent Yield (MEY): In three years average, the highest mustard equivalent yield was found in T_4 (1673 kg ha^{-1}) where 100% Mustard + 40% cowpea used followed by T_3 treatments (1609 kg ha^{-1}) and T2 treatment (1514 kg ha^{-1}). The lowest mustard equivalent yield was found in sole mustard (1380 kg ha^{-1}) .

Cost and return analysis

Cost-return of mixed cropping mustard with cowpea has been given in Table 3. The average data showed that the highest gross return (Tk. 108745 ha^{-1}) and gross margin (Tk. 60095 ha^{-1}) was obtained from the treatment T_4 (100% mustard + 40% cowpea) followed by T_3 (100% mustard + 30% cowpea). The lowest gross return (Tk. 89700 ha^{-1}) and gross margin (Tk. 47020 ha^{-1}) was obtained from treatment T_1 (Sole mustard). So, it is clearly evident that mixed cropping is more profitable than sole crop.

Farmer's opinion

The farmers obtained more yield from mustard and cowpea as mixed cropping that is more profitable than the sole cropping. One irrigation is needed for better mustard yield but extra fertilizer could be applied for higher yield of cowpea.

Table 2. Seed yield and yield attributes of Mustard at Bhola during the year 2019-20 to 2021-22 (Pooled)

Treatments	Siliqua plant^{-1} (no)	Seeds siliqua^{-1} (no)	1000 – seed weight (g)	Seed yield (t ha^{-1})
T_1= Sole mustard (100%)	78.58	23.91	3.26	1.38
T_2=100% Mustard + 20% cowpea	75.37	20.67	3.21	1.30
T_3=100% Mustard + 30% cowpea	71.88	20.43	3.15	1.27
T_4=100% Mustard + 40% cowpea	67.31	19.24	3.10	1.21
LSD $_{(0.05)}$	2.42	3.10	2.43	0.05
CV (%)	14.55	8.42	7.43	12.40

Table 3. Seed yield and yield attributes of **Cowpea** at Bhola during the year 2019-20 to 2021-22 (Pooled)

Treatments	Plant no. m^{-2}	No. pod plant^{-1}	No. seeds pod^{-1}	1000- seed wt (g)	Seed yield (t ha^{-1})
T_2	4.65	12.57	10.54	97.37	0.31
T_3	6.23	11.87	11.26	98.15	0.49
T_4	7.85	15.98	12.48	97.88	0.67
LSD $_{(0.05)}$	1.27	2.06	3.26	NS	0.13
CV (%)	9.87	11.53	8.25	8.90	8.17

Note: T_1= Sole mustard (100%), T_2= (100% Mustard + 20% cowpea), T_3= (100% Mustard + 30% cowpea), T_4= (100% Mustard + 40% cowpea)

Table 4. Cost and return analysis of Mustard and Cowpea mixed cropping at Bhola during 2019-20 to 2021-22 (Average).

Treatment	Yield (kg ha^{-1})		MEY (kg ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tkha^{-1})	Gross margin (Tk ha^{-1})
	Mustard	Cowpea				
T_1= Sole mustard (100%)	1380	-	1380	89700	42680	47020
T_2= 100% Mustard + 20% cowpea	1300	310	1514	98410	44150	54260
T_3= 100% Mustard + 30% cowpea	1270	490	1609	104585	46380	58205
T_4= 100% Mustard + 40% cowpea	1210	670	1673	108745	48650	60095

Note: Mustard @ 65 Tk/kg and Cowpea @ 45 Tk/kg, MEY=Mustard Equivalent Yield

Conclusion

After three-year of experimentation, it may be concluded that 100% mustard with 40% cowpea is the most profitable as compared to other treatment combination when grown as mixed crop in Bhols. So, mixed cropping is more profitable than the sole cropping and risk of cultivation of one crop can be reduced by mixed cropping.

MIXED CROPPING OF MUSTARD WITH LENTIL AT A DIFFERENT SEEDING RATIOS

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Abstract

The experiment was undertaken to study the effect of lentil (var. BARI Masur-8) and mustard (var. BARI Sharisa-14) mixed cropping in different plant population at Shibpur and Paba, Rajshahi during 2021-2022 cropping season. Pure stand of two crops as well as three mixed cropping ratios (90% lentil + 10% mustard, 80% lentil + 20% mustard, 70% lentil + 30%

mustard) was used. Mixed cropping (90% lentil + 10% mustard) and(70% lentil + 30% mustard) treatment gave the superior yield (1.92 t ha^{-1}) in compared to sole lentil and other mixed cropping treatment. The maximum gross return, gross margin and BCR were also recorded in the T_1(90% lentil + 10% mustard) that was followed by sole lentil T_4 (100% lentil).

Introduction

Mixed cropping is the agricultural practice of growing two or more crops in the same piece of land area at the same time. It offers effective weed suppression, pest and disease control and use of soil resources under organic farming systems. Mixed cropping reduces the risk of total crop failure as two or more different crops are cultivated simultaneously in the same field. Successfully intercropping system gives higher cash return total production per unit area and diversified crop production than that of growing sole crop and provides greater resource use efficiency. Lentil (Lens culinaris) is the most popular pulse crop in Bangladesh. The area of lentil cultivation in the country is decreasing day by day because of poor yield. Both mustard and lentil are cultivated as sole crop throughout the country in Rabi season and sometimes as mixed crop in farmer's field. On the other hand, Mustard (Brassica campestris) is the major oil seed crop, which also ranks first position among the oil crops grown in Bangladesh. It covers about 70 % of the total oil seed production and the yield of this crop in Bangladesh is found much lower than the other countries of the world due to lower yield potential of existing local variety. The present study was therefore, undertaken to verify the agronomic and economic performance of mixed cropping of lentil with mustard and to ensure the maximum utilization of the land for higher yield and economic return.

Materials and Methods

The field trial was conducted at the farmer's field of Shibpur and Paba, Rajshahi during *Rabi* season 2021-22 to find out the best compatible mixed crop combination of lentil with mustard in terms of economic return. The experiment was laid out in a randomized complete block design with three compact replications. The unit plot size was 4 m x 5 m. There were four treatments combination viz., T_1: 90 % Lentil+10% Mustard, T_2:80 % Lentil+20% Mustard, T_3: 70 % Lentil+30% Mustard and T_4: 100 % Lentil. The variety of lentil and mustard were BARI Masur-8 and BARI Sharisa-14, respectively. Seeds of both crops were sown on 15 & 23 November 2021 simultaneously. The fertilizer doses were 21-18-21-9-2-1.2 kg ha^{-1} N-P-K-S-Zn-B receptively. The plot was fertilized with 100% of fertilizer for main crop in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. All the fertilizer was applied as basal dose during final land preparation. All intercultural operations viz. weeding, thinning etc were done when needed. The mustard crop was harvested on 9 & 12 February 2022 and lentil was harvested on 10 & 13 March 2022. The yield and yield components of lentil and mustard were recorded from randomly selected 10 plants and the data were analyzed statistically and the mean differences were adjudged by LSD. Lentil equivalent yield and BCR were calculated to ascertain the efficiency of intercropping. Economic analysis was done on the basis of existing market prices of input and output (Reddy and Reddi, 1992).

Results

Yield and yield attributes of lentil: Significant variation was observed among the treatments (Table 1). The highest plant height, plants m^{-2}, pods $plant^{-1}$, seed pod^{-1} and 1000-- seed weight of lentil was obtained from T_4 followed by T_1 as a result, highest seed yield (1.81 t ha^{-1}) was also found in T_4. followed by T_1 (1.66 t ha^{-1}) and lowest from T_2 (1.40 t ha^{-1}).

Yield and attributes of mustard: Significant variation was observed among the treatments (Table 2). The highest plant height, plants m^{-2}, siliqua $plant^{-1}$, grains $siliqua^{-1}$ and 1000 seed weight of mustard was obtained from T_3 as a result, the highest seed yield (0.58 t ha^{-1}) was also found in T_3 (70 % Lentil+ 30% Mustard) and lowest (0.30 t ha^{-1}) from T_1 (90 % Lentil +10% Mustard).

Lentil equivalent yield (LEY): Lentil equivalent yield was found maximum (1.92 t ha^{-1}) in treatment T_1 (90% lentil + 10% mustard) followed by T_3 (70% lentil + 30% mustard) of mixed cropping lentil with mustard and minimum in T_4 (1.81 t ha^{-1}) was recorded. (Table 3). Lentil mixed cropped with mustard gave more yield due to proper utilization of nutrient and sunlight, also it controls the weed growth and restore soil moisture effectively contribute higher yield.

Cost and return analysis

Cost and return analysis of mixed cropping lentil with mustard has been given in Table 3. The higher gross return (Tk 153360 ha^{-1}) and gross margin (Tk. 118810 ha^{-1}) was obtained from treatment T_1 and lowest in T_2 (Tk.. 143710 ha^{-1}) and (Tk. 103810 ha^{-1}), respectively. The higher BCR was was also found in T_1 (4.44) followed by T_3 (4.41) and lowest BCR from T_2 (3.60).

Farmer's opinion

Mustard and lentil as mixed cropping is more profitable than the sole cropping Minimize the risk of cultivation by one crop of mixed cropping Single irrigation is needed for better mustard yield but lentil cannot tolerate water logging, so irrigation should be done carefully.

Table 1. Yield and yield contributing characters of lentil during 2021-22

Treatment	Plant height (cm)	Branch plant^{-1}	Pods plant^{-1}	1000 -seed weight (g)	Seeds plant^{-1}	Seed yield (t ha^{-1})
T_1		3.61	55.0	24.6	67.6	1.66
T_2	46.5	3.45	54.6	23.8	64.5	1.40
T_3	46.5	3.38	51.3	23.7	62.8	1.42
T_4	47.8	3.65	55.7	24.8	69	1.81
LSD (0.05)	2.76	0.54	11.5	0.43	25.3	0.27
CV (%)	6.80	18.34	25.74	2.08	31.83	20.13

[Legend:- T_1: 90 % Lentil+10% Mustard, T_2:80 % Lentil+20% Mustard, T_3: 70 % Lentil+30% Mustard and T_4: 100 % Lentil]

Table 2. Seed yield and yield contributing characters of mustard during 2021-22

Treatment	Plant height (cm)	Branch plant^{-1}	Siliqua plant^{-1}	Seed siliqua^{-1}	1000- seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	85.5	2.54	34.5	29.9	3.67	0.30	2.56
T_2	87.7	2.60	37.9	30.4	3.64	0.47	3.51
T_3	87.7	2.83	39.4	29.4	3.83	0.58	5.24
LSD	4.23	0.66	8.11	2.23	0.37	0.08	34.5
CV (%)	5.47	28.10	24.47	8.39	11.22	22.07	20.85

[Legend:-T_1: 90 % Lentil+10% Mustard, T_2:80 % Lentil+20% Mustard and T_3: 70 % Lentil+30% Mustard]

Table 3. Equivalent yield and Cost and return analysis of lentil mixed cropped with mustard at Rajshahi during 2021-22

Treatments	Lentil Equivalent Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
T_1	1.92	153360	34550	118810	4.44
T_2	1.80	143710	39900	103810	3.60
T_3	1.92	153540	34850	118690	4.41
T_4	1.81	144800	35150	109650	4.12

**Price: Lentil Tk. 80 kg^{-1}&Mustard Tk. 60 kg^{-1} Urea: Tk.16 kg^{-1}, TSP: Tk. 22 kg^{-1}, MoP: Tk.15 kg^{-1}, Gypsum: Tk.7 kg^{-1}, Boron: Tk.100 kg^{-1} [Legend:- T_1: 90 % Lentil+10% Mustard, T_2:80 % Lentil+20% Mustard, T_3: 70 % Lentil+30% Mustard and T_4: 100 % Lentil]

Conclusion

The mixed cropping of lentil with mustard gave higher yield and economic returns over sole cropping of lentil. So, it can be concluded that mixed cropped of lentil with mustard is better than sole lentil.

MIXED CROPPING OF BLACK CUMIN WITH LENTIL ATDIFFERENT SEED RATIOS

M. S. RAHMAN, M. M. ANWAR, M. N. A. SIDDQUIE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

The experiment was undertaken to study the effect of lentil (var. BARI Masur-8) and black cumin (var. BARI Kalojira-1) mixed cropping in different plant population at Paba and on station, Rajshahi during 2021-2022 cropping season. Pure stand of two crops as well as mixed cropping ratios (T_1=80% lentil + 20% black cumin, T_2=70% lentil + 30% black cumin, T_3=100% lentil and T_4=100% black cumin) was treatment variables. Mixed cropping of lentil and black cumin (T_1= 90% lentil + 10% black cumin) gave the superior yield (1.92 t ha^{-1}) in compared to sole lentil and other mixed cropped treatment. The maximum gross return, gross margin and BCR were also recorded in the T_1 (90% lentil + 10% black cumin) that was followed by sole lentil T_4 (100% lentil).

Introduction

Mixed cropping is the agricultural practice of growing two or more crops on the same land at the same time. Mixed crop reduces the risk of total crop failure as two or more different crops are cultivated simultaneously on the same land. Lentils (Lens culinaris) are the most popular pulse crop in Bangladesh. The area under lentil cultivation in the country is decreasing day by day due to lack of good yield. Spices are the parts of plants used as a flavoring or seasoning. Due to diversified uses, spices have great demand in the world market. The agro-ecological conditions are congenial for the cultivation of most of the spices crops. Area under spice crop cultivation is about 3.46 lakh hectare, which comprises 2.46 percent of the total cultivated land of the country. Black cumin (*Nigella sativa*) is one of the most promising aromatic and medicinal condiments commonly used to add fragrance and taste in dishes, bakery, biscuits and culinary items. It is widely used as an ingredient for soups, pickles and other dishes. In this context, t the trial has been undertaken to find out the adoption and yield potential of minor spices in coastal area and popularize the spices varieties in the southern region of Bangladesh.

Materials and Methods

The field trial was conducted at the farmer's field of Shibpur and Paba, Rajshahi during *Rabi* season 2021-22 to find out the best compatible mixed crop combination of lentil with blackcumin in terms of economic return. The experiment was laid out in a randomized complete block design with three compact replications. The unit plot size was 8 m x 10 m. There were four treatments combination viz., (T_1=80% lentil + 20% black cumin, T_2=70% lentil + 30% black cumin, T_3=100% lentil and T_4=100% black cumin. The variety of lentil and black cumin were BARI Masur-8 and BARI kalojira 1, respectively. Seeds of both crops were sown on 11 December, 2021. The fertilizer doses were 21-18-21-9-2-1.2 kg ha^{-1} N-P-K-S-Zn-B receptively. The plot was fertilized with 100% of fertilizer for main crop in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. All the fertilizer was applied as basal dose during final land preparation. All intercultural operations viz. weeding, thinning etc were done when needed. The lentil crop was harvested on 4April 2022 and black cumin was harvested on 16 April 2022. The yield and yield components of lentil and black cumin were recorded from randomly selected 10 plants and the data were analyzed statistically and the mean differences were adjudged by LSD. Lentil equivalent yield and BCR were calculated to ascertain the efficiency of intercropping. Economic analysis was done on the basis of existing market prices of input and output (Reddy and Reddi, 1992).

Results

Seed yield and yield attributes of lentil: The plant height, pods plant^{-1} and seeds pod^{-1} was no significant difference among the treatments (Table 1). But 1000 -seed weight and seed yield were significant difference among the treatments. The higher seed yield was recorded in T_3 (1.18t ha^{-1}) and lowest from T_2 (0.63 t ha^{-1}).

Black cumin: Results showed that the plant height, pods plant^{-1} and seeds pod^{-1} was no significant difference among the treatments (Table 2). Seed yield variation is significantly influenced by the treatments and it was higher T_4 (1.25 t ha^{-1}) treatment and lowest in T_1 (0.36 t ha^{-1}) treatment.

Lentil equivalent yield (LEY): Lentil equivalent yield was found maximum (3.64t ha^{-1}) in treatment T_4 (100% black cumin) and minimum lentil equivalent yield (1.18t ha^{-1}) was recorded in T_3 (sole lentil) (Table 3). In this experiment sole black cumin gave more LEY yield due to higher price of black cumin.

Cost and return analysis:

Cost and return analysis of mixed cropping lentil with black cumin has been given in Table 3. The higher gross return (Tk. 291200 ha^{-1}) and gross margin (Tk. 248300 ha^{-1}) was obtained from treatment T_1 and lowest in T_2 (Tk. 94400 ha^{-1}) and (Tk. 56250 ha^{-1}) respectively. The higher BCR was found in T_4 (6.79) and lowest from T_3 (2.47).

Farmers' opinion

Farmers are impressed to see the performance of mixed crop of lentil with black cumin. They showed positive attitude about mixed crop for obtaining higher yield and economic return.

Table 1. Seed yield and yield contributing characters of lentil during Rabiseason of 2021-22

Treatment	Plant height (cm)	Pods plant^{-1}	Seeds pod^{-1}	1000- seed weight (g)	Seed yield (t ha^{-1})
T_1: 80% lentil+20 % Black cumin	46.9	51.0	1.86	25.1	1.01
T_2: 70% lentil+30 % Black cumin	48.1	58.4	1.83	20.8	0.63
T_3: 100 % Lentil	47.3	48.4	1.83	26.1	1.18
LSD (0.05)	3.01	20.6	0.119	6.41	0.53
CV (%)	2.83	18.45	2.85	11.78	24.79

Table 2. Seed yield and yield contributing characters of black cumin during Rabi season of 2021-22

Treatment	Plant height (cm)	Pods plant^{-1}	Seeds pod^{-1}	1000- seed weight (g)	Seed yield (t ha^{-1})
T1: 80% lentil+20 % Black cumin	66.4	21.8	70.5	2.66	0.36
T2: 70% lentil+30 % Black cumin	68.5	22.0	70.5	2.69	0.49
T4: 100 % Black cumin	72.8	23.2	69.8	2.63	1.25
LSD (0.05)	7.28	3.2	4.49	0.38	0.43
CV (%)	4.64	6.83	2.82	6.87	27.24

Table 3. Equivalent yield and Cost and return analysis of lentil mixed cropped with black cumin at Rajshahi during 2021-22

Treatment	Lentil Equivalent yield (LEY)	Gross return (Tk ha^{-1})	Toal cost (Tk ha^{-1})	Gross Margin (Tk ha^{-1})	BCR
T_1	2.18	174400	39900	134500	4.37
T_2	2.22	177800	40900	136900	4.35
T_3	1.18	94400	38150	56250	2.47
T_4	3.64	291200	42900	248300	6.79

Conclusion

Sole cropping of black cumin was more profitable than other treatments due to higher market price of black cumin, so it can be concluded that sole black cumin is better than other treatments.

PERFORMANCE OF MIXED LENTIL AND LINSEED UNDER STRIP AND CONVENTIONAL TILLAGE METHOD

M. S. RAHMAN, M. M. ANWAR, M. N. A. SIDDQUIE, M. J. ISLAM AND M. M. I. CHOWDHURY

Abstract

The experiment was undertaken to study the effect of lentil (var. BARI Masur-8) and linseed (var. BARI Tisi-3) mixed cropping in different plant population at Paba and on station, Rajshahi during 2021-2022 cropping season. Pure stand of two crops as well as three mixed cropping ratios (90% lentil + 10% linseed, 80% lentil + 20% linseed, 70% lentil + 30% linseed) was used as treatment variables. Mixed cropping of lentil and linseed (T_6= 75% lentil + 25% linseed) gave the higher yield (1.79 t ha^{-1}) in compared to sole and other mixed cropped treatment. The maximum gross return, gross margin and BCR were also recorded in the T_6 (75% lentil + 25% linseed) that was followed by T_5 (50% lentil+50% linseed) and lowest in T_3 (sole linseed).

Introduction

In Bangladesh, pulses play a vital role in agriculture as well as in human diets. Now a day's national pulse production within rice based system is declining dramatically day by day because of competition with the other winter crops like wheat, maize, boro rice, potato and vegetables. But the demand of pulses is increasing continuously. As a source of plant protein, the reduction of pulses production is a major concern of the government. Lentil (*Lens culinaries*L.) is one of the most important winter pulse grown in Bangladesh. It plays an important role in human diet and also in improving soil fertility by fixing atmospheric nitrogen. The short duration variety, mixed cropping of lentil with linseed will be a promising technology for pulse and oil seed production. But the successful establishment of mixed lentil and linseed mostly depends on available soil moisture, which might be influenced by sowing time by strip planting. Considering the following objectives, the present experiment was undertaken for successful lentil and linseed production as mixed crop:

Materials and Methods

The field trial was conducted at the farmer's field of Shibpur and Paba, Rajshahi during *Rabi* season 2021-22 to find out the best compatible mixed crop combination of lentil with linseed in terms of economic return. The experiment was laid out in a randomized complete block design with three compact replications. The unit plot size was 8m x 5m. There were four treatments combination viz., T_1=Solo linseed conventional, T_2=Solo linseed Strip, T_3=Solo lentil conventional, T_4=Solo lentil Strip, T_5=50% lentil+50% linseed, T_6=75% lentil+25% linseed and T_7= Mixed (80% lentil+ 20% linseed). The variety of lentil and linseed were BARI Masur-8 and BARI Sarisa-14, respectively. Seeds of both crops were sown on 17 November and 4 December, 2021 simultaneously. The fertilizer doses were 21-18-21-9-2-1.2 kg ha^{-1} N-P-K-S-Zn-B receptively. The plot was fertilized with 100% of fertilizer for main crop in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. All the fertilizer was applied as basal dose during final land preparation. All intercultural operations viz. weeding, thinning etc were done when needed. The linseed crop was harvested on 22 March 2022 and lentil was harvested on 23 & 29 March 2022. The yield and yield components of lentil and linseed were recorded from randomly selected 10 plants and the data were analyzed statistically and the mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984). Lentil equivalent yield and BCR were calculated to ascertain the efficiency of intercropping. Economic analysis was done on the basis of existing market prices of input and output (Reddy and Reddi, 1992).

Results

Yield and yield attributes of lentil: Plant height, pods plant^{-1} and seeds pod^{-1} was no significant difference among the treatments (Table 1). 1000- seed weight and seed yields were significant difference among the treatments.The higher seed yield was recorded in T_6 (0.94t ha^{-1}) and lowest from T_7 (0.75 t ha^{-1}).

Linseed: The plant height, pods plant^{-1} and seeds pod^{-1} was no significant difference among the treatments (Table 2). Seed yield variation is significantly influenced by the treatments and it was higher T_4 (1.11 t ha^{-1}) treatment and lowest in T_7 (0.62 t ha^{-1}) treatment.

Lentil equivalent yield (LEY): Maximum lentil equivalent yield (1.79 t ha^{-1}) was recorded in the treatment T_6 (75% lentil + 25% linseed) followed by T_5 (50% lentil + 50% linseed) of mixed cropping lentil with linseed and minimum lentil equivalent yield (0.66 t ha^{-1}) in T_3 (sole linseed conventional). Lentil equivalent yield was higher in T_6 where 10% linseed was used with 90% lentil. lentil mixed cropped with linseed gave more yield due to proper utilization of nutrient and sunlight, also it controls the weed growth and restore soil moisture effectively contribute higher yield.

Cost and return analysis: Cost and return analysis of mixed cropping lentil with linseed has been given in Table 3. The higher gross return (Tk. 142910 ha^{-1}) and gross margin (Tk. 108060 ha^{-1}) was obtained from treatment T_6 and lowest in T_3 (Tk. 52510 ha^{-1}) and (Tk. 12610 ha^{-1}), respectively. The higher BCR was found in T_6 (4.10) followed by T_5 (3.86) and lowest BCR from T_3 (1.32).

Farmers' opinion

Farmers showed positive attitude about mixed crop for obtaining higher yield and economic return.

Table 1. Seed yield and yield contributing characters of lentil during Rabi season of 2021-22

Treatment	Plant height (cm)	Branch plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	1000 - seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	43.5	4.65	46.1	1.90	21.2	0.83	1.41
T_2	44.7	5.3	64.9	1.90	20.9	0.92	1.59
T_5	39.3	3.5	45.7	2.00	21.3	0.82	1.61
T_6	42.3	4.85	57.0	1.95	21.2	0.94	1.79
T_7	42.2	3.85	64.0	1.95	21.2	0.75	1.57
LSD (0.05)	6.8	2.48	36.9	0.14	0.35	0.38	0.5
CV (%)	10.42	36.43	43.14	4.7	1.07	60.31	46.61

T_1: Solo lentil conventional, T_2: Solo lentil Strip, T_5: 50% lentil+50% linseed , T_6=75% lentil+25% linseed and T_7=Mixed (80% lentil+ 20% linseed

Table 2. Seed yield and yield contributing characters of linseed during Rabi season of 2021-22

Treatment	Plant height (cm)	Branch Plant^{-1}	Pods Plant^{-1}	Seeds Pod^{-1}	1000- seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_3	53.0	5.85	111	8.35	4.33	0.64	1.31
T_4	53.2	5.96	134	9.26	4.45	1.11	1.32
T_5	52.5	6.05	126	8.75	4.37	0.88	1.38
T_6	54.3	7.40	164	9.25	4.37	0.71	1.32
T_7	50.7	8.64	165	8.7	4.31	0.62	1.23
LSD (0.05)	6.45	3.19	85.45	1.24	0.73	0.31	0.26
CV (%)	7.67	26.65	34.96	8.89	10.57	28.61	13.57

[Legend:- T_3=Solo linseed conventional, T_4=Solo linseed Strip, T_5: 50% lentil+50% linseed , T_6=75% lentil+25% linseed and T_7=Mixed (80% lentil+ 20% linseed)]

Table 3. Equivalent yield and Cost and return analysis of lentil mixed cropped with linseed at Rajshahi during 2021-22

Treatment	Lentil equivalent yield (LEY t ha^{-1})	Gross return (Tk ha^{-1})	Toal cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
T_1	0.85	67810	39900	27910	1.70
T_2	0.94	75190	35150	40040	2.14
T_3	0.66	52510	39900	12610	1.32
T_4	1.13	90120	34550	55570	2.61
T_5	1.68	134500	34850	99650	3.86
T_6	1.79	142910	34850	108060	4.10
T_7	1.50	120020	34850	85170	3.44

[Legend: T_1=Solo linseed conventional, T_2=Solo linseed Strip, T_3=Solo lentil conventional, T_4=Solo lentil Strip, T_5=50% lentil+50% linseed, T_6=75% lentil+25% linseed and T_7=Mixed (80% lentil+ 20% linseed)]

D. Relay Cropping

PERFORMANCE OF MASTARD VARIETIES AS RELAY CROP WITH T. AMAN RICE

G. N. HASAN & M. R.H. ANIK

Abstract

A field trial was conducted in the farmer's field at Daulatkhan and Bhola sadar, Bhola during 2020-21 and 2021-22 cropping season to study the performance of Mustard varieties as relay crop with T. Aman. Three varieties of mustard viz. BARI Sharisha-14, BARI Sharisha-15 and BARI Sharisha-17 were tested in the farmer's field. Among the tested varieties, BARI Sharisha-17 gave the maximum seed yield both the consecutive year (1.30 & 1.40 t ha^{-1}) and BARI Sharisha-15 gave the minimum one (1.18 &1.23 t ha^{-1}). Average of two years, the highest gross return (Tk. 102000 ha-1) and gross margin (Tk. 59020 ha-1) was obtained from the treatment T_3 (var. BARI Sharisha-17) followed by T_1 (var. BARI Sharisha-14). The lowest gross return (Tk. 90750 ha-1) and gross margin (Tk. 47770 ha-1) was obtained from mustard var. BARI Sharisha-15 but BCR (2.37) was found from BARI Sharisha-17 due to higher yield.

Introduction

Relay cropping is essentially a special version of double cropping, where the second crop is planted into the first crop before harvest, rather than waiting until after harvest as in true double croppingRelay cropping leads to zero tillage which improves the structure, reduces soil compaction and helps in maintaining organic matter content of soil. The soil remains covered and thereby reduces the chances of erosion of the upper fertile layer of soil. It also reduces farm labor and consumption of fuel resulting in reduction of expenses. Mustard is one of the most important winter oilseeds grown in Bangladesh. In Bhola more than 7000 ha area remains under mustard cultivation (DAE, Bhola). Delay sowing of mustard due to late T.aman harvest causes different problems like excessive rain after cultivation, severe insect attacked in hot climatic condition resulting yield loss. The short duration variety, relay cropping of Mustard with T. Aman rice will be a promising technology for reduction of turnaround time. But the successful establishment of relay mustard mostly depends on available soil moisture, which might be influenced by sowing time and also by the T.Aman rice and mustard variety. Besides the short duration variety, relay cropping of mustard with T.Aman rice will be a promising technology for reduction of turnaround time. Considering that point of view, the present experiment was designed for successful mustard production as relay crop and to evaluate the performance of Mustard varieties as relay crop with T. Aman.

Materials and Method

An experiment on mustard was conducted at farmer's field at Daulatkhan and Bhola sadar, Bhola during 2020-21 and 2021-22 cropping season. Three varieties of mustard viz. BARI Sharisha-14, BARI Sharisha-15 and BARI Sharisha-17 were tested in the farmer's field as relay crop with T. Aman rice. The experiment was set up in Randomized Complete Block Design with three dispersed replications. The unit plot was 80 m^2. The seeds were broadcasted within the T.Aman rice when the soil moisture was optimum. Fertilizer was applied according to FRG-2018 to individual plot. The required amount of urea and Mop were top dressed after 20-25 days of T.Aman harvest. First weeding was done at the time of first thinning. When 80% of the pods turned brown in colour, the crop was assessed to attain maturity. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return . Data were collected on different yield and yield components and analyzed statistically using Crop Stat analytical package.

Result and Discussion

The seed yield and yield attributes of mustard varieties are presented in Table 2 & Table 3. The maximum days to flowering was found in BARI Sharisha-17 (86.52 & 88.50) and the lowest in BARI Sharisha-14 (78.23 & 82.60) in both the years. The maximum siliqua plant^{-1} (71.35 & 76.13) was obtained from BARI Sharisha-14 but number of siliquas per plant (26.36 & 28.44) was higher in BARI Sharisha-17.. 1000- seed weight significance difference was not found among the varieties. The highest ssed yield (1.33 and 1.40 tha^{-1}) was recorded from BARI Sharisha-17 followed by BARI Sharisha-14 (1.25 and 1.32 tha^{-1}) and the lowest from BARI Sharisha-15 (1.18 and 1.23 tha^{-1}) in both the years.

Cost and return analysis (average of 2 years): Cost-return of relaying mustard with T.Aman rice has been given in Table 3. The highest gross return (Tk. 105000 ha^{-1}) and gross margin (Tk. 53520 ha^{-1}) was obtained from the treatment var. BARI Sharisha-17 followed by var. BARI Sharisha-14. The lowest gross return (Tk. 90750 ha^{-1}) and gross margin (Tk. 43770 ha^{-1}) was obtained from treatment var. BARI Sharisha-15but higher BCR (2.14) was found from var. BARI Sharisha-17 due to higher seed yield.

Farmer's Opinion

Farmers are happy to obtained higher yield from the mustard var. BARI Sharisha-17. Pest attack was lowest in all the varieties compared to loca one l. They demanded quality seed for next year cultivation in large area.

Table 2. Seed yield and yield attributes of Mustard varieties in Bhola during 2020-21.

Treatment	Days to maturity	Plants/ m^{-2})	Siliqua plant^{-1} (no)	Seeds Siliqua^{-1}	1000 -seed wt. (g)	Seed yield (t/h)
BARI Sharisha-14	78.23	56.95	71.35	21.25	2.96	1.25
BARI Sharisha-15	83.40	57.42	68.34	22.85	2.83	1.18
BARI Sharisha-17	86.52	58.16	61.35	26.36	3.10	1.33
LSD(0.05)	4.23	NS	2.90	1.03	NS	0.06
CV (%)	6.34	8.84	10.23	9.89	6.58	7.63

Table 2. Seed yield and yield attributes of Mustard varieties in Bhola during 2021-22.

Treatment/varities	Days to maturity	Plants/ m^{-2} no)	Siliqua plant^{-1} (no)	Seeds Siliqua^{-1} (no)	1000- seed wt. (g)	Seed yield (t/h)
BARI Sharisha-14	82.60	58.14	76.13	23.60	3.16	1.32
BARI Sharisha-15	85.37	60.48	72.54	20.37	3.12	1.23
BARI Sharisha-17	88.50	59.35	64.20	28.44	3.23	1.40
LSD(0.05)	2.85	NS	3.24	3.11	NS	0.09
CV (%)	8.41	7.81	7.23	10.89	7.87	6.94

Table 3. Cost and return analysis of Mustard as relaying with T.Aman at Bhola (av. of 2 years).

Treatment (varieties)	Seed yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
BARI Sharisha-14	1.29	96750	42980	53770	2.25
BARI Sharisha-15	1.21	90750	42980	47770	2.11
BARI Sharisha-17	1.36	102000	42980	59020	2.37

Note: Price of Mustard @ 75 Tk/kg

Conclusion

Mustard var. BARI Sharisha-14 and 17 were found promising mustard variety relaying in T. Aman rice field.. Among the varieties, mustard var. BARI Sharisha-17 performed better in consecutive years as relay crop for increasing mustard production in Bhola region. So, it could be recommended for up scaling in large area relaying with T. Aman following appropriate production technologies.

PERFORMANCE OF GRASS PEA VARIETIES AS RELAY WITH T. AMAN RICE IN LOW LYING AREAS

K U AHAMMAD AND M H RAHMAN

Abstract

An experiment was carried out at Tularampur MLT site, Narail during 2021-22. There were five treatments viz. T_1= BARI Khesari-1, T_2= BARI Khesari-2, T_3= BARI Khesari-3, T_4= BARI Khesari-5 and T_5= Local used . . The experiment was laid out in RCB with 3 replications. Seed yield and yield contributing characters of of khesari were influenced significantly due to relay cropping with T. aman. The highest see yield (1.75 t ha^{-1}) was obtained from var. BARI Khesari-5 followed by BARI Khesari-3 (1.56 t ha^{-1}), Local (1.53 t ha^{-1}) and lowest from var. BARI Khesari-2 (1.32 t ha^{-1}). The highest gross margin (51250 Tk.ha^{-1}) and benefit cost ratio (3.73) was found from var. BARI Khesari-5 followed by BARI Khesari-3. The lowest gross margin (34050 Tk.ha^{-1}) and benefit cost ratio (2.82) was found from BARI Khesari-2.

Introduction

Grass pea (Lathyrus sativus L.) is one of the hardiest pulses suitable for relay cropping with paddy rice (Sharma RN *et al* 2000). It has potential among grain legumes for its tolerance to harsh conditions and its adaptability to unfavorable environments with little disease or insect problems. It requires no major input costs and is easy to cultivate under relay cropping system with paddy rice and also a cheap source of protein and fodder. In addition to nutritional benefits, grass pea has an important role for improving soil fertility by adding around 67 kg ha^{-1} of nitrogen through biological nitrogen fixation in a single season, thereby conferring yield and protein benefits for the subsequent non-legume crop (Wang F*etal.,* 2000). Grass pea is grown as relay crop with rice in other countries like Nepal, India etc. In Bangladesh, it is also grown as relay cropping in some pocket areas. Over long period of time, farmers of Narail have been growing local variety of grass pea in their low-lying areas. Introduction of BARI developed varieties may increase their yield and income. Keeping this view , the experiment has been undertaken to evaluate the performance of BARI grasspea varieties for increasing yield and farmers' income.

Materials and Methods

An experiment was carried out at Tularampur MLT site, Narail during 2021-22. There were five treatments, viz. T_1= BARI Khesari-1, T_2= BARI Khesari-2, T_3= BARI Khesari-3, T_4= BARI Khesari-5 and T_5= Local were used. The experiment was laid out in RCB with 3 replications. The plot size t was 4 m x 5 m. Seeds of khesari were broadcast (before 15 days of T. aman harvesting) on 10-15 November 2021. Fertilizers were used @ 20-20-15-10kg N-P-K-S kg ha^{-1} (FRG, 2018). All fertilizers were applied after harvesting of T. aman. Weeding, irrigation and other intercultural operations were done properly. Khesari was harvested during 08-12 March 2022. Data on yield and yield contributing characters were taken and statistically analyzed with MSTAT-C software.

Results and Discussion

Seed yield and yield contributing characters of of khesari were influenced significantly due to relay cropping with T. aman rice (Table 1). The highest seed yield (1.69 t ha^{-1}) was obtained from BARI Khesari-5 variety followed by BARI Khesari-3 (1.51 t ha^{-1}), Local (1.50 t ha^{-1}) and lowest from BARI Khesari-2 (1.29 t ha^{-1}). The highest gross margin (51245 Tk.ha^{-1}) and benefit cost ratio (3.71) was found from BARI Khesari-5 followed by BARI Khesari-3. The lowest gross margin (34041 Tk.ha^{-1}) and benefit cost ratio (2.79) was found from BARI Khesari-2.

Farmers' opinion

Farmers are satisfied with the yield of khesari var. BARI Khesari-5 and BARI Khesari-3 compared to local variety. So, the experiment may be repeated for the next year for conclusion.

Table 1. Seed yield and yield contributing character of grasspea as relay cropping with T.Aman during, 2021-22

Treatment	Plant height (cm)	Plant population/m^2	TGW (g)	Seed yield (kg ha^{-1})	Straw weight (t ha^{-1})
BARI Khesari-1	63 bc	94b	47.73 c	1.34 c	1.63 c
BARI Khesari-2	64 b	95b	48.25 c	1.29 c	1.74 bc
BARI Khesari-3	61c	97a	51.43b	1.51b	1.81b
BARI Khesari-5	68a	98a	52.13a	1.69a	2.04a
Local	65 b	92 c	49.15 bc	1.50b	1.79 b
CV (%)	3.71	8.68	2.54	6.33	4.29
LSD (0.05)	0.458	3.748	0.753	0.071	0.072

Table 2. Cost and return analysis of grasspea as relay cropping with T. Aman during 2021-22

Treatment		Gross return Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
BARI Khesari-1		53600	18750	34850	2.74
BARI Khesari-2		52800	18750	34041	2.79
BARI Khesari-3		62400	18750	43650	3.33
BARI Khesari-5		70000	18750	51245	3.71
Local		61200	18750	42450	3.26

Market price (Tk./kg): Grasspea=40

E. Component Technologies

WEED MANAGEMENT FOR DRY DIRECT SEEDED AUS RICE IN HIGH BARIND TRACT

M.S. HOSSAIN, M.E.A. PRAMANIK AND J.C. BARMAN

Abstract

Conservation agriculture (CA) is based on minimum soil disturbance, permanent soil cover, and crop rotation; it is promoted as a sustainable alternative to systems involving conventional tillage. Direct seeded rice (DSR) is one of the CA technologies. Adoption of DSR changes weed dynamics and communities and therefore necessitates adjusting weed control methods. A field experiment was conducted at Farming System Research and Development (FSRD) site, Basantapur, Godagari, Rajshahi during 2020 and 2021 to develop effective weed management strategies for DSR Aus rice in High Barind Tract. Six weed management strategies such as-WM_1:

Pre-emergence (no spray) +post-emergence (no spray); WM_2: Pre-emergence (Pendimethalin) + post-emergence (no spray); WM_3: Pre-emergence (no spray) + post-emergence (Bispyribac + Pyrazosulfuron Ethyl), WM_4: Pre-emergence (Pendimethalin) + post-emergence (Bispyribac + Pyrazosulfuron), WM_5: Pre-emergence (Pendimethalin) + post-emergence (Penoxulam) and WM_6: Pre-emergence (Pendimethalin)+post-emergence (Hand weeding) was used as treatment variables. A randomized complete block design with three replications was used with strip tillage system. Weed management treatment WM_4 recorded the highest grain (4.63 and 4.64 t ha^{-1} in 2020 and 2021, respectively) and straw yield (5.10 and 5.14 t ha^{-1}, in 2020 and 2021, respectively) of Aus rice. The WM_5 was identical with WM_4 considering the yield performance. The WM_4 and WM_5 also showed minimum weed population and dry weed biomass. Considering cost and return analysis, these two packages also gave higher gross return and gross margin.

Introduction

Conservation agriculture (CA) is said to result in sustainable farming systems as it saves time, economic inputs and natural resources. An increasing trend has been observed in CA to enhance sustainability without compromising land productivity over the last decade in South Asia. Potato-Aus or Boro-T. Aman rice is one of the major cropping patterns in High Barind Tract (HBT) covering an area of 12500 ha (Ali et al., 2018). Farmers normally cultivate late Boro or early Aus rice after harvest of Potato. Rice var. BRRI dhan82 and Bina dhan19 have recently developed as Aus rice varieties with high yield potentiality. Dry direct seeded rice (DSR) in no-till or till soil is an alternate option for transplanting rice. It can easily save those resources. But due to weed management constraints farmers are hesitate to adopt the DSR technology. Weed control is a greater challenge to achieve the success of DSR. Till now little effort has been taken for managing weed and improving crop yields in Bangladesh. Hence, the present investigation was undertaken to find out the effective and sustainable weed management strategy for increasing grain yield of Aus rice in DSR system.

Materials and Methods

A field experiment was conducted at Farming System Research and Development (FSRD) site, Basantopur, Godagari, Rajshahi during 2020 and 2021 to develop sustainable and effective weed management strategies for DSR technology in HBT. The soil of the experimental plots belongs to Amnura series under AEZ 26. Six weed management packages were compared for Strip tillage system. A RCB design with three replications was used. The treatments were as follows-

Treatment	Pre-emergence	Post-emergence
WM_1	No-spray	No-spray
WM_2	Pendimethalin	No-spray
WM_3	No-spray	Bispyribac+Pyrazosulfuron Ethyl
WM_4	Pendimethalin	Bispyribac+Pyrazosulfuron Ethyl
WM_5	Pendimethalin	Penoxsulam
WM_6	Pendimethalin	Hand weeding

After harvest of potato, the land was tilled with rotavator. The seeds of Aus rice (var. Bina dhan19) were sown with strip tillage machine in dry soil on early April each year. A flood irrigation was provided immediately after seed sowing to create proper soil moisture for seed germination. Different weed management strategies were applied as per treatment specimen. Pendimethalin is a pre-emergence herbicide. It was sprayed soil moist condition before germination of weed (1-2 days after irrigation). Bispyribac + Pyrazosulfuron Ethyl or Penoxsulam was used as post-emergence herbicides and applied at 3-leaf stage of weeds. Fertilizer dose was used as per Fertilizer Recommendation Guide' 2018,BARC, 2018). The unit plot size was 8 m × 5 m. All the fertilizers except urea were applied as basal. Urea was applied as top dressing in three equal splits at 20, 40 and 60 days after seed sowing. Intercultural operations viz. thinning, irrigation, fungicide and insecticide spray were done in order to support normal plant growth. For weed count , four permanent 0.20 m^2 (40 cm × 50 cm) quadrates were established in each of the plot. Weed was counted separately as grasses, broadleaf and sedges at 40 days after sowing and counted weed was uprooted and oven dried for measuring dry biomass. The recorded data for weed number and biomass were converted to gram per squre meter. Data on yield was recorded and converted into ton per hectare (t ha^{-1}). All the yield and weed data was analyzed statistically with open-source software R (R Core Team, 2021).

Results and Discussion

Effect of weed managements on DSR Aus rice: Yield and yield components of Aus rice responded significantly to different weed management practices (Table 1). The maximum grain yield (4.63 and 4.64 t ha^{-1}, in 2020 and 2021, respectively) and straw yield (5.10 and 5.14 t ha^{-1} in 2020 and 2021, respectively) were obtained from WM_4 where pre-emergence (Pendimethalin) and Post emergence (Bispyribac+Pyrazosulfuron) herbicides were applied. This is due to the best performances of all yield contributing characters viz., effective tiller m^{-2}, grain $panicle^{-1}$ and 1000-grain weight. The WM_5 showed second highest grain yield (4.27 and 4.24 t ha^{-1} in 2020 and 2021, respectively) where both pre-emergence (Pendimethalin) and Post emergence (Penoxsulam) herbicides were also applied. The treatment WM_3 contained only post emergence herbicide gave significantly higher grain yield (3.90 and 3.86 t ha^{-1}in 2020 and 2021, respectively) than that of WM_2 (3.40 and 3.43 ha^{-1}in 2020 and 2021, respectively) wherever only pre-emergence herbicide was applied. The minimum grain (1.20 and 1.24 t ha^{-1}in 2020 and 2021, respectively) and straw yield (2.20 and 2.60 t ha^{-1}in 2020 and 2021, respectively) were obtained from treatment WM_1 where no weed was controlled.

Effect of weed managements on different types of weeds on DSR Aus rice at 40 DAT: Weed management treatments significantly affected the number and biomass of different types of weeds. In DSR rice, grass and broadleaf weed were observed more than that of sedge wee. Higher total number of weeds and maximum biomass were found in treatment (WM_1) where no weed management option was applied and minimum number of weeds in treatment WM_4 in both the years (Table 2).

Cost and return analysis of different treatments

Economic analysis of weed management strategies in DSR Aus rice are given in Table 3. The maximum gross return (Tk. 120850 ha^{-1}) and gross margin (Tk.116981 ha^{-1}) were obtained from treatment with WM_4 (Pendimethalin, Bispyribac+Pyrazosulfuron) followed by treatment WM_5 (Pendimethalin, Penoxsulam). The lowest gross margin (Tk. 32200 ha^{-1}) was obtained from WM_1 (no weed management). Any single herbicide application either pre-emergence or post-emergence did not give higher gross return and gross margin. But the highest MBCR over weedy treatment (WM_1) was found from treatment WM_3 (40.02) and followed by WM_2 (27.19) as the treatment cost was lower. The lowest MBCR over control (8.87) was recorded from WM_6 where pre-emergence + hand weeding was applied.

Table 1. Effect of weed managements on the yield and yield attributes of DSR Aus rice in at FSRD site, Basantopur Rajshahi

Treatment	Plant height (cm)	Tiller m^{-2}	Panicle length (cm)	Grains $panicle^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
			2020				
WM_1	66.07e	87.67d	9.83d	51.33d	18.17c	1.20e	2.20c
WM_2	86.27d	328.33c	16.77c	88.67c	19.47b	3.40d	4.63b
WM_3	95.33bc	359.00bc	18.30bc	122.33ab	20.10d	3.90c	5.03ab
WM_4	101.73a	403.33a	21.50a	136.33a	21.13a	4.63a	5.10a
WM_5	100.50ab	378.67ab	20.37a	129.00a	20.33ab	4.27b	5.07a
WM_6	92.43c	353.00bc	18.40b	106.67bc	19.63b	3.97c	4.93ab
LSD(0.05)	5.89	38.89	1.59	21.57	0.95	0.24	0.40
CV (%)	5.58	6.71	5.01	11.22	5.65	6.72	6.93
			2021				
WM_1	88.33d	105.67d	9.80c	57.67d	18.12f	1.24e	2.60c
WM_2	97.67bc	349.00c	15.60ab	83.33c	18.32e	3.43d	4.61b

Treatment	Plant height (cm)	Tiller m^{-2}	Panicle length (cm)	Grains $panicle^{-1}$	1000-grain weight (g)	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)
WM_3	101.00ab	386.33ab	17.50ab	128.30b	19.71c	3.86c	5.13ab
WM_4	104.67a	415.00a	20.00a	144.67a	20.81a	4.64a	5.14a
WM_5	100.67b	372.66bc	18.17a	129.00b	20.40b	4.24b	5.32a
WM_6	94.67c	359.67bc	12.87bc	118.00b	19.44d	3.93bc	5.13ab
LSD (0.05)	3.92	31.82	4.99	13.40	0.08	0.32	0.53
CV (%)	5.20	5.28	10.51	6.68	1.21	6.98	6.25

Table 2. Different characters of weeds as influenced by different weed managements in DSR rice 40 DAT at FSRD site, Basantopur Rajshahi

Treatment	Grass		Broad leaf		Sedge		Total	
	No.	Biomass ($g\ m^{-2}$)	No.	Biomass ($g\ m^{-2}$)	No.	Biomass ($g\ m^{-2}$)	No.	Biomass ($g\ m^{-2}$)
2020								
WM_1	103.33a	30.83a	90.00a	19.17a	50.00a	18.33a	243.33a	68.33a
WM_2	66.67b	12.67b	54.17b	5.00c	26.67b	5.00c	147.50bc	22.67c
WM_3	36.67cd	6.83bc	45.00bc	5.83c	11.67c	4.00c	93.33de	16.67d
WM_4	30.00d	5.67c	20.83c	4.17c	10.00c	5.50c	60.83e	15.33d
WM_5	47.33bcd	9.83bc	45.00bc	6.17c	15.00bc	5.33c	107.33cd	21.33c
WM_6	61.67bc	11.67bc	68.33ab	12.50b	25.00b	9.50b	155.00b	33.67b
LSD (0.05)	25.25	6.75	26.33	3.35	13.83	3.21	40.41	7.25
CV (%)	14.10	18.75	16.73	12.38	15.88	15.28	16.50	12.69
2021								
WM_1	33.67c	19.67d	132.33a	80.67a	4.00c	2.33c	183.67a	102.67a
WM_2	93.67a	55.67b	17.67d	11.83cd	14.33b	8.33a	133.00c	75.83bc
WM_3	60.33b	65.33a	17.67d	8.17d	24.33a	9.67a	131.00c	83.17b
WM_4	96.00a	45.67c	32.33c	21.67b	2.67c	1.00cd	102.33d	37.33d
WM_5	100.67a	26.00d	32.33c	11.33cd	0.00d	0.00d	125.67c	65.00c
WM_6	99.67a	43.67c	70.67b	14.67c	13.33b	6.67b	170.00b	68.33c.
LSD (0.05)	10.70	9.62	7.97	6.35	2.19	1.66	11.13	12.98
CV (%)	7.29	12.40	8.67	14.12	12.34	15.55	45.34	9.90

Table 3. Cost and return analysis of different weed management options at FSRD site, Basantopur Rajshahi (two years average)

Treatment	Gross return ($Tk.\ ha^{-1}$)	Total variable cost ($Tk.\ ha^{-1}$)	Gross margin ($Tk.\ ha^{-1}$)	MBCR
WM_1	32200	0	32200	-
WM_2	89630	2112	87518	27.19
WM_3	102530	1757	100773	40.02
WM_4	120850	3869	116981	22.91
WM_5	111820	4787	107033	16.63
WM_6	104180	8112	96068	8.87

NB., Pendimethalin (3.0 L ha^{-1})- Tk. 2625, Bispyribac (600 g ha^{-1})-Tk. 525, Penoxsulam (94 ml ha^{-1})- Tk. 1875, Pyrazosulfuron Ethyl (188 g)- Tk. 375.

Conclusion

From the results, it can be concluded that application of pre-emergence (pendimethalin) and post-emergence (Bispyribac+Pyrazosulfuron) (WM_4) could be a promising practice for higher yield as well as economic benefit in DSR Aus rice.

INTEGRATED WEED MANAGEMENT OF MUNGBEAN

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Abstract

A field study was carried out at the farmer's field of Rahmatpur, Babuganj, Barishal to evaluate some weed control options in mungbean cultivation in late rabi season of 2021. The experiment was carried out with five different weed control options e.g. i) Control (W_1) ii) One hand weeding at 20 DAE (W_2), iii) BARI weeder at 20 DAE (W_3), iv) W_2 + BARI weeder at 20 DAE (W_4) v) Weednil @1.5ml/L water at 20 DAE (W_5) under randomized complete block design with three replications. Mungbean var. BARI Mung-6 was used . Results revealed that, (one hand weeding at 20 DAE + Application of BARI Weeder at 40 DAE) significantly increases seed yield of mungbean (1635.3 kg ha^{-1}). The highest BCR could be obtained from application of BARI weeder at 20 DAE (4.04).

Introduction

Mungbean (*Vigna radiata*) is an important component in the intensive crop production system for its short life cycle and is one of the most leading pulse crops of Bangladesh. The agroecological condition of Bangladesh is favorable for growing this crop. However, one of the major constraints in mungbean production is weed competition. The loss of mungbean yield due to weeds ranges from 65.4% to 79.0% (Shuaib, 2001; Dungarwal *et al*., 2003). The reduction in mungbean seed yield due to weeds was estimated 69% by Yadav and Singh (2005). Uncontrolled weedy plots reduced mungbean yield 57% as compared with weed free condition (Hossain et al., 2010). Among the weeds, different types of grasses and sedges are the major problem (Khan et al., 2011). Besides causing crop losses, weeds creating competition for nutrients, space, water etc. reduce the crop yield and the quality of produce hence; reduce the market value of the turnout (Arif et al., 2006). As most mungbean is sown as broadcast, it is difficult to weed them and therefore, farmers do not weed at all in the mungbean field. In most cases, one to two weeding are necessary. For the success of summer production of mungbean in Bangladesh, the role of weeding needs to be emphasized (FAO/UNDP, 1984). Weed competition with mungbean persisting for 20-30 days after emergence was very critical and prolonged competition resulted in substantial yield reduction (Naeem et al., 1999). But there are many options for weed control- like hand weeding, spading; use of herbicide *etc.* but which one is more effective and economically viable for southern belt is not identified. Under the above circumstances, it is necessary to know the effective and economic weed control method for mungbean cultivation in late rabi season.

Materials and Methods

The experiment was conducted at farmer's field of Babuganj, Barishal in randomized complete block design with three replications during March 2022. The unit plot size was 5 rows × 4 m long. The treatments were : *i*) Control (W_1) *ii*) One hand weeding at 20 DAE (W_2), *iii*) BARI weeder at 20 DAE (W_3), *iv*) W_2 + BARI weeder at 20 DAE (W_4) *v*) Weednil @1.5ml/L water at 20 DAE (W_5). Mungbean var. BARI Mung- 6 was selected. The crop was sown at a spacing of 30 cm X 10 cm. The experiment was sown on 15th March, 2022. The experimental field was fertilized with @20-40-20-10 kg ha^{-1} of NPKS as basal dose. Yield and different yield contributing characters were measured at harvest. The collected data were analyzed by the statistical software R and the least significant differences were calculated BY DMRT at 5% level of significance (Gomez and Gomez, 1984).

Results and Discussion

Yield and yield performance of mungbean was influenced by the different methods of weed control (Table 6). Different weed control options had demonstrated significant variation for all yield contributing characters except number of pod/plant and seed/pod. One hand weeding +BARI weeder at 40 DAE (W4) showed highest plants/m^2 (26) whereas W_1 (control) treatment had maintained the least (17). Number of pod/plant an seeds /pod did not varied significantly among the weed control options. The maximum hundred seed weight (5.71g) observed from W_4

treatment *e.g.* one hand weeding + BARI weeder at 40 DAE. The highest seed yield (1635.3 kg ha^{-1}) was obtained from W_4 treatment *e.g.* one hand weeding + BARI weeder at 40 DAE. The lowest seed yield of mungbean was recorded from W_1 treatment *e.g.* control (746.7 kg ha^{-1}).

Profitability analysis:

Profitability analysis of mungbean as affected by different weed control options were represented in Table-7. The highest BCR was obtained from W_3 treatment (4.04). The least BCR was recorded from W_2 treatment (2.31).

Farmer's opinion

Farmers usually do not remove weeds in mungbean. They liked BARI weeder as it was labor saving. But, weeds having taproot systems cannot be uprooted by BARI weeder. Moreover, they opined that selective herbicide was not effective against broad leaf weed.

Table 1. Seed yield and yield contributing characters of mungbean as influenced by different weed management options during late rabi, 2021-2022

Treatments	Plants /m^2	No. of pod/plant	No. of seed/pod	1000-seed weight (g)	Seed Yield (Kg ha^{-1})
Control	17 c	31.67	10.17	4.38 c	746.7 d
One hand weeding at 20 DAE	20.67 bc	35	10.93	4.26 c	1020 c
BARI weeder at 20 DAE	21.33 abc	34	11.67	5.20 b	1345.3 b
One Hand weeding +BARI weeder at 40 DAE	26 a	36.33	11	5.71 a	1635.3 a
Spraying of weednil at 20 DAE@ 1.5 ml/L	25.47 ab	29	11	5.38 ab	1156.7 c
CV (%)	11.62	12.17	9.55	6.78	6.50

Table 2. Profitability analysis of mungbean affected by different weed control options during late rabi of 2021-2022

Treatments	Seed yield (kg ha^{-1})	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})	BCR
Control	746.7	44802	15000	29802	2.98
One hand weeding at 20 DAE	1020	61200	27500	33700	2.23
BARI weeder at 20 DAE	1345.3	80817	20000	60817	4.04
One Hand weeding +BARI weeder at 40 DAE	1635.3	98118	28500	69618	3.44
Spraying of weednil at 20 DAE@ 1.5 ml/L	1156.7	69402	22500	46902	3.08

Unit Mungbean price: 60 Tk. /kg

Conclusion

With the findings it can be concluded that, W_4 treatment *e.g.*one hand weeding at 20 DAE + BARI weeder at 40 DAE gave the highest seed yield in respect of other treatments. But, W_3 treatment *e.g.* BARI weeder at 20 DAE gave the highest benefit cost ratio. Therefore, one hand weeding at 20 DAE + application of BARI weeder at 40 DAE could be good option for weed control.

PLANTING DATE INFLUENCE PHENOLOGY, GROWTH AND YIELD OF CHICKPEA IN HIGH BARIND TRACT

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Abstract

A study was conducted to evaluate the effect of planting date on phenology, growth, and yield of chickpea varieties. The experiment comprised of three planting dates viz., 20 November, 20 November and 10 December andtwo chickpea varieties, viz., BARI Chola-5 and BARI Chola-11 in two separate trials. The experiment was laid out in a randomized complete block design with three replications. It was observed that chickpeas var. BARI Chola-5 (6-7days) emerged earlier than that of BARI Chola-11 (7-8 days). The BARI Chola-5 took 64-66, 71-73. 91-93, and 111-125 days for its floral initiation, 1st flower, pod starting, and physiological maturity, respectively. Delayed planting took less time to mature. The variety recorded 105-110, 863-994, 963-1074, 1278-1334, and 1780-1969-1276 GDD for its emergence, floral initiation, 1st flower, pod starting and physiological maturity, respectively. Early crop planting recorded higher GDD for all stages of BARI Chola-5. The BARI Chola-11 received 7-8, 36-39, 44-45, 49-51 and 105-116 days for its emergence, floral initiation, 1st flower, pod starting and physiological maturity, respectively. BARI Chola-11, delayed planting took somewhat more time for emergence, floral initiation, 1st flower and pod starting but less time for pod maturity. The variety received 124-128, 543-594, 619-706, 703-784 and 1633-1748 GDD for its emergence, floral initiation, 1st flower, pod starting and physiological maturity, respectively. Crops planted on a delayed date recorded lower GDD for all the stages in the variety. The seed yield of BARI Chola-5 (1.26-1.65 t ha-1) was higher than that of BARI Chola-11 (0.93-1.34 t ha-1). The BARI Chola-5 gave the highest seed yield planted on 20 November. Contrarily, the BARI Chola-11 showed the maximum seed yield from 30 November followed by 20 November.

Introduction

Chickpea (Cicer arietinum L.) is an important quality pulse crop of Bangladesh which contains almost double the amount of protein as compared to cereals and can supplement the cereal-based diet to improve the nutritional value of food. In Bangladesh, chickpea is generally grown under rain-fed or residual soil moisture conditions in the rabi season after the harvest of rice during October-March. Among the major pulses grown chickpea ranks fifth in area and production but second in consumption priority. It is a popular pulse crop in the High Barind Tract (HBT) in the north-west of Bangladesh (BBS, 2019). According to World Health Organization (WHO) report, per capita requirement for pulse is 45 g. At the farmers level, the average yield of chickpea is very low due to lack of knowledge of selecting and planting the suitable variety and using appropriate agronomic practices. Among the various agronomic practices, planting time is the single most important factor influencing the yield of chickea. Planting time is important for pulses that have to be adjusted or alternative cropping patterns developed (Maniruzzaman and Miah, 1991). Because of differences in agro-ecological conditions, the best time to plant chickpeas varies from variety to variety and region to region. But little information is available on different varieties of chickpea with time of planting particularly of HBT. The present study was therefore undertaken to find out (i) the suitable planting date of chickpea, (ii) days to phenologies (iii) growing degree days (GDD) and (iv) yield performance of chickpea varieties with different planting dates.

Materials and Methods

The experiment was conducted at the farmers field of the Farming System Research and Development site, Basantopur, Godagari, Rajshahi (lat. 24º25.539´N; long. 88º24.680´E; 31 masl) under On-Farm Research Division, Rajshahi BARI, Barind station, Rajshahi of High Barind Tract (AEZ#26 during Rabi 2021-22. . Texturally the soil was silty clay loam with pH 5.8, organic matter 0.94%, total nitrogen 0.06%, available phosphorus 11.55 ppm, available Sulphur 8.45 ppm, and exchangeable potassium 0.22 me 100 g^{-1} soil. The site is on flood-free, high land with low-permeability soil (BARC, 2018). The experimental site enjoys a subtropical monsoon climate characterized by heavy precipitation during the months of April to October and scanty rainfall during the months of November to March. The monthly average temperature ranges from 10 °C in January to 35 °C in April. Absolute maximum and minimum temperatures are 42°C and 5°C in the months of April-May and January, respectively. The experiment comprised of three sowing dates viz., (i) 20 November, (ii) 30 November and (iii) 10 December. The three sowing dates was tested on BARI developed two chickpea varieties viz., BARI Chola-5 and BARI Chola-11 separately. The experiment was laid out in a randomized complete block design with three replications. The size of each unit plot was 12 m^2 (4×3 m). The seeds were sown at a spacing of 40 cm in continuous seeding. Experimental land was uniformly fertilized with 20-20-20 kg ha^{-1} of N-P-K in the form of urea, triple super phosphate and muriate of potash, respectively at the final land preparation. Crop management practices such as weeding, thinning, irrigation and plant protection measures were done as per requirement. The most important stages like emergence, flower initiation, first flowering, pod starting and physiological maturity were recorded in days when 50% of a variety of each replication reached a definite stage as the representative of that stage. The daily meteorological data from First Class Meteorological Observatory, Shyampur, Rajshahi were used. The growing degree days (GDD) were calculated according to the formulae of Rajput (1980). Growing degree days (GDD) = (Tmax + Tmin) / 2-Tb (Here, Tmax = Maximum temperature, Tmin = Minimum temperature, Tb = Base temperature = 5°C). Data on yield attributes were taken 5 randomly selected plants per plot. The yield was recorded at 16% moisture content of chickpea seed.Analysis of variance was done with the help of open-source computer package R. Difference among treatment means were tested with the least significant difference (LSD) test (R Core Team, 2021).

Results and Discussion

Crop environment

Daily maximum and minimum air temperature and rainfall data are presented for the cropping season in Fig. 1. November and December were the rainless months while 39.1 mm rainfall was recorded in the month of February which hampered pulse cultivation and insects and pests were notice. The temperature went down up to 8ºC at the month of early February 2022. There was an incidence of pod borer. Pod borer was controlled by spraying Nitro (Cypermethrin and Chlorpyriphos) 1 ml L^{-1} water and Shaham 5 SG (Abamectin benzoate) at the rate of 0.1 g L^{-1} water with 7 days interval.

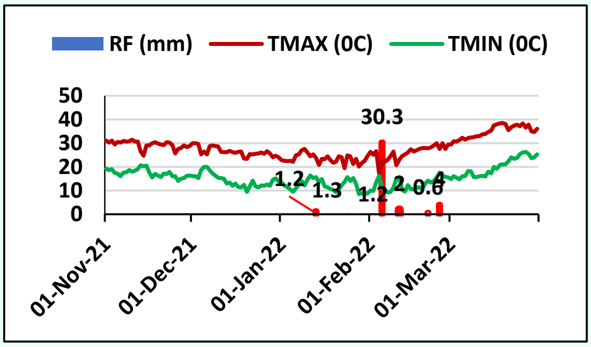

Fig.1 Daily weather parameters during November 2021 to March 2022

Phenology

BARI Chola-5: Different phenological stages along with required days of BARI Chola-5 differed significantly due to the sowing date (Fig. 2). The BARI Chola took 6-7 days for its emergence while early sowing (20 and 30 November) took t 6 days. The result indicated that delay in sowing decreased the time to attain floral initiation (64-66 days) and 1st flower (71-73 days). The number of days taken for attainment of the above two stages was in the order of 20 November > 30 November > 10 December. In case of pod starting, the maximum days were obtained on 20 November followed by 10 December and 10 March. The minimum days to attain the stages

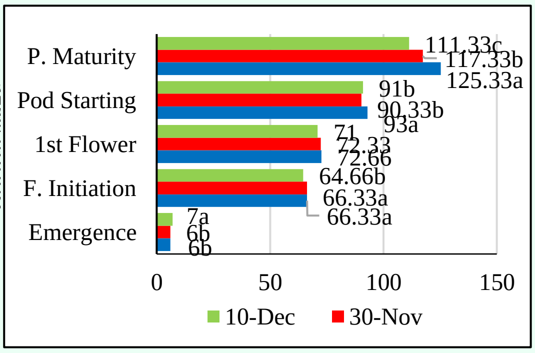

Fig. 2 Phenology of BARI Chola-5 influenced by sowing dates

were recorded from sowing on 30 November. Days to physiological maturity were decreased with the delaying sowing as the crop was forcedly matured due to raising of air temperature at the later stage. The BARI Chola-5 took 111 to 125 days for its maturity. The number of days to attain maturity for different sowing dates was in the order of 10 December>30 November>20 November.

BARI Chola-11: BARI Chola-11 is a newly developed variety. Days to all phenological stages were significantly influenced by different sowing dates (Fig. 3). The BARI Chola-11 took more time than BARI Mung-6 for its emergence. Normally it required 7 to 8 days while later sowing (10 December) needed the highest days. The floral initiation started at 36.33 to 37.66 days after sowings. Pod starting appeared at 49.33 to 50.66 days while 30 November (49.33 days) required the lowest time. However, the BARI Chola-11 matured early than that of BARI Chola-5. It matured 105.66 to 116 days after sowing while the delayed sowing took the minimum time (105.66 days).

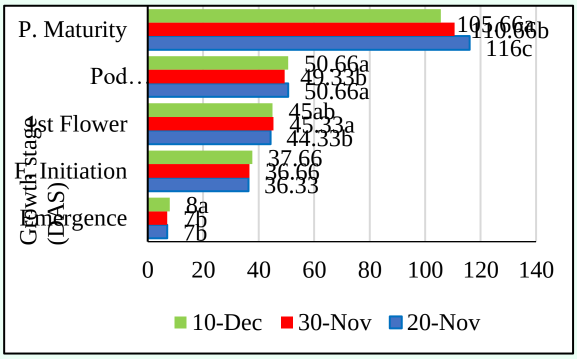

Fig. 3 Phenology of BARI Chola-11 influenced by sowing dates

Growing degree days (GDD)

BARI Chola-5: The requirement of GDD in all growth stages was influenced significantly by different sowing dates of BARI Chola-5 (Fig. 4). The emergence required 105.3 to 110.2 while sowing on 20 November recorded the highest. In case of floral initiation and 1st flower, GDD was decreased with the delaying sowing. The GDD for floral initiation was 863.28 to 994.15 and for 1st flower was 963.13 to 1073.68. Again, the GDD was also decreased sowing from 20 November to 10 December for pod starting and pod maturity. For pod starting, the GDD was calculated from 1260.46 to 1333.93. The physiological maturity of BARI Chola-5 required 1780.07 to 1969.20 GDD while the maximum was from sowing on 20 November.

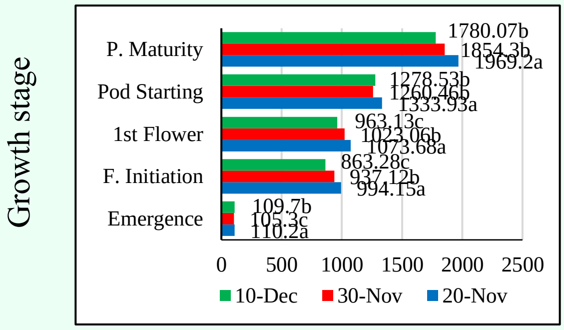

Fig. 4 GDD of BARI Chola-5 influenced by sowing dates

BARI Chola-11l: Growing degree days in all growth stages of BARI Chola-11 differed significantly due to different sowing dates (Fig. 5). The GDD was reduced by delaying sowing for all the growth stages and in order of 20 November>30 November>10 December. The GDD was recorded 122.45-127.75, 543.53-593.62, 618.97-706.46, and 702.88-783.93 for emergence, floral initiation, 1st flower, and pod starting, respectively. In physiological maturity, the maximum GDD was recorded from early sowing on 20 November (1748.07) and the minimum one from sowing on 10 December (1632.50) due to forced maturity of late sowing crops.

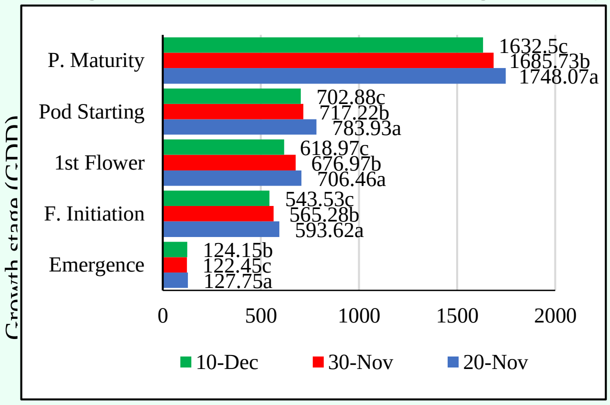

Fig. 5 GDD of BARI Chola-11 influenced by sowing dates

Seed yield

BARI Chola-5: Yield and yield attributes of BARI Chola-5 were significantly affected by planting dates (Table 1). The crop planted on 20 November produced the highest seed yield (1.65 t ha^{-1}) followed by 30 November (1.52 t ha^{-1}). The lowest seed yield was obtained from sowing on 10 December (1.26 t ha^{-1}). The higher yield was obtained from the crop planted on 20 November might be due to higher pods $plant^{-1}$ (86.00), seeds pod^{-1} (1.60), and 100-seed weight (13.20 g). Stover yield was also the highest in the same date planted on 20 November (1.88 t ha^{-1})

BARI Chola-11: Significant variations in seed yield and yield attributes of BARI Chola-11 were observed due to planting dates (Table 1). BARI Chola-11 gave a comparatively lower seed yield than BARI Chola-5. The plants sown on 20 November (1.34 t ha^{-1}) and 30 November (1.47 t ha^{-1}) gave the maximum and similar seed yield while the maximum yield was from 30 November. The crops which were planted on 10 December produced the minimum yield (0.97 t ha^{-1}). The higher no. of pods $plant^{-1}$, seeds pod^{-1} and 100-seed weight contributed to higher seed yield. The maximum stover yield was obtained from the plants sowing on 30 November.

Table 1. Yield and yield attributes of chickpea influenced by sowing dates

Treat	Plant height (cm)	Plant pop. (no./m^2)	Pods $Plant^{-1}$ (No)	Seeds Pod^{-1} (No)	100-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
BARI Chola-5							
20 Nov	55.33a	21.56a	86.00a	1.60a	13.20a	1.65a	1.88a
30 Nov	50.44ab	22.68a	70.46b	1.46ab	12.68b	1.52b	1.73b
10 Dec	44.57b	20.15a	56.53c	1.13b	11.50c	1.26c	1.46c
LSD (0.05)	8.08	4.49	10.36	0.413	0.39	0.07	0.10
CV (%)	7.11	9.24	6.41	13.04	1.37	1.94	2.61
BARI Chola-11							
20 Nov	71.50a	22.95a	37.33b	1.13a	19.75a	1.34ab	1.76a
30 Nov	65.61a	24.02a	45.73a	1.33a	20.40a	1.47a	1.90a
10 Dec	64.23a	19.86a	28.33c	1.13a	19.75a	0.97c	1.42b
LSD (0.05)	8.66	5.46	7.66	0.32	1.38	0.14	0.19
CV (%)	5.69	10.81	9.11	11.78	3.04	5.04	5.02

Conclusion

From the study, it may be concluded that planting on 20 November for BARI Chola-5 and 30 November for BARI Chola-11 were suitable for the cultivation of Chickpea in the High Barind Tract.

EFFECT OF MULCH ON ZERO TILLAGE GARLIC PRODUCTION IN COASTAL AREA

G. N. HASAN AND M. R.H. ANIK

Abstract

An experiment was conducted at Bhola sadar and Daulatkhan under Bhola district during the rabi season of 2021-22 to evaluate the suitable mulch material for garlic under zero tillage condition and to increase the production as well as farmer's income. There were three treatments i.e., T_1: Rice straw mulch, T_2: Water hyacinth mulch and T_3: No mulch. The tested garlic variety was BARI Rashun-1. Among the treatments, the highest average bulb yield (6.79 t ha^{-1}) and gross margin (Tk. 292540 ha^{-1}) were obtained from T_1 treatment. The lowest yield (4.16 t ha^{-1}) and gross margin (Tk. 154000 ha^{-1}) were obtained from T_3 treatment. In case of benefit-cost ratio, the highest value (3.55) was recorded from rice straw mulch and the lowest (2.61) in no mulch.

Introduction

Garlic (*Allium sativum*) is a promising spices and cash crop in Bangladesh. Bangladesh produces only 6, 53,000 metric tons of garlic from 79,000 hectares against the requirement of 7, 72,000 metric tons per annum (Anon., 2019). There are some progressive farmers grow garlic after harvest of *T. Aman* rice with no or less care and input in different places. In Bhola district, some land remains fallow after *B. Aman* harvest. Garlic can easily be grown in that area for large scale production under zero tillage. Surface mulching either by synthetic plastic sheets or natural organic waste material is now a days being used to protect plants from root borne diseases and for water conservation. Garlic is sensitive to moisture stress and high temperature and found about 60% reduction in yield when it was associated with water stress (Miko et al., 2000). Mulch checks water loss by evaporation, conserves soil moisture and suppress weed thereby increasing the yield of garlic (Islam et al., 2007). Under such condition, mulching could be a good substitute for irrigation. As such, an experiment is required in that area to select a suitable variety of garlic and mulching method which increase crop production by utilizing fallow land as well as farmers' income. BARI has developed some HYV garlic varieties and its less pest and diseases susceptible. Conservation agriculture is a promising technology for increasing productivity with less cost of cultivation. Therefore, the present experiment was undertaken to evaluate the performance of garlic variety under zero tillage and with mulch in Bhola region.

Materials and methods

The experiment was conducted at Bhola sadar and Daulatkhan upazilla under Bhola district during the rabi season of 2021-22 to evaluate the suitable mulch material for garlic under zero tillage condition and to increase the production as well as farmer's income. The experiment was laid out in RCB design with four dispersed replications. There were three treatments *i.e.,* T_1: Rice straw mulch, T_2: Water hyacinth mulch and T_3: No mulch. The unit plot size was 5 m x 4 m . Cloves of garlic were sown on 29/11/2021 to 28/12/2021 with 10 cm x 10 cm spacing. The tested garlic variety was BARI Rashun-4. The land was fertilized with 100-53-166-20 kg NPKS ha^{-1}. The full dose of PKS and 1/3rd of N was applied during final land preparation. The remaining 2/3rd urea were applied in two equal installments at 3 and 6 weeks after sowing (DAS). One irrigation was provided at 40 DAS. Required amount of rice straw and water hyacinth as mulching material was 1875 and 3750 kg ha^{-1}, respectively. Other necessary management was done for the normal growth and development of the crop. The crop was harvested during 10 to 21 April, 2022. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. Total gross margin was calculated by subtracting cost of production from the total gross return. Necessary data were collected plot wise and analyzed statistically using Crop Stat analytical package.

Results and Discussion

Effect of mulch on yield and yield contributing characters of garlic under zero tillage varied significantly (Table 1). The highest number of plants m^{-2} was higher in T_1 (62) treatment and the lowest in T_3 (57) treatment. The highest days to maturity (127 days) was observed in T_2 and shortest time to maturity (118 days) in T_3 treatment. The tallest plant height was observed in T_1 (67.84 cm) followed by T_2 (65.17 cm) and the shortest plant in T_3 (58.50 cm) treatment.Individual maximum t bulb weight was recorded in T_1 (14.38 g) which was statistically similar to T_2 treatments but significant from T_3 where the lowest bulb weight (9.51 g) was recorded. The maximum t bulb yield (6.79 t ha^{-1}) was found in T_1 followed by T2 (6.23 t ha^{-1}) treatment but significantly different from T_3 treatment with lowest yield (4.16 t ha^{-1}).. Zero tillage with mulch using water hyacinth (Kabir et al., 2011) and rice straw (Islam et al., 2015) significantly retained soil moisture and suppressed weed growth which enhanced crop growth and development (Karaye & Yakubu, 2006). Jamil et al. (2005) reported that straw mulch increased yield and yield contributing traits of garlic and they recommended straw much for garlic production. Zero-tillage system helps to increase water and fertilizer use efficiency of crop as results yield increase as compared to tillage condition (Triplett Jr & Dick, 2008).

Economic analyses: The values in the Table 2 indicated that the total cost of production was the highest (114860 Tk. ha^{-1}) in rice straw mulch but the lowest (95600 Tk. ha^{-1}) from no mulch. On the contrary, the highest value of gross margin (292540 Tk. ha^{-1}) was obtained from rice straw mulch and the lowest (154000 Tk. ha^{-1}) from no mulch. In case of benefit-cost ratio, the highest BCR value (3.55) was recorded from rice straw mulch and the lowest BCR (2.61) in no mulch.

Pest incidence: Tip burn disease was successfully controlled by applying Rovral.

Farmers' opinion

This technology is new one in Bhola region. The farmers of this area are interested in growing garlic along with rice straw mulch.

Table 1. Effect of mulch on yield and yield contributing characters of BARI Rashun-1 in Bhola during the rabi season of 2021-22

Treatment	Plantsm^{-2}	Days to maturity (cm)	Plant height (cm)	Clove per bulb	Individual bulb weight (g)	Bulb yield (t ha^{-1})
T_1	62	125.00	67.84	26.75	14.38	6.79
T_2	60	127.00	65.17	24.31	13.19	6.23
T_3	57	118.00	58.50	20.24	9.51	4.16
$LSD_{0.05}$	2.75	2.38	4.31	2.51	2.87	2.38
CV (%)	6.20	7.95	8.27	10.33	8.45	7.82

T_1: Rice straw mulch, T_2: Water hyacinth mulch and T_3: No mulch

Table 2. Cost and return analysis of garlic (var. BARI Rashun-1) influenced by mulching in Bhola during the rabi season of 2021-22.

Treatments		Gross return (Tk. ha^{-1})	TC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
T_1		407400	114860	292540	3.55
T_2		373800	110500	263300	3.38
T_3		249600	95600	154000	2.61

Garlic bulb price (Tk. kg^{-1}) = 60

Conclusion

In zero-tillage system, soil moisture conserved during the entire growth period of crop as mulch is used. In this system, bulbs are planted directly into untilled soil which contains previous crop residues. It offers plants to absorb soil moisture for their initial development. Results of the experiment clearly indicated thatgarlic var. BARI Rashun-1 was more productive and profitable on zero tillage in rice straw and water hyacinth mulch compared to no mulch . Thus, garlic could be successfully grown in zero tillage using both rice straw and water hyacinth mulch after T. Aman rice harvest in Bhola district to increase cropping intensity and system productivity with profitability.

EFFECT OF PLANTING METHOD ON THE YIELD OF LENTIL

MA ISLAM, MS ALAM and MRA MOLLAH

Abstract

A field experiment was conducted in the farmer's field of Sujaitput, Sonatola, Bogura during the rabi season 2021-22 to observe the performance of lentil (BARI Masur 8) under different tillage options in the KaratoaBangali Floodplain soil (AEZ#4). Four tillage options i.e.,T_1 = Seeding with bed planterT_2 = Seeding with PTOS, T_3 = Seeding with strip planter and T_4 = Farmers' practice were used in this program. Lentil exhibited a characteristic responses toward different tillage options. Machinery tillage-based cultivation system provided higher yield benefits to the BARI Masur-8. Among the options, the bed planter tillage method was superior in yield and economic return. The maximum seed yield (1750 kgha^{-1}) was obtained from the bed planting system followed by STRIP planting system (1642 kgha^{-1}) and the minimum from the farmers practice (1518 kgha^{-1}). Overall 7.51 to 15.28% yield advantage was achieved from the mechanized seeding system of lentil. Higher seed yield contributed to the higher economic return. Maximum gross return (Tk.146040 t ha^{-1}) was obtained in BARI Masur 7 and Bed planter tillage option.

Introduction

Lentil is a popular winter pulse crop farmed all over the world. In terms of acreage and production, it is the second most significant pulse crop in Bangladesh, but it ranks first in terms of consumer preference. Lentil is often grown after harvesting puddle transplanting monsoon rice. Lentil seeds are seeded using 3-4 ploughings and hand disseminating, with irrigation after seeding. This takes time and money and raises the danger of soil structural damage, erosion, and moisture loss (Govaerts et al., 2009). Due to the lengthy period of Aman rice and excessive soil wetness, no tillage device could be used to prepare the soil for seed bed to sowing lentil in the major lentil area. Furthermore, a lack of agricultural workers is delaying lentil seeding. As a result, lentils could not be sown at the optimal period (mid-November) and encountered an inverse environment, resulting in autumn illness and, ultimately, yield loss. Poor lentil performance and yields necessitate the introduction of innovative seeding technologies that address management issues (e.g., damp soil from prior cultures, manpower scarcity). Different direct seeding technologies, including as strip tillage (ST), zero or minimal tillage (Z), bed planting (BP), and power tiller operated seeder, have recently been adopted in Bangladesh (PTOS). These methods alleviated the difficulties of excess soil moisture at sowing time, agricultural labor scarcity, late sowing, the misuse of expensive fossil fuels, and CO2 emissions directly or indirectly. Pulses may be planted and cultivated effectively using Conservation Agriculture (CA) technology, according to research studies accessible in Bangladesh (Barma et al., 2014). In drought-prone places where sowing and initial plant establishment may be done using the leftover soil moisture available immediately after monsoon rice harvest, reduced tillage-based lentil production has proven to be more feasible (Bell and Johansen, 2009). After the harvest of T. Aman rice, farmers in the Bogura region frequently plant lentils. They prepare the ground by plowing 2-3 times with a regular power tiller, then laddering, which results in a loss of residual soil moisture and a delay in Lentil sowing. While operating the bed planter on the field, raised beds and furrows between two beds are created. Raised beds like this may aid in soil moisture conservation. Because water can easily flow through furrows, crops like lentils and other legumes can avoid unexpected waterlogging when cultivated on raised beds. Strip tillage seeding conserves soil moisture as well. PTOS provides the crops with the same amenities. All of these machines provide little surface soil disturbance since they seed in one pass. They not only provide consistent seeding depth, but they also ensure optimal population density. Together, these factors make it easier for crops to establish themselves in the field. In light of this, research was conducted to determine the efficacy of mechanical seeding methods based on reduced tillage to increase lentil performance.

Materials and Methods

The experiment was conducted in Sujaipur under the MLT site Sonatola, Bogura during the 2021-22 cropping season. The area belongs to the agro ecological zone of KaratoaBangali Floodplain (AEZ=4). There are four different treatments viz., T_1 = Seeding with bed planter, T_2 = Seeding with PTOS, T_3 = Seeding with strip planter and T_4 = Farmers' practice which were evaluated at randomized complete block design (RCBD) with three replications. Seed of BARI Masur-8 was sown in the unit plots with the size of 7 m × 8 m. Row to row distance of lentil was 30cm for STRIP and PTOS while 20cm for BED system. Farmer's practice experience seeding by broadcast method. The crop was fertilized with 20-18-20-10-1.5 kg ha^{-1} as form of N-P-K-S-B, respectively. Fertilizer was broadcasted in land surface. T. Aman rice residues were used and maintained height 15-20 cm and utilize the residual soil moisture. At the sowing time soil moisture was recorded around 30%. Lentil seeds were sown on 12 November 2021 and harvested on 20 March

2021. The crop was sprayed with Luna sensation 500 SC @ 1.5 g/L for two times to control Stemphylium disease. The crops were harvested from the central 3 m x 3 m area of each plot and the yields were converted to kg ha^{-1}. The data were subjected to variance analysis using the computer statistical software package R. The means separations were done by LSD at 5% levels of probability when the F value was significant.

Results and Discussion

There was yield advantages observed in lentil (Table 1) which was influenced by different tillage options. The pods per plant and the thousand seed weight more or less similar in case of all tillage options. The maximum plant height (47.33cm), number of branch/plant (16.81), pods/plant (101.57), 1000 grain weight (23.14g), grain yield (1750 kg ha^{-1}) was obtained from Bed planter tillage option followed by STRIP tillage system and the minimum plant height (43.12cm), number of branch/plant (9.37), pods/plant (82.33), 1000 grain weight (21.23g), grain yield (1518 kg ha^{-1}) was obtained from farmers' practice. The maximum stover yield was (2020 kg ha^{-1}) obtained from Bed planter tillage followed by strip tillage method. The minimum stover yield was recorded (1630 kg ha^{-1}) from the farmer's practice, i.e. normal power tiller tillage method. About 7.51 to 15.28% yield advantage was achieved from the mechanized seeding system of lentil of which Bed system resulted in 15.28% higher yield over the farmers' practice. Higher yield in machinery-based seeding systems over the farmers practice might be due to many advantages from seeding machinery as they ensured seed placement at optimum depth with proper seed ratio, unified seed germination as well as growth and development of the crop plants. Besides line seeding helped in easy intercultural operations which together ultimately contributed to the yield and yield contributing characters of the crop.The maximum gross return (Tk.129030ha^{-1}) was recorded in Bed planter tillage method due to higher yield of lentil. Cost of production was similar for Strip, PTOS and Bed planter tillage (Tk 43690 ha^{-1}) and slightly higher for farmer's practice (Tk 48760 ha^{-1}). The gross margin and benefit cost ratio (BCR) also higher in Bed planter tillage method. The maximum BCR (2.95) were obtained from the treatment Bed planter tillage method followed by STRIP and PTOS system and the minimum from the farmers' practice a traditional cultivation system (Table 2).

Farmer's Opinion

Farmers are interested to grow lentil by using machinery for higher yield and economic return as well as easy intercultural operations.

Table 1. Performance of lentil under different tillage options during 2021-22 at MLT site Sonatola, Bogura

Treatment	Plant Height (cm)	Plant/m^2 (No.)	Number of Branching (No.)	Pod/ pla nt (No.)	1000 seed weight (gm)	Grain Yield (Kg ha^{-1})	Stover Yield (Kg ha^{-1})	% Yield increase over farmers practice
T_1 = Seeding with bed planter	47.33 a	132.24 b	16.81 a	101.57 a	23.14	1750 a	2020 a	15.28
T_2 = Seeding with PTOS	44.65 b	129.46 b	12.45 b	94.78 b	22.46	1632 ab	1680 b	7.51
T_3 = Seeding with strip planter	46.54 ab	130.67 b	14.68 a	98.36 ab	22.72	1642 ab	1800 ab	8.16
T_4 = Farmers' practice	43.12 b	180.41 a	9.37 c	82.33 c	21.23	1518 b	1630 b	-
CV (%)	5.53	6.37	4.73	5.13	4.08	3.48	5.05	-

Table 2. Economic analysis of lentil under different tillage options during 2021-22 at MLT site Sonatola, Bogura

Varieties	Return from grain (Tk ha^{-1})	Return from stover (Tk ha^{-1})	Gross return (Tk ha^{-1})	Total cultivation cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
T_1 = Seeding with bed planter	126000	3030	129030	43690	85340	2.95
T_2 = Seeding with PTOS	117504	2520	120024	43690	76334	2.75
T_3= Seeding with strip planter	118224	2700	120924	43690	77234	2.77
T_4 = Farmers' practice	109296	2445	111741	48760	62981	2.29

Input: Urea: 16 Tk kg^{-1}, TSP: 22 Tk kg^{-1}, MoP: 15 Tk kg^{-1}, gypsum: 10 Tk kg^{-1}, zinc sulphate: 150 Tk kg^{-1}, boric acid: 150 Tk kg^{-1}, tillage cost :10000 Tk ha^{-1}, irrigation (1 time): 1000 Tk ha^{-1} and labour: 400 Tk day^{-1} (8 hours), Lentil seed: 120 Tk kg^{-1}
Output: Lentil seed: 72 Tk kg^{-1}, Lentil stover: 1.5 Tk kg^{-1}.

Conclusion: It is revealed that the Bed planter tillage methods performed better. It may be disseminated for farmers' field in Bogura region for lentil cultivation.

EFFECT OF PLANTING TIME ON SWEET POTATO IN CHAR LAND CONDITION

ABDULLAH-AL-MAHMUD AND MD JAHANGIR ALAM AND MD MAZHARUL ANWAR

Abstract

The experiment was conducted by OFRD, BARI at Chinirpotol char of Saghata, Gaibandha, during the rabi season of 2021-22 to find out the suitable planting time of sweet potato vines and increase the productivity in char land condition. Three sowing dates were compared: T1: 15 October, T2: 30 October, and T3: 15 November along with three sweet potato varieties: V1: BARI Mistialu-8, V2: BARI Mistialu-12, and V3: Local following the RCBD (factorial) design. Higher root yield was recorded from BARI Mistialu-8 (37.6 t ha^{-1}) when the vines were planted on 15 October followed by BARI Mistialu-12 (35.6 t ha^{-1}).. The root yield of sweet potato was significantly decreased with late plantated from 15 October. The root yield was decreased by 17-19.9% in BARI Mistialu-8 and by 7.4-13.8% in BARI Mistialu-12 for every 15 days of late vine plantating from 15th October. Considering the variety, BARI Mistialu-8 and BARI Mistialu-12 produced 62% (avr. 31.9 t ha^{-1}) and 53% (aver. 30.2 t ha^{-1}) more yield compared to the local sweet potato variety (avr. 19.7 t ha^{-1}).

Introduction

Sweet potato (*Ipomoea batatas* L.) is the fourth most important food crop in Bangladesh after rice, wheat, and Potato (Delowar and Hakim, 2014). Sweet potato is rich in many vitamins and minerals as well as beneficial fibers (Bovell-Benjamin, 2007). It provides 438% and 37% of the daily value of vitamin A and C, as well as vitamin B, manganese, copper, and iron (Szalay, 2017). At present, children in rural and char areas (1-6 years of age) in Bangladesh are at high risk for night blindness due to vitamin A deficiency, which affects 2% of all children. Moreover, an average of about 88 children are blinded every day (Banglapedia, 2019). Sweet potato is mainly cultivated by marginal or subsistence farmers in various river belts, char lands, delta islands, and seasonal flood plains (Ahmed *et al*., 1998). It yields satisfactory under adverse climates and soil conditions as well as the use of minimum inputs (Ndolo *et al.,* 2001).Total production of sweet potatoes in Bangladesh has increased by 3.16% and the area by 1.94% (FAOSTAT, 2015; 2017). Currently, about 245719 t of sweet potato is being produced from an area of 24553 ha of land with an average of 10 t ha-1 (BBS, 2020). The average yield is very low in Bangladesh compared to many tropical to subtropical countries due to the cultivation of local and low-quality native sweet potato varieties (FAOSTAT, 2017). BARI has developed some high-yielding sweet potato varieties with improved management production techniques which are important in increasing the yield and income of sweet potato growers (BARI, 2019). The climatic condition of northern Bangladesh is suitable for sweet potato production. In Char areas. fFarmers are usually grow sweet potato starting from October after the floodwater receded and continued up to the end of December. There has no specific suitable time recommendation for sweet potato vine plantation in char areas . Considering this point of view, a time sowing experiment has been undertaken at farmers' fields to find out a suitable plantating time for sweet potato in char lands.

Materials and Methods

An On-Farm trial of sweet potato was conducted at Chinirpotol char of Saghata, Gaibandha during 2021-22. The experiment was laid out in a RCBD (Fatorial) design with six dispersed replications. Three sowing dates were compared: T1: 15 October, T2: 30 October and T3: 15 November along with three sweet potato varieties: V1: BARI Mistialu-8, V2: BARI Mistialu-12, and V3: Local,maintaining 60 cm X 25 cm spacing. Manures and fertilizers were applied at the rate of 10 t ha^{-1}cowdung and $N_{80-120}P_{25-35}K_{80-120}S_{10-15}Zn_2B_1$ ha^{-1}, respectively in the form of urea, TSP, MoP, gypsum, zinc sulfate, and boric acid. Fifty percent of N, K, and a full dose of other fertilizers were applied during final land preparation. The rest amount of the N and K fertilizers were applied at 30--35 DAP (FRG, 2018). The crop was harvested on 1 March 2022 and continued up to 30 March 2022. The root yield and yield components of sweet potato were recorded and analyzed statistically using STAR software at 5% level of significance ($p<0.05$).

Result and Discussion

There was a significant interaction between sowing time and variety on root yield of sweet potato but no effect on vine plant^{-1}, Plant density m^{-2}, root plant^{-1}, root weight plant$^{-1,}$ and individual root weight (Table 1 and 2). The maximum root yield (37.6 t ha^{-1}) was produced by BARI Mistialu-8 on 15 October due to higer root yield plant^{-1} (524.2 g) and individual root weight (72.1 g) that was statistically similar to BARI Mistialu-12 (35.6 t ha^{-1}) with the same vine plantating date. Late planting since October 15 has resulted in a significant reduction in sweet potato root yield. Due to late planting every 15 days from 15th October, the root yield has been decreased by 17-19.9% in BARI Mistialu-8 and by 7.4-13.8% in BARI Mistialu-12.

Considering the variety, BARI Mistialu-8 produced 51-71% (or 9.1-15.6 t ha^{-1}) with an average of 61% and BARI Mistialu-12 produced 17-19% (8.6-13.6 t ha^{-1}) with an average of 17% more root yield compared to the local sweet potato variety (17.8-22.0 t ha^{-1}). The reason for more root yield produced by BARI Mistialu-8 and BARI Mistialu-12 is due to highest root weight plant-1 (521.6-524.2 g) and individual root weight (65.1-72.1 g), but despite the smaller number of roots, it did not have much effect on the yield.

Table 2. Root yield and yield components of sweet potato at char areas of Saghata, Gaibandha during 2021-22

Sowing time	Vine plant^{-1}	Plant density (no.m^{-2})	No. of root plant^{-1}	Root weight plant^{-1} (g)	Individual root weight (g)
15-Oct	5.14	6.22	8.37	513.9 a	63.3 a
30-Oct	5.16	5.94	8.06	444.8 b	57.4 ab
15-Nov	5.22	5.64	8.20	421.1 b	52.6 b
Variety					
BARI Mistialu-8	5.50 b	6.07	8.01 b	524.2 a	72.1 a
BARI Mistialu-12	6.11 a	5.81	7.31 c	521.6 a	65.1 a
Local	3.93 c	5.93	9.31 a	334.0 b	36.1 b
Sowing time	ns	ns	ns	53.4	7.8
Variety	0.60	ns	0.52	53.4	7.8
Sowing time × Variety	ns	ns	ns	ns	ns
CV (%)	11.49	8.23	6.38	11.62	13.55

Table 3. Interaction effect of sowing time and variety of sweet potato at char areas of Gaibandha during 2021-22

Sowing time	Variety		
	Root yield (t ha^{-1})		
	BARI Mistialu-8	BARI Mistialu-12	Local
15-Oct	37.6 a	35.6 a	22.0 a
30-Oct	31.2 b	28.5 b	19.3 ab
15-Nov	26.9 c	26.4 b	17.8 b
LSD (0.05)	2.89		
CV (%)	6.14		

Conclusion

It may be concluded that15 October is the best time for sweet potato vine plantation in the char land area of Gaibandha. This is the first-year experiment and should be continued for the next year for final recommendation.

PERFORMANCE OF WATER HYACINTH RESIDUE AS AN ORGANIC MANURE FOR CAULIFLOWER PRODUCTION AT AEZ-14

M M HOWLADER

Abstract

The experiment was conducted at FSRD site, Gopalganj and Nazirpur, Pirojpur during rabi season 2021-`22 to access the performance of water hyacinth as an organic source for production of cauliflower. There are four doses of different organic fertilizer viz. T_1= RDCF (Recommended dose of chemical fertilizers) + 5 t ha^{-1} cowdung (control), T_2= RDCF + 5 t ha^{-1} water hyacinth residue, T_3= RDCF + 8 t ha^{-1} water hyacinth residue, T_4= RDCF + 11 t ha^{-1} water hyacinth residue as treatment. Result revealed that treatment T_1 gave the maximum card yield (44.69 t ha^{-1}) with 5 t ha^{-1} cowdung but statistically similar yield (43.28 t ha^{-1}) by T_4 treatment where residue of water hyacinth was used 11 t ha^{-1} with recommended chemical fertilizer. The lowest yield (34.03 t ha^{-1}) was observed in T_2 treatment where 5 t ha^{-1} residue of water hyacinth used. The highest gross return (893800 Tk. ha^{-1}) and BCR (3.61) was found from treatment T_1 followed by T_4 treatment with gross return and BCR (865600 Tk. ha^{-1} and 3.5), respectively.

Introduction

Farmers are using fertilizer unbalanced way that hamper soil health. Judicial use of fertilizer is necessary for conserving soil health but it is very difficult to maintain for deficit of organic manure like cowdung. But the residue of water hyacinth is more available in Gopalganj region which can be used as alternate source of cowdung. Water hyacinth residue is the de-compost of water hyacinth. Already, farmers of this region use this residue as alternate source of organic manure for vegetable production. But till to now they have no idea actually how much residue need for a unit land area for vegetable production. Thus, the present study was taken to determine suitable amount of water hyacinth residue for vegetable production.

Materials and Methods

The experiment was conducted at FSRD site, Gopalganj and Nazirpur, Pirojpur during *rabi* season 2021-`22 to determine the amount of residue of water hyacinth as an organic source for production of cauliflower. The experiment was laid out in RCBD design with six replication. The treatments were viz. T_1= RDCF (Recommended dose of chemical fertilizers) + 5 t ha^{-1} cowdung (control), T_2= RDCF + 5 t ha^{-1} water hyacinth residue, T_3= RDCF + 8 t ha^{-1} water hyacinth residue, T_4= RDCF + 11 t ha^{-1} water hyacinth residue. The unit plot size was 4 m x 4 m. The land was fertilized with organic fertilizer (as per treatment) and N-P-K-S-Zn-B fertilizer at the rate of 60-30-50-12-1.2-1 kg ha^{-1}. Seedling were transplanting at 27 and 30 November 2021 with 60 cm × 40 cm spacing. Half N fertilizer and full dose of others fertilizer were applied as basal and remaining N was top dressed at 15, 30 and 45 days after transplanting. All the intercultural operations were done as and when necessary. The crop was harvested at 27 January to 12 February 2022. Data on yield and yield contributing characters were taken and statistically analyzed with MSTAT-C software.

Table-1. Initial soil nutrient status of experiment field at Gopalganj and Pirojpur district during *rabi* season in 2021-`22

Location	pH	OM%	Ca (meq/ 100g)	Mg (meq/ 100g)	K (meq/ 100g)	Total N%	P (ppm)	S (ppm)	B (ppm)
Sadar, Gopalganj	6.09	6.19	17.8	1.46	0.046	0.33	6.0	31	0.30
Najirpur, Pirojpur	7.2	4.5	10.6	3.21	0.093	0.22	5.7	26	0.28

Results and Discussion

A significant variation was found in different dose of organic fertilizer (Table-2).The maximum plant height (51.18 cm) was found from cowdung 5 t ha^{-1} (T_1) but statistically similar height

(49.95 cm) by T_4 treatment where residue of water hyacinth was used 11 t ha^{-1} as an organic fertilizer with recommended chemical fertilizer. The lowest plant height (40.78 cm) was recorded from treatment T_2 .Curd length, curd diameter and single curd wt. was found highest from the same treatment (T_1) which was 14.47cm, 20.61 cm and 1.66 kg, respectively followed by similar length, diameter and single curd wt. from T_4 i.e., 13.93cm, 19.15 cm and 1.61 kg, respectively. The lowest curd length, diameter and single curd wt. were found from T_2.. The treatment T_1 gave the highest yield (44.69 t ha^{-1}), plant height, curd length, curd diameter and single curd weight but identical to T_4 (43.28 t ha^{-1}) but the lowest yield (34.03 t ha^{-1}) was recorded from T_2 due to lower yield contributing characters.

Economic analysis

The highest gross return (Tk. 893800 ha^{-1}), gross margin (Tk. 646455 ha^{-1}) and BCR 3.61 were observed from T_1 followed by T_4 treatment where its gross return, gross margin and BCR were 865600 Tk. ha^{-1}, 646455 Tk. ha^{-1} and 3.5, respectively. The lowest gross return (Tk. 680600 ha^{-1}), gross margin (Tk. 451630 ha^{-1}) and BCR 2.97 were observed from T_2 .(Table-3).

Table-2. Effect of different doses of water hyacinth residue on yield and yield contribution characters of cauliflower at Gopalganj region during *rabi* season in 2021-`22

Treatment	Plant height (cm)	Curd length (cm)	Curd diameter (cm)	Single curd wt.(kg)	Curd yield (t ha^{-1})
T_1	51.18	14.47	20.61	1.66	44.69
T_2	40.78	10.39	15.19	1.31	34.03
T_3	44.12	11.39	17.79	1.39	37.36
T_4	49.95	13.93	19.85	1.61	43.28
CV(%)	5.66	7.05	10.17	6.53	6.3
LSD (0.05)	4.65	2.01	4.28	0.20	5.36

T_1= RDCF (Recommended dose of chemical fertilizers) + 5 t ha^{-1} cowdung (control), T_2= RDCF + 5 t ha^{-1} water hyacinth residue, T_3= RDCF + 8 t ha^{-1} water hyacinth residue, T_4= RDCF + 11 t ha^{-1} water hyacinth residue.

Table-3. Cost- benefit analysis of cauliflower production by using different doses of water hyacinth residue at Gopalganj region during *rabi* season in 2021-`22

Treatment		Gross income (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})	BCR
T_1		893800	247345	646455	3.61
T_2	34.03	680600	228970	451630	2.97
T_3		747200	233470	513730	3.20
T_4		865600	246970	618630	3.50

Cost: Cowdung -5000.00 t ha^{-1}, Water hyacinth residue -3000.00 t ha^{-1} and Price: Cauliflower-20 Tk. kg^{-1} .

Conclusion

From the study it was revealed that water hyacinth residue (11 ton ha^{-1}) best for cauliflower production as a alternate source of 5 ton ha^{-1} cowdung. For conformation the trial, needs to be conducted in next year.

EFFECT OF DIFFERENT PLANTING METHODS ON THE YIELD AND MATURITY DURATION OF SUNFLOWER IN THE HAOR AREA OF KISHOREGANJ

M. MOHIUDDIN

Abstract

A field study was conducted at Guroy, Nikli upazilla under OFRD, BARI, Kishoreganj during 2021-22, to observe the effects of different ages poly bag seedlings on yield and maturity duration of sunflower in the haor areas of Kishoreganj. The experiment was laid out in a RCBD with three replications. The treatments were i. e; a. Poly bags seedling at 7 days, b. Poly bags seedling at 14 days and c. Direct seeding. Sunflower var. BARI Surjomukhi-3 was used. Among the treatments, the highest seed yield was found from direct seeding (1.68 t ha^{-1}) followed by poly bags seedling at 7 days (1.56 t ha^{-1}) and poly bags seedling at 14 days (1.47 t ha^{-1}). The highest gross return (84000 Tk ha^{-1}), gross margin (36180 Tk ha^{-1}) and BCR (1.76) was calculated from direct seeding followed by Poly bags seedling at 7 days but maturity earlier in poly bags seedling at 14 days.

Introduction

Haor is bowl-shaped large tectonic depression and receive surface runoff water by rivers, Khals and consequently, a haor becomes very extensive water body in monsoon period. In Bangladesh, 17% of the country's land covering by haor area. Most of the farmers are haor agriculture, practicing Boro-fallow-fallow cropping pattern. They transplant boro in the last week of January to first week February. Before going to boro season, most the land remains fallow i.e; about 90 days. In some lands are high lands where haor farmers are cultivating sweet potato, chilli, maize and other vegetable crops. But mustard, sunflower can be grown in this situation. but at rabi season sunflower takes 90 to 100 days to mature that creates a problem to next boro crop. Late transplanting of boro at haor areas could be destroyed by early flash flood.. According to the Ministry of Commerce, the country imports 2.2-2.6 million tonnes of crude soybean and palm oils annually against the domestic demand of 2.2 million tones. Therefore, sunflower cultivation in the haor area could be meet up the oil scarcity in Bangladesh to a small extent. Keeping this problem in mind, the experiment has been undertaken to find out short duration variety of sunflower for haor area with higher income.

Materials and Methods

The experiment was carried out in farmer's field at Guroi, Nikli, Kishoreganj during 2021-22 to observe the performance of transplanting poly bags seedling and line sowing (Farmer's practice). Three treatments were viz; i) Transplanting poly bags seedling at 7 days, ii) Transplanting poly bags seedling at 14 days and iii) Direct line sowing (Farmer's practice). The design was RCB with three dispersed replications. The variety was BARI Surjomukhi-3. In Polybags 6:1 ratios of soil and poultry manure mix soil media was filled up with 250 g soil containing poly pack followed by seed sowing at 2-3 cm depth. For the seedling establishment, the poly bags 7 days and the poly bags 14 days were sown in 15 November 2021 and 08 November 2021. Again, transplanting and sowing (Farmers practice) were executed followed by 60 cm × 25 cm spacing in 10 m x 8 m individual plots on 21 November 2021. The seeds rate was 28 kg ha^{-1} in farmers practice and 25 kg ha^{-1} for transplanting purposes. Fertilizer dose was N_{92} P_{36} K_{70} S_{27} $Zn_{3.7}$ $B_{1.7}$ Kg ha^{-1}. One-third urea and all others fertilizers were applied as basal during final land preparation. The remaining one-third urea was applied as a top dress at 35 DAS and the rest of urea was applied at 60 DAS. Three irrigations were used. All intercultural operations were done as and when necessary. In case of cutworm infestation, Karate was used three times at the rate of 1.5 ml L^{-1} water. The 7 days poly bags seedlings, 14 days poly bags seedlings and direct line sowing (Farmer's practice) crops ware harvested at 07 February/2022, 22 January/2022 and 25 February/2022 after the maturity of flowers. Data recorded on yield, and yield-contributing characters were subjected to statistical analysis by (LSD) Statistix 10 for windows 1998. Analytical software. Tallahassee, SLA, USA.

Results and Discussion

Seed yield and yield contributing attributes of sunflower were influenced significantly by the different planting system (Table 1). The maximum plant height was found at poly bags seedling at 14 days (83.21 cm) followed by farmer's practice (82.76 cm) and poly bags seedling at 7 days (79.2 cm). The highest head diameter was found in farmer practice (12.23 cm) and the lowest from poly bags seedling at 7 days (10.50 cm). The highest weight of head (163.58 gm) and seed/ head (283.51 .) was found at farmer practice and the lowest from poly bags seedling at 7 days (128.62 gm) and (252.12.), respectively. The highest seed weight/head was found at farmer practice (18.34 gm) and the lowest from poly bags seedling at 14 days (16.42 gm). The maximum

1000- grain weight was found from poly bags seedling at 7 days (62.34 gm) and minimum from farmer practice (60.17gm). The highest seed yield was obtained from farmer practices (1.68 t ha^{-1}) and the lowest from poly bag seedling at 14 days (1.47 t ha^{-1}). The yield contributing characters showed superiority at farmers practice because of lifetime difference. According to the planting method, total field duration was found highest in farmers practice (96 days) followed by poly bags seedling at 7 days (84 days) and poly bags seedling at 14 days (75 days). Though the farmers practice had higher yield potential (1.68 t ha^{-1}) but it had long field duration (12-21 days more) than other treatments.

Farmers' opinion

Since sunflower cultivation is totally new in the haor area thus farmers are very much keen to grow dwarf type and short duration sunflower variety for next crop like jute or kenaf.

Table 1. Seed yield and yield contributing characters of sunflower under different planting methods during 2021-22

Treatments	Plant height (cm)	Head dia. (cm)	Wt. of head (gm)	Seed/ head (No.)	Seed wt/head (gm)	1000-seed wt. (gm)	Seed Yield (t ha^{-1})	Duration (days)
Poly bags seedlings at 7 days	79.2	10.50	128.62	252.12	17.61	62.34	1.56	84
Poly bags seedlings at 14 days	83.21	12.13	162.03	270.10	16.42	60.17	1.47	75
Direct seeding	82.76	12.23	163.58	283.51	18.34	61.05	1.68	96
CV (%)	3.03	7.59	6.91	1.46	1.43	3.81	5.03	-
LSD (0.05)	5.43	2.11	24.04	9.01	0.67	5.18	0.31	-

Table 2. Cost benefit analysis of sunflower in different planting methods during 2020-21

Treatments	Gross return (Tk ha^{-1})	TC (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
Poly bags seedlings at 7 days	78000	50730	27270	1.54
Poly bags seedlings at 14 days	73500	50730	22770	1.45
Direct seeding	84000	47820	36180	1.76

Conclusion

Sunflower var. BARI Surjomukhi is an promising oilseed crop for the upper catena of haor areas. If seeds are available to the farmers within September in haor area then they will cultivate sunflower. But, farmers' need training on package technology of sunflower production.

EFFECT OF PLANTING METHODS ON THE YIELD OF GINGER

M. A. ISLAM, M.M. ZAMAN, R. ARA AND S. ZAMAN

Abstract

The experiment was conducted at in the farmer filed of Fulbaria under Mymensingh district during of 2021-2022 to find out the effect of planting methods and varieties on the growth and yield of ginger. The treatments were : Ginger variety i) BARI Ada-1 (V_1), ii) BARI Ada-2 (V_2), iii) BARI Ada-3 (V_3), iv) Advanced line (V_4), and local cultivar (V_5); and planting methods: i) Ridge method (M1), ii) Furrow method (M2), iii) Flat method (M3). Ginger varieties had significant influence on all the parameters. The highest rhizome yield (16.7 t ha^{-1}) was produced by advanced line followed by BARI Ada-2 while the lowest yield (14.1 t ha^{-1}) produced by BARI Ada-1. Planting method also significantly influenced the growth of plant. The highest rhizome yield (19.8 t ha^{-1}) produced by ridge method followed by furrow method while the lowest yield (17.0 t ha^{-1}) produced by flat method. The highest gross return (Tk. 1002000 ha^{-1}) and gross margin (Tk.683700 ha^{-1}) was recorded from advanced line might be

due to higher yield potentiality. The lowest gross return (Tk. 846000.00 ha^{-1}) and gross margin (Tk.527700 ha^{-1}) was recorded from BARI Ada-1. Out of three methods, the highest gross return (Tk. 1188000ha^{-1}) and gross margin (Tk. 869700 ha^{-1}) was recorded from ridge method might be due to higher yield potentiality. The lowest gross return (Tk. 1020000.00 ha^{-1}) and gross margin (Tk.7011700.00 ha^{-1}) was recorded from flat method.

Introduction

Ginger (*Zingiber officinale* Rosc.) belonging to the family Zingiberaceae is one of the most important spice crops in Bangladesh. Ginger, which is a herbaceous perennial, usually grown as an annualIn Bangladesh about 10280 hectares of land is under ginger cultivation with an annual production of 81715 metric tons (BBS, 2020). The main production regions of Bangladesh are Chittagong, Khagrachari, Bandarban,Rangamati, Tangail, Mymensingh, Dhaka and Rangpur. The average yield of ginger in the farmer's field of Bangladesh is lower compared to other countries like Japan, China and Nepal. Islam *et al.,* (2012) was found 2.17 benefit cost ratio (BCR) while studying the performance of ginger cultivation in Khagrachari district of Bangladesh and also concluded that appropriate use of input, proper technical efficiency can improve the yield by 15%. The farmers of Fulbaria upazilla under Mymensingh district cultivate ginger following traditional method with local cultivar with low yield potentiality. BARI have already released three ginger varieties; BARI ada-1, BARI Ada-2 and BARI Ada-3 with higher yield potential. (20-25 t ha^{-1}) against local cultivar yield (10-15 t ha^{-1}). So, cultivation of BARI variety with improve planting method may increase the yield and income of the farmer. Moreover, the performance of BARI variety with improve planting method needs to be evaluated at farmers field condition

Material and Methods

The trial was conducted at Fulbaria, Mymensingh during 2021-22. The treatments were Ginger variety : i) BARI Ada-1 (V_1), ii) BARI Ada-2 (V_2), iii) BARI Ada-3 (V_3), iv) Advanced line (V_4), and local cultivar (V_5); and planting methods: i) Ridge method (M1), ii) Furrow method (M2), iii) Flat method (M3). The experiment was laid out in the Randomized Complete Block Design (Factorial) with three replications. The unit plot size was 2 m × 2 m . The experimental plot was well prepared with ploughing followed by laddering using power tiller. The seeds of ginger were sown on 12 April 2021 with a spacing of 50 cm × 25 cm. Before sowing, seeds were treated with fungicide Bavistin @0.2% to prevent seed and soil borne diseases. The field was fertilized with 140-54-117-20-1 Kg N-P-K-S-Zn-B ha^{-1}, respectively and 5 ton cow dung per hectare. The entire cow dung, P, S, Zn & half of K were applied as basal. Half of N was applied at 50 DAP. Rest amount of N and K were applied as two installments at 80 and 110 DAP, respectively. Three weeding were done on 25, 50 and 100 days after sowing. Other intercultural operations were done as and when necessary. The crop was harvested on 15, January 2022 when the leaves turned yellow and started to dry. Economic analysis was done on the basis of prevailing market price of the commodities. Data on yield and yield contributing characters were taken and statistically analyzed with MSTAT-C software.

Results and Discussion

Effect of varieties: Ginger varieties had significant influence on different parameters (Table 1). The highest plant height (50.6cm), number of tillers per hill (14.4), weight of primary rhizome (57.1g) per plant, weight of secondary rhizome (254 g) per plant, total weight of primary and secondary rhizome (321 g) per clump, and the highest rhizome yield (16.7 t ha^{-1}) produced by advanced line followed by BARI Ada-2 while yield contrfibuting characters lower as well as yield (14.1 t ha^{-1}) by BARI Ada-1.

Effect of planting method: Planting method significantly influenced the parameters (Table 2). There was trend to increase in plant height in furrow method (46.40 cm) followed by flat method (45.37 cm) and ridge method (44.33 cm). Number of tillers per hill (14.23), weight of primary rhizome (56.3) per plant, weight of secondary rhizome (274.6 g) per plant, total weight of primary and secondary rhizome (330.9 g) per clump, and the highest rhizome yield (19.8 t ha^{-1}) produced by ridge method followed by furrow method while the lowest yield attributes as well as yield

(17.0 t ha^{-1}) produced by flat method. It is fact that in the ridge method, the soil texture is loos and friable, so that the soil aeration is maximum in the flat method as result soil was more compact and soil aeration was minimum.

Cost and return analysis

The gross return and gross margin were varied among the varieties (Table 3). Out of five varieties, the highest gross return (Tk. 1002000 ha^{-1}) and gross margin (Tk.683700 ha^{-1}) was recorded from advanced line might be due to higher yield potentiality. The lowest gross return (Tk. 846000 ha^{-1}) and gross margin (Tk.527700 ha^{-1}) was recorded from BARI Ada-1. The gross return and gross margin were also varied among the planting method (Table 4). Out of three methods, the highest gross return (Tk. 1188000 ha^{-1}) and gross margin (Tk. 869700 ha^{-1}) was recorded from ridge method might be due to higher yield potentiality. The lowest gross return (Tk. 1020000 ha^{-1}) and gross margin (Tk.7011700 ha^{-1}) was recorded from flat method.

Farmers' are interested to grow the advanced line and BAR Ada-2 with ridge and furrow method for its higher yield potentiality and economic return.

Table 1. Effect of varieties on yield and yield attributes of ginger

Treatments	Plant height (cm)	No of tiller hill^{-1}	Weight of primary rhizome hill^{-1} (g)	Weight of secondary rhizome hill^{-1} (g)	Total weight of rhizome hill^{-1} (g)	Rhizome yield (t ha^{-1})
BARI Ada-1 (V_1)	42.0	12.2	48.2	235	294	14.1
BARI Ada-2 (V_2)	47.3	13.8	54.7	267	309	16.2
BARI Ada-3 (V_3)	39.3	13.1	50.1	245	305	14.7
Advanced line (V_4)	50.6	14.4	57.1	279	321	16.7
local cultivar (V_5)	40.9	13.5	52.1	254	317	15.3
LSD ($_{0.05}$)	3.04	0.16	1.21	5.83	3.77	0.31
CV (%)	3.68	0.65	1.23	1.21	0.64	1.09

Table2. Effect of planting methods on yield and yield attributes of ginger

Treatments	Plant height (cm)	No of tiller hill^{-1}	Weight of primary rhizome hill^{-1} (g)	Weight of secondary rhizome hill^{-1} (g)	Total weight of rhizome hill^{-1} (g)	Rhizome yield (t ha^{-1})
Ridge method (M1)	44.33	14.23	56.3	274.6	330.9	19.8
Furrow method (M2)	46.40	13.45	52.8	258.1	310.9	18.7
Flat method (M3)	45.37	12.43	48.1	234.7	282.8	17.0
LSD ($_{0.05}$)	0.57	ns	4.2	20.9	25.2	1.5
CV (%)	0.55	6.5	3.6	3.6	3.6	3.6

Table 3. Cost and return analysis on Ginger varieties

Treatments	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Ada-1 (V_1)	846000	318300	527700
BARI Ada-2 (V_2)	972000	318300	653700
BARI Ada-3 (V_3)	882000	318300	563700
Advanced line (V_4)	1002000	318300	683700
local cultivar (V_5)	918000	318300	599700

Table 4. Cost and return analysis on planting methods

Treatments	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Ridge method (M1)	1188000	318300	869700
Furrow method (M2)	1086000	318300	767700
Flat method (M3)	1020000	318300	7011700

Price of input and output: Urea: 16 Tk. kg^{-1},TSP: 22 Tk. kg^{-1}, MOP: 15 Tk. kg^{-1}, Gypsum: 12 Tk. kg^{-1}, Zinc sulphate: 150 Tk. kg^{-1}, Boric acid: 240 Tk. kg^{-1}, Market price of Ginger 60 Tk. kg^{-1}.

Conclusion

Advanced line and BARI Ada-2 with ridge performed better over other varieties and planting method. This is first year trial. It may be repeated one year more for final recommendation.

PERFORMANCE OF GARLIC WITH ZERO TILLAGE METHOD IN COASTAL REGION

M M ISLAM, KN ISLAM AND MSI KHAN

Abstract

An experiment was conducted at MLT site Bauphal, Patuakhali in the Rabi season of 2021-22 to find out the performance of garlic production under zero tillage condition. Two types of sowing methods i.e. T_1 = Sowing in zero till field and T_2 = Sowing in ploughed field (traditional) was tested in the trial. The significant influence was found on yield and yield contributing traits of garlic. It was observed that all the studied traits were higher in zero-tillage condition. Plant establishment was higher in zero tillage plots as the plants absorbed required moisture during early growing stage. The highest bulb yield (7.23 t ha^{-1}) was obtained from zero tillage field compared to tillage system (6.49 t ha^{-1}). Zero tillage system also gave the highest gross return (Tk. 361500) and gross margin (Tk. 263500) as its production cost was lower than tillage system.

Introduction

Garlic (*Allium sativum* L) is an aromatic herbaceous plant and the second most widely used Allium after onion (Bose and Som, 1990). This crop is extensively cultivated in many countries of the world including Bangladesh as a popular spice crop. Garlic is a rich source of carbohydrate and phosphorus (Rahman *et al.,* 2007). The average yield of garlic in this country is only 5.21 t ha^{-1} (BBS, 2012). The poor yield of garlic may be due to the lack of inadequate soil and water management practices with reference to soil water shortage in the soil profile. Zero tillage crop production need low water requirement and other cultural practices. Fallow – Fallow - T. Aman is the major cropping pattern in coastal region where some lands remain fallow in Rabi due to excessive moisture in the field. In these lands, garlic may be cultivated in zero tillage for higher yield and benefit.

Materials and Methods

The trial was conducted at MLT site Bauphal, Patuakhali in the rabi season of 2021-22 to observe the performance of garlic under zero tillage condition. Two types of sowing methods i.e. T_1 = Sowing in ploughed field (traditional) and T_2 = Sowing in zero till field was tested in the trial. The experiment was laid out in randomized complete block design with 3 dispersed replications. The unit plot size was 8m x 5m. Local garlic variety was used as the test crop. The crop was planted at a spacin15 cm x 10 cm on the muddy soil just 2 to 3 days after harvesting T. aman rice. Then the muddy soil surface was covered by rice straw. Planting was done manually using one clove per hole. The crop was fertilized with N_{155}-P_{35}-K_{125}-S_{20} kg ha^{-1}. One third nitrogen was applied as basal and two third was top dressed in two equal installments at 25 and 50 days after planting. Other fertilizers were applied on the muddy soil as basal before planting and covering the soil surface by rice straw. In case of tillage system, the experimental plots were ploughed by a power tiller followed by laddering up to a depth of 10 cm were done until the desired depth was achieved for planting the clove. The plots were fertilized as zero tillage system.. The crop was planted on 02 December 2021 and harvesting was done on 10 April 2022 when the plants reached maturity showing the normal sign of drying out of most of the leaves and the top leaves started drying and natural dropping at the neck.

Results and Discussion

It was observed that the emergence of clove, plant height and leaf number was significantly influenced by planting systems. In zero tillage plot, the emergence of clove (89%), plant height (49.74cm) was higher than tillage plots (emeregence: 82% and plant height: 47.31cm). The effects of planting system on bulb diameter were significant and higher in traditional planting system. Bulb diameter was higher in tillage (7.98 cm) compared to zero-tillage (7.34 cm). The effects of planting system on number of cloves per bulb were insignificant. The highest bulb yield was found in zero-tillage (7.23 t ha^{-1}) compared to tillage (6.49 t ha^{-1}) system (Table 1). In zero-tillage system, straw mulch was used after planting of cloves which help to conserved soil moisture as well as suppressed weed infestation therefore vegetative growth of plant was improved. Zero-tillage system helps to increase water and fertilizer use efficiency of crop as a results yield increase as compared to tillage condition (Triplett Jr & Dick, 2008). Zero tillage with mulch using water hyacinth (Kabir *et al.,* 2011) and rice straw (Islam *et al.,* 2015) significantly retained soil moisture and suppressed weed growth which enhanced crop growth and development (Karaye & Yakubu, 2006). Jamil *et al.* (2005) reported that straw mulch increased yield and yield contributing traits of garlic. From the economic point of view, the highest gross return (Tk.361500 ha^{-1}), gross margin (Tk.263500 ha^{-1}) and BCR (3.68) was recorded from Zero tillage method and the lowest return (Tk.32500 ha^{-1}) was recorded from tillage system wiyh BCR (2.95), respectively.

Farmers Opinion

Farmers opined that this practice is new in the area but satisfactory yield in zero tillage garlic cultivation could be obtained. They also opined to continue this low cost technology for garlic cultivation practice next year to increase garlic area in the region.

Table 1. Plant populations, growth and yield contributing parameters of Garlic at Bauphal, Patuakhali during 2021-22.

Variety	Emergence at 30 DAP (%)	Plant height 80 DAP (cm)	Bulb diameter (cm)	Cloves/bulb (No.)	Bulb yield (t ha^{-1})
T_1	82	47.31b	7.98b	13.76b	6.49b
T_2	89	49.74a	8.05a	14.89a	7.23a
t- value	NS	0.045	0.48	0.046	0.07

Table 2: Economic analysis of Garlic at Patuakhali during 2021-22

Variety		Gross Return (Tk. ha^{-1})	Total Cost (Tk ha^{-1})	Gross Margin (Tk. ha^{-1})	BCR
T_1		324500	110000	214500	2.95
T_2		361500	98000	263500	3.68

Garlic Price (Tk/kg) = 50

Conclusion

In zero-tillage system, seeds/bulbs are planted directly into untilled soil which contains previous crop residues. This system minimizes soil disturbance and allow crop residues to remain on the soil. It offers plants to absorb soil moisture for their initial development. Furthermore, zero-tillage conserved soil moisture during the entire growth period of crop as mulch is used. In these ways, zero tillage reduce irrigation frequency for garlic production consequently production cost reduced. Available moisture at the root zone enhanced vegetative growth and ultimately improved yield in the zero-tillage system. This technology may be recommended for coastal region.

EFFECT OF DIFFERENT SOWING DATES ON THE YIELD OF MUNGBEAN IN COASTAL AREA

KN ISLAM, MM ISLAM AND MSI KHAN

Abstract

The experiment was conducted at Keoyabunia, Amtoli, Borguna during late rabi season of 2021-22 to find out suitable sowing date for increasing yield in coastal area.. Mungbean var.BARI Mung-6 was used.The treatment consisted of three sowing dates (20 January, 30 January and 9 February). The yield and yield contributing characters of mungbean plant was significantly affected by the different sowing dates. January 20 sowing seeds produced maximum pods/plant (20.53), number of seeds/pod (11.67), 1000-seed weight (51.53 g), seed yield (1.73 t ha^{-1}), stover yield (3.03 t ha^{-1}) and harvest index (37.86 %) .. The seed yield decreased by 2.31 and 27.75% when seed sown early (20 January) or late (9 February) due to lower yield components. The maximum gross return (Tk. 112450 ha^{-1}) was obtained from T_2 as well as gross margin (Tk. 70900 ha^{-1}) and BCR (2.71) from same treatment. The lowest gross return was recorded from T_3 (Tk. 81250 ha^{-1}) with BCR (1.96).

Introduction

Effort was made to introduce mungbean in the late rabi season in southern Bangladesh.. Mungbean (*Vigna radiata* L.) is an important cash crop which can be successfully cultivated under rainfed conditions during late Rabi season in the coastal areas of Bangladesh. After harvesting T.aman, there is a huge potential for expansion mungbean in this region. However, various factors are responsible for the successful yield of mungbean at farmer's field such as, awareness of farmer about sowing date, using high yielding variety, proper planting system , proper plant protection measures and balanced application of fertilizers. Among the various agronomic practices, sowing date is the most important factor influencing the yield of mungbean. It affects duration of vegetative, reproductive and maturity period of mungbean (Soomro and Khan 2003), and on the other hand, helps in realizing potential yield (Singh *et al.* 2010). Sowing date adjustment may help to overcome the problem of increasing the yield of the crop partially. Mungbean is also drought tolerant and can grow with a minimum supply of nutrients. However farmers are still following traditional method of cultivation i.e. traditional variety seeds, without fertilizer , weeding, insect control measure etc. as a result their yields are low. As ecology of southern region of Bangladesh is different from other parts of the country so optimum sowing date for mungbean need to be identified for getting higher yield. Considering the above facts, the present experiment was undertaken to find out the optimum sowing date as well as ensure higher yield in coastal area.

Materials and Methods

The experiment was conducted at Keoyabunia, Amtoli, Borguna during late rabi season of 2021-22 in farmer's field during January to April 2022. The treatment comprised of three dates of sowing: 20 January (T_1), 30 January (T_2) and 9 February (T_3). Mungbean var. BARI Mung-6 was used as experimental material. The seed rate @ 30 kg ha^{-1} was used. The experiment was laid out in RCB design with 3 dispersed replications having unit plot size 8 m x 5 m. Seeds were sown according to plots in line 30 cm apart. The land was fertilized with N_{23}, P_{17} and $K_{17.5}$ kg ha^{-1} at the time of final land preparation. Weeding was done at 15 days after sowing followed by thinning to keep plant to plant distance of 10 cm. Other intercultural operations were done as and when necessary to ensure normal growth of crops. Plant protection measures were taken as required. In addition, Imitaf and Coragen was sprayed @ 0.5 ml L^{-1} to control insect pests such thrips and pod borers, respectively. The crops were harvested by hand picking of pods at different dates as per maturity. Seed yield was recorded at 10-12% moisture content. The seed yield and other relevant data were recorded and analyzed statistically.

Results and Discussion

Significant variation was found in case of plant height among the different days of sowing. Plant height ranged from 26.03 to 28.47 cm. The maximum plant height was recorded in T_3 (9

February) which was statistically similar to T_2 (30 January). The shortest plant was recorded in T_1 (20 January). Plant height increased gradually with delay in sowing due to increased temperature as reported by Poehlman (1991).

Seed yield of mungbean was significantly influenced by sowing date (Table I). Results revealed that treatment T_2 (30 January) sowing produced the highest seed yield, which resulted from the highest number of pods/plant (20.53), seeds/pod (11.67) and 1000-seed weight (51.33 g) than the other days of sowing. The T_3 (9 February) treatment gave significantly lower yield contributing characters. The maximum seed yield (1.73 t ha^{-1}) was obtained from sowing on 30 January followed by 20 January (1.69 t ha^{-1}) might be due to suitable temperature which enhanced the vegetative as well as reproductive growth of the crop and lowest from 9 February (1.25t ha^{-1}).. Similar trends were recorded from stover yield (t ha^{-1}). Treatment T_2 and T_1 produced statistically similar harvest index (37.86 and 36.78%, respectively). Number of days required for first flowering was reduced with delay in sowing; the resultant effect might be due to increased temperature. Crop sown on 30 January required 48 days to reach first flowering stage, while crop sown on 9 February attained the same stage in 42 days only. Days required for first harvesting also followed the similar trend. The last sown crop took only 74 days to allow first harvesting, which was mainly due to earliest flowering. On the other hand, the crop sown earliest required more than 81 days for first harvesting this might be due to delayed flowering.

Cost Benefit analysis

The gross margin and benefit cost ratio (BCR) varied depending on the variable cost in treatments. The maximum gross return (Tk. 112450 ha^{-1}), gross margin (Tk. 70900 ha^{-1}) and BCR (2.71) was recorded from 30 January followed by 20 January. The lowest economic gross return was recorded from 9 February](Tk. 81250 ha^{-1}) as well as BCR (1.96).

Table 1. Yield contributing characters and seed yield of mungbean as influenced by sowing date during rabi 2021-22

Treat.	Plant height (cm)	Days to first flowering	Days to first harvesting	Number of pods/ plant	Number of seeds/ pod	1000-seed wt. (g)	Seed Yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
T_1 = 20 January	26.03b	48.33 a	81.67 a	20.33 a	10.67 ab	50.67 a	1.69 a	2.89 a	36.78 a
T_2 = 30 January	28.13a	45.33 b	78.67 b	20.53 a	11.67 a	51.33 a	1.73 a	3.03 a	37.86 a
T_3 = 9 February	28.47a	42.67 c	74.33 c	17.67 b	9.67 b	48.67 b	1.25 b	2.55 b	33.12 b
CV (%)	1.43	0.73	0.85	3.18	5.42	1.75	3.55	3.77	4.16
LSD 0.05)	0.90	0.76	1.51	1.40	1.31	1.99	0.12	0.24	3.38

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV = Coefficient of Variation

Table 2. Cost benefit analysis as influenced by sowing date during Rabi, 2020-21

Treatments	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Benefit cost ratio (BCR)
T_1	109850	41550	68300	2.64
T_2	112450	41550	70900	2.71
T_3	81250	41550	39700	1.96

Conclusion

Sowing date on 30 January could be adapted for obtaining high yield of mungbean var. BARI Mung-6 for southern region of Bangladesh.

EFFECT OF SOWING TIME ON YIELD AND QUALITY OF BRINJAL VARIETY BARI BEGUN-12

M M ISLAM, KN ISLAM AND M S I KHAN

Abstract

An experiment was conducted at MLT site Kuakata, Patuakhali in the Rabi season of 2021-22 to identify the optimum sowing time of BARI Begun 12 to obtain higher quality fruit and maximum yield under farmers' field condition.Four transplanting treatments viz., T_1=15 October , T_2= 30 October , T_3= 15 November , and T_4= 30 November was used. The result showed that early October to early November treatment gave the earliest harvest with highest fruit yield and highest harvest interval. TreatmenT$_2$ t gave maximum fruit weight (594.35gm) with highest fruit yield (46.85 t ha^{-1}) and T_4 treatment gave lowest yield (27.96 ton ha^{-1}) with shortest harvest period. From the economic point, the maximum gross return (Tk.1171250 ha^{-1}), gross margin (Tk.976750 ha^{-1}) and BCR (6.03) was recorded from T_2 treatment, followed by T_1. The lowest gross return (Tk.699000 ha^{-1}) was recorded from late transplanting and BCR (3.60).

Introduction

Bainjal is a very popular vegetable in Bangladesh. BARI has released one large fruit weight brinjal variety named BARI Begun12. The variety has already popular to the farmers and consumers for its higher yield, attractive size, shape, color and taste. But it is a winter variety and day length sensitive.The age of seedlings to be transplanted is very important for proper establishment in the field and production of good quality fruits as well as high yield. Tender aged or over aged seedlings are not suitable for better yield. Medium aged seedlings results in greater leaf area, high yield and number of fruits per plant and greater average fruit weight (Hassan, 1967). Its fruit quality and production affected by sowing time. Late showing gave low yield and poor quality fruit. So, the present experiment was taken to identify the optimum sowing time of BARI Begun 12 to obtain higher quality fruit and maximum yield.

Materials and Methods

The experiment was conducted at MLT site Kuakata, Patuakhali in the rabi season of 2021-22 to identify the optimum sowing time of brinjal var. BARI Begun 12 to obtain higher quality fruit and maximum yield under farmers field condition. Four transplanting treatment viz., T_1=15 October , T_2= 30 October , T_3= 15 November , and T_4= 30 November was used. The experiment was laid out in RCB design with three dispersed replications. The unit plot size was 8m x 2m with spacing 1m x 0.80 m was used. Seedlings were grown in the seedbed and 30 days seedling transplanted to the main field at six leaf stages. The field was fertilized with 10 t ha^{-1} Cow dung, N, P, K, S, B and Zn @ 180, 80, 120, 30, 2 and 4 kg, respectively. N, P, K, B and Zn was applied in the form of urea, TSP, MoP, gypsum, Boric acid and zinc sulphate respectively. Entire cowdung, all TSP, One third of MoP, entire gypsum, boric acid and zinc sulphate was applied during final land preparation. Urea was applied in five equal split at 7 days after transplanting, 25 , 45, 55 and 75 DAT. The remaining MoP was applied in three equal split at 25 , 45 and 55 DAT with urea. All other intercultural operations were done as and when necessary. Data on yield and yield contributing attributes were recorded and analyzed with CropStat analytical package.

Results and Discussion

Seedling growth and days of flowering varied with sowing time. 15th October transplanting gave first flowering where as 30th November gave late flowering as well as harvesting starting point. It is probably due to temperature effects which may cause pollen infertility or inhibit pollination. Maximum plant height (118.42 cm) was obtained from T_2 which was reduced gradually with time and minimum plant height (105.30 cm) from T_4 Individual fruit weight was higher in T_2, followed by treatment T_1, T_3 and T_4. Maximum fruit per plant (13.45) was found in T_2 which was statistically similar with T_3. Lowest fruit number was obtained from T_4 (8.24). The maximum fruit yield (46.85 t ha^{-1}) was obtained on 30th October transplanting which is statistically similar with 15th October transplanting (39.07 t ha^{-1}). The lowest yield was recorded 30 November transplanting (Table 2).

The maximum gross return (Tk.1171250), gross margin (Tk.976750 ha^{-1}) and BCR (6.03) was recorded from T_2 treatment, followed by T_1. The lowest gross return (Tk.699000 ha^{-1} and BCR (3.60) was recorded from late transplanting (Table 3).

Table 1. Seedling age for transplanting, flowering, Fruiting and harvesting under different treatments

Treatments	Seedling Age for Transplanting	Date of Flowering	Date of Fruit Set	Date of First Harvesting
T_1	30	20November	29October	07 December
T_2	30	29November	30October	16- December
T_3	30	14 December	22November	05- January
T_4	30	28December	5December	22-Janruary

NB. T_1=15 October transplanting , T_2= 30 October transplanting, T_3= 15 November transplanting, and T_4= 30 November transplanting

Table 2. Growth and yield parameters of BARI Begun 12 at Kuakata, Patuakhali during 2021-22

Treat.	Plant height (cm)	Single fruit weight (g)	Number of fruit plant^{-1}	Fruit yield (t ha^{-1})
T_1	115.45	572.34	10.71	39.07
T_2	118.42	594.35	13.45	46.85
T_3	105.30	500	11.37	30.18
T_4	117.68	455.73	8.24	27.96
LSD (0.05)	11.76	17.85	4.85	11.76
CV	6.84	5.74	2.75	3.25

Table 3: Cost benefit analysis ob Brinjal var. BARIBegun12 at Kuakata, Patuakhali, 2021-22

Treatments	Gross Return (Tk. ha^{-1})	Total Cost (Tk ha^{-1})	Gross Margin (Tk. ha^{-1})	BCR
T_1	976750	194500	782250	5.03
T_2	1171250	194500	976750	6.03
T_3	754500	194500	560000	3.88
T_4	699000	194500	504500	3.60

Potato Price (Tk kg^{-1}) = 2

Conclusion

The result showed that highest fruit yield could be obtained from brinjal var. BARI Begun-12 when seeds are sown in September and transplanted early to mid October. Transplanting in mid November or later may cause very poor yield may not be profitable to the farmers.

VALIDATION TRIAL OF MAIZE SEEDLING TRANSPLANTATION IN COASTAL AREA

M M ISLAM, KN ISLAM AND M S I KHAN

Abstract

The experiment was conducted at MLT site Kuakata, Patuakhali during the rabi season of 2021-2022 to establish a sowing practice for maize cultivation in fallow saline coastal area after Aman rice harvest. Seeds/seedlings of hybrid Miracle variety were sown/transplanted in two planting systems (T_1=Direct seed sowing, and T_2= 20 days old polybag seedling). The polybag seedlings establishment rate was higher (98%) and maturity 20 days earlier than direct seed sowing. The highest grain yield was obtained from seedling transplantation method (8.27 t ha^{-1}) and lowest obtained from direct seed sowing method (7.46 t ha^{-1}).

Introduction

In the southern region, huge land remains fallow in the Rabi season after harvest of T. Aman. Among these, a significant part is medium highland and the area would be about 50% of the total fallow land, where maize can be grown without competition or with a less competition with Rabi crops. The cultivable areas in coastal districts are affected with varying degrees of salinity, but there is enough area which are non-saline. The most severe difficulties for crop production in the dry regions are high concentration of toxic ions especially NaCl either in soil or in irrigation water (Ahmed, 2010). In Bangladesh, total land area and production of maize are 395500 ha and 279500 m tons, respectively (FAO, 2015). Hybrid maize varieties cultivation could be a break through option for southern region. But after T. aman harvest land become dry, crop establishment become very difficult. So, to find out a way to crop establishment polybag seedling transplantation may be an alternative. In this way, a huge fallow land in the rabi season could be under cultivation, so that socio-economic condition of the farmers would be changed. Considering the above facts, the experiment was undertaken to observe the performance of hybrid maize seedlings transplantation in coastal environment.

Materials and Methods

The experiment was conducted at MLT site Kuakata, Patuakhali, in the rabi season of 2021-22 to verify the effect of different planting method for Maize cultivation in coastal area of Patuakhali under farmers field condition. There were two different methods i.e., T_1=Direct seed sowing and, T_2=20 days old maize seedling transplantation was used. The experiment was laid out in RCB design with three compact replications having unit plot size 10 m x 10 m. Twenty days old seedlings were transplanted on 07 January 2021 and an another plot seeds sown in the same day. Crops of transplanted plots were harvested on 25 April 2022 and 13 May 2022 of seed sowing plot. Fertilizers were applied @ 250-55-110-40-5-1.5 N-P-K-S-Zn-B Kg ha^{-1} respectively. A light irrigation was done after seedling transplatation. The crop was irrigated twice at 20 DAS and 55 DAS. Weeding was done after 7 days of irrigation. Data on yield and yield contributing attributes were recorded and analyzed with CropStat analytical package.

Results and Discussion

Morphological and yield influences by planting methods in different locations are presented in Table 1-2. In seedling transplanting method, plant establishment was higher (91%) than direct seeding method (82%). Plants of direct seeding were somewhat taller than transplanting one. Plants were vigorous up to 30 days after transplanting but after 60 days the plants of both the treatments same. Tassels were produced 26-32 days earlier in transplanted plants than direct sowing plants consequently transplanted plants matured 25-30 days earlier. So, farmers get more return from transplanting field due to early cob marketing. Cob length was almost similar but due to varying number of grain/cob (448.7 & 438.7) and 1000- grain weight (280 & 285) transplanting plants gave higher yield (8.27 t ha^{-1}). From economic analysis, early market price was higher so highest gross return (Tk.181940 ha^{-1}) and BCR (1.89) was obtained from transplanting method.

Farmers' opinion:

Farmers showed interest on maize seedling transplantation as plant establishment is higher in saline soil condition and they can earn more by early marketing of cob.

Table 1. Physiological influence of different planting methods at Kuakata

Treatment	Plant establishment (%)	Plant height (cm)	Plant vigority*		Days to tasseling	Days to Maturity
			At 30 day	At 60 day		
T_1	91	199.7	2	3	41	134
T_2	82	201.1	3	3	73	119

1 = poor growth, 2 = medium growth and 3= Good growth

Table 2. **Grain** yield and yield attributes of maize as influenced by planting methods at Kuakata**.**

Treatment	Cob length (cm)	Grains/ cob (No)	1000-grain wt. (g)	Grain yield (t ha^{-1})
T_1	17.1	438.7	280	7.46
T_2	17.0	448.7	285	8.27
t-value	4.30	5.02	3	0.439

*T_1=Direct seed sowing, T_2= 2**0** days old polybag seedling*

Table 3: Economics of the treatments of the trial at Kuakata, Patuakhali during 2021-22

Treatments	Gross Return (Tk. ha^{-1})	Total Cost (Tk ha^{-1})	Gross Margin (Tk. ha^{-1})	BCR
T_1	149200	90500	58700	1.65
T_2	181940	96000	85940	1.89

Maize Price T_1- Tk. 20/kg & T_2- Tk. 22/kg

EFFECT OF DIFFERENT MULCH MATERIAL ON SOIL SALINITY AND YIELD OF COWPEA

K N ISLAM, M M ISLAM AND M S I KHAN

Abstarct

This trial was carried out at the farmer's field of Kuakata, Kalapara, Patuakhali during late Rabi season of 2021-22 to find out an effective ways to retain moisture in the soil by the use of mulching materials in winter cowpea production. Surface mulch has significant effect in reducing evaporation and decreasing soil salinity level. Different mulch materials such as T_1: no mulch, T_2: straw mulch, T_3: rice husk and T_4: polythene mulch was tested under randomized complete block design with three replications. Cowpea var. BARI Felon-1 was used . Results revealed that, polythene mulch (1.69 t ha^{-1}) significantly increased the highest seed yield of cowpea whereas the lowest (1.48 t ha^{-1}) from no mulch but higher BCR could be found from straw mulch treatment (1.49) followed by no mulch (1.37).

Introduction

Cowpea (*Vigna unguiculta* L.) is one of the important food and cash crops in Bangladesh. It is extensively uttered as 'Felon' and usually grown as a sole crop or in intercropping with other field crops such as cereals. Cowpea is an important grain legume in drier regions and marginal areas of the tropics and Sub-tropics (El Naim and Jabereldar, 2010). This crop is more salinity and drought tolerant than common bean. Moreover, cowpea grain is more or less the same as other pulses, with a relatively low-fat content and high total protein concentration. . Mulch is one of the most beneficial and simplest agronomic practices. It decreases the weed population by hindering emergence, primarily in the initial crop phase, in addition to increasing the organic matter in the soil and preventing erosion caused by rainfall (Monquero *et al.*, 2009, Pereira *et al.*, 2011). Surface-applied mulch is an effective method which provide several benefits to crop production through improving water, heat energy and nutrient status in soil, preventing soil and water loss, preventing soil salinity from flowing back to surface, and controlling weed (Bu *et al.*, 2002). In recent years some studies were conducted on the effect of rice husk in improving water holding capacity of soil. It also increased organic matter content of the soil and subsequently increased crop yield (Begum and Khan 2013). However there is no detailed report comparing the effect of straw, rice husk and polythene mulch on cowpea growth in saline area. This experiment was aimed at determining the effect of different mulch on the growing of cowpea cultivation under field situation in the saline area of Bangladesh.

Materials and Methods

This trial was conducted at Kuakata, Kalapara, Patuakhali during Rabi 2021-22 in randomized complete block design with three replications. The unit plot size was 10 m × 10 m long.. Cowpea var. BARI Felon-1 was used and sown on 5 January 2022 at the rate of 50 kg ha^{-1} in line sowing having 40 cm apart. The land was fertilized with $N_{13.82}$, P_9 and K_{15} kg ha^{-1} at the time of final land preparation as basal dose. The treatments were : T_1 = No mulch, T_2 = Straw mulch, T_3= Rice husk and T_4= Polythene mulch. All intercultural operations were done as and when necessary to ensure normal growth and development of crops. Plant protection measures were taken as required. In addition, Imitaf and Coragen was sprayed @ 0.5 ml L^{-1} to control insect pests such thrips and pod borer, respectively. The plants of polythene mulch treated plot were dying, thus pods were collected 5 days earlier than other treated plots. Mature pods of polythene mulch treated plots harvested from 29 March to 12 April 2022 and other treated plots from 4 April to 19 Apri 2022. The data were statistically analyzed and means were separated by critical difference (CD) values at 5% level of significance.

Results and Discussion

The results of yield and yield attributes of cowpea was affected by different types of mulch material (Table 1). The maximum plant height (81.33 cm) was recorded on T_4 (polythene mulch) followed by T_2 (straw mulch) and T_3 (rice husk) and the lowest (60.47 cm) in T_1 (no mulch). Different mulching materials had non-significant variation on plants m^{-2}, pod length (cm), pods plant^{-1} and seeds pod^{-1}. 1000-seed weight (g) showed significant difference among mulch materials. The maximum weight (97 g) was recorded in T_4 (polythene mulch) followed by T_2 (straw mulch) and T_3 (rice husk) and the lowest (89.67) from T_1 (no mulch). The result indicated that the effect of different mulching material on seed yield of cowpea was significantly increased than control. The highestseed yield (1.69 t ha^{-1}) was observed in T_4 (polythene mulch) followed by T_2 (straw mulch) and T_3 (rice husk) and the lowest yield (1.48 t ha^{-1}) from T_1 (no mulch).

This cost and return analysis revealed the performance of different mulching materials. Cost of production mainly varied due to the fact that the mulch material is different (Table 2). The higher gross return (101400 Tk. ha^{-1}) was obtained from T_4 (polythene mulch) but T_2 (straw mulch) treated plots gave the higher BCR (1.49) than the other treatments. This might be due to higher cost of polythene mulch materials. The treatment T_3 (rice husk) showed the lower BCR (1.21).

Effect on salinity: Salinity level of the experimental plots were from 1.1 to 1.2 dS/m during seed sowing then it increased with time up to 4.7 dS/m throughout the growing season (Figure 1).

Note that, first week of February, salinity levels decreased due to rainfall. It was observed that throughout the season the higher salinity level was observed in T_1 (No mulch).

Table 1. Seed yield and yield attributes on cowpea as affected by different mulching materials during 2021-22

Treatment	Plant height (cm)	Plant population m^{-2}	Pod length (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})
T_1	60.47 c	16.33	13.73	11.30	11.73	89.67 c	1.48 b
T_2	68.40 b	17.67	14.77	12.07	12.23	94.67 ab	1.64 a
T_3	66.70 b	17	14.47	11.37	12.07	91.33 ab	1.61 ab
T_4	81.33 a	18	14.43	12.20	12.53	97 a	1.69 a
CV (%)	4.36	3.99	2.54	6.66	2.99	2.52	4.04
CD $_{(0.05)}$	6.05	ns	ns	ns	ns	4.68	0.13

Note: T_1 = No mulch, T_2 = Straw mulch, T_3 = Rice husk and T_4 = Polythene mulch, CD = Critical difference, CV = Coefficient of Variation, ns = Non-Significant

Table 2. Cost and return analysis of cowpea as affected by different mulching materials during 2020-21

Sl. No.	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})	BCR
T_1	88800	64985	23565	1.37
T_2	98400	66150	31965	1.49
T_3	96600	79750	14965	1.21
T_4	101400	80150	20765	1.27

Note: Cowpea @ 60 Tk. kg^{-1}

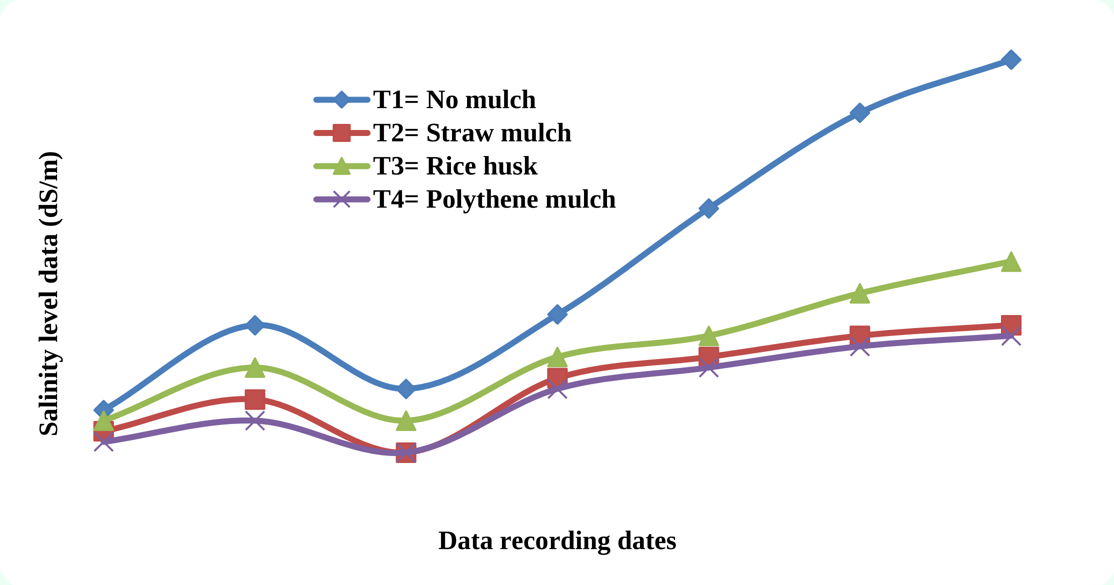

Figure 1: Showing salinity level at different mulching materials treated plot

Conclusion

From these findings, different mulch materials had different effect on soil conditions and significantly gave higher yield over control. Since, mulching is not common practiced by farmers at saline area for cowpea cultivation, therefore such trial may be conducted next year to motivate the farmers.

EFFECT OF SEED POTATO CUTTING ON THE PERFORMANCE OF POTATO PLANTED WITH POTATO PLANTER

M. S. H. MOLLA, M. Z. FERDOUS, M. A. A. H. TALUKDER AND S.M.A.H.M. KAMAL

Abstract

Mechanization in potato cultivation is the time demand and an experiment was conducted on it at FSRD site, Ajoddhapur, Rangpur under On-Farm Research Division, BARI, Rangpur during the 2021-22 to identify the suitable cutting dimension of seed Potato for production with Potato planter and to increase profitability of the farmers. Among the potato varieties, BARI Alu-41 produced maximum tuber yield (30.79 t ha^{-1}). Whole tuber was produced identically higher yield (29.99 t ha^{-1}) with single cut of tuber in lengthwise (29.45 t ha^{-1}) under planting with BARI potato planter. Single cut of tuber in crosswise was produced the lowest tuber yield (26.95 t ha^{-1}) compared to other cutting system even farmers practice (28 t ha^{-1}). Cutting effect on potato varieties was found insignificant. In terms of economicl point of view, potato planting with planter was more profitable than manual planting in farmers practice due to low production cost as well as relatively higher yield except planting with crosswise cut tuber. Potato tuber might be allowed to cut in lengthwise or even multi-cut but should

remain at least two eyes to make about 30 mm size for fitting with the seed meter cup under planting with BARI potato planter.

Introduction

Rangpur region is a very suitable area for Potato production. Potato cultivation especially planting is a labor-consuming and mechanized planting through planter may be the best alternate. But, in Potato planter, seed meter cup size is the important determinant for seed size maintenance. Among the cultural practices the seed rate, seed size, number of eyes per tuber are the factors that affect the plant growth and finally the tuber yield and quality (Rykbost and Locke, 1999; Nolte et al., 2003). Size of the seed Potato affects the number of stems per hill, as the number of eyes per tuber is related to the surface area of the tuber. Therefore, large tubers lead to a greater number of stems per hill and ultimately higher tuber number per plant and reduced average tuber weight besides higher seed rate. Since, seed Potato is a precious material, therefore, its use in large quantity will lead to a higher cost of cultivation on one hand and its dumping into the soil will lead to wastage of food material on the other hands. Moreover, small-size (A grade) seed tuber is often unavailable. It is documented that seed accounts for about 40% of the total cost of cultivation, hence its judicious use is very important for profitable Potato farming. The seed rate comes out to be low by planting small tubers or by using cut seed pieces, besides increased average tuber weight. From the above views, the trial was conducted at the farmer's field level using the BARI developed potato planter.

Materials and Methods

The experiment was conducted at FSRD site, Ajoddhapur, Rangpur under On-Farm Research Division, BARI, Rangpur during 2021-22 to identify the suitable cutting dimension of seed Potato for production with Potato planter and to increase profitability of the farmers. Five cutting dimension of seed potato i.e. C_1: Potato single cut on lengthwise (31-50 mm tuber) and planting by machine (60x25cm^2), C_2: Potato single cut on crosswise (31-50 mm tuber) and planting by machine (60x25cm^2), C_3: Potato multiple cut with at least 2 eyes (>50 mm tuber) and planting by machine (60x25cm^2), C_4: Whole Potato (25-30 mm tuber) planting by machine (60x25cm^2), C_5: Farmer practice (cut seed Potato and manual planting(50x20cm^2) were tested on two potato varieties (V_1: BARI Alu-25, V_2: BARI Alu-41). BARI has developed potato planter was used.. The potato varieties were in main plot and cutting treatments were in sub-plot maintaining split- plot design in three dispersed replications. The unit plot size was 10 m x 8 m. The crop was planted on 22-23 November 2021 and harvested on 20-21 February 2022. The crop was fertilized with 135, 30, 110, 22, 2, 1, and 5000 kg N, P, K, S, Zn, B and cowdung, respectively. The sources of nutrients were urea for N, TSP for P, M_0P for K, Gypsum for S, Zinc sulphate for Zn and Boric acid for B. Aphid was observed in Potato field and it was sprayed with Asataf @ 2 g L^{-1} water during 30 days after planting. For controlling late blight disease of potato, Dithane M-45 @ 4 g L^{-1} water was applied 5 times starting from 30 DAP and continued up to 70 DAP at an interval of 10 days. Folicure was sprayed @ 2 ml L^{-1} at 65 DAT for controlling leaf blight. The crop was was harvested at maturity.. Data on yield and yield attributes was recorded and converted to ton per hectare.

Results and Discussion

From the table 1, it was found that potato var. BARI Alu-41 produced higher tuber yield (30.79 t ha^{-1}) than BARI Alu-25 (26.45 t ha^{-1}). Though the single tuber weight was higher in BARI Alu-25 (73.07 g), but the maximum tuber number per plant in BARI Alu-41 (7.12) made it high yielder.

Identically higher plant height was observed in potato planting with whole tuber (71.95 cm) and single cut in lengthwise (69.33 cm), where the lowest plant height was observed in single cut in crosswise tuber planting (62.39 cm) (Table 2). The highest number of stem per plant (3.55) and tuber per plant (7.59) was found in whole tuber planting with planter, which helped to produce higher tuber yield (29.99 t ha^{-1}) in this treatment. The second highest tuber per plant (6.49) with moderate single tuber weight (68.69) contributed more to produce the identically higher tuber yield (29.45 t ha^{-1}) in single cut tuber in lengthwise with whole tuber planting system under planting with planter. The lowest tuber yield was obtained from single cut tuber in crosswise planting with planter (26.95 t ha^{-1}) due to very less number of tuber per plant (5.87) and relatively poor plants per square meter (6.14).

Though the relatively higher plant height was observed in potato planting with whole tuber irrespective of different varieties, but other parameters i.e., plant population, stem per plant, tuber per plant, single tuber weight and tuber yield was insignificant under variety and tuber cutting interaction treatment (Table 3).

Cost and return analysis: The highest gross margin was obtained from whole tuber planting by planter (Tk. 84543 ha^{-1}) followed by single cut tuber in lengthwise planting with planter (Tk. 83271 ha^{-1}) (Table 4). Higher tuber yield and low production cost contributed to increase gross margin in these treatments than farmers practice with manual planting (Tk. 65735 ha^{-1}).

Farmers' opinion

Farmers were pleased by planting potato in time with potato planter. They opined that cutting of potato in length wise is more suitable for them.

Table 1. Tuber yield and yield attributes of potato under different cutting dimension as affected by t potato variety at FSRD site Ajoddhapur, Rangpur during , 2021-22.

Variety	Plant pop^n m^{-2} (no.)	Plant height (cm)	Stem plant^{-1} (no.)	Tuber plant^{-1} (no.)	Single tuber wt. (g)	Tuber yield (t ha^{-1})
V_1= BARI Alu-25	6.83	69.33a	2.70	5.79b	73.07a	26.45b
V_2= BARI Alu-41	6.55	65.33b	3.38	7.12a	67.59b	30.79a
$LSD_{0.05}$	NS	1.30	NS	0.90	2.63	1.54
CV (%)	4.18	4.23	24.37	8.85	6.38	7.42

Table 2. Tuber yield and yield attributes of potato as affected by potato cutting dimension at FSRD site Ajoddhapur, Rangpur during 2021-22.

Variety	Plant pop^n m^{-2} (no.)	Plant height (cm)	Stem plant^{-1} (no.)	Tuber plant^{-1} (no.)	Single tuber wt. (g)	Tuber yield (t ha^{-1})
C_1= Single cut lengthwise & mechanize	6.99	69.33ab	3.03b	6.49b	68.69	29.45a
C_2= Single cut crosswise & mechanize	6.14	62.39c	2.67b	5.87c	77.66	26.95d
C_3= Multi cut and mechanize	6.62	68.01b	3b	6.19bc	73.17	28.73b
C_4= Whole tuber and mechanize	7.13	71.95a	3.55a	7.59a	58.82	29.99a
C_5= Farmers practice and manual	6.58	64.97c	2.95b	6.14bc	73.30	28c
$LSD_{0.05}$	NS	2.87	0.47	0.49	NS	0.62
CV (%)	10.77	3.48	12.55	6.22	14.53	8.77

Table 3. Cost and return of potato production under different cutting dimension at FSRD site Ajoddhapur, Rangpur during the year of 2021-22

Cutting dimension	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
C_1= single cut lengthwise & mechanize	235587	152316	83271
C_2= single cut crosswise & mechanize	215600	152316	63284
C_3= Multi cut & mechanize	229827	150300	79527
C_4= Whole tuber & mechanize	239893	155350	84543
C_5= Farmers practice & manual	223987	158252	65735

Price (Tk. kg^{-1}): Urea-16, TSP-22, MP-15, Gypsum-10, Zinc Sulphate-150, Boric acid-160, Potato-08

Conclusion

From the above discussion it is clear that planting of potato with potato planter is more profitable than manual planting. However, the experiment needs to be continue for a sloid conclusion.

EFFECT OF SOWING DATES AND VARIETIES ON EARLY PLANTED POTATO

S.M.A.H. M. KAMAL, M. Z. FERDOUS, M. S. H. MOLLA AND M. A. H. TALUKDER

Abstract

A field trail was conducted at Magura, Kishoreganj, Nilphamari, OFRD, Rangpur with five potato varieties and three sowing dates to find out early suitable potato varieties in Rangpur region during Rabi season 2021-22. The maximum tuber yield of 36.86 t ha^{-1} was obtained from 10 October sowing with var. BARI Alu-90. The same treatment also recorded gross return (921450 Tk. ha^{-1}), gross margin(729050 Tk. ha^{-1}) and benefit cost ratio (4.78) than other tested varieties. However, newly developed potato varieties viz., BARI Alu-90, 29 and 41 were given highest tuber yield production in this area with compare to local variety .

Introduction

Rangpur is one of the potato growing regions in Bangladesh. Most of the farmers of this area are producing potato in early winter due to high market price. Now, potato cultivation is one of the cash crops of the farmers of this region. In Kisorganj Upazila of Nilphamari and different Upazilas of Rangpur District, farmers are growing early potato in some pocket areas. Already, most of the farmers are practiced by local variety in early condition but yield performance and diseases susceptibility are not satisfactory. BARI has developed some early potato varieties which is better than local varieties. As such the trial was conducted to find out the suitable sowing date and variety (s) for early potato cultivation with compared to local one.

Materials and Methods

The experiment was conducted at Magura, Kishoreganj, Nilphamari, OFRD, Rangpur during Rabi season 2021-22 to find out the suitable sowing date and variety (s) for early potato cultivation and compared to local verities. The experimental site represents the agro-ecological zone (AEZ-3) recognized as "Tista Mender Flood Plain Soil". The design was followed with RCB (Factorial) with three dispersed replications. The experiment was started 10 October, 2021 and crop was harvested on 13-29 December, 2021(on and average harvest after 60 days). The rain fall was recorded 221.2 mm in October/21 (appendics-1).Early sowing hampered the growth by Rainfall (September to whole October. The treatment comprises of five sowing date: 10 October (D_1), 17 October (D_2) and 25 October (D_3) and five varieties such as BARI Alu-13(V_1), BARI Alu-29 (V_2), BARI Alu-41 (V_3), BARI Alu-90 (V_4) and local seven (V_5). Weeding, irrigation and spraying were done as required. Fertilizers were applied at the rate of 325-200-250-100-8-6-7000 Kg ha^{-1} of Urea-TSP-MP-Gypsum-Zinc-Boron-CD (BARI , 2019) y. Half of Urea, whole amount of TSP, MoP, Gypsum, Zinc and Boron were applied as basal. Remaining the rest of urea was top dressed at 35 days and mixed thoroughly with the soil as soon as possible for better utilization. Data were taken on different growth parameters and compiled and analyzed with Statistic-10 software.

Results and Discussions

The results have been presented in table 1-3. Consider of date and varieties, the maximum tuber yield (37.44 t ha^{-1}) obtained from $D_3 \times V_4$ followed by $D_1 \times V_4$ (36.86 t ha^{-1}) and $D_2 \times V_4$ (36.69 t ha^{-1}) .Tuber yield was showed higher in early October than late October's sowing due to decrease temperature. Potato gives better yield on low temperature (10^0c-18^0c). In early condition, tuber yield production was low but price was high. . Treatment D_3 V_4 was recorded the highest tuber yield (36.99t ha^{-1}) (Table 1) In economic view, $D_1 \times V_4$ interaction treatment was given the highest gross return (921450 Tk. ha^{-1}), gross margin (729250 Tk. ha^{-1}) and benefit cost ratio (4.78) where late sowing showed low income (Table 3). Local variety seven's tuber yield was recorded 29.53 t ha^{-1} after 60 days harvest. Farmer of this area, this popular early variety (seven) was harvested after 50 days due to high market price. The most of the farmers were cultivated on the last September to first week of October but this year sowing time was delay for late shower. However, potato var. BARI Alu -90, 29 and 41 with 10 October sowing time was showed better performance as compared to other treated varieties and sowing times.

Table 1. Interaction between tuber yield and yield contributing characters on sowing time and varieties of potato at Magura, Kishoreganj, MLT site, Nilphamari, OFRD, Rangpur during 2021-22

Treatments	Plant height (cm)	Tubers/plant (no.)	Wt. of tuber/plant (kg)	Tuber yield (t ha^{-1})
D_1 x V_1	82.53 fgh	6.7 h	0.23 g	12.737 h
D_1 x V_2	90.43 c	10.7 d	0.62 d	35.045 d
D_1 x V_3	86.47 de	8.1 g	0.63 cd	34.969 d
D_1 x V_4	92.37 bc	9.8 f	0.71 a	36.858 a
D_1 x V_5	81.77 fgh	10.1 ef	0.43 f	28.854 ef
D_2 x V_1	81.07 gh	7.1 h	0.24 g	14.188 g
D_2 x V_2	84.27 ef	11.6 bc	0.65 bc	35.585 cd
D_2 x V_3	87.57 d	11.0 cd	0.63 cd	35.167 cd
D_2 x V_4	101.07 a	10.7 de	0.71 a	36.692 ab
D_2 x V_5	82.73 fg	10.9 d	0.48 e	28.327 f
D_3 x V_1	82.63 fgh	7.2 h	0.26 g	14.813 g
D_3 x V_2	79.93 h	12.0 ab	0.67 b	35.976 bc
D_3 x V_3	93.5 b	11.7 ab	0.63 cd	35.543 cd
D_3 x V_4	100.13 Aa	12.0 ab	0.73 a	37.436 a
D_3x V_5	84.17 ef	12.3 a	0.48	29.533e
FP	85.50	9.0	0.21	9.975
LSD(0.05)	2.72	0.59	0.034	855.4
CV (%)	1.86	3.51	3.83	1.70

D_1 = 10/10/21, D_2 = 17/10/21, D_3 = 25/10/21, V_1= DBARI Alu-13, V_2= BARI Alu-29, V_3= BARI Alu-41, V_4= BARI Alu-90 and V_5= Seven (local)

Table 2. Market price with cost benefit analysis on early sowing date and varieties at Magura, Kishoreganj, MLT site, Nilphamari, OFRD, Rangpur during 2021-22

Treatments	Market Price (Tk/kg)	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})	BCR
D_1 x V_1	25	318425	192400	126025	1.65
D_1 x V_2	25	876125	192400	683725	4.55
D_1 x V_3	25	874225	192400	681825	4.54
D_1 x V_4	25	921450	192400	729050	4.78
D_1 x V_5	25	721350	192400	528950	3.74
D_2 x V_1	16	227000	192400	34600	1.17
D_2 x V_2	16	569360	192400	376960	2.95
D_2 x V_3	16	562672	192400	370272	2.92
D_2 x V_4	16	587072	192400	394672	3.05
D_2 x V_5	16	473232	192400	260832	2.35
D_3 x V_1	14	207382	192400	14982	1.07
D_3 x V_2	14	503664	192400	311264	2.61
D_3 x V_3	14	497602	192400	305262	2.58
D_3 x V_4	14	524104	192400	331704	2.72
D_3 x V_5	14	413462	192400	221062	2.14
FP	40	399000	185500	213500	2.15

D_1 = 10/10/21, D_2 = 17/10/21, D_3 = 25/10/21, V_1= DBARI Alu-13, V_2= BARI Alu-29, V_3= BARI Alu-41, V_4= BARI Alu-90 and V_5= Seven (local) FP= Farmers Practice

Conclusion

Potato var. BARI Alu -90, 29 and 41 were showed better performance in early cultivation than local one at Kisorganj Upazila. Besides, farmers and market demand showed better for BARI Alu-90 and BARI Alu-41 due to red skin colour.

YIELD PERFORMANCE OF DIFFERENT GARDEN PEA VARIETIES AT SHERPUR REGION

M. M. RAHMAN, A.K.M.Z.U. NOOR AND M.S. RAHMAN

Abstract

The experiment was conducted in the farmer's field at Char habor, Sreebordi, Sherpur during rabi season 2021-2022 to evaluate different pea varieties. Three pea varieties viz., BARI Motorsuti-1, BARI Motorsuti -2 and Natore local were included in this experiment. Result revealed that garden pea var. BARI Motorsuti-2 gave highest pod yield of 14.82 t ha^{-1} whereas Natore local produced lowest yield 7.73 t ha^{-1}. But highest gross return 3,84,900/-Tk. ha^{-1} and Gross margin 2,73,100/-Tk. ha^{-1} was recorded in BARI Motorsuti -1.

Introduction

Pea (Pisum sativum) is well known as a vegetable and one of the important legumes in Bangladesh. Green pods and immature seeds are rich in vitamin and have a balanced amino acid composition. The crops become popular for its high nutritive value and good taste. In Bangladesh the area of pea was 7, 490 ha. and production was 8,051 ton (BBS, 2021). It contains 15-35% protein, 20-25% starch, 4-10% sugar, 0.6-1.5% fat and 2-4% minerals (Makasheva, 1983). Crops variety is very important for higher production. Some variety has short life cycle but some long with different type of pod and seed. In this context, the experiment was conducted to find out the suitable variety for Sherpur region.

Materials and Methods

The experiment was conducted at Char habor, Sreebordi, Sherpur during rabi season of 2021-2022. Three pea varieties viz., BARI Motorsuti -1, BARI Motorsuti -2 and Natore local were included in this experiment. The experiment was laid out in a RCB design with three replications. Seeds of each variety was sown maintaining 25 cm row to row and 12 cm plant to plant spacing. The seed rate was 100 kg ha^{-1}. Seeds were sown on 8 December, 2021. Fertilizers were applied @ 46-30-50 kg ha^{-1} N-P-K fertilizer with 10 t ha^{-1} cowdung. Furadan was applied during final land preparation and indofil and tilt were sprayed to control red rust. Crop were harvested on 8-13 March, 2022. Data were analyzed statistically by using the IRRI-STAR software.

Results

The pod yield and yield attributes of different varieties are presented in Table 1. The maximum pods plant^{-1} 11.27, seeds pod^{-1} 6.0 and green pod yield (14.8 t ha^{-1}) was obtained from BARI Motorsuti-2 followed by BARI Motorsuti-1 while lowest pods plant^{-1} 9.93 and green pod yield 7.73 t ha^{-1} in Natore local. The crop duration was 88-93 days. The highest gross return was found Tk. 3,84,900/-ha^{-1} and gross margin Tk. 2,73,100/-ha^{-1} from BARI Motorsuti-1 due to higher price t. Though BARI Motorsuti-2 resulted highest yield but due to low price it gave lower gross return and margin ie. Tk 3,00,416/- ha^{-1} and Tk 1,88,616/- ha^{-1}, respectively.

Farmers' are interested to cultivate BARI Motorsuti-1due to market price is high.

Table 1. Yiels and Yield attributes of motorsuti varieties at Char habor, Sreebordi, Sherpur during 2021-22

Variety	Plant height (cm)	Pods plant^{-1}	Seeds pod^{-1}	Pod Yield (t ha^{-1})	Stover yield (t ha^{-1})
BARI Motorsuti -1	65.47 c	11.27 a	6 a	12.7 b	3.90 b
BARI Motorsuti -2	80.87 b	10.20 b	4.93 c	14.8 a	4.08 a
Natore local	97.67 a	9.93 b	5.40 b	7.73 c	3.50 c
CV (%)	0.54	2.59	3.24	1.10	1.38

Table 2. Cost and return analysis of motorsuti varieties at Char habor, Sreebordi, Sherpur during 2021-22

Variety	Gross return (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})
BARI Motorsuti -1	3,84,900/-	1,11,800/-	2,73,100/-
BARI Motorsuti -2	3,00,416/-	1,11,800/-	1,88,616/-
Natore local	3,12,700/-	1,11,800/-	2,00,900/-

Price of green BARI motosuti-1 pod Tk 30.0 kg^{-1}, BARI motosuti-2 pod Tk 20.0 kg^{-1}, Natore local pod Tk 40.0 kg^{-1} and Stover Tk 1.0 kg^{-1}.

Conclusion

BARI Motorsuti-1 could be expanded in Sherpur region though it takes 90 days, it can be fitted Motorshuti- Jute- Taman cropping pattern.

EFFECT OF SOWING DATE ON YIELD PERFORMANCE OF GARDEN PEA VARIETY

M.S. RAHMAN, M. M. RAHMAN AND A.K.M.Z.U. NOOR

Abstract

The experiment was conducted in the farmer's field at Tarakandi, Sherpur sadar, Sherpur during the rabi season of 2021-2022 to evaluate sowing time on pea production. Three time sowing ie. 10th November, 25th November and 10th December was included . Result reveal that maximum pod yield (9.30 tha^{-1})was obtained from 25th November sowing whereas 10th December sowing produced lowest pod yield (7.27 t ha^{-1}). Highest gross return 4,75,075/-Tk ha^{-1} and Gross margin 3,67,675/-Tk ha^{-1} was recorded from 10th November sowing.

Introduction

Pea (Pisum sativum) is well known as a vegetable and one of the important legumes in Bangladesh. Green pods and immature seeds are rich in vitamin and have a balanced amino acid composition. The crops become popular for its high nutritive value and good taste. In Bangladesh the area of pea was 7, 490 ha. and production was 8,051 ton in 2020 (BBS, 2021). It contains 15-35% protein, 20-25% starch, 4-10% sugar, 0.6-1.5% fat and 2-4% minerals (Makasheva,1983). Sowing time is very important for successful crop production. Early and off time production gives higher price of the commodity especially vegetable crops. The experiment was conducted to find out the suitable time for motorshuti production in this region.

Materials and Methods

The experiment was conducted at Tarakandi, Sherpur sadar, Sherpur during the rabi season of 2021-2022 to evaluate sowing time on pea production. Three sowing time ie. 10th November, 25th November and 09th December was included . The experiment was laid out in a RCB design with three replications. The plot size was 5m x 4m. The variety BARI Motorsuti-3 was used as planting material . Seeds were sown maintaining 25 cm row to row and 12 cm plant to plant spacing. The seed rate was 100 kg ha^{-1}. Fertilizers were applied @ 46-30-50 kg ha^{-1} N-P-K fertilizer with 10 t ha^{-1} cowdung. Furadan was applied during final land preparation for controlling soil insect's and Indofill. Tilt were sprayed to control red rust. Crop were harvested 11 January, 30 January and 17 February 2022, respectively. Data were analyzed statistically by using the IRRI-STAR software.

Results

The pod yield and yield attributes of garden pea for different sowing time (Table1). The maximum t pods plant^{-1} 6.93, seeds pod^{-1} 4.27 and green pod yield (9.30 t ha^{-1}) was obtained from 25th November sowing followed by 10th November whereas lowest pod per plant 5.80, seed per pod 4.13 and green pod yield 7.27 t ha^{-1} observed in 10th December sowing. The crop duration was found maximum 68 days at 10th December sowing and minimum 64 days from 105th

November sowing. From the table -2 the highest gross return was found Tk. 475075 ha^{-1} and gross margin Tk. 3,67,675 ha^{-1} from 10th November sowing due to early market and higher price . Lowest gross return and margin ie. Tk 3,73,333 ha^{-1} and Tk 2,,65933 ha^{-1}, respectively was recorded from 10th December sowing. Though 25th November resulted highest yield but due to availability and low price it resulted lower gross return and margin than 10th November sowing.

Farmer's opinion

Farmers' are interested to cultivategarden pea var. BARI Motorsuti-3 in early November due to market price is high.

Table 1. Pod yield and yield attributes of motorsuti on different sowing date at Tarakandi, Sherpur sadar, Sherpur during 2021-22

Sowing date	Field duration (days)	Plant height (cm)	Pods plant^{-1}	Seeds pod^{-1}	Yield (t ha^{-1})	Stover yield (t ha^{-1})
10th November	64 b	55.53	6.87 a	4.20	8.82 b	6.10 a
25th November	67 a	55.40	6.93 a	4.27	9.30 a	5.27 b
10th December	68 a	54.47	5.80 b	4.13	7.27 c	5.0 b
CV %	0.87	1.0	3.95	3.89	2.51	3.86

Table 2. Cost and return analysis of different sowing date of motorsuti at Tarakandi, Sherpur sadar, Sherpur during 2021-22

Sowing date	Gross return (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})
10th November	4,75,075/-	1,07,400/-	3,67,675/-
25th November	4,29,033/-	1,07,400/-	3,21,633/-
10th December	3,73,333/-	1,07,400/-	2,65,933/-

Price of green pod BARI motosuti-3, at 10th November sowing Tk 52.0 kg^{-1}; 25th November sowing Tk 45.0 kg^{-1}; 10th December sowing Tk 50.0 kg^{-1} and Stover Tk 2.0 kg^{-1};

Conclusion

Garden pea var. BARI Motorsuti-3 coul t be cultivated early November due to high price in Sherpur region. It take only 64 days which can be fitted Motorshuti- Boro -T. aman cropping pattern.

EFFECT OF PLANT SPACING ON BULB YIELD OF ONION

M. M. RAHMAN, A.K.M.Z.U. NOOR AND M.S. RAHMAN

Abstract

The experiment was undertaken to determine the effect of different plant spacing on bulb yield of onion. Three different spacing's viz., 5x10 cm, 10x10 cm and 15x10 cm was used Onion var. BARI Piaz-4 was used . The results showed that plant spacing had significant effects on bulb yield of onion. The weight of individual onion bulb was highest (41.62 g) with the widest spacing of 15x10 cm. The overall bulb yield ha^{-1} was the highest (25.74 t ha^{-1}) at wider spacing (15 x10cm) and the lowest (19.74 t ha^{-1}) at closer spacing (5x10 cm). Maximum Gross return and gross margin per hectare were found Tk.5,14,800/- and Tk.3,98,555/- from wider spacing (15 x10cm).

IntroductionOnion is the most important of the bulb crops cultivated commercially in most parts of the world. The crop is grown for consumption both in the green state as well as in mature bulbs. In Bangladesh total Production 2.26 million ton from the area of 1.94 lac hectare (BBS,2021 Its production and productivity is not required level due to reluctant use of appropriate agronomic management practices and improved technology.. To increase the yield of onion, emphasis must be given on adopting improved varieties, plant spacing, depth of planting and other cultural measures. The closer plant spacing is one of the cultural practices to control bulb size, shape and yield (Geremew et al., 2010). The higher yield and better control of over or under bulb size could be obtained if plants are grown at optimum density. Total bulb yield can be increased as population density increases (Kantona *et al.,* 2003). Planting of onion at optimum density also gives the best economic return (Rashid and Rashid, 1976). Considering the above situations, the present study was undertaken to determine the effects of different plant spacing on bulb yield of onion at Sherpur region.

Materials and Methods

On-Farm Research Division, Sherpur carried out during rabi season, 2021-22 at Jalalpur and kursha in Nakla under Sherpur district. Three different spacing's viz., 5x10 cm, 10x10 cm and 15x10 cm was used. The experiment was conducte in a RCBD with 5 dispersed replication maintaining plot size 5.0 m x 4.0m. Onoin var. BARI Piaz-4 was used . Seeds were sown in seedbed on 24 November, 2021. The seedlings were transplanted on 6 January, 2022. Fertilizers were applied in the field as per BARI recommended dose. Rovral sprayed twice at the rate of 0.2% at 15 days interval for controlling purple blotch. The crop was harvested on 7 April, 2022. Data were analyzed statistically following a programme Statistical Tool for Agricultural Research (STAR).

Results

The bulb yield and yield attributes are presented in Table-1 and gross return, variable cost and gross margin of onion in Table-2. From table 1. Plant height, leaves plant^{-1}, pseudo stem diameter, bulb diameter, average bulb weight did not vary significantly but dry matter of leaves, bulb and bulb yield varied . Average bulb weight ranged 36.1 to 41.6 gm. The highest bulb yield(25.74 t ha^{-1}) was obtained from wider spacing (15x10 cm) while lowest yield (19.74 t ha^{-1}.) in closest spacing 5x10 cm The highest gross return and gross margin per hectare were found Tk. 5,14,800/-and Tk. 3,98,555/, respectively from wider spacing 15x10 cm.

Table-1. Bulb yield and yield attributes of onion on different spacing at Nakla, Sherpur during 2021-22

Treatment	Plant height (cm)	Leaves plant^{-1}	Pseudo stem dia. (cm)	DM of leaves (%)	Bulb dia. (cm)	Avg. Bulb Wt. (gm)	DM of bulb (%)	Bulb yield (t ha^{-1})
5x10 cm	54.04 a	6.40	1.18	4.41	4.04 b	36.1	11.2 c	19.7 b
10x10 cm	55.08 a	6.70	1.29	4.42	4.08 b	40.8	11.5 b	21.9 b
15x10 cm	49.86 b	6.72	1.16	5.29	4.24 a	41.6	12.2 a	25.7 a
CV (%)	6.80	9.27	8.64	7.26	11.80	9.51	1.50	8.18

Table-2. Gross return, variable cost and gross margin of onion at Nakla, Sherpur during 2021-22

Treatments	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
5x10 cm	3,94,800/-	1,16,245/-	2,78,555/-
10x10 cm	4,37,000/-	1,16,245/-	3,20,755/-
15x10 cm	5,14,800/-	1,16,245/-	3,98,555/-

Price of onion =Tk 20.0 kg^{-1}

Conclusion

It can be concluded from the study that the widest spacing of 15 x10 cm produced significantly the highest bulb yield per hectare because wider spacing received more nutrients, light and moisture compared to closer spacing which is probably the cause of better performance and yield of individual onion at wider spacing.

PERFORMANCE OF SESAME UNDER DIFFERENT SOWING OPTIONS

M.A. ISLAM, M.R. ALAM, M. MANIRUZZAMAN AND M.S.H. MOLLA

Abstract

A field experiment was conducted at farmer's field of Gangarampur, Pabna during March to July in 2021 to study the performance of sesame under different planting methods of sesame. Four sowing methods viz., raised bed planting (RB), relay cropping (RC), strip planting (SP) and conventional method as farmer's practice (CT) were applied on sesame var. BARI Til-4. The results of the experiment showed that days to 50% flowering and days to maturity in RC were earlier than RB, SP and CT. Relay method produced lower plant populations than other treated plots. The tallest plant was recorded at CT and the lowest at RC treatment. The highest pods/plant was recorded from RB and the lowest pods/plant at RC treatment. The maximum seed yield (1.14 t ha^{-1}) was obtained at CT which was statistically similar to RB (1.13 t ha^{-1}) and SP (1.10 t ha^{-1}), and the lowest seed yield (1.67 t ha^{-1}) from RC treatment.

Introduction

Sesame is one of the important oil seed crop grown in kharif-1 season. In last couple of years climate change induced effect especially changes in rainfall pattern exhibit potential threat for sesame cultivation in kharif season. In many areas of Bangladesh, heavy rainfall severely affects the crop at early growth stage to flowering and resulted in partial or total damage of the crops. Sometimes farmers ensure re-sowing if the crop damaged at early stage. However, considering the above context it is imperative to find out suitable sowing option addressing sowing time and method for successful adoption of sesame at farmer's field. Therefore, the experiment has been conducted to evaluate the performance of sesame under different sowing options, reduce crop loss due to rainfall/excessive soil moisture induced by climate change and increase sustainable production and famer's income.

Materials and methods

A field experiment was conducted in a farmer's field of Gangarampur, Pabna during Kharif-II season (March to July) in 2021. The experimental field is characterized by calcareous soil belonging to the High Ganges River Floodplain, Agro-Ecological Zone 11 (UNDP and FAO, 1988). The experiment consist of four sowing methods:raised bed planting (RB), relay cropping (RC), strip planting (SP) and conventional method as farmer's practice (CT).The experiment was laid in a Randomized Complete Block Design (RCBD) with threedispersed replications. Each plot size measured 25 x 8 m2 and the test variety of sesame was BARI Til-4. The seed rate of sesame was 8 kg ha^{-1}. Fertilizers were applied to the plots at the rate of 125, 150, 50, 110, 5, 10 kg ha^{-1} of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid respectively(FRG, BARC 2018). One-half of urea, whole amount of triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid were applied during final land preparation. The rest urea was top-dressed just before flowering. In case of RB and SP methods, seed were line sowing while seeds were broadcasted in relay and conventional method. The intercultural operations like thinning, weeding and plant protection measures were done as per necessary. The grain yield was adjusted to 12% moisture content. Economic analysis for various sowing methods was conducted by using the variable costs and income from sale of seed and stover of sesame. Gross margin from all treatments was calculated by subtracting expenses for all variable inputs from the calculated gross return. The GenStat 17th Edition and R-software package was used and mean differences between treatments were separated by the least significant difference (LSD 0.05) (Gomez and Gomez, 1984).

Results and Discussion

Effects of different sowing options on yield attributes and yield of sesame are shown in Table 1. The results showed that days to 50% flowering in RC were 2, 4 and 5 days earlier than RB, SP and CT treated plants. Similarly, days to maturity at RC were 2-3 days earlier than that of SP, RB and CT treated plants. Relay method produced lower plants (31 plants m^{-2}) than other treated plots.

The maximum plant height (131 cm) was recorded at CT which was at par with that of SP and the lowest (103 cm) at RC treatment. The maximum pods plant^{-1} (41) was recorded from RB which was statistically similar to SP (39) and CT (37), and the lowest pods plant^{-1} (33) at RC treatment. The seeds/pod and 1000-seed weight were not significantly affected by sowing methods. The maximum seed yield (1.14 t ha^{-1}) was obtained at CT which was statistically similar to RB (1.13 t ha^{-1}) and SP (1.10 t ha^{-1}), and the lowest seed yield (1.67 t ha^{-1}) from RC treatment. The reason of decreasing grain yield in RC might be due to minimum plants along with lower plant height and minimum number of pods plant^{-1} in RC treated plot.

Economic Performance

The economic performance of sesame under different sowing options are shown in Table 2. The highest gross margin (Tk. 31909 ha^{-1}) and BCR (1.6) was obtained from SP treatment while the lowest gross margin (Tk. 14745 ha^{-1}) from RC treatment which might be due to lower gross return (Tk. 64895 ha^{-1}) from conventional cultivation techniques. However, higher gross return (Tk. 88005 ha^{-1}) and higher production cost (Tk. 56900 ha^{-1}) was also recorded from CT treatment.

Table 1. Effects of different sowing options on yield attributes and yield of sesame in 2021 at OFRD, Pabna

Planting method	Days to 50 % flowering	Days to maturity	Plantsm^{-2}	Plant height (cm)	Pods plant^{-1}	Seeds pod^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
SP	46	87	30	120	39	72	2.8	1.10	2.34
RB	44	87	30	109	41	71	2.9	1.13	2.28
RC	42	85	18	103	33	71	2.9	0.84	1.67
CT	47	88	31	131	37	74	2.7	1.14	2.28
CV (%)	0.6	0.5	4.1	4.4	6.1	9.2	2.1	5.7	6.9
$LSD_{0.05}$	0.6**	0.9**	2.2**	10.2**	4.6*	ns	ns	0.12**	0.3**

RB – Raised bed planting; RC – Relay method; SP – Strip planting and CT – Conventional method; TSW – 1000-seed weight

Table 2. Cost benefit analysis od different sowing of sesame in 2021 at OFRD, Pabna

Planting method	Cost of cultivation (TK. ha^{-1})	Gross return (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
SP	52400	84309	31909	1.6
RB	56150	87255	31105	1.6
RC	50150	64895	14745	1.3
CT	56900	88005	31105	1.5

RB – Raised bed planting; RC – Relay method; SP – Strip planting and CT – Conventional method; TSW – 1000-seed weight. Market price of sesame (Tk kg^{-1}): grain – 75 and straw – 1

Conclusion

It could be concluded that strip planting system and raised bed in this experiment had no significant yield benefit over the conventional tillage in sesame.But Considering economic performance, strip planting and raised beds can result in highergross margin and BCR compared to other sowing methods. Hence, strip planting and raised bed planting methods may be beneficial for sesame cultivation..

RAINFALL AND VEGETATION DYNAMICS IN BANGLADESH BASED ON LANDSAT TIME-SERIES ANALYSIS

TASLIMA ZAHAN, SUMAN BISWAS, SHAKHAWAT HOSSAIN, SHEIKH ISHTIAQUE AND APURBA K. CHAKI

Abstract

Monitoring changes in vegetation growth has been subjected to considerable research in Bangladesh during the last few years. Combined data sets of satellite-derived Normalized Difference Vegetation Index (NDVI) and climatic factor viz. rainfall to analyze spatio-temporal patterns of changes in vegetation growth and their relation with changes in rainfall of the whole country from 1985 to 2020 was studied.

Introduction

Vegetation is one of the most significant components of terrestrial ecosystems on the earth (Zhe and Zhang, 2021; Duveiller et al., 2018; Shen et al., 2016). Vegetation dynamics and its response to climate change is sensitive (Wang et al., 2015) and have been recognized as a core topic in global change research, especially since the satellite-derived Normalized Difference Vegetation Index (NDVI) was available (Piao et al., 2011; Myneni et al., 1997). The NDVI is considered to be a good indicator of vegetation greenness and activity (Guay et al., 2014). In Bangladesh, there are six seasons, but three seasons are distinct named the pre-monsoon hot season (March-May), rainy monsoon season (June-October) and a cool dry winter season (November-February). During the pre-monsoon and monsoon seasons, rice is the main crop that exists throughout the country. In the dry winter season, mostly horticultural crops are grown. The dry winter season remains mostly rainless and the crops that grow in this season mostly depends on irrigation. Since, source of irrigation is a great concern in crop production for northern and southern part of Bangladesh, rainfall has a significant importance in vegetation coverage. Therefore, a study was designed to get idea about the pattern and distribution of rainfall over the years over the country and also to evaluate the relationships of vegetation dynamics from satellite-derived NDVI using Landsat time-series with the rainfall.

Materials and Methods

Study area

The data of rainfall was collected from 36 weather station of Bangladesh Meteorology Department (BMD) to get the rainfall scenario of the whole Bangladesh (23.6850° N and 90.3563° E).

Rainfall Map preparation:

BMD daily rainfall data for all stations have been used in this study. The following procedure has been followed;

1. Making monthly accumulated rainfall (mm) from daily rainfall data (mm/day) (processed in MS Excel).
2. Calculating 5 yearly average of rainfall for each month of dry season (Oct-Mar) for the respective years. Such as Oct 1985 rainfall is representing average of October rainfall in preceding years (1981-1985) (processed in MS Excel).
3. All the monthly accumulated rainfall (5 yearly average) are organized in columns as "Oct 1985", "Oct 1990", …, "Mar 2015", "Mar 2020" and 35 BMD stations in columns.
4. The 5 yearly average monthly accumulated rainfall (mm) in the database is standardized (0 to 1) to make comparable all the rainfall maps in a homogeneous scale.
5. The database is imported ArcGIS environment and interpolated using "Kriging" interpolation tool based on "Ordinary Kriging" method and "Spherical Semivariogram" model.
6. Map layouts are generated in ArcGIS 10.8

***NDVI Map Preparation*:**

NDVI map is preparate using Google Earth Engine. Landsat-8 30-meter resolution imageries are used to derive median NDVI image (October 2020-March 2021) of Bangladesh. The following procedure have been followed here:

1. Import Bangladesh country shapefile in GEE
2. Import USGS Landsat 8 Level 2, Collection 2, Tier 1 images for Bangladesh by filtering cloud cover <=5% within the period of 2020-10-01 to 2021-03-31.
3. Apply scale factor based on Landsat metadata.
4. Calculate median image for the respective dry season of 2020-21 using the following bands: 'SR_B2','SR_B3','SR_B4','SR_B5','SR_B6','SR_B7'.
5. Calculate NDVI from the median image using the following formula:
    a. NDVI = ('SR_B5'-'SR_B4')/('SR_B5'+'SR_B4')
6. Export the derived image in 30-meter resolution and prepare a Map Layout in ArcGIS 10.8

Results and discussion

Trend of rainfall pattern and distribution

The monthly total rainfall of the whole country had been analyzed from 1985 to 2020 and a significant spatio-temporal change was marked out (Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5 and Fig. 6).

<u>Month: October</u>

There was a distinct variation in year-to-year rainfall distribution throughout the country (Fig. 1). The month of October was almost rainless all over the country during 1985 whereas in the other years small amount of rainfall occurred at different parts of the country. Most of the year rainfall was found at the coastal belt of the southern part of the country and this might be happened due to tropical cyclone strike at that time.

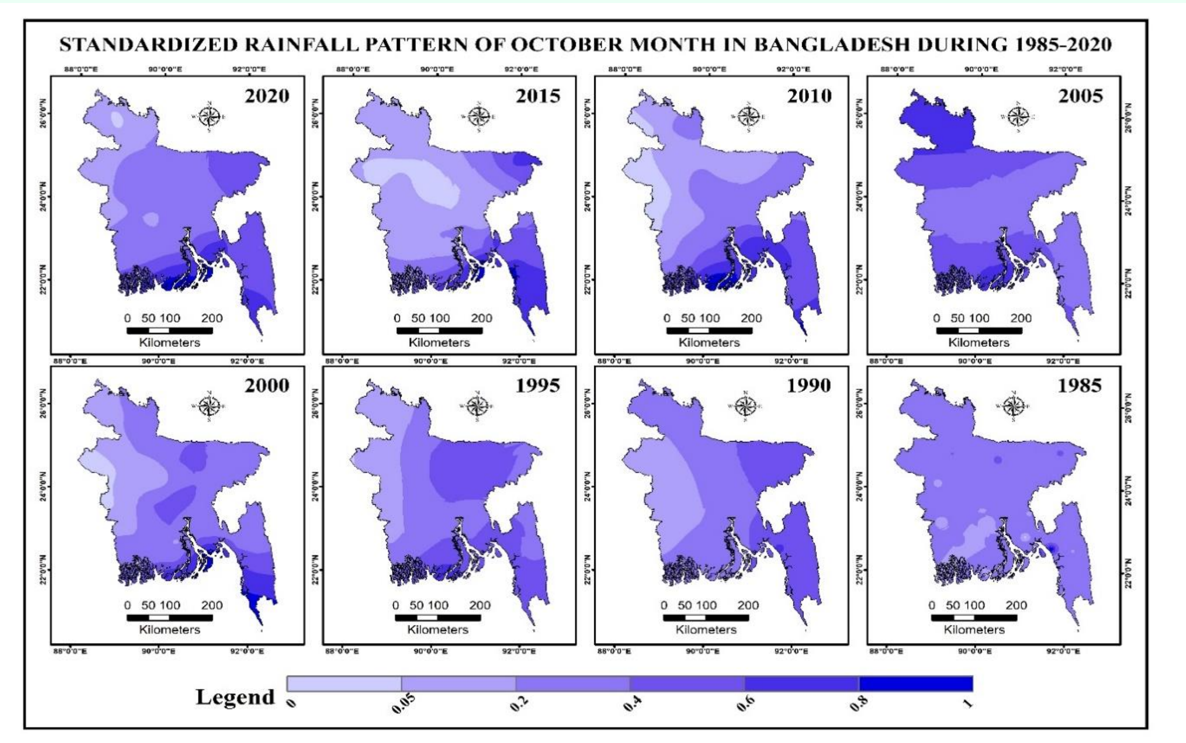

Fig. 1. Standardized rainfall pattern in the month of October in Bangladesh during 1985-2020

Month: November

During the month of November, coastal belt received more amount of rainfall than the other parts of the country in 1985, 1990, 195, 2005 and in 2010 (Fig. 2). Only exception was found in the 2015 and that year rainfall was mostly occurred at the North-Western part to middle eastern part of the country.

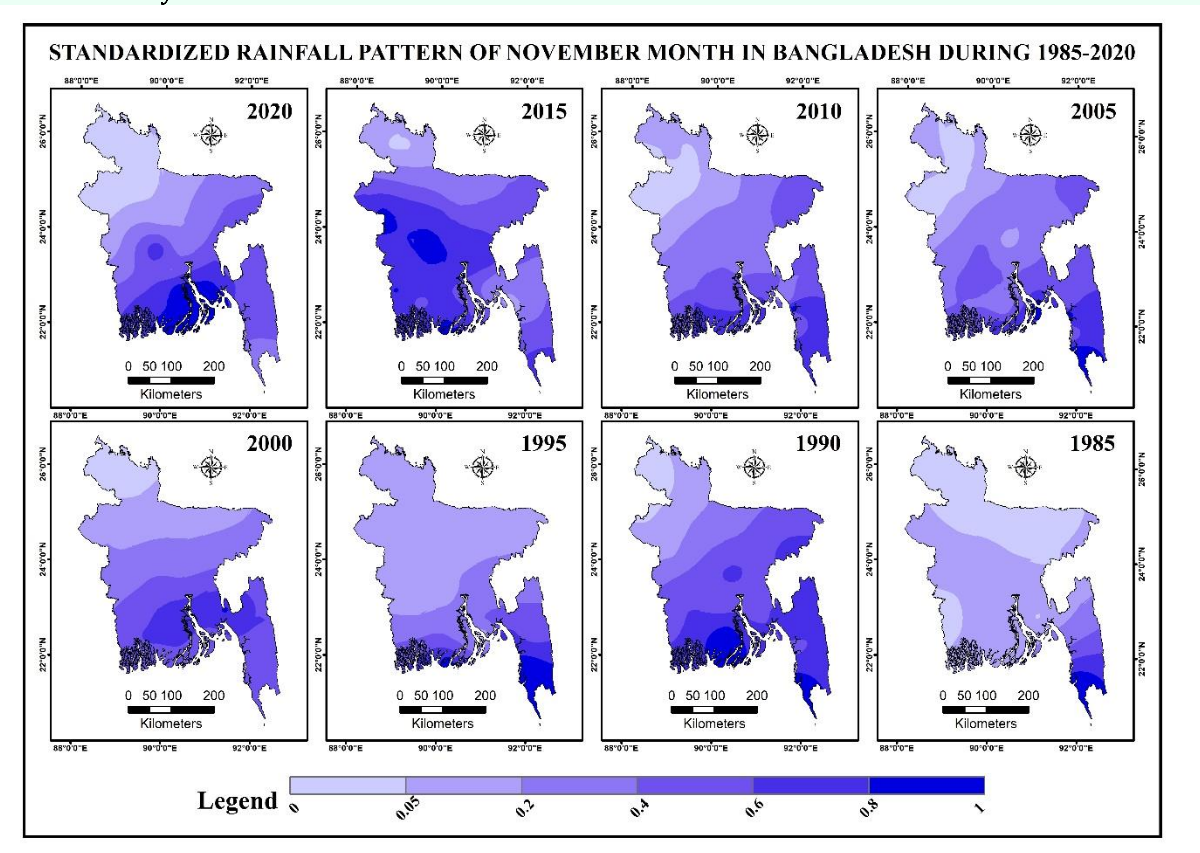

Fig. 2. Standardized rainfall pattern in the month of November in Bangladesh during 1985-2020

Month: December

The month of December was rainless throughout the country during the year of 2005, 2010 and to some extent in 2015 (Fig. 3). In the year of 1990 and 2000, few amounts of rainfall were occurred only Eastern-southern part of the country. During 1995, rainfall was only distributed middled part of eastern, western and center parts of the country. In 2020, only eastern part was received some rainfall.

Month: January

Most of the study years except 1995 and 2005, almost all the parts of the country were rainless during the month of January (Fig. 4). In 1995, Northern part and lower Western part received more rainfall than the other parts of the country. In 2005, a small area of lower western part have received some rainfall.

Month: February

The month of February had some rainfall in most of the years in some parts of the country except the year of 1990 and 2000 (Fig. 5). The year of 1995, 2005, 2010 and also 2020 received remarkable rainfall at upper Eastern part (Sylhet region) compared to the other parts of the country.

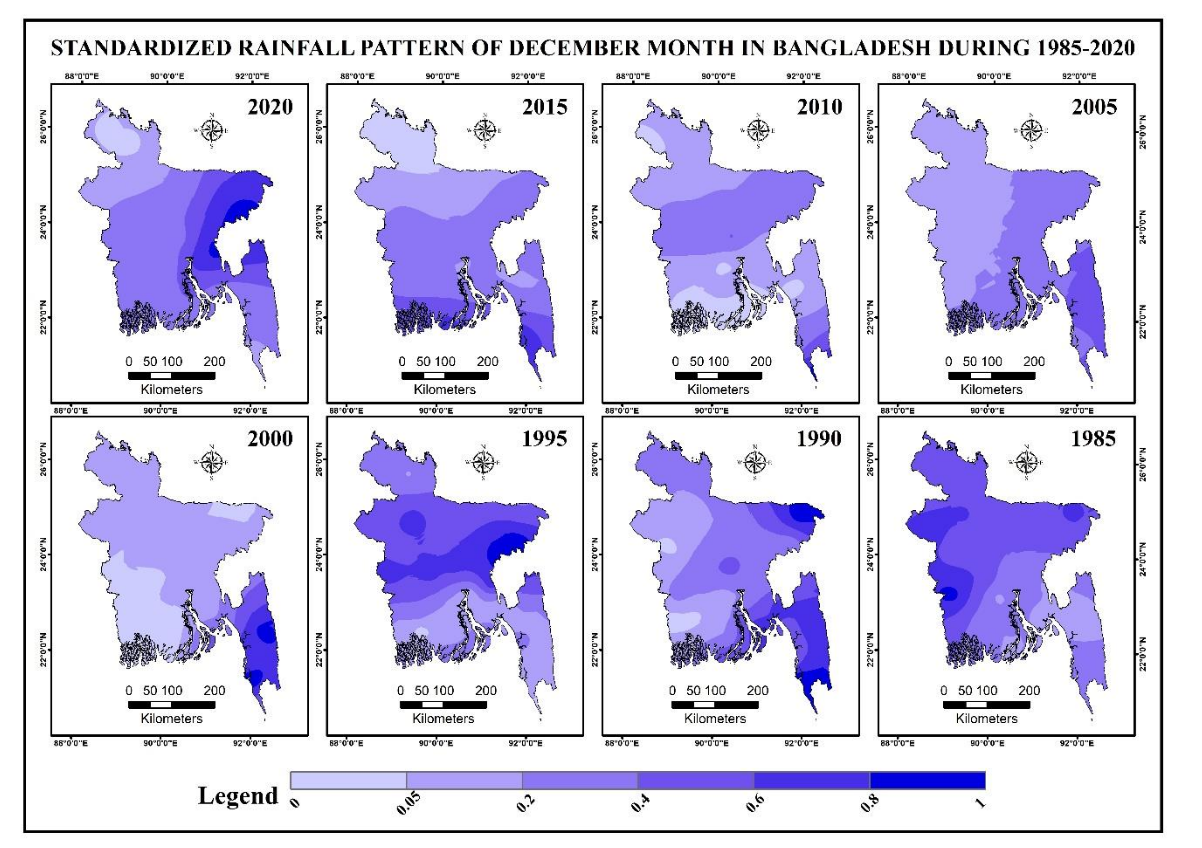

Fig. 3. Standardized rainfall pattern in the month of December in Bangladesh during 1985-2020

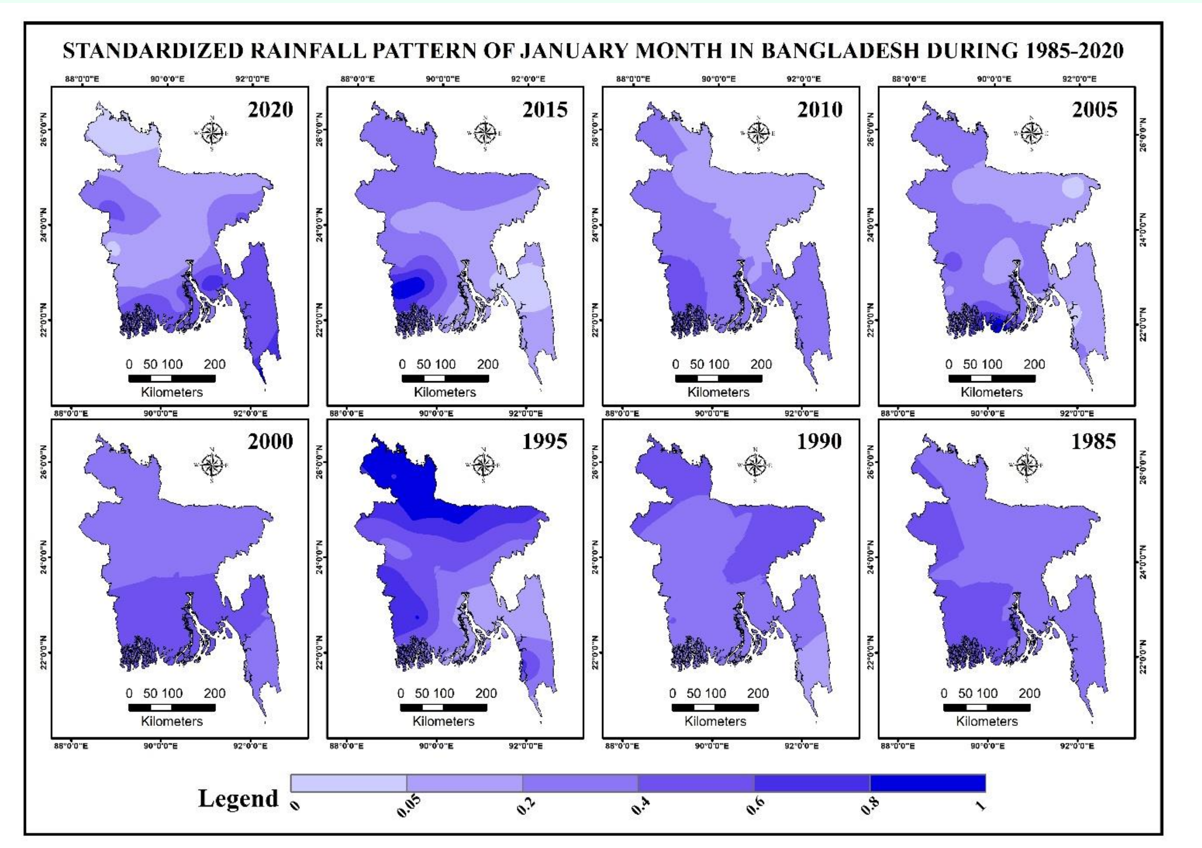

Fig. 4. Standardized rainfall pattern in the month of January in Bangladesh during 1985-2020

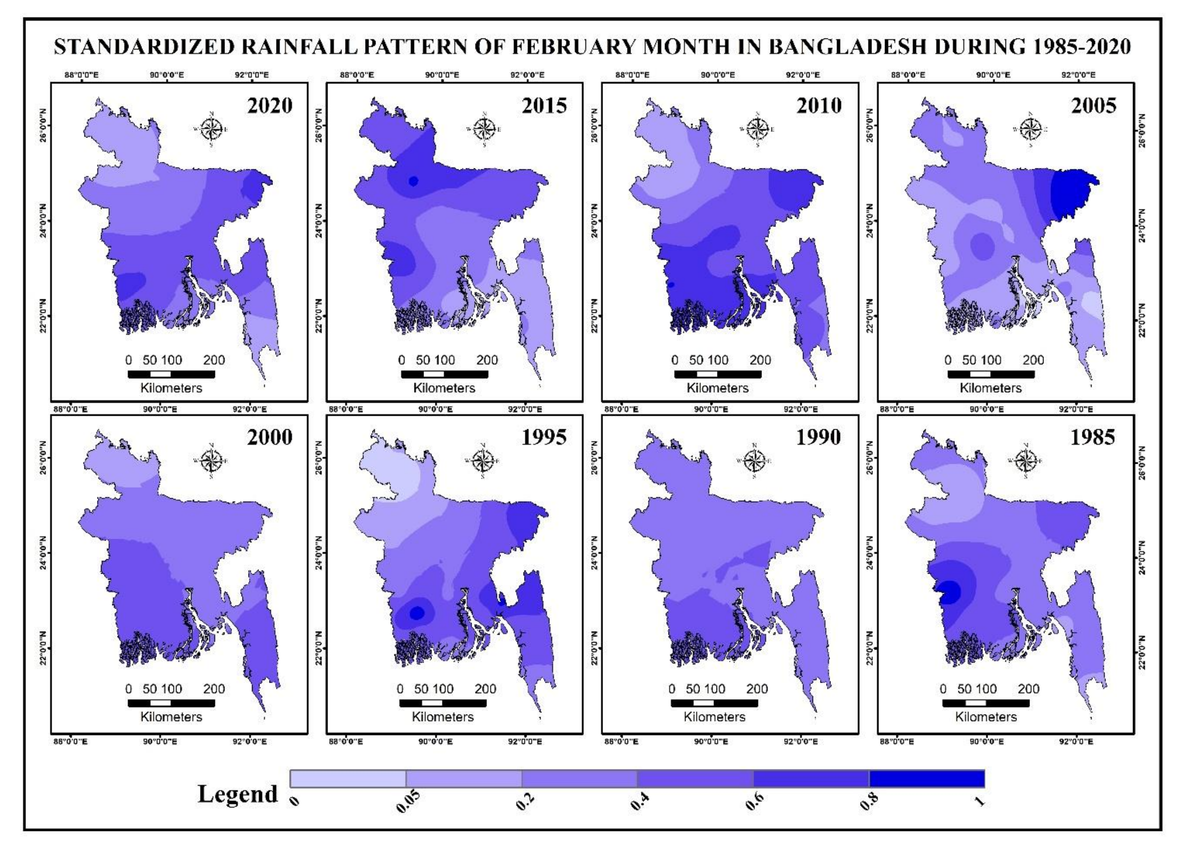

Fig. 5. Standardized rainfall pattern in the month of February in Bangladesh during 1985-2020

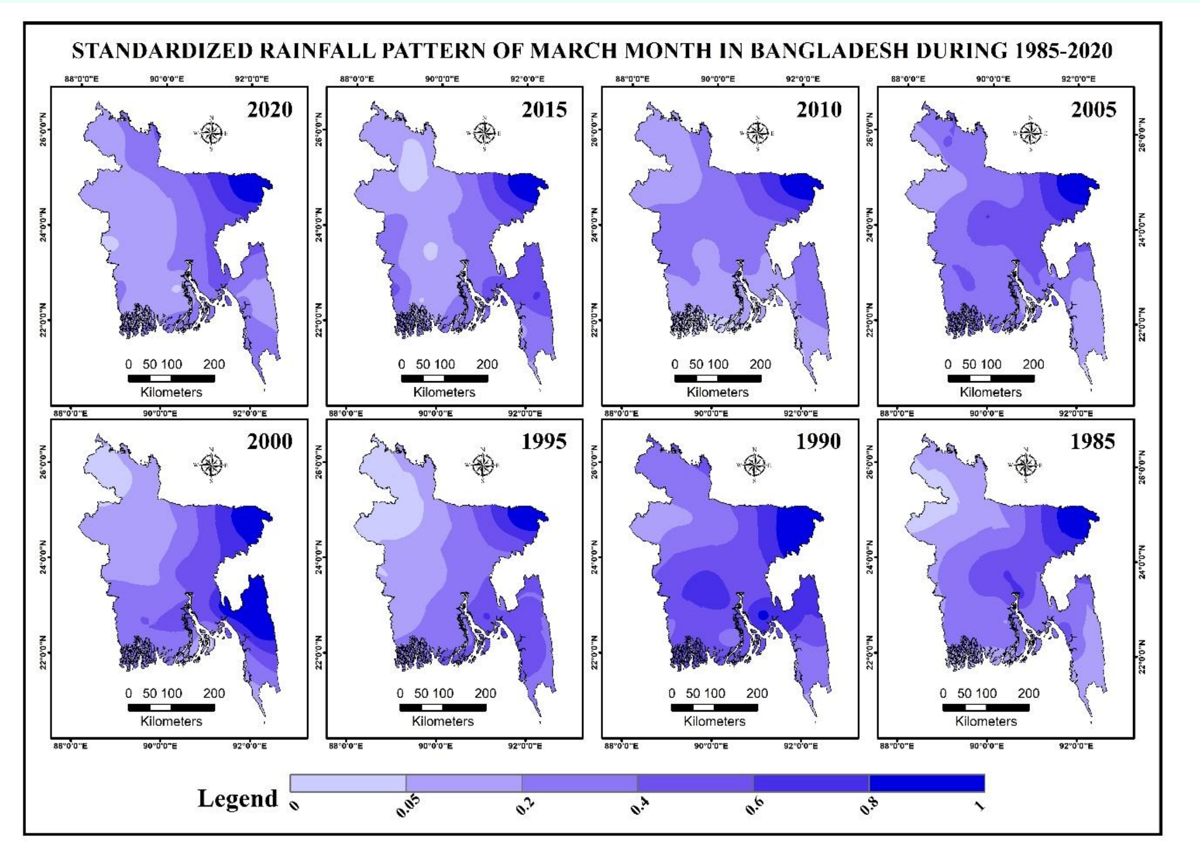

Fig. 6. Standardized rainfall pattern in the month of March in Bangladesh during 1985-2020

Month: March

The upper Eastern part (Sylhet region) received rainfall each and every year of the study (Fig. 6) and the lower Eastern part have received rainfall only in 1990 and 2000.

Vegetation dynamics based on NDVI

The healthiest vegetation in the year of 2020-21 was found in the Eastern-Southern part of Bangladesh (Chottagram region) and in the Western-southern part (Bagerhat region) because of having the dense forest (Fig. 7). More crop cultivation was observed in middle of Western, Eastern and the Center part of the country. Most of area of Khulna region and Sunamganj region showed low NDVI because of growing no crop. In Khulna region, most of land remains fallow during dry season because of excessive moisture and salinity of soil. On the other hand, because of having the large haor area in Sunamganj, land under crop cultivation is very much minimum. Moreover, poor vegetation was also observed in the upper Northern part of the country because of being rainless in the most critical period of growing winter crops and it means the months of October and November were rainless in that areas that hampered the planting of the winter crops.

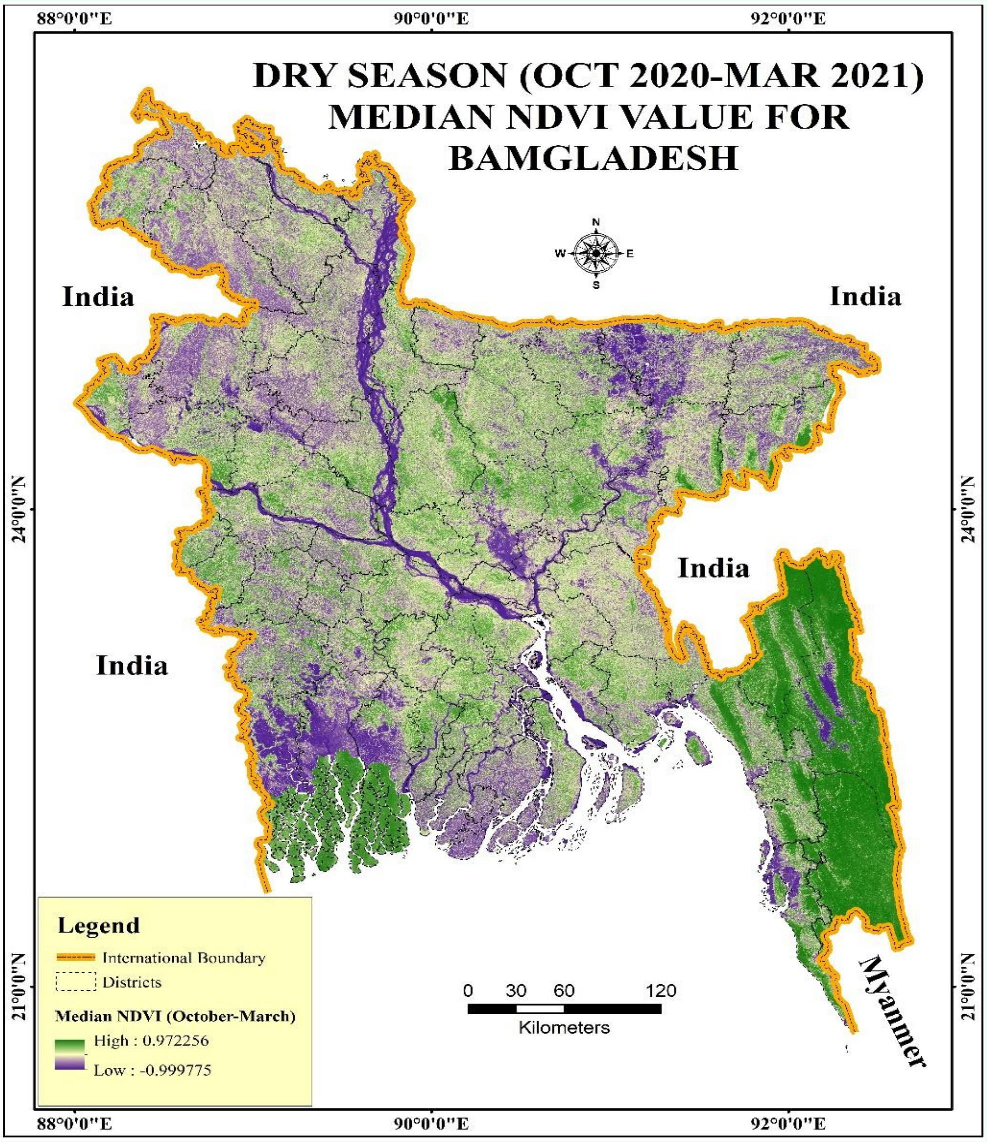

Fig. 7. Landsat satellite-derived Median NDVI for the dry season (October-March) of 2020-2021 in Bangladesh

Conclusion

The study identified that the most rainless month of the dry winter season was November, and no rainfall was occurred in that month in most of years of the study. The Northern part was rainless in the year of 2020 compared to the other parts of the country and poor vegetation was also observed in that area for that particular year. Therefore, the results clearly indicates that vegetation dynamics is greatly dependent on rainfall.

EFFECT OF TRANSPLANTING TIME ON ONION BULB YIELD LOSS OF BARI PIAZ-4

SELIM AHMED AND AFM RUHUL QUDDUS

Abstract

A trial was conducted at the FSRD Site, Sholakundu, Faridpur during the *rabi*, 2020-21 and 2021-22 to find out the optimum planting time of BARI Piaz-4 for reducing bulb yield. The experiment was laid out in randomized complete block (RCB) design with five compact replications. Four treatments were considered as T_1 =seedling transplanting at 20 December, T_2 =seedling transplanting at 30 December T_3 = seedling transplanting at 10 January and T_4 =seedling transplanting at 20 January. BARI Piaz-4 was used as planting material in the study. The highest average bulb yield (28.46 t ha^{-1}) was obtained from T_1 followed by T_2 (26.51 t ha^{-1}). The lowest bulb yield (15.33 t ha^{-1}) was recorded in T_4. Early transplanted onion showed better bulb yield due to favorable weather condition especially minimum temperature and higher sun shine hour resulting well vegetative growth and bulb development. Considering economic benefit, maximum average gross return (Tk. 586988 ha^{-1}) and gross margin (Tk. 380135 ha^{-1}) were obtained from early transplanted seedling. The minimum gross margin (Tk. 54328 ha^{-1}) was observed in late transplanted seedling (Table 8). The bulb yield loss gradually increasing 7%, 34% and 92% in 30 December, 10 January and 20 January, respectively in against of 20 December seedling transplanting.

Introduction

Onions are photo-thermo-periodic; that means they are sensitive to temperature and also to daylight. Day length or daylight hours stimulates the onion plant to start making a bulb (and to stop making leafy growth). Each onion variety will form a bulb only after it has received a certain number of hours of daylight each day for a certain number of days. For vegetative growth, 9-10 hours day length is necessary and for bulb development, 10-12 hours day length is better. Temperature stimulates the onion plant to stop making a bulb. Around 15° C temperature is needed for vegetative growth and up to 21° C temperature is essential for bulb development. Onion prefers moderate temperature and short days for the vegetative growth. Thus, Sunshine hour and temperature is correlated for bulb production. Bulbing begins in response to increasing day-length. Temperature and light spectral quality also affect the onset for bulbing, but these effects are minor compared to day-length. Planting time of seedling is very important for onion cultivation as it affects bulb yield, quality and shelf life. In a trial during 2019-20 in Faridpur and in Rajbari was observed bulb yield decreased gradually with planting time varied every ten days onward. Farmers normally plant onion seedling on 30 December to 20 January depending on weather or zoe condition of lands. With these views the trial was undertaken to find out optimum planting time of BARI Piaz-4 in Faridpur region.

Materials and Methods

The trial was conducted at the FSRD Site, Sholakundu, Faridpur during the rabi, 2020-21 to find out optimum planting time of BARI Piaz-4 for minimizing yield loss. The experiment was laid out in randomized complete block (RCB) design with four compact replications. Four treatments were considered as T_1 =Seedling transplanting at 20 December, T_2 =Seedling transplanting at 30 December, T_3 = Seedling transplanting at 10 January and T_4 =Seedling transplanting at 20 January.

BARI Piaz-4 was used as planting material in the study. The unit plot size was 3m × 3m. The land preparation was done with power tiller. Forty-five to Fifty day's old seedlings were transplanted on according to treatment maintaining 15cm × 10cm spacing. The land was fertilized with 140-60-60-30-3-1.5 kg N-P-K-S-Zn-B ha^{-1} in the form of urea, TSP, MOP, gypsum, zinc sulphate and boric acid, respectively. All of fertilizer, P, S, Zn and B, and half of N and K was applied as basal during final land preparation. Remaining N and K was applied in two equal splits at 21 DAT and 39-43 DAT under moist soil condition and mixed thoroughly with the soil. Weeding and mulching was done thrice at 16-20, 26-28 & 40-49 DAT and the cropland was irrigated four times at pre planting, immediate after planting, 21-25 and 39-50 DAT. Four times fungicides (Rovral at 10-14, 40-45 DAT, Amister top at 22 DAT, and Nativo at 54-64 DAT) and insecticide (Imitaf at 22, 40-45, 54-64 DAT and Amamectin benzoet at 62-72 DAT) were applied. The crop was harvested on March 22-31 2021 (71 to 92 DAT) and March 24-8 April 2022 (79-95 DAT). Data on yield contributing characters and yield were collected during maturity stage. The collected data were analyzed through R software. Mean comparison was done using DMRT value at 5% level of probability.

Results and Discussions

The 10 days interval data of average maximum & minimum temperature (°C), relative humidity (%) and sunshine hour for different transplanting time of onion seedling was stated in Table 1. From this table, it was observed that, trend of maximum & minimum temperature (°C) was the same in both years. Total sunshine hour was higher in 2021-22 (44.32) than that of 2020-21. Growth parament, yield attributes and bulb yield of onion as influenced by different transplanting time of onion seedling during 2021-22 and 2020-21 were presented in Table 2 to 7. Different transplanting time showed significant influence on yield attributes and bulb yield. The highest average plant height (55.75 cm) was recorded in T_2 treatment where seedling was transplanted on 30 December followed by T_1 (54.55 cm) which was 20 December. The lowest plant height (49.63 cm) was recorded in T_4 treatment where seedling was transplanted on 20 January. Average number of leaves per plant was ranged between 5.09 (T_4) to 5.62 (T_3). Significantly the highest number of bulb kg^{-1} was calculated from T_4 treatment (69.55 nos. in 2021-22 and 45.30 nos in 2020-21) followed by T_3 treatment and the average lowest from T_1 (27.33 nos). The highest average single bulb wt. was calculated in T_1 (36.73 g) followed by T_2 (34.05 g). The lowest average single bulb wt. was observed from T_4 (18.52 g). The early transplanted seedling (20 Dec and 30 Dec) received higher sunshine hour and minimum temperature which was helpful for vegetative development resulting better bulb formation (Table 1). The number of average bulbs m^{-2} was ranged between 73.6 (T_3) to 82.61 (T_4). Late transplanted seedling (20 January) produced the highest average number of bulb m^{-2} (82.61) but lowest in single bulb weight (18.52 g), number of leaves $plant^{-1}$ (5.09) and plant height (49.63 cm) due to might be lowest minimum temperature (11.89° C in 2020-21 and 11.67° C in 2021-22) found on vegetative growth stage. The highest average % of bolting bulb (2.92%) was calculated from T_1 and lowest (0%) from T_4. The highest average (4.03 cm) base diameter was obtained from T_1 followed by T_2. The lowest base diameter was 3.14 cm which was found from T_4 treatment. The highest average bulb yield (28.46 t ha^{-1}) was obtained from T_1 followed by T_2 (26.51 t ha^{-1}). The lowest bulb yield (15.33 t ha^{-1}) was recorded in T_4. Early transplanted onion showed better bulb yield due to favorable weather condition especially minimum temperature and higher sun shine hour resulting well vegetative growth and bulb development. The bulb yield loss gradually increasing 7%, 34% and 92% in 30 December, 10 January and 20 January, respectively in against of 20 December seedling transplanting. Considering economic benefit, maximum average gross return (Tk. 586988 ha^{-1}) and gross margin (Tk. 380135 ha^{-1}) were obtained from early transplanted seedling. The minimum gross margin (Tk. 54328 ha^{-1}) was observed in late transplanted seedling (Table 8).

Farmers' opinion

Farmers were happy to observe the results of better bulb yield which was transplanted on 20 to 30 December.

Table 1. Average maximum & minimum temperature (°C), relative humidity (%) and sunshine hour every 10 days interval for different transplanting time of onion seedling

Date with 10 days interval	Maximum temperature (°C)		Minimum temperature (°C)		Relative humidity (%)		Sunshine (hour)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
20 Dec to 29 Dec	24.99	24.92	12.37	13.62	77.1	80.20	7.03	4.97
30 Dec to 9 Jan	27.76	25.07	13.86	13.43	74.3	80.55	8.03	6.95
10 Jan to 19 Jan	24.07	24.71	13.67	14.81	79.4	78.70	1.96	5.52
20 Jan to 29 Jan	23.88	23.45	12.86	13.8	83.8	78.90	4.34	4.39
30 Jan to 8 Feb	25.76	24.46	11.89	11.67	69.1	77.40	7.32	6.98
9 Feb to 18 Feb	29.1	25.63	14.07	13	72.5	71	5.73	7.51
19 Feb to 28 Feb	31.94	29.25	17.86	16.02	67.9	72.10	7.23	8.0

Source: Meteorology Dept. Faridpur, 2020-21 and 2021-22

Table 2. Growth parameter of onion as influenced by different planting time of seedling at FSRD site, Faridpur during the *rabi* season of 2021-22

Treatments	Plant height (cm)	Leaves plant^{-1} (Nos)	Base diameter (cm)	Bulbs kg^{-1} (nos)	Bolted bulb (%)
T_1 (20 Dec)	54.06 b	5.18 ab	3.98 a	29.39 d	3.050 a
T_2 (30 Dec)	55.70 a	5.32 a	3.87 a	32.23 c	1.508 b
T_3 (10 Jan)	54.44 b	5.24 ab	3.37 b	39.60 b	0.168 c
T_4 (20 Jan)	49.46 c	4.94 b	2.92 c	69.55 a	00 c
CV (%)	1.55	4.37	3.53	3.69	30.18

Table 3. Yield attributes and yield of onion as influenced by planting time of seedling at FSRD site, Faridpur during the *rabi* season of 2021-22

Treatments	Bulbs m^{-2} (nos)	Single bulb wt (g)	Bulb yield (t ha^{-1})	Bulb yield loss (%) over 20 Dec transplanting
T_1 (20 Dec)	76.14 ab	33.89 a	25.80 a	--
T_2 (30 Dec)	76.17 ab	31.07 b	24.23 a	6.50
T_3 (10 Jan)	74.31 b	25.35 c	18.87 b	38.19
T_4 (20 Jan)	82.24 a	14.39 d	11.84 c	119.68
CV (%)	6.36	3.56	7.40	--

Table 4. Growth parameter of onion as influenced by planting time of seedling at FSRD site, Faridpur during the *rabi* season of 2020-21

Treatments	Plant height (cm)	Leaves plant^{-1} (Nos)	Base diameter (cm)	Bulbs kg^{-1} (nos)	Bolted bulb (%)
T_1 (20 Dec)	55.05 a	5.75 a	4.09 a	25.28 c	2.80 a
T_2 (30 Dec)	55.80 a	5.85 a	4.08 a	27.03 bc	1.70 a
T_3 (10 Jan)	53.45 ab	6 a	3.83 b	30.42 b	0.28 b
T_4 (20 Jan)	49.80 b	5.25 b	3.36 c	45.30 a	0 b
CV (%)	5.12	3.70	3.69	9.88	61.25

Table 5. Yield attributes and yield of onion as influenced by planting time of seedling at FSRD site, Faridpur during the *rabi* season of 2020-21

Treatments	Bulbs m^{-2} (nos)	Single bulb wt (g)	Bulb yield (t ha^{-1})	Bulb yield loss (%) over 20 Dec transplanting
T_1 (20 Dec)	78.66 b	39.57 a	31.13 a	--
T_2 (30 Dec)	77.66 b	37.04 a	28.79 a	8
T_3 (10 Jan)	72.89 c	32.96 b	24.01 b	30
T_4 (20 Jan)	82.99 a	22.65 c	18.82 c	65
CV (%)	2.75	5.26	6.49	--

Table 6. Growth parameter of onion as influenced by different planting time of seedling at FSRD site, Faridpur during the *rabi* season (average of 2 years)

Treatments	Plant height (cm)	Leaves plant^{-1} (nos)	Base diameter (cm)	Bulbs kg^{-1} (nos)	Bolted bulb (%)
T_1 (20 Dec)	54.55	5.46	4.03	27.33	2.92
T_2 (30 Dec)	55.75	5.58	3.97	29.63	1.60
T_3 (10 Jan)	53.94	5.62	3.6	35.01	0.22
T_4 (20 Jan)	49.63	5.09	3.14	57.42	0

Table 7. Yield attributes and yield of onion as influenced by different planting time of seedling at FSRD site, Faridpur during the *rabi* season (average of 2 years)

Treatments	Bulbs m^{-2} (nos)	Single bulb wt (g)	Bulb yield (t ha^{-1})	Bulb yield loss (%) over 20 Dec transplanting
T_1 (20 Dec)	77.4	36.73	28.46	--
T_2 (30 Dec)	76.91	34.05	26.51	7
T_3 (10 Jan)	73.6	29.15	21.44	34
T_4 (20 Jan)	82.61	18.52	15.33	92

Table 8. Cost and returns analysis of onion as influenced by different planting time of seedling at FSRD site, Faridpur during the *rabi* season (average of 2 years)

Treatment	Bulb yield (t ha^{-1})	Gross return (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})
T_1 (20 Dec)	28.46	586988	206853	380135
T_2 (30 Dec)	26.51	546769	204975	341794
T_3 (10 Jan)	21.44	388600	200343	188258
T_4 (20 Jan)	15.33	249113	194785	54328

Price of average input (Tk kg^{-1}): Urea: 16, DAP: 16, MoP: 15, Gypsum: 10, Zinc: 195, Boron: 240, seed: 3000
Output price (Tk kg^{-1}): Onion bulb: 20 December: 20.63, 30 December: 20.63, 10 January: 18.13, 20 January: 16.25

Conclusion

From the result of two years, the highest average bulb yield (28.46 t ha^{-1}) was obtained from T_1 followed by T_2 (26.51 t ha^{-1}). The lowest bulb yield (15.33 t ha^{-1}) was recorded in T_4. So, yield loss may reduce 7%, 34% and 92% planting of onion seedling on 30 December, 10 January and 20 January, respectively in against of 20 December seedling transplanting.

EFFECT OF SELECTIVE HERBICIDE IN BLACK CUMIN IN FARIDPUR

AFM RUHUL QUDDUS AND SELIM AHMED

Abstract

A field trial was conducted at the FSRD site, Faridpur during the *rabi* 2021-22 to find out the optimum dose of Oxadiazon and to reduce cost of production and increase yield in black cumin. The experiment was laid out in a randomized complete block design with three dispersed replications. Activar was used as trade name of Oxadiazon group. Seven treatments were considered as T_1: Activar @ 0.25 ml 1 Lt^{-1} of water, T_2: Activar @ 0.50 ml 1 Lt^{-1} of water, T_3: Activar @ 0.75 ml 1 Lt^{-1} of water, T_4: Activar @ 1 ml 1 Lt^{-1} of water, T_5: Activar @ 1.5 ml 1 Lt^{-1} of water, T_6: Activar @ 2.0 ml 1 Lt^{-1} of water, and T_7: No weeding. BARI Kalozira-1 was used as planting material. Among the weed species, *Chenopodium album* (Bathua), *Convolvulus arvensis* (Bindu), *Oryza sativa* (Rice), *Echinochloa colonum* (Khude Shama) were the common weeds in black cumin field. The highest number of weed density (50.73 m^{-2}) were recorded from T_6 followed by T_4 and the lowest (17.03 m^{-2}) from T_2 where Activar @ 0.50 ml 1 Lt^{-1} of water was applied. The dry weight of the entire weeds ranged between 34.99 g m^{-2} (T_2) to 109.44 g m^{-2} (control). Weed persistence index (WPI) was also varied from 0.23 (T_7) to 0.71 (T_3). The lowest value from T_4 (0.24) and T_5 (0.26) of WPI stated that, weed was effectively controlled. The significantly highest seed yield (1155.7 kg ha^{-1}) was recorded in T_2

treatment which was at par with T_1 (1118.0 kg ha^{-1}). The seed yield decreased with increase in herbicidal dose. The lowest seed yield (938.0 kg ha^{-1}) was calculated from $T_{6.}$ can be attributed minimum number of crop plants, number of capsules per plant, number of seeds per capsule. Seed yield was increased 18.62% in T_2 over control (no weeding) which was followed by T_1 (14.75 %). The highest gross return (Tk. 231140 ha-1) was registered with T_2 followed by T_1 (Tk 223600 ha^{-1}) and the lowest gross return (Tk 187600 ha^{-1}) was calculated from T_6 due to obtain the lowest seed yield. The highest gross margin (Tk 168744 ha^{-1}) was obtained from T_2 and the lowest from T_6 (Tk 123704 ha^{-1}).

Introduction

Black cumin (*Nigella sativa* L.) is an annual herbaceous plant belongs to family Ranunculaceae. In Faridpur, a total of 3000 ha of land remains engaged in black cumin cultivation. Farmers cultivate black cumin but obtain lower yield due to weed interference. Weed interference like grass *Digitatia sangunalis* (Anguli), Cynodon dactylon (Durba) etc and broad leaf type *Chenopodium album* (Bathua), *Convolvulus arvensis* (Bindu), *Vicia sativa* (Bon masur), *Saussurea affinis* (Bon shimul) weed in black cumin can reduce 60-85% yield (Ahmad and Gafoor, 2004). Literature cited that; $^2/_3$ times weeding is required for black cumin. Recently, farmers started use of herbicide like oxadiazon group with different doses as post emergence (20-25 DAE) but do not get expected output. In comparison with manual weeding, it provides more effective, economic, and easier solution for weed management. Oxadiazon controls the growth of certain undesirable weeds such as broad leaves, grasses, sedge etc. Considering above all situation, the present study was designed to find out the suitable herbicidal optimum dose of Oxadiazon and to reduce cost of production and increase yield in black cumin.

Materials and Methods

The trial was conducted at FSRD Site, Faridpur in AEZ#12 during the *rabi* 2021-22 to find out the suitable herbicidal optimum dose of Oxadiazon and to reduce cost of production and increase yield in black cumin. The experiment was laid out in a randomized complete block design with three dispersed replications. Activar was used as trade name of Oxadiazon group. Seven treatments were considered as T_1: Activar @ 0.25 ml 1 Lt^{-1} of water, T_2: Activar @ 0.50 ml 1 Lt^{-1} of water, T_3: Activar @ 0.75 ml 1 Lt^{-1} of water, T_4: Activar @ 1 ml 1 Lt^{-1} of water, T_5: Activar @ 1.5 ml 1 Lt^{-1} of water, T_6: Activar @ 2.0 ml 1 Lt^{-1} of water, and T_7: No weeding. BARI Kalozira-1 was used as planting material.

The unit plot size was 5 m x 3 m. Seeds were sown in line maintaining 40 cm spacing with continuous seed sowing on 2 December 2021 (resowing was done on 18 December 2021 for Jawad effect). The crop was fertilized with 100-40-30-18-2-1 kg ha^{-1} N-P-K-S-Zn-B, respectively. All amount of P, K, S, Zn & B and half of N was applied as basal during final land preparation. The remaining N were applied in two splits at 29 and 51 days after sowing (DAS) under moist soil condition and mixed thoroughly with the soil for better utilization. Three times irrigations were provided at immediately after sowing, 1st and 2nd top dressing of N. Insecticide under the group Emamectin benzoate was applied to control pod borer for two times at 78 and 92 DAS. The crop was harvested during 7 April 2022 at 111 DAS. Herbicide was applied at 28 Days after emergence (DAE). Necessary data on population of weed species in black cumin plot (weed density), relative weed density (%), green weight and dry weight of weed (g), weed persistence index were collected. Species wise weed population was counted at random from an area of one 1 m^2 per each plot with quadrate (1m x 1m) at before herbicide apply (24 DAE) and after apply (47 DAE) and the dry weight of weed species was determined after in an oven-drying for 72 hours at 70^{o}C. The weight of the dried samples was taken and the average data were expressed as weed biomass (g m^{-2}). The frequency of different weeds was determined, and the density of each species was calculated according to Odum (1971).

Five plants of black cumin in each plot were selected randomly to gather data on yield components. Data on plant population m^{-2} were recorded at physiological maturity and the crop was harvested plot-wise at full maturity. The harvested crop was bundled separately with tag and then brought to the threshing floor. Yield and yield components were recorded after harvesting the crop. Seed and stalk were dried in the sun to minimize the moisture and converted to yield (kg ha^{-1}). Data were recorded on plant height (cm), capsules plant^{-1} (no.), seeds capsule^{-1} (no.), 1000-seed weight (g) and seed yield (kg ha^{-1}). The analysis of variance (ANOVA) of collected data were performed statistically using 'R' software (version: R-3.3.1) (R Core Team, 2016) and mean separation was done by DMRT.

Results and Discussion

Weed indices: The number of weed species and relative weed density was affected by different Oxadiazon dose related treatment. It was observed that *Chenopodium album* (Bathua), *Convolvulus arvensis* (Bindu), *Oryza sativa* (Rice), *Echinochloa colonum* (Khude Shama) were the common weeds in black cumin field. Others weeds were Bajra, durba, Chechi, bonpalong, Fotka etc). Among the common weed species, *Chenopodium album* (Bathua) and *Convolvulus arvensis* (Bindu) were the most dominant broad leaf weeds (Table 1). Before herbicide spray, the highest number of weed density (73.67 m^{-2}) were recorded from T_4 where Activar @ 1 ml 1 Lt^{-1} of water was applied followed by T_6 where Activar @ 2 ml 1 Lt^{-1} of water was applied and the lowest (41.20 m^{-2}) from no weeding plot (control). The total weed density decreased after herbicide spray than before spray (Table 2). The highest number of weed density (50.73 m^{-2}) were recorded from T_6 followed by T_4 and the lowest (17.03 m^{-2}) from T_2 where Activar @ 0.50 ml 1 Lt^{-1} of water was applied (Table 2). In the control plot, relative weed density was found lower during harvest might be due to intra species competition of weed. The weed density percentage of *Chenopodium album* decreased higher after spray from T_4 (1297) followed by T_6 (1175) and T_5 (482). In case of *Convolvulus arvensis,* after spray the weed density was nil from T_1, T_2, T_3 and T_6. T_2 (267%) followed by T_1 (64%) treatments effectively reduced the rice population. T_2 and T_3 treatment controlled *Echinochloa colonum* @ 142% and 63%, respectively. The other weed species showed decreased weed density results. The dry weight of the entire weeds ranged between 34.99 g m^{-2} (T_2) to 109.44 g m^{-2} (control). As the weeds were allowed to grow for longer period in control plot, they produced greater biomass resulting in the greater dry weight. The differences in the dry weight of weeds can be attributed to the differences in the density of weeds (Table 2) and fresh weight of the weeds (Table 3). Weed persistence index (WPI) was also varied from 0.23 (T_7) to 0.71 (T_3). The lowest value from T_4 (0.24) and T_5 (0.26) of WPI stated that, weed was effectively controlled.

Yield components and yield of black cumin: Yield and yield parameters of the black cumin affected by different Oxadiazon (Activar) dose showed significant result which was stated in Table 4. The significantly highest plant height (71.5 cm) was documented in T_1. The lowest plant height (54.1 cm) was recorded in the treatment T_6 due to might be higher doses of herbicide (T_4 to T_6) affect on the plant height. Greater plant height of black cumin was observed in those treatment where lower dose of herbicide was applied (T_1 to T_3). Effect of Oxadiazon doses on plant population of black cumin was significant. The number of plant population m^{-2} was ranged between 112 (T_2) to 100 (T_6). Number of capsules per plant of black seed was affected significantly by different doses of Oxadiazon spray. The maximum number of capsules (12) was recorded in T_2 followed by T_1 (11.40). The minimum number of capsules (9.30) was recorded in T_6 treatment. The highest number of seeds per capsules (77.30) was recorded in T_2 followed by T_1 (76.4). The variation among weed crop competition period was non-significant for 1000-seed weight in black cumin. The significantly highest seed yield (1155.7 kg ha^{-1}) was recorded in T_2 treatment which was at par with T_1 (1118.0 kg ha^{-1}). The seed yield decreased with increase in herbicidal dose. The lowest seed yield (938.0 kg ha^{-1}) was calculated from T_6. can be attributed minimum number of crop plants, number of capsules per plant, number of seeds per capsule. Seed yield was increased 18.62% in T_2 over control (no weeding) which was followed by T_1 (14.75 %). The improvement in seed yield under these treatments may be attributed to lower herbicidal dose with favorable plant growth.

Economic analysis of different Oxadiazon dose on black cumin has shown in Table 5. The highest gross return (Tk. 231140 ha-1) was registered with T_2 followed by T_1 (Tk 223600 ha^{-1})

and the lowest gross return (Tk 187600 ha^{-1}) was calculated from T_6 due to obtain the lowest seed yield. The highest gross margin (Tk 168744 ha^{-1}) was obtained from T_2 and the lowest from T_6 (Tk 123704 ha^{-1}).

Farmers opinion

Farmers were interested to apply Activar @ 0.50 ml 1 Lt^{-1} of water for easily controlled weed.

Table 1. Effect of different weed species population and their relative weed density in black cumin field before spray during the rabi 2021-22 at Faridpur.

Treatment	*Chenopodium album* (Bathua)		*Convolvulus arvensis* (Bindu)		*Oryza sativa (Rice)*		*Echinochloa colonum (Khude Shama)*		Others (Bajra, durba, Chechi, bonpalong, Fotka etc)		Total weed density (no. m^{-2})
	WD (no. m^{-2})	RWD (%)	WD (no. m^{-2})	RWD (%)	WD (no. m^{-2})	RWD (%)	WD (no. m^{-2})	RWD (%)	WD (no. m^{-2})	RWD (%)	
T_1	15.92	35.83	0.99	2.22	24.07	54.18	1.6	3.60	1.85	4.16	44.43
T_2	11.95	24.20	1.73	3.50	29.88	60.52	3.58	7.25	2.23	4.52	49.37
T_3	15.55	34.51	0.62	1.37	24.81	55.07	1.6	3.55	2.47	5.48	45.05
T_4	19	25.79	2.59	3.51	45.18	61.33	4.32	5.86	2.58	3.50	73.67
T_5	16.54	27.08	2.72	4.45	35.4	57.97	4.19	6.86	2.22	3.64	61.07
T_6	15.68	22.16	1.36	1.92	47.28	66.84	2.22	3.14	4.2	5.94	70.74
T_7	13.20	32.03	0.12	0.29	26.91	65.32	0.49	1.19	0.49	1.19	41.20

T_1: Activar @ 0.25 ml 1 Lt^{-1} of water, T_2: Activar @ 0.50 ml 1 Lt^{-1} of water, T_3: Activar @ 0.75 ml 1 Lt^{-1} of water, T_4: Activar @ 1 ml 1 Lt^{-1} of water, T_5: Activar @ 1.5 ml 1 Lt^{-1} of water, T_6: Activar @ 2.0 ml 1 Lt^{-1} of water, and T_7: No weedingWD: Weed density (no. m^{-2}) RWD: Relative weed density (%)

Table 2. Effect of different weed species population and their relative weed density in black cumin field after spray during the rabi 2021-22 at Faridpur

Treatment	*Chenopodium album* (Bathua)		*Convolvulus arvensis* (Bindu)		*Oryza sativa (Rice)*		*Echinochloa colonum (Khude Shama)*		Others (Bajra, durba, Chechi, bonpalong, Fotka etc)		Total weed density (no. m^{-2})
	WD (no. m^{-2})	RWD (%)	WD (no. m^{-2})	RWD (%)	WD (no. m^{-2})	RWD (%)	WD (no. m^{-2})	RWD (%)	WD (no. m^{-2})	RWD (%)	
T_1	7.16	30.06	0	0	14.69	61.67	1.23	5.16	0.74	3.11	23.82
T_2	6.42	37.70	0	0	8.15	47.86	1.48	8.69	0.98	5.75	17.03
T_3	7.78	30.59	0	0	15.80	62.13	0.98	3.85	0.87	3.42	25.43
T_4	1.36	2.76	0.61	1.24	42	85.23	3.33	6.76	1.98	4.02	49.28
T_5	2.84	6.67	0.62	1.46	34.69	81.45	3.08	7.23	1.36	3.19	42.59
T_6	1.23	2.42	0	0	45.18	89.06	1.85	3.65	2.47	4.87	50.73
T_7	10	29.25	0	0	23.45	68.59	0.25	0.73	0.49	1.43	34.19

T_1: Activar @ 0.25 ml 1 Lt^{-1} of water, T_2: Activar @ 0.50 ml 1 Lt^{-1} of water, T_3: Activar @ 0.75 ml 1 Lt^{-1} of water, T_4: Activar @ 1 ml 1 Lt^{-1} of water, T_5: Activar @ 1.5 ml 1 Lt^{-1} of water, T_6: Activar @ 2.0 ml 1 Lt^{-1} of water, and T_7: No weeding

Table 3. Green weight, weed biomass and weed persistence index of black cumin in different dose of herbicide after spray in Faridpur during 2021-22

Treatment	Green weight (g m^{-2})	Weed dry weight (g m^{-2})	Weed persistence index (WPI)
T_1 (activar 0.25 ml Lt^{-1} water)	182.32	52	0.68
T_2 (activar 0.50 ml Lt^{-1} water)	139.42	34.99	0.64
T_3 (activar 0.75 ml Lt^{-1} water)	198.04	57.50	0.71
T_4 (activar 1ml Lt^{-1} water)	142.36	38.36	0.24
T_5 (activar 1.5 ml Lt^{-1} water)	122.05	35.75	0.26
T_6 (activar 2 ml Lt^{-1} water)	128.35	37.72	0.23
T_7 (no weeding)	414.98	109.44	--

Table 4. Effect of oxadiazone group of herbicide on yield and yield contributing characters of black seed during 2021-22

Treatment	Plant height (cm)	Plant population m^{-2} (nos.)	Capsules $plant^{-1}$ (nos.)	Seeds $Capsules^{-1}$ (nos.)	1000 seed weight (g)	Seed yield (kg ha^{-1})	Seed yield increased over control (%)
T_1	71.50 a	110.7 ab	11.4 ab	76.4 ab	1.96 a	1118.0 ab	14.75
T_2	69.60 ab	112.0 a	12.0 a	77.3 a	1.93 a	1155.7 a	18.62
T_3	68.0 bc	107.7 abc	10.6 bc	72.9 bc	1.93 a	1082.3 bc	11.08
T_4	59.60 d	105.7 bcd	10.7 bc	71.9 c	1.93 a	1034.3 cd	6.16
T_5	56.70 e	102.7 cd	10.3 c	67.0 d	1.93 a	1019.0 de	4.59
T_6	54.10 f	100.0 d	9.3 d	63.7 d	1.90 a	938.0 f	-3.73
T_7	66.73 c	104.7 cd	10.5 bc	67.5 d	1.93 a	974.3 ef	--
CV (%)	2.19	3.14	5.07	3.13	2.95	2.72	--

T_1: Activar @ 0.25 ml 1 Lt^{-1} of water, T_2: Activar @ 0.50 ml 1 Lt^{-1} of water, T_3: Activar @ 0.75 ml 1 Lt^{-1} of water, T_4: Activar @ 1 ml 1 Lt^{-1} of water, T_5: Activar @ 1.5 ml 1 Lt^{-1} of water, T_6: Activar @ 2.0 ml 1 Lt^{-1} of water, and T_7: No weeding

Table 5. Cost and return of black cumin as affected by herbicidal dose during *rabi* season of 2021-22 in Faridpur

Treatment	Seed yield (kg ha^{-1})	GR (Tk ha^{-1})	TVC (Tk ha^{-1})	GM (Tk ha^{-1})
T_1 (activar 0.25 ml Lt^{-1} water)	1118.0	223600	62146	161454
T_2 (activar 0.50 ml Lt^{-1} water)	1155.7	231140	62396	168744
T_3 (activar 0.75 ml Lt^{-1} water)	1082.3	216460	62646	153814
T_4 (activar 1ml Lt^{-1} water)	1034.3	206860	62896	143964
T_5 (activar 1.5 ml Lt^{-1} water)	1019.0	203800	63396	140404
T_6 (activar 2 ml Lt^{-1} water)	938.0	187600	63896	123704
T_7 (no weeding)	974.3	194860	60896	133964

Output price (Tk kg^{-1}): 200

Conclusion

Herbicide named, Activar @ 0.50 ml Lt^{-1} of water and 0.25 ml Lt^{-1} of water gave the highest seed yield and gross margin though the highest number of weeds was controlled through 1 to 2 ml Lt^{-1} of water. This is one year study. For final decision, next year experiment will be conducted.

IDENTIFICATION OF CRITICAL WEED COMPETITION PERIODS FOR BLACK CUMIN IN FARIDPUR

SELIM AHMED AND AFM RUHUL QUDDUS

Abstract

A field trial was conducted at the FSRD site, Faridpur during the *rabi* 2020-21 and 2021-22 to find out the critical weed competition periods for black cumin. The experiment was laid out in a randomized complete block design with four dispersed replications. Five treatments were considered as T_1: weeds are allowed to compete with black cumin for 30 days after emergence (DAE), T_2 (farmers practice): weeds are allowed to compete with black cumin for 40 DAE, T_3: weeds are allowed to compete with black cumin for 50 DAE, T_4: weeds are allowed to compete with black cumin for 60 DAE and T_5: No weeding (control). In the year 2021-22, the highest number of weed density (145 m^{-2}) were recorded from T_1 followed by T_3 and the lowest from no weeding plot (49 m^{-2}) or control plot. During 2020-21, the highest number of weed density (432 m^{-2}) were recorded from T_1 followed by T_2 and the lowest (74 m^{-2}) from control. The total weed density decreased with increased in competition periods due to might be enhancing intra weed competition. The highest weed biomass (162.99 g m^{-2} in 2021-22 and 51.06 g m^{-2} in 2020-21) was obtained from no weeding (control) plot and the lowest dry weight (22.48 g m^{-2} in 2021-22 and 9.8 g m^{-2} in 2020-21) was calculated from T_1. Weed persistence index (WPI) was also varied from 0.047 (T_1) to 0.16 (T_3) for 2021-22 and 0.03 (T_1) to 0.55 (T_5) in 2020-21. The significantly highest seed yield (1391 kg ha^{-1} for 2021-22, 1087 kg ha^{-1} for 2020-21 and average 1239 kg ha^{-1}) was recorded in T_1 treatment. The average seed yield decreased with increase in competition periods. The lowest average seed yield (731 kg ha^{-1}) in control plot can be attributed to maximum weed density and minimum number of crop plants, number of capsules per plant, number of seeds per capsule and 1000-seed weight. Average seed yield was increased 69% in T_1 over control which was followed by T_2 (55%). The highest average gross return (Tk. 244703 ha^{-1}) was registered with T_1 where weeds were allowed to compete with black cumin for 30 DAE followed by T_2 (Tk 223768 ha^{-1}) and the lowest gross return (Tk 144373 ha^{-1}) was calculated from control plot due to obtain the lowest seed yield. Weeds must be controlled within 40 days after emergence of black cumin to avoid the risk of economic yield loss as 30 and 40 DAE had been found to be the critical period of weed crop competition in black cumin.

Introduction

There is a period during the life cycle of a crop when it is most sensitive to presence of weeds. This period is known as critical period of competition (Mubeen et al., 2009). The critical weed crop competition period is very important for planning efficient weed control strategy. It varies with season and nature of crops and weeds. Black seed (Nigella sativa L.) is an annual herbaceous plant belonging to family Ranunculaceae, also known as black cumin. In Faridpur, a total of 3000 ha land remains engaged in black cumin cultivation. In winter, black cumin crop face a severe competition with weeds like sedge, grass and broad leaf type weed resulting lower yield (0.94-1.10 t ha^{-1}). Literature cited that, 2/3 times weeding is required for black cumin. Farmers generally make one weeding or thining at 40 DAE. However, there is no information available about the critical weed competition period in black cumin production in the context of Bangladesh. Therefore, the trial was designed with the objective to find out the critical weed competition periods for black cumin.

Materials and Methods

The trial was conducted in medium highland with irrigation facilities under the farmers' field situation at the FSRD Site, Faridpur in AEZ#12 during the *rabi* 2020-21 and 2021-22. The experiment was laid out in a randomized complete block design with four dispersed replications. Five treatments were considered as T_1: weeds are allowed to compete with black cumin for 30 days after emergence (DAE), T_2 (farmers practice): weeds are allowed to compete with black cumin for 40 DAE, T_3: weeds are allowed to compete with black cumin for 50 DAE, T_4: weeds are allowed to compete with black cumin for 60 DAE and T_5: No weeding. BARI Kalozira-1 was used as planting material. The unit plot size was 2 m x 1.5 m.

Seeds were sown in line maintaining 40 cm spacing with continuous seed sowing on 26-30 November 2020 and 28 November 2021 (resowing on 18 December 2021 was done for cyclone " *jawad"* effect). The crop was fertilized with 100-40-30-18-2-1 kg ha^{-1} N-P-K-S-Zn-B, respectively. All amount of P, K, S, Zn & B and half of N was applied as basal during final land preparation. The remaining N were applied in two splits at 28-35 and 50-55 days after sowing (DAS) under moist soil condition and mixed thoroughly with the soil for better utilization. Three times irrigations were provided at immediately after sowing, 1st and 2nd top dressing of N. Weeding was done according to experimental design. Each treatment received only one weeding at different time (30 DAE, 40 DAE, 50 DAE and 60 DAE). Insecticide under the group Emamectin benzoate was applied to control pod borer for two times at 77-89 and 92-103 DAS. The crop was harvested during 28-31 March 2021 at 123 DAS and 7 April 2022 at 110 DAS. Necessary data on population of weed species in black cumin plot (weed density), relative weed density (%), green weight and dry weight of weed (g), weed persistence index were collected. Species wise weed population was counted at random from an area of one 1 m^2 per each plot with quadrate (1m x 1m) at 30 DAE (days after emergence) and the dry weight of weed species was determined after in an oven-drying for 72 hours at 70°C. The weight of the dried samples was taken and the average data were expressed as weed biomass (g m^{-2}). The frequency of different weeds was determined, and the density of each species was calculated according to Odum (1971).

Five plants of black cumin in each plot were selected randomly to gather data on yield components. Data on plant population m^{-2} were recorded at physiological maturity and the crop was harvested plot-wise at full maturity. The harvested crop was bundled separately with tag and then brought to the threshing floor. Yield and yield components were recorded after harvesting the crop. Seed and stalk were dried in the sun to minimize the moisture and converted to yield (kg ha^{-1}). Data were recorded on plant height (cm), capsules $plant^{-1}$ (no.), seeds $capsule^{-1}$ (no.), 1000-seed weight (g) and seed yield (kg ha^{-1}). The analysis of variance (ANOVA) of collected data were performed statistically using 'R' software (version: R-3.3.1) (R Core Team, 2016) and mean separation was done by DMRT.

Results and Discussion

Weed indices: The number of weed species and relative weed density was affected by different weed competition period (Table 1 and 2). It was observed that weed species were different for both years except *Chenopodium album* (Bathua), *Convolvulus arvensis* (Bindu) and Cynodon dactylon (Durba). During the year of 2020-21, Durba was under others category but during 2021-22 it was at individual category (Table 1). *Vicia sativa* (Bon masur), *Saussurea affinis* (Bon shimul), *Digitatia sangunalis* (Anguli) were the common weeds in black cumin field during 2020-21 and *Oryza sativa* (rice), *Cyperus rotundus* (Mutha) during 2021-22. Among the weed species, *Chenopodium album* (Bathua), *Convolvulus arvensis* (Bindu), *Vicia sativa* (Bon masur) and *Saussurea affinis* (Bon shimul) were the most dominant broad leaf weeds (Table 2). During the 2021-22, most weeds were found as grass. Number of weed density was lower in 2021-22 than that of 2020-21. In the year 2021-22, the highest number of weed density (145 m^{-2}) were recorded from T_1 followed by T_3 where weeds are allowed to compete with black cumin for 50 DAE and the lowest from no weeding plot (49 m^{-2}) or control plot. During 2020-21, the highest number of weed density (432 m^{-2}) were recorded from T_1 where weeds are allowed to compete with black cumin for 30 days after emergence (DAE) followed by T_2 (Weed competition period 40 DAE) and the lowest (74 m^{-2}) from control. The total weed density decreased drastically with increased in competition periods due to might be enhancing intra weed competition during 2020-21. But, in 2021-22, from T_2 to T_4, total weed density remains mostly same. Early germinated weeds suppressed the late germinated weeds resulting lower weed density in control plot. During the year of 2020-21, the relative weed density of *Chenopodium album* decreased with increase in competition period (89.80% for T_1 and 43.24% for control plot) but, in the year of 2021-22, the trend was different where relative weed density in control plot was found highest (79.59%). In case of *Convolvulus arvensis* for 2020-21, the relative weed density increased (2.08% for T_1 and 32.43% for control) with each increase in competition period but for 2021-22, exception was observed in T_4 and control plot. Increase in the density with increased competition period can be attributed to availability of more time for the germination and growth of weeds. The other weed species for both the years showed different relative weed density results with increasing or decreasing trends according to increasing competition periods. Dry weight (weed biomass) of all the weeds was affected by weed crop competition period (Table 3 and 4). Weed biomass was higher in 2021-22 than that of 2020-21. The dry weight of the entire weeds increased with each increased competition period during both the years except T_4 in 2021-22. The highest weed biomass (162.99 g m^{-2} in 2021-22 and 51.06 g m^{-2} in 2020-21) was obtained from no weeding (control) plot and the lowest dry weight (22.48 g m^{-2} in 2021-22 and 9.8 g m^{-2} in 2020-21) was calculated from T_1. As the weeds were allowed to grow for longer period, they produced greater biomass resulting in the greater dry weight. The differences in the dry weight of weeds can be attributed to the differences in the density of weeds (Table 1 and 2) and fresh weight of the weeds (Table 3 and 4) depending upon the duration of competition period. The results are in accordance with those of Hussain et al. (2009) who reported increase in weed dry weight with increased competition periods in black cumin crop. Weed persistence index (WPI) was also varied from

0.047 (T_1) to 0.16 (T_3) for 2021-22 and 0.03 (T_1) to 0.55 (T_5) in 2020-21 (Table 3 and 4). The lowest value of WPI from T_1 stated that, weed was effectively controlled where weed crop competition period was 30 DAE. This may be attributed to better control of weeds due to suppress of weed emergence through weed control at 30 DAE.

Yield components and yield of black cumin: Yield and yield parameters of the black cumin affected by different weed competition period showed significant result which was stated in Table 5, 6 and 7 (average). The highest average plant height (59.03 cm) was documented in T_1 where weeds were allowed to compete with black cumin for 30 days after emergence (DAE). The lowest average plant height (49.20 cm) was recorded in the treatment T_5 where no weeding was performed. Greater plant height of black cumin in competition period of 30 DAE might have been due to more availability of resources in the absence/less of weeds for rest of the growing period. The minimum plant height in no weeding can be attributed to greater competition and suppressive effect of weeds. Effect of weed competition periods on plant population of black cumin was significant for both the years. The highest average number of plant population m^{-2} (108.50) was obtained from T_1 followed by T_2 (103.88) where weed competition period was 40 DAE. The lowest average number of plant population m^{-2} (92.38) was obtained from T_5. Reduced plant population with higher competition period might have been due to greater struggle for resources. Number of capsules per plant of black seed was affected significantly by weed crop competition periods for both the years. The maximum average number of capsules (12.98) was recorded in T_1 followed by T_2 (11.53). The minimum number of capsules (9.20) was recorded in no weeding treatment. The minimum number of capsules per plant was due to augmented competition between weeds and crop plants throughout the life span. The depletion of resources by weeds resulted in scarcity of resources and ultimately crop plants had a smaller number of capsules with short stature. The average number of seeds per capsules ranged between 64.86 (T_5) to 73.48 (T_1). The variation among weed crop competition period was significant for 1000-seed weight in black cumin for 2020-21 but for 2021-22, it was non-significant. The significantly highest seed yield (1391 kg ha^{-1} for 2021-22, 1087 kg ha^{-1} for 2020-21 and average 1239 kg ha^{-1}) was recorded in T_1 treatment. The average seed yield decreased with increase in competition periods. The lowest average seed yield (731 kg ha^{-1}) in control plot can be attributed to maximum weed density and minimum number of crop plants, number of capsules per plant, number of seeds per capsule and 1000-seed weight. Average seed yield was increased 69% in T_1 over control which was followed by T_2 (55%). The improvement in seed yield under these treatments may be attributed to more weed reduction at critical growth stages of crops which favored healthy plant growth. The results of two year study leads to the conclusion that the maximum seed yield in black cumin could be obtained by competition with weed for 30 DAE during initial growth phase of the crop. Therefore, weeds must be controlled within 40 days after emergence of black cumin to avoid the risk of economic yield loss as 30 and 40 DAE had been found to be the critical period of weed crop competition in black cumin.

Average economic analysis of different weed competition period on black cumin has shown in Table 8. The highest average gross return (Tk. 244703 ha^{-1}) was registered with T_1 where weeds were allowed to compete with black cumin for 30 DAE followed by T_2 (Tk 223768 ha^{-1}) and the lowest gross return (Tk 144373 ha^{-1}) was calculated from control plot due to obtain the lowest seed yield. But, T_1 and T_2 treatments attributed the highest cost (Tk. 74266 ha^{-1}) due to need excess 10 labors for weeding than other treatments and less cost in (Tk. 59266 ha^{-1}) in control (T_5). At early stage of weeding at 30 and 40 DAE, weeds were smaller in size resulting excess labor was needed. The highest gross margin (Tk 170437 ha^{-1}) was obtained from T_1 and the lowest from no weeding plot (Tk 85107 ha^{-1}).

The results of the study lead to the conclusion that the maximum seed yield in black cumin could be obtained by keeping the plots weed free during initial growth phase of the crop. Therefore, weeds must be controlled within 40 days after emergence of black cumin to avoid the risk of economic yield loss. Thus, weed crop competition period of 30 and 40 DAE had been found to be the critical period of weed crop competition in black cumin.

Farmers opinion

Weeding was done at 40 Days after emergence of black cumin. Farmers were interested to apply weeding at 30 DAE for highest seed yield and economic return.

Table 1. Effect of different weed species population and their relative weed density in black cumin field during the rabi 2021-22 at Faridpur

Treatment	*Chenopodium album* (Bathua)		*Convolvulus arvensis* (Bindu)		*Oryza sativa* (rice)		*Cyperus rotundus* (Mutha)		*Cynodon dactylon* (durba)		Others (keshor, *khude shama*, bajra, sechi)		Total weed density (no. m^{-2})
	WD (no. m^{-2})	RWD (%)	WD (no. m^2)	RWD (%)	WD (no. m^2)	RWD (%)	WD (no. m^2)	RWD (%)	WD (no. m^2)	RWD (%)	WD (no. m^{-2})	RWD (%)	
T_1	111	77.0	4	2.95	10	6.8	2	1.2	5	3.3	13	8.52	145
T_2	74	67.89	5	4.58	13	11.93	2	1.83	5	4.59	10	9.15	109
T_3	65	59.1	8	7.27	13	11.82	2	1.82	8	7.27	14	12.74	110
T_4	65	61.3	6	5.66	17	16.04	2	1.89	6	5.66	10	9.43	106
T_5	39	79.59	0	0	0	0	0	0	6	12.24	4	8.16	49

T_1: weeds are allowed to compete with black cumin for 30 days after emergence (DAE), T_2 (farmers practice): weeds are allowed to compete with black cumin for 40 DAE, T_3: weeds are allowed to compete with black cumin for 50 DAE, T_4: weeds are allowed to compete with black cumin for 60 DAE and T_5: No weeding (control)
WD: weed density and RWD: Relative weed density

Table 2. Effect of different weed species population and their relative weed density in black cumin field during the rabi 2020-21 at Faridpur

Treatment	*Chenopodium album* (Bathua)		*Convolvulus arvensis* (Bindu)		*Vicia sativa* (Bon masur)		*Saussurea affinis* (Bon shimul)		Others (Anguli and durba)		Total weed density (no. m^{-2})
	Weed density (no. m^{-2})	Relative weed density (%)	Weed density (no. m^{-2})	Relative weed density (%)	Weed density (no. m^{-2})	Relative weed density (%)	Weed density (no. m^{-2})	Relative weed density (%)	Weed density (no. m^{-2})	Relative weed density (%)	
T_1	388	89.80	9	2.08	17	3.94	15	3.47	3	0.69	432
T_2	311	88.60	23	6.55	8	2.28	8	2.28	0.7	0.20	351
T_3	135	71.43	27	14.29	11	5.82	16	8.47	0	0	189
T_4	65	52.85	34	27.64	12	9.76	12	9.76	0	0	123
T_5	32	43.24	24	32.43	9	12.16	9	12.16	0	0	74

T_1: weeds are allowed to compete with black cumin for 30 days after emergence (DAE), T_2 (farmers practice): weeds are allowed to compete with black cumin for 40 DAE, T_3: weeds are allowed to compete with black cumin for 50 DAE, T_4: weeds are allowed to compete with black cumin for 60 DAE and T_5: No weeding (control)

Table 3. Green weight, weed biomass and weed persistence index of black cumin in different weed competition period at Faridpur during 2021-22

Treatment	Green weight (g m^{-2})	Weed dry weight (g m^{-2})	Weed persistence index (WPI)
T_1 (Competition for 30 DAE)	118.94	22.48	0.047
T_2 (Competition for 40 DAE)	265.01	53.46	0.15
T_3 (Competition for 50 DAE)	331.19	58.82	0.16
T_4 (Competition for 60 DAE)	313.69	49.23	0.14
T_5 (Control/No weeding)	513.78	162.99	--

Table 4. Green weight, weed biomass and weed persistence index of black cumin in different weed competition period at Faridpur during 2020-21

Treatment	Green weight (g m^{-2})	Weed dry weight (g m^{-2})	Weed persistence index (WPI)
T_1 (Competition for 30 DAE)	51.10	9.80	0.03
T_2 (Competition for 40 DAE)	42.43	15.16	0.06
T_3 (Competition for 50 DAE)	237.72	39.04	0.29
T_4 (Competition for 60 DAE)	229.13	46.65	0.55
T_5 (Control/No weeding)	257.55	51.06	--

Table 5. Effect of different weed competition periods on yield and yield contributing characters of black seed during 2021-22

Treatment	Plant height (cm)	Plant pop. m^{-2} (nos.)	Capsules $plant^{-1}$ (nos.)	Seeds $capsules^{-1}$ (nos.)	1000 seed wt. (g)	Seed yield (kg ha^{-1})	Seed yield increased over control (%)
T_1	63.35 a	108.25 a	12.90 a	82.95 a	2.02 a	1391 a	62
T_2	58.90 b	103.25 b	11.35 b	78.10 b	2.02 a	1238 b	44
T_3	56.15 c	103.50 b	10.80 bc	76.45 bc	1.97 a	1074 c	25
T_4	55.40 c	102.25 bc	10.35 c	73 cd	1.97 a	1001 c	17
T_5	52.70 d	98.25 c	9.70 d	70.47 d	1.95 a	858 d	--
CV (%)	2.87	2.91	3.33	3.18	2.97	5.53	--

Table 6. Effect of different weed competition periods on yield and yield contributing characters of black seed during 2020-21

Treatment	Plant height (cm)	Plant pop.n m^{-2} (nos.)	Capsules $plant^{-1}$ (nos.)	Seeds $Capsules^{-1}$ (nos.)	1000 seed weight (g)	Seed yield (kg ha^{-1})	Seed yield increase over control
T_1	54.70 a	108.75 a	13.05 a	64 a	1.93 a	1087 a	80
T_2	50.55 b	104.50 b	11.70 b	62.10 b	1.93 a	1029 a	70
T_3	51.10 b	99 c	10.85 bc	60.75 bc	1.90 ab	912 b	51
T_4	48.70 b	98.50 c	10.10 c	61.40 b	1.85 b	850 c	41
T_5	45.70 c	86.50 d	8.70 d	59.25 c	1.87 ab	604 d	--
CV (%)	3.28	2.53	6.78	1.93	1.86	4.34	

Table 7. Effect of different weed competition periods on yield and yield contributing characters of black seed (av. of 2 years)

Treatment	Plant height (cm)	Plant pop. m^{-2} (nos.)	Capsules $plant^{-1}$ (nos.)	Seeds $Capsules^{-1}$ (nos.)	1000 seed weight (g)	Seed yield (kg ha^{-1})	Seed yield increase over control (%)
T_1	59.03	108.50	12.98	73.48	1.98	1239	69
T_2	54.73	103.88	11.53	70.10	1.98	1133	55
T_3	53.63	101.25	10.83	68.60	1.94	993	36
T_4	52.05	100.38	10.23	67.20	1.91	925	27
T_5	49.20	92.38	9.20	64.86	1.91	731	--

Table 8. Cost and return of black cumin as affected by weed competition during *rabi* season in Faridpur (average of 2 years)

Treatment	Seed yield (t ha^{-1})	GR (Tk ha^{-1})	TVC (Tk ha^{-1})	GM (Tk ha^{-1})
T_1 (Competition for 30 DAE)	1239	244703	74266	170437
T_2 (Competition for 40 DAE)	1133	223768	74266	149502
T_3 (Competition for 50 DAE)	993	196118	69266	126852
T_4 (Competition for 60 DAE)	925	182688	69266	113422
T_5 (No weeding)	731	144373	59266	85107

Output price (Tk/kg): Seed: 197.50 (2020-21: 195 Tk kg^{-1} and 2021-22: 200 Tk kg^{-1})

Conclusion

Weeding at 30 days after emergence decreased the weed infestation, weed biomass and weed persistence index followed by weed crop competition period of 40 DAE resulting the highest seed yield and gross margin. Thus, weed crop competition period of 30 and 40 DAE had been found to be the critical period of weed crop competition in black cumin.

B. Plant Protection Measures

BIO-RATIONAL BASED MANAGEMENT TECHNIQUES FOR THE CONTROL OF MANGO FRUIT FLY, *BACTROCERA DORSALIS* IN RAJSHAHI REGION

J.C. BARMAN, M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

Adaptive trials were conducted at farmer's field of Charghat and Bagha upazilla of Rajshahi district during the mango fruiting season of 2022 in a randomized complete block design with 4 treatments and 10 replications. The treatments were assigned as follows: T_1= Sanitation + soil drenching with microbial pesticide, (*Metarhizium anisopliae*) + use of methyl eugenol pheromone trap, T_2= Sanitation + soil drenching with microbial pesticide, (*Metarhizium anisopliae*) + use of attract and kill method, T_3= Sanitation + soil drenching with microbial pesticide, (*Metarhizium anisopliae*) + use of male attractant impregnated yellow sticky trap and T_4= Farmer's practice (2 sprays with Malathion/ Shobicron/ Sevin). Among the treatments, Male attractant impregnated yellow sticky trap was more effective in catching mango fruit fly male adult populations followed by attract & kill method and methyl eugenol pheromone trap, respectively. But attract and kill method can catch both of male and female populations. Maximum abundance of male populations was found during mid-May to mid-June while that of female populations during mid-May to mid-June. The lowest fruit infestation (3.9–4.3%) was found in plants where attract and kill methods were installed followed by male attractant impregnated yellow sticky trap (4.7–6.0%) and methyl eugenol pheromone trap (5.5–6.64%). The highest infestation was found in farmer's practice (9.4–12.1%) where insecticides were sprayed to control mango fruit fly. Considering marginal cost benefit ratio attract & kill method produced the highest marketable yield (98.67 kg/tree) and higher MBCR (9.28).

Introduction

Mango or "Aam" in Bengali, is very popular fruit for its characteristic taste, flavour and fragrance. Mango *(Mangifera indica L)* is one of the ancient fruits of Indian origin (Butani, 1979). Bangladesh is one of the major mango producing countries along with India, Pakistan, Mexico, Brazil, The Philippines etc. Mango is one of the most common, important and popular fruits in Bangladesh. It is considered as the “king of fruits”. Besides, having delicious taste, captivating flavor with multifarious colour, it is excellent source of nutritive values. Both unripe and ripe mangoes are good source of vitamin-C, the deficiency of which causes scurvy and swelling of hands and feet (Hossain, 1989). In Bangladesh, the mango growing area is expanding each year, especially in north-western region and hilly areas. Like many other crops, it also has some problems in cultivation. Many factors are responsible for the yield of mango. Besides many other factors, insect pests play a vital role for the low yield and poor quality of mango fruits. Among insect pests, the mango fruit fly, *Bactrocera dorsalis* (Hendel) (Tephritidae: Diptera) is a major pest of mango fruits Khirsapat, Langra and Fazli varieties of mango (Karim, 1989). It reduces the marketable yield of mango. A huge quantity of mango fruits may be lost due to the fruit fly infestation each year. Farmers use only chemical pesticides indiscriminately even mixture of several chemicals at very high frequency and over dose to save their mango crop which have several limitations like ineffectiveness, killing of pollinators, parasitoids and predators, resulting in resurgence of other pest populations, develop resistant insect biotypes and excessive residues in marketable fruits. Therefore, the present study was undertaken for the management of the mango fruit fly, which is eco-friendly and safe for the environment.

Materials and Methods

The trial was conducted at farmer's field of Charghat and Bagha upazilla of Rajshahi district during the mango fruiting season of 2022 in a randomized complete block design with 4 treatments and 10 replications. One mango tree was considered as one treatment replication. Around 20 years old mango trees of BARI Aam-2 (Lakhna) variety were used for the study. The treatments were assigned as follows: T_1= Sanitation + soil drenching with microbial pesticide, (*Metarhizium anisopliae*) + use of methyl eugenol pheromone trap, T_2= Sanitation + soil drenching with microbial pesticide, (*Metarhizium anisopliae*) + use of attract and kill method, T_3= Sanitation + soil drenching with microbial pesticide, (*Metarhizium anisopliae*) + use of male attractant impregnated yellow sticky trap and T_4= Farmer's practice (2 sprays with Malathion/ Shobicron/ Sevin).

Year-round activities were done in the mango orchards starting from August 2021 with removal of dead and decades, unnecessary shoots, ploughing the orchard, application of fertilizers and soil drenching. Soil recharge was applied at two splits: first application was done on August 2021 and the second on the first week of April 2022. Fifty-gram *Metarhizium anisopliae* was applied on the soil of the tree canopy area and the soil was drenched and watered with a hand water shower. Methyl eugenol pheromone trap, male attractant impregnated yellow sticky trap and attract & kill method were installed on 26 April 2022. Randomly selected 50 fruits from each tree were tagged for the study. In 1989, Karim reported that *Bactrocera dorsalis* prefer to lay eggs on mango fruits at 30 to 40 days before crop harvest. So, 40-45 days before crop harvest was selected as proper time of installation of methyl eugenol pheromone trap, male attractant impregnated yellow sticky trap and attract & kill methods for the protection of fruit fly infestation. Randomly selected 50 fruits were also tagged for the control treatment in the same way. Methyl eugenol was used in a transparent plastic jar containing soap water at the bottom. Male attractant impregnated yellow sticky trap was hanged in the branches of the tree at man height with thread. In attract & kill methods, male attractant was used in the trunk and female attractant was hanged in the branches with hook. The number of male fruit fly captured in the trap was counted at every 7 days interval. Similarly, the number of male and female fruit flies captured in attract and kill methods was counted at every 7 days interval. At the time of harvest, harvested fruits of all treatments were checked for recording fruit fly infestation and recorded yield data. Per cent fruit fly infestation was calculated using the following formula:

$$\%\ \text{Fruit fly infestation} = \frac{\text{No. of infested fruits}}{\text{Total no. of harvested fruits}} \times 100$$

Results and Discussion

Fruit fly catch: Male fruit fly catch in both locations has been shown in figure 1 and figure 2. Male attractant impregnated yellow sticky trap was more effective in catching mango fruit fly male adult populations followed by attract & kill method and methyl eugenol pheromone trap, respectively, in both locations. The abundance of mango fruit fly adult male populations was noticed from first week of May 2022 and maximum number of populations was found during the period of mid-May to mid-June i.e., up to crop harvest. Higher number of male populations was found at Charghat as compared to Bagha upazilla.

Attract and kill method can catch both of male and female populations. Higher number of mango fruit fly female populations was found at Bagha as compared to Charghat upazilla (Figure 3). The figure reveals that abundance of female populations was more during the period of mid-May to first week of June showing the peak during the last week of May.

Fruit infestation: Efficacy of different treatments in controlling mango fruit fly infestation during 2022 mango season at Charghat and Bagha upazilla of Rajshahi district has been illustrated in Table 1 and 2. It is revealed from Table 1 & 2 that **t**he lowest fruit infestation (3.9–4.3%) was found in plants where attract and kill methods were installed as compared to male attractant impregnated yellow sticky trap (4.7–6.0%) and methyl eugenol pheromone trap (5.5–6.64%). The highest infestation was found in farmer's practice (9.4–12.1%) where insecticides were sprayed to control mango fruit fly.

Considering marginal cost benefit ration attract & kill method produced the highest marketable yield (98.67 kg/tree) and higher MBCR (9.28) followed by methyl eugenol pheromone trap (6.40) and male attractant impregnated yellow sticky trap (5.70). The lowest marketable yield (79.4 kg/tree) was obtained from farmer's practice (Table 3).

Farmer's reaction

Farmers got better crop yield from the attract & kill method, methyl eugenol pheromone trap and male attractant impregnated yellow sticky trap installed trees. Neighboring farmers visited the field and were impressed to see the eco-friendly mango fruit fly management techniques. Farmers preferred attract & kill methods and male attractant impregnated yellow sticky trap for their easy application. They also expressed their eager to get both attract & kill methods, and male attractant impregnated yellow sticky trap.

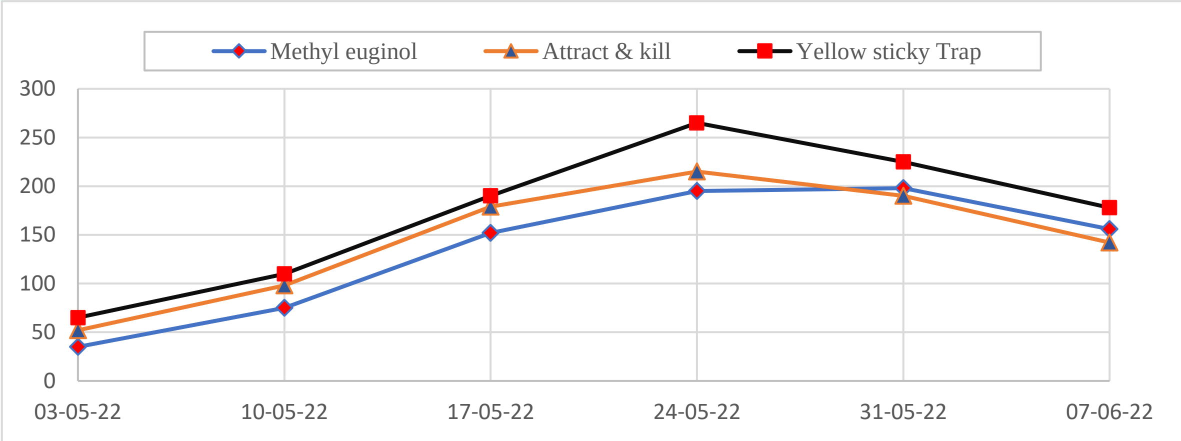

Fig.1. Male catch on different dates in methyl eugenol pheromone trap and attract & kill method at Charghat, Rajshahi during 2022 mango crop season.

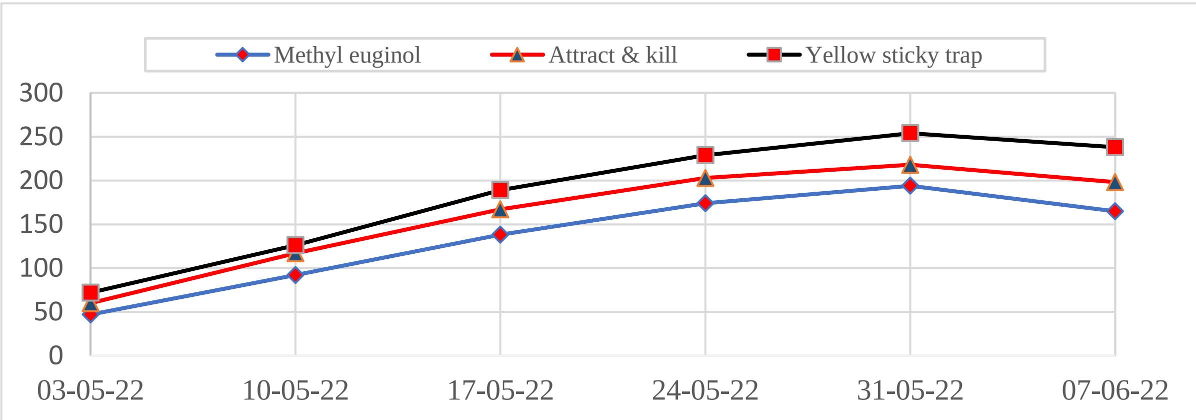

Fig.2. Male catch on different dates in methyl eugenol pheromone trap and attract & kill method at Bagha, Rajshahi during 2022 mango crop season.

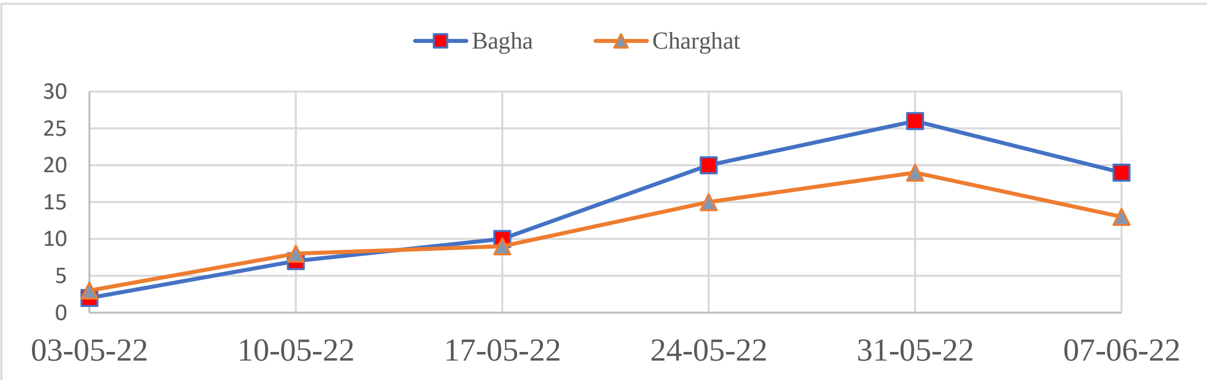

Fig.3. Female catch on different dates in attract & kill method at Charghat and Bagha of Rajshahi district during 2022 mango crop season.

Table 1. Efficacy of different treatments in controlling mango fruit fly, *Bactrocera dorsalis* (Hendel) during 2022 mango season at Charghat, Rajshahi (average of 10 plants)

Treatment	No. of tagged fruits	No. of harvested fruits	No. of healthy fruits	No. of infested fruits	% Fruit infestation
Methyl eugenol	100	92.0	86.9	5.1	5.5
Attract & Kill method	100	89.7	86.2	3.5	3.9
Male attractant impregnated yellow sticky trap	100	87.2	83.0	4.2	4.7
Farmer's practice	100	85.4	77.4	8.0	9.4

Table 2. Efficacy of different treatments in controlling mango fruit fly, *Bactrocera dorsalis* (Hendel) during 2021 mango season at Bagha, Rajshahi (average of 10 plants)

Treatment	No. of tagged fruits	No. of harvested fruits	No. of healthy fruits	No. of infested fruits	% Fruit infestation
Methyl eugenol	100	84.4	78.8	5.6	6.64
Attract & Kill method	100	88.2	84.4	3.8	4.3
Male attractant impregnated yellow sticky trap	100	87.2	82.0	5.2	6.0
Farmer's practice	100	85.6	75.2	9.4	12.1

Table 3. Benefit cost analysis after application of different treatments for controlling mango fruit fly during 2021 mango season (average data of Charghat and Bagha upazilla was used)

Treatments	Pest management cost (Tk/tree)	Marketable yield (Kg/tree)	Gross return (Tk/tree)	Net return (Tk/tree)	Adjusted net return (Tk/tree)	Marginal Benefit Cost Ratio
Methyl eugenol	60	90.50	3620	3560	384	6.40
Attract & Kill method	75	98.67	3946.80	3871.80	695.80	9.28
Male attractant impregnated yellow sticky trap	80	92.80	3712	3632	456	5.70
Untreated Control	0	79.4	3176	3176	-	-

Market price of Mango = Tk 40/ kg, Cost of methyl eugenol @ Tk 60/tree, Cost of attract & kill method @ Tk 75/tree and cost of male attractant impregnated yellow sticky trap @ 80 Tk/tree.

Conclusion

All of three treatments viz. methyl eugenol pheromone trap, attract & kill method and male attractant impregnated yellow sticky trap effectively reduced mango fruit fly infestation as compared to farmer's practice. Attract & kill methods and male attractant impregnated yellow sticky trap got more popularity for theirs easy installation.

ICM TECHNIQUES IN REDUCING FLOWER AND FRUIT DROPPING OF MANGO IN HIGH BARIND TRACT

J.C. BARMAN, M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

On-farm trials of Integrated Crop Management (ICM) techniques were conducted during 2021-22 mango season at farmer's field of two different regions of high Barind tract (HBT) viz. Godagari of Rajshahi and Sapahar of Naogaon districts, to increase mango production by reducing flower and fruit dropping following randomized complete block design (RCBD). ICM package includes: application of recommended fertilizer dose; two sprays with imidacloprid (Confidor) 70 WG @ o.2 g/litre of water with mancozeb (Indofil) M 45 @ 2.0 g/litre of water-

1st spray within 10 days of flowering and 2nd after one month of the first application; three irrigations starting from full bloom to fruit maturity at 15 days interval; two sprays with 2% urea solution at pea and marble stages of fruit growth were done. On the other hand, non-ICM package includes farmer's practice only. Results indicated that 28 to 32.35% mango fruits by number and 9.12 to 17.15% yield by weight were increased in ICM packages as compared to non-ICM practices at two different study areas.

Introduction

Mango *(Mangifera indica L)* is one of the ancient fruits of Indian origin (Butani, 1979). Bangladesh is one of the major mango producing countries along with India, Pakistan, Mexico, Brazil, The Philippines etc. Mango is one of the most common, important and popular fruits in Bangladesh. It is considered as the "king of fruits". Besides, having delicious taste, captivating flavor with multifarious colour, it is excellent source of nutritive values. Both unripe and ripe mangoes are good source of vitamin-C, the deficiency of which causes scurvy and swelling of hands and feet (Hossain, 1989). In Bangladesh, the mango growing area is expanding each year, especially in north-western region and hilly areas. Like many other crops, it also has some problems in cultivation. Many factors are responsible for the yield of mango. Besides many other factors, insect pests and diseases; lack of optimum doses of fertilizers application and irrigation play a vital role for the low yield and poor quality of mango fruits. Among insect pests, Mango leafhoppers (MLHs) are the most destructive pests of all the mango varieties in Bangladesh (Karim, 1989). If not properly controlled, MLHs may cause a loss of 20-100 per cent of the inflorescences (Karim, 1989). Damage is mostly caused by the enormous number of hopper nymphs which feed on inflorescences and new leaves by sucking plant sap. The voracious feeding of the nymphs causes the inflorescences to wither and turn brown. Even fertilized flowers may not give fruits and very young fruits may drop due to withering of florets for reasons of physical injury and sap sucking by the nymphs. The MLHs also excrete honeydew which encourages development of sooty mould on the surface of leaves and shoots where the honeydew is retained. The black coating of the sooty mould interferes photosynthetic activity of the affected plant parts resulting non-setting of flowers and dropping of immature fruits (Karim 1989; Wen and Lee 1978).

Till now, chemical control is considered as the best way to control hopper populations and anthracnose diseases of mango in major mango growing areas of Bangladesh. In recent years, a drastic change in cropping pattern is seen in high Barind areas of Rajshahi and Naogaon districts. Mango orchards are growing there rapidly and farmers are getting lower yield due to their shallow knowledge about how to control mango hoppers and reduce flower and fruit dropping. Bangladesh Agricultural Research Institute has developed Integrated crop management techniques, that comprise Spraying of chemicals in proper time for hopper and anthracnose control, timely application of fertilizers and irrigation, can reduce flower and fruit dropping and enhance fruit yield (Sarker *et. al*., 2017). Therefore, the present study was undertaken to validate ICM technologies for increased mango production by reducing flower and fruit dropping caused by mainly insects, diseases, inadequate and improper application of fertilizers and irrigation in high Barind regions.

Materials and Methods

The trial was conducted at farmer's field of 2 different locations viz. Godagari of Rajshahi and Sapahar of Naogaon districts during 2021-22 mango season following randomized complete block design (RCBD) with 2 treatments (ICM and Non-ICM) and 10 replications. One mango tree was considered as one treatment replication. Around 15 years old mango trees of Khirsapat (at Godagari) and 10 years old mango trees of BARI Aam 3 (at Sapahar) varieties were used for the study. ICM package includes: application of recommended fertilizer dose; two sprays with imidacloprid (Confidor) 70 WG @ o.2 g/litre of water with mancozeb (Indofil) M 45 @ 2.0 g/litre of water- 1st spray within 10 days of flowering and 2nd after one month of the first application; three irrigations starting from full bloom to fruit maturity at 15 days interval; two sprays with

2% urea solution at pea and marble stages of fruit growth were done. On the other hand, non-ICM package includes farmer's practice only.

In ICM package, recommended full doses of fertilizers (except urea and MoP) were applied at the end of September following standard method. Remaining fertilizers were split into two parts 1st of which was applied at pea stage and 2nd at mature stage of fruit growth. The insecticide Confidor 70 WG @ 0.2 g/litre of water and fungicide Indofil M 45 @ 2.0 g/Litre of water were applied twice as a full cover spray on mango trees from the ground with the help of a high volume and high-pressure power sprayer: the first application within 10 days of flowering (before opening of the flower) and the second at pea stage of the fruit growth (after 30 days of the first application). Three irrigations were applied starting from full bloom to fruit maturity at 15 days interval. At the time of harvest, the number of mango fruits counted and recorded by weight and number for comparing the yield of ICM and non-ICM packages.

Results and Discussion

Fruit retention and fruit yield: The results on the effect of Integrated Crop Management (ICM) packages in reducing flower and fruit dropping of mango in two different regions of high Barind tract (HBT) are presented in Table 1 & 2. Results indicated that 28 to 32.35% mango fruits by number and 9.12 to 17.15% yield by weight were increased in ICM packages as compared to non-ICM practices at two different study areas. Year-round management of the orchard and fertilizer application in splits might enhance the production of mango. Report says that yearly soil application of NPK markedly increased the number of mango fruit per plant, fruit weight, yield and fruit quality (Reddy *et al*., 2000; Satapathy and Banik, 2002; Sharma *et al*., 2000; Suriyapananont and Subhadrabandhu, 1992; Zhou *et al*., 2001)

Farmer's reaction

Farmers got better crop yield from trees where ICM packages were applied. Neighboring farmers visited the field and were impressed to see improved management techniques for better mango yield.

Table 1. Effect of ICM packages in reducing flower and fruit dropping of mango (variety: Khirsapat of 15 years old) at Godagari, Rajshahi during 2021-22 mango season

Treatments	No. of healthy fruits (mean of 10 plants)	%Increase (+)/ Decrease (-) over non-ICM	Average fruit weight (g)	%Increase (+)/ Decrease (-) of fruit weight
ICM	233.0	28 (+)	240.5	9.12 (+)
Non-ICM	182.0	-	220.4	-

Table 2. Effect of ICM packages in reducing flower and fruit dropping of mango (variety: BARI Aam 3 of 10 years old) at Sapahar, Naogaon during 2021-22 mango season

Treatments	No. of healthy fruits (mean of 10 plants)	%Increase (+)/ Decrease (-) over non-ICM	Average fruit weight (g)	%Increase (+)/ Decrease (-) of fruit weight
ICM	135.0	32.35 (+)	201.5	17.15 (+)
Non-ICM	102.0	-	172.0	-

Conclusion

ICM packages increased 28% mango fruits retention and 9.12% yield on Khirsapat at Godagari, Rajshahi, and 32.35% mango fruit retention and 17.15% yield on BARI Aam 3 at Sapahar, Naogaon over non-ICM practices.

INCIDENCE OF CHICKPEA POD BORER, *HELICOVERPA ARMIGERA* HUBNER ON THE PROMISING VARIETIES OF CHICKPEA

J.C. BARMAN, M.E.A. PRAMANIK, M.S. HOSSAIN AND M.A. HOSSAIN

Abstract

The trial was conducted in the farmer's field at Basantopur FSRD site, Godagari, Rajshahi during Rabi 2021-22 crop season to find out the abundance of chickpea pod borer and to provide indication of chickpea pod borers infestation level/status and its effect on grain yield of chickpea following randomized complete block design (RCBD) with 6 promising varieties and 3 replications. Six promising varieties of chickpea were: T_1 = BARI Chola-5, T_2 = BARI Chola-9, T_3 = BARI Chola-10, T_4 = BARI Chola-11, T_5 = Binachola-4 and T_6 = Bnachola-8. Experimental plot size was 4m x 4m and planting spacing was 40cm x 10cm. First appearance of chickpea pod borer larvae was found 76 days after sowing which was rapidly increased just two weeks after the first appearance. The highest appearance of pod borer larvae was recorded 2nd and 3rd week after first appearance. The infested pod ranged from 7.94 to 16.29% and the highest pod damage was obtained from BARI Chola-11 where the lowest from Binachola-8. BARI Chola-9 produced the highest grain yield (1215 kg ha $^{-1}$) though a moderately higher per cent pod damage (11.12%) was found on it.

Introduction

Chickpea, *Cicer arietinum* L. is one of the important pulse crops in Bangladesh. It is generally grown under rainfed or residual soil moisture conditions in rabi season. Recent years chickpea growing areas and production are decreasing in trend because of crop competition with rabi crops and other factors. Although most of the people thinks that chickpea areas and production were decreased due to pod borer infestation. Yes, the pod borer, *Helicoverpa armigera* (Hubner) is a major and most serious pest in most of the chickpea growing areas (Begum *et al.*, 1992). A country wide survey indicated that averages of 30 to 40 per cent pods were found to be damaged by pod borer with 400 kg ha $^{-1}$ grain loss (Rahman, 1990). In favourable condition, pod damage goes upto 90-95 per cent (Shengal and Ujagir 1990; Sachan and Katti 1994). The young caterpillar skeletonizes the leaves, while grown up caterpillar bores into the pods and feeds the seeds inside and cause significant yield loss. At present, we don’t know the status of pod borer infestation level in the growing areas and exactly its effect on grain yield. With this view, the present study was taken to finding out the abundance and infestation status of pod borer and its effect on grain yield.

Materials and Methods

The trial was conducted at farmer's field at Basantopur FSRD site, Godagari, Rajshahi during Rabi 2021-22 crop season to find out the abundance of chickpea pod borer and to provide indication of chickpea pod borers infestation level/status and its effect on grain yield of chickpea following randomized complete block design (RCBD) with 6 treatments and 3 replications. Six promising varieties of chickpea considered as treatments of the experiment which were: T_1 = BARI Chola-5, T_2 = BARI Chola-9, T_3 = BARI Chola-10, T_4 = BARI Chola-11, T_5 = Binachola-4 and T_6 = Binachola-8. Experimental plot size was 4m x 4m and planting spacing was 40cm x 10cm. The was prepared by ploughing and recommended fertilizers viz. Urea, TSP, MoP and Boric acid were applied at the rate of 40-90-40-7.5 kg ha $^{-1}$ as basal. No irrigation was applied. Regular observations were made to monitor the incidence of pod borer. First incidence of pod borer in chickpea field was recorded. Pod borer population per square meter was recorded.

At maturity, all the pods were collected from randomly placed 1 m^2 quadrants in each plot and examined. The damaged (bored) and total number of pods were counted and the per cent pod damage was determined using the following formula:

$$\% \text{ Pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Crops of the central four rows were harvested and then threshed. The grains were cleaned and dried in the bright sunshine. The grain yield obtained from each plot was converted into per hectare.

Results and Discussion

Abundance of pod borer: First appearance of chickpea pod borer larvae was found 76 days after sowing which was rapidly increased just two weeks after the first appearance. The highest appearance of pod borer larvae was recorded 2nd and 3rd week after first appearance (Fig.1). Total number of pod borer was found highest in BARI Chola-9 plot (33.7) where the lowest in BARI Chola-10 plot (19.67).

Pod damage and yield: The infested pod ranged from 7.94 to 16.29% and the highest pod damage was obtained from BARI Chola-11 where the lowest from Binachola-8. BARI Chola-9 produced the highest grain yield (1215 kg ha $^{-1}$) though a moderately higher per cent pod damage (11.20%) was found on it and it might be happened due to the higher yield potentiality of the variety. The yield must be more if proper management practice is done to control pod borer infestation.

Farmer's reaction

Farmers were pleased to get better grain yield from BARI Chola-9 and BARI Chola-10 plot. Neighboring farmers visited the field and were impressed to see the better performance by BARI Chola-9 and BARI Chola-10 varieties.

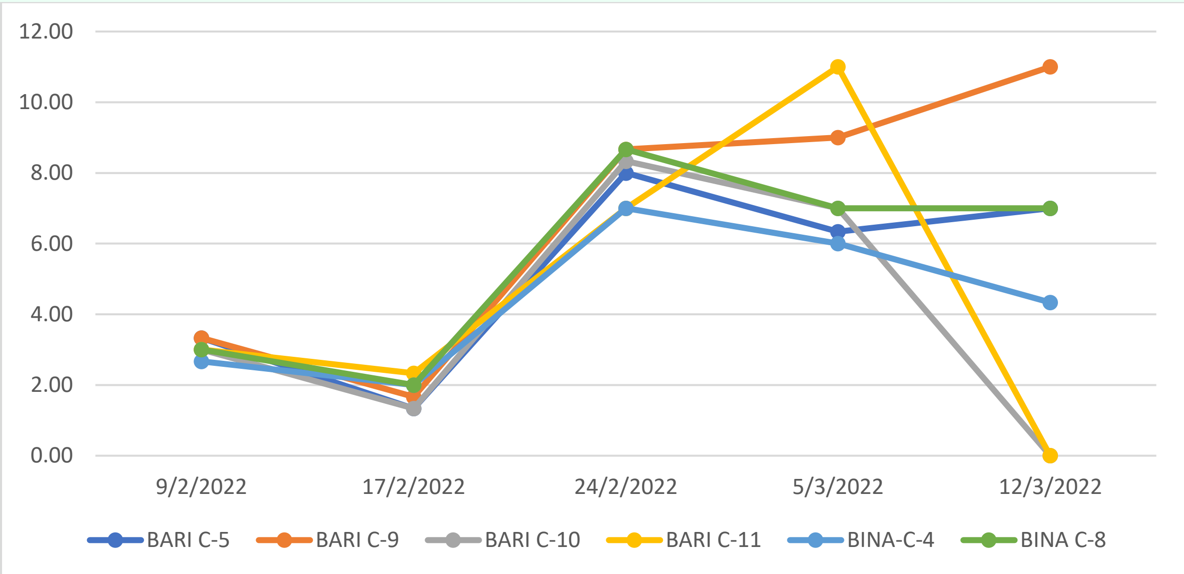

Fig.1. Abundance of chickpea pod borer on different varieties over time during Rabi season 2021-22 at Basantopur, Godagari, Rajshahi.

Table 1. Pod borer infestation and grain yield of different treatments during Rabi season 2021-22 at Basantopur, Godagari, Rajshahi

Treatments	No. of Fresh Pod	No. of Damaged Pod	Total No. of Pod	Pod Damage (%)	Grain yield (kg ha $^{-1}$)
BARI Chola-5	343.33 a	32.03 bc	375.36 a	8.51 de	1102.67 b
BARI Chola-9	305.67 b	38.43 ab	344.10 d	11.20 c	1215 a
BARI Chola-10	272 c	43.33 a	315.33 e	13.72 b	1111.67 b
BARI Chola-11	235 d	44.67 a	279.67 f	16.29 a	1050 b
Binachola-4	321.33 ab	30.20 c	351.53 c	10.11 cd	936.67 c
Binachola-8	337.33 ab	29 c	366.33 b	7.94 e	1089.33 b
LSD (5%)	33.293	6.799	6.799	2.125	78.488
CV (%)	6.05	10.30	3.10	10.34	3.97

Conclusion

BARI Chola-9 and BARI Chola-10 varieties produced higher grain yield. The yield must be more if proper management practice is done to control pod borer infestation.

BIORATIONAL BASED MANAGEMENT OF POD BORER, *HELICOVERPA ARMIGERA* HUBNER INFESTING CHICKPEA

J.C. BARMAN, M.E.A. PRAMANIK, M.S. HOSSAIN AND M.A. SARKER

Abstract

The experiment was conducted in the farmer's field at Basantopur FSRD site, Godagari, Rajshahi during Rabi 2021-22 crop season to evaluate different biopesticide based IPM packages against chickpea pod borer, *Helicoverpa armigera* (Hubner) attacking chickpea following randomized complete block design (RCBD) with 6 treatments and 3 replications (dispersed). Six treatments were: T_1 = Pheromone mass trapping + Spraying of Spinosad (Success 2.5 SC) @ 1.2 ml/l of water, T_2 = Pheromone mass trapping + Spraying of Minchu-plus (Bt + Spinosad) @ 2 ml/l of water, T_3 = Pheromone mass trapping + Spraying of *Celastrus angulatus* (Bio-chamak 1% EW) @ 2.5 ml/l of water, T_4 = Pheromone mass trapping + Spraying of Chlorantraniliprole (Coragen 18.5 SC) @ 0.5 ml/l of water, T_5 = Farmers practice: Spraying of Nitro 505 EC (Cypermethrin + Chlorpyriphos) spray @ 2 ml/l of water and T_6 = Untreated control. Results indicated that the infested pod ranged from 2.88 to 20.05% and there was significant difference among the treatments. All treatment applications significantly reduced the pod damage and increased grain yield over untreated control. The lowest pod damage (2.88%) and highest grain yield ((1.43 t ha^{-1}) were recorded from sex Pheromone mass trapping + Spraying of *Celastrus angulatus* (Bio-chamak 1% EW) @ 2.5 ml/l of water followed by sex Pheromone mass trapping + Spraying of Chlorantraniliprole (Coragen 18.5 SC) @ 0.5 ml/l of water (1.36 t ha^{-1}).

Introduction

Chickpea, *Cicer arietinum* L. is one of the important pulse crops in Bangladesh. It is generally grown under rainfed or residual soil moisture conditions in rabi season. Recent years chickpea growing areas and production are decreasing in trend because of crop competition with rabi crops and other factors. Although most of the people thinks that chickpea areas and production were decreased due to pod borer infestation. Yes, the pod borer, *Helicoverpa armigera* (Hubner) is a major and most serious pest in most of the chickpea growing areas (Begum *et al.*, 1992) which causes both quantitative and qualitative loss. A country wide survey indicated that averages of 30 to 40 per cent pods were found to be damaged by pod borer with 400 kg ha^{-1} grain loss (Rahman, 1990). In favourable condition, pod damage goes upto 90-95 per cent (Shengal and Ujagir 1990; Sachan and Katti 1994). The recommended management strategies of this obnoxious pest in Bangladesh are primarily based on synthetic insecticides (Rahman 1991). Preferences of chemical insecticides are due to their easy availability and applicability, but their excessive and indiscriminate use has resulted in the development of insecticidal resistance in the pest and environmental pollution (Phokela *et al*. 1990). The increasing concern environmental awareness of pesticide hazards has evoked a worldwide interest.

There is a need to explore alternatives, encompassing available pest control methods and techniques in order to reduce the sole dependence to chemical insecticides. For this purpose, integrated pest management comprising biopesticides seems to be the most appropriate approach to achieve sustainability in chickpea production. Ahmed and khalique (2002) did experimentation and reported forecasting adult populations of *H. armigera* on chickpea through pheromone traps and its role in management of this insect. Khalique and Ahmed (2005) reported compatibility of bio-pesticides with chemical insecticide for management of *H. armigera* (Hubner). Bt field test results indicated that microbial insecticides can be used (with and without adjuvant) for management of *H. armigera* populations infesting chickpea and their use would reduce reliance on toxic chemicals (Ahmed *et al*. 2012). The biologically-derived insecticides or microbial insecticides such as Bt. HNPV can be used as component of integrated pest management (IPM) approach because of their specificity in killing target insect pest to provide an environmentally safe and suitable alternative to generally hazardous, broad spectrum chemical insecticides used against *H. armigera* (Hubner). As far as environmental protection is concerned, there is need for complimentary use of microbial insecticides in support of IPM. In view of this, the present study was planned to evaluate the efficacy of different biorational based IPM package (s) against chickpea pod borer.

Materials and Methods

The experiment was conducted in the farmer's field at Basantopur FSRD site, Godagari, Rajshahi during Rabi 2021-22 crop season to evaluate different biorational based management strategies against pod borer infesting chickpea following randomized complete block design (RCBD) with 6 treatments and 3 replications (dispersed). Six treatments were: T_1 = Pheromone mass trapping + Spraying of Spinosad (Success 2.5 SC) @ 1.2 ml/l of water, T_2 = Pheromone mass trapping + Spraying of Minchu-plus (Bt + Spinosad) @ 2 ml/l of water, T_3 = Pheromone mass trapping + Spraying of *Celastrus angulatus* (Bio-chamak 1% EW) @ 2.5 ml/l of water, T_4 = Pheromone mass trapping + Spraying of Chlorantraniliprole (Coragen 18.5 SC) @ 0.5 ml/l of water, T_5 = Farmers practice: Spraying of Nitro 505 EC (Cypermethrin + Chlorpyriphos) spray @ 2 ml/l of water and T_6 = Untreated control. Experimental plot size was 10m x 10m and planting spacing was 50cm x 10cm. The land was prepared by ploughing and recommended fertilizers viz. Urea, TSP, MoP and Boric acid were applied at the rate of 40-90-40-7.5 kg ha $^{-1}$ as basal. Agronomic practices were done as recommended.

Sex pheromone traps (40 traps ha^{-1}) were installed in the experimental field at 45 days after sowing (DAS) maintaining 25m distance among the traps. Sex pheromone lures of *Helicoverpa armigera* were placed in BARI developed water traps and moth catcher traps for capturing adult moths. The pheromone traps were placed just above the crop canopy by means of bamboo support. The traps were kept in the chickpea field throughout the cropping season. Spraying Spinosad (Success 2.5 EC) @ 1.2 ml/l of water, C. angulatus (Bio-chamak 1% EW) @ 2.5 ml/l of water and chlorpyriphos + cypermethrin (Nitro 505 EC) @ 2ml/l of water was done during pod formation stage. Regular observations were made to monitor the incidence of pod borer. First incidence of pod borer in chickpea field was recorded. Pod borer population per square meter was recorded.

At maturity, all the pods were collected from randomly placed 1 m^2 quadrants in each plot and examined. The damaged (bored) and total number of pods were counted and the per cent pod damage was determined using the following formula:

$$\%\ \text{Pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Crops of the central four rows were harvested and then threshed. The grains were cleaned and dried in the bright sunshine. The grain yield obtained from each plot was converted into per hectare. Catch of adult *H. armigera* moths were also recorded weekly from each pheromone trap.

Results and Discussion

Pod damage: The infested pod ranged from 2.88 to 20.05% and there was significant difference among the treatments (Table 1). All treatment applications significantly reduced the pod damage over untreated control, and the lowest pod damage (2.88%) was observed in T_3 = Pheromone mass trapping + Spraying of *Celastrus angulatus* (Bio-chamak 1% EW) @ 2.5 ml/l of water that did not differ significantly with other treatments except farmers' practice. The highest pod damage (20.05%) was obtained from untreated control. The highest pod damage reduction

(85.64%) was found in T_3= Pheromone mass trapping + Spraying of *Celastrus angulatus* (Bio-chamak 1% EW) @ 2.5 ml/l of water.

Seed yield: Significantly highest seed yield (1.43 t ha^{-1}) was obtained from T_3 = Pheromone mass trapping + Spraying of *Celastrus angulatus* (Bio-chamak 1% EW) @ 2.5 ml/l of water that was at par with T_4 = Pheromone mass trapping + Spraying of Chlorantraniliprole (Coragen 18.5 SC) @ 0.5 ml/l of water (1.36 t ha^{-1}). Other three treatments produced statistically similar seed yield. The lowest seed yield was obtained from untreated control (0.85 t ha^{-1}). Application of biopesticides produced 51.76-68.24% yield increase over untreated control (Table 2).

Farmer's reaction

Farmers were pleased to get better grain yield from biopesticides treated chickpea plots. Neighboring farmers visited the field and were impressed to see the better performance of biopesticides to control chickpea pod borer.

Table 1. Effect of treatments on mean pod borer infestation of chickpea at FSRD site, Basantopur, Godagari, Rajshahi during Rabi-2021-22

Treatment packages	pod damage (%)	Pod damage reduction over control (%)	Moth trapped/ trap/week (Avg. of 10 weeks
Pheromone mass trapping + Spraying of Spinosad (Success 2.5 SC) @ 1.2 ml/l of water	3.88 c	80.65	0.91
Pheromone mass trapping + Spraying of Bt kurstaki + Spinosad (Minchu-plus) @ 2 ml/l of water	4.53 c	77.41	1.14
Pheromone mass trapping + Spraying of *Celastrus angulatus* (Bio-chamak 1% EW) @ 2.5 ml/l of water	2.88 c	85.64	1.03
Pheromone mass trapping + Spraying of Chlorantraniliprole (Coragen 18.5 SC) @ 0.5 ml/l of water	4.04 c	79.85	1.18
Farmers practice: Spraying of Cypermethrin + Chlorpyriphos (Nitro 505 EC) @ 2 ml/l of water	7.14 b	64.39	-
Untreated Control	20.05 a	0	-
LSD (5%)	2.474	-	-
CV (%)	15.17	-	-

Table 2. Effect of treatments on seed yield of chickpea at FSRD site, Basantopur, Godagari, Rajshahi during Rabi-2021-22

Treatment packages	Seed yield (t ha^{-1})	Yield increase over control (%)
Pheromone mass trapping + Spraying of Spinosad (Success 2.5 SC) @ 1.2 ml/l of water	1.30 bc	52.94
Pheromone mass trapping + Spraying of Bt kurstaki + Spinosad (Minchu-plus) @ 2 ml/l of water	1.29 bc	51.76
Pheromone mass trapping + Spraying of *Celastrus angulatus* (Bio-chamak 1% EW) @ 2.5 ml/l of water	1.43 a	68.24
Pheromone mass trapping + Spraying of Chlorantraniliprole (Coragen 18.5 SC) @ 0.5 ml/l of water	1.36 ab	60
Farmers practice: Spraying of Cypermethrin + Chlorpyriphos (Nitro 505 EC) @ 2 ml/l of water	1.22 b	43.53
Untreated Control	0.85 c	-
LSD (5%)	0.0924	-
CV (%)	4.09	-

Conclusion

Application of biopesticides reduced the pod borer infestation and produced higher grain yield. Among the treatments T_3 = Pheromone mass trapping + Spraying of *Celastrus angulatus* (Bio-chamak 1% EW) @ 2.5 ml/l of water showed better performance in reducing pod borer infestation with higher seed yield.

SURVEY AND DOCUMENTATION OF INSECT PESTS ATTACKING POTATO IN RAJSHAHI REGION

J.C. BARMAN, M.E.A. PRAMANIK AND M.S. HOSSAIN

Abstract

Survey was conducted at farmer's field of Godagari, Tanor and Mohanpur upazilla of Rajshahi district during Rabi 2021-22 crop season to document insect pests attacking potato. Six different insects were found and among them, two insects e.g. cutworm and aphids were major. Other insects like crickets, leaf miner and Spodoptera were minor pests in potato fields.

Introduction

Potato is the world's most important non-grain food crop worldwide under Solanaceae family (Sanwen Huang *et al*. 2011). It is grown in more than 125 countries and consumed almost daily by more than a billion people. Due to the suitable environment, potato production is being increased day by day and in 2019 Bangladesh became the seventh largest potato producing country in the world. It produced 1.09 crore tones in 2018-19 (DAE). Potato has become the third most important food terms in Bangladesh (FAO, 2016). For the entirety year, it is utilized as the primary vegetable. The weather condition favours potato production but because of the tropical and humid climate the potato cultivation is severely affected by the pests such as insect, diseases and weeds etc. However, the current status of insect pests has not been properly investigated in Bangladesh. For managing insect pests, farmers rarely imply integrated pest management (IPM) tactics. Rather, they often apply chemical pesticides to get rid of insect infestation (Alam *et al*., 2016). The yield and production of potato are hampered by insect pest attack. Different sucking pests, common cutworm, *Helicoverpa*, leaf miner, root aphids etc. are causing serious damage to potato in Bogura and Joipurhat regions. These pests may be migrated to newly expanded potato growing areas of high Barind tract (HBT) and may cause serious damage to potato production. Therefore, the present study was undertaken for the documentation of insect pests attacking potato in HBT of Rajshahi.

Methodology

Survey work on the incidence of insect pests of potato was conducted at farmer's fields of Godagari, Tanor and Mohanpur upazilla of Rajshahi district during Rabi 2021-22 crop season. Data were collected by face-to-face interview and visiting potato fields. Incidence of insect pests were documented and damage severity was recorded following standard procedures. The information of the farmers' knowledge on insect pests of potato and their management practices has been discussed.

Results and Discussion

The data obtained from the survey are presented in Table 1. In response of the farmers in the surveyed area, the maximum farmers used BARI alu-7 (Diamant) comprising about 95% crop areas and rest 5% area comprised by other varieties including BARI alu-25 (Asterix). Farmers reported insect pests attack and disease infection as major hurdle of potato production. Most of the farmers reported that the potato was infested in the field by cutworm, which was followed by aphid infestation. Some farmers also reported that the potato was attacked by potato tuber worms, followed by leaf miner, mole cricket, field cricket, leaf hoppers and whitefly. The insect pests attacking potato in the fields in Bangladesh are enlisted in Table 2 (Nasif *et al*. 2018). The potato farmers faced high incidence of disease (late and early blight of potato, fusarium and brown rot, leaf roll virus, common scab, black heart, root knot etc.) and insect/pests (cut worm, aphids, tuber moth, cricket, leaf hopper etc.) still remain a drawback to attain maximum yield of potato (Siddique et al., 2015). General activities taken by farmers for the management of insect pests and diseases in the potation fields are given in the Table 3.

Farmers expressed their eager to get good potato seed and IPM techniques for the management of insect pests and diseases in the potato fields.

Table 1. Insect pests of potato in field condition at Godagari, Tanor and Mohanpur of Rajshahi during 2021-22 *Rabi* crop season.

Name	Family	Plant parts infested	Destructive stage of the pest	Status
Cutworm (*Agrotis ipsilon*)	Noctuidae	Root, seedling stage	Larvae	Major
Aphid (*Macrosiphum euphorbiae*)	Aphididae	Vegetative parts	Nymph and adult	Major
Leaf miner (*Liriomyza huidobrensis*)	Gelechiidae	Leaf, vegetative stage	Larvae	Minor
Mole cricket (*Gryllotalpa africana*)	Gryllotalpidae	Root, seedling stage	Adult	Minor
Field cricket (*Brachypterypes portensus*)	Gryllidae	Root, seedling stage	Adult	Minor
Spodoptera litura	Noctuidae	Leaf, vegetative stage	Larvae	Minor

Table 2. Various insect pests of potato in field condition (Nasif *et al*. 2018; ZH Prodhan).

Name	Family	Plant parts infested	Destructive stage of the pest	Status
Cutworm (*Agrotis ipsilon*)	Noctuidae	Root, seedling stage	Larvae	Major
Aphid (*Macrosiphum euphorbiae*)	Aphididae	Vegetative parts	Nymph and adult	Major
Potato tuber worm (*Phthorimaea operculella*)	Gelechiidae	Tuberization stage	Larvae	Minor
Leaf miner (*Liriomyza huidobrensis*)	Gelechiidae	Leaf, vegetative stage	Larvae	Minor
Mole cricket (*Gryllotalpa africana*)	Gryllotalpidae	Root, seedling stage	Adult	Minor
Field cricket (*Brachypterypes portensus*)	Gryllidae	Root, seedling stage	Adult	Minor
Leaf hoppers (*Empoasca fabae*)	Cicadellidae	Leaf, vegetative stage	Nymph and adult	Minor
Whitefly (*Bemisia tabaci*)	Aleyrodidae	Leaf, vegetative stage	Nymph and adult	Minor
Helicoverpa armigera	Noctuidae	Leaf, vegetative stage	Larvae	Minor
Spodoptera litura	Noctuidae	Leaf, vegetative stage	Larvae	Minor
Mealy bug (*Dysmicoccus brevipes*)	Pseudococcidae	Leaf, stem, twig	Nymph and adult	Minor
Root aphid (first reported by ZH Prodhan in Bd.		Root, tuber	Nymph and adult	Major (localized)

Table 3. Activities taken by farmers for the management of insect pests and diseases in potato field during 2021-22 crop season in Rajshahi region.

Name of insecticides/ fungicides	**Group name**	**Time of application**	**Target insects/ diseases**
Furadan	Carbofuran	During planting of seed tubers	Cutworm
Irrigation followed by herbicide spray	Roundup (glyphosate), pendimethalin	3-5 days after planting, during earthing-up	Weeds
Dursban	Chlorpyrifos	During plant initiation period	Cutworm, sucking insects
Fungicide(s)+ Insecticides + Vitamins	Mancozeb/ Mancozeb Metalaxyl + Chlorpyrifos	Starts at 10-12 days after plant initiation & continued at 7-10 days intervals.	Disease & insects
Fungicide(s) + Insecticides	Carbendazim + Chlorpyrifos	At 55 days after plant initiation, 1-2 sprays	To enhance tuber formation
If the weather becomes foggy or rains occur, farmers spray a cocktail of several chemicals			

Conclusion

BARI alu-7 (Diamant) is the most popular variety in the study area. Potato production and yield is being attacked by various insect pests and diseases. Common cutworm was found to be the major insect pest in the field. The farmers are used to spray various types of insecticides and fungicides indiscriminately to get rid of insect and disease attack in the potato fields.

SURVEY, MONITORING AND DOCUMENTATION OF MAJOR INSECT PESTS OF PULSE CROPS IN HIGH BARIND TRACT

M.E.A. PRAMANIK, S. HOSSAIN AND J.C. BARMAN

Abstract

A field survey was conducted in western region of Bangladesh during rabi season, 2020-21 and 2021-22 to record the infestation and major pest of pulse crops in High Barind Tract in Bangladesh. Insects have not been a major problem in lentil production in HBT. But aphid and pod borer occasionally cause some problems. Six pests are recorded in lentil crops, e.g., cutworms, aphid, pod borer, whitefly, green sting bug and thrips. Among these pests, thrips infestation was more severe. Besides, several insects live and feed on chickpea plant. Foliage, buds, flowers, pods, roots and even root nodules are eaten by one or more insect pests. In Barind area, seven pests are seldom infested in the chickpea field, e.g., black cutworm, common cutworm, green semilooper, green sting bug, aphid, whitefly and pod borer. On the other hand, four types of insect pests' infestation were observed in grasspea, e.g., aphid, green sting bug, thrips and cowpea weevil/bruchid.

Introduction

The High Barind Tract (HBT) (AEZ-26) having clay loam and clayey soils. Low monsoon precipitation causes soil moisture stress, which makes it difficult for rabi crops to develop well, even after early kharif-1 crops have been harvested. Depending on the crop, the kind of storage, and the climatic circumstances, infestations during storage might be one of the most disastrous of all. In 1947, the FAO estimated that annual losses due to insect attack during storage accounted for around 10% of global productivity, but other writers believe that this figure is low when compared to previous societies (Buckland 1978; Smith and Kenward 2011). Ethnographic research shows how different farming populations, even those without access to chemicals or modern technology, actively fight against insect pests and other animals causing damages to their crops. They are aware of their existence and they aim to have pest-free crops (Narayanasamy 2006). One of the reasons of replacing a crop might be that it was too susceptible to insect pest infestation or other diseases (e.g., Dark and Gent 2001). Pulse is an important crops its introduced newly in HBT area. Recently, in Barind area, most of the farmers are interested to cultivate pulse crops for off-chance crop. Unfortunately, the crop is attacked by a number of insect pests. Pests attack the crop on the leaves and roots, causing significant losses. As a result, pest documentation is required in order to build effective management plans. The goal of this research is to identify pests and their destructive potential.

Materials and Methods

Survey will be carried out in two upazilla of Godagari, Rajshahi and Nachole, Chapainawabganj during rabi season 2020-21 and 2021-22. Three pulse growing areas of each upazilla and five samples will be selected per location. Ten plants will be selected from each sample and examined carefully to identify the insect pests and their infestation status. The collected data will be processed and analyzed properly.

Results and Discussion

Infestation of pests of pulse crops (Lentil, chickpea and grasspea) are started after emergence of seedling. Infestation status of lentil pests in both region (Godagari and Nachole) has shown in Table 1, 2 & 3. Aphids damage lentil plants directly by feeding on them and more seriously transmit plant viruses. Both nymphs and adults suck the plant sap from the tender leaves, stems and pods, and mostly colonize on the young leaves and growing points, which become characteristically deformed. Host reaction to insect feeding are not characteristic but large populations on young plants can prevent their normal growth, affecting yield. The infestations of crops are always initiated by alate forms produced on pre-infested plants. Thrips are minute (1 to 2 mm), elongate insects with four extremely slender wings in which the develop-mental stages resemble the adults, but are lighter coloured and wingless. Thrips attack leaves, flowers and pods by puncturing the plant organs and sucking up the sap, causing silvery blotches and dashes. As the attack increases the leaves and flowers become distorted and under heavy infestation can occasionally cause serious economic damage (Table 1, 2 & 3). The adults are large and brown and up to 20 mm long, are active at night and lay hundreds of eggs singly on the underside of leaflets. Larvae can reach 40 mm, and have different and quite attractive coloration, but mostly green. Fully grown larvae, usually 6th instars drop to the soil to pupate. The larvae cause damage to the leaves with young instars scraping the surface of leaflets and feeding on flowers, while older larvae feed on foliage and more damagingly on pods.

Seven chickpea pests have been recorded in both regions (Godagari and Nachole). Pest population of chickpea in both region (Godagari and Nachole) has been shown in Table 4, 5 & 6. Among the insect-pests, pod borer is the most severe yield reducer throughout Bangladesh, while the bruchids cause severe damage in storage. Other minor insect pests of chickpea are cutworm, green semilooper, green sting bug and whitefly. *Helicoverpa* is the main pest in chickpeas. Chickpeas are susceptible to significant yield loss caused by *Helicoverpa* from pod set through to harvest. Whilst *Helicoverpa* can cause reductions in both yield and quality, the economic threshold for minimizing yield loss is much lower than that which would result in a reduction in grain quality (Table 4, 5 & 6).

In grasspea crop, four pests have been recorded in both regions (Godagari and Nachole). Grasspea pests in both region (Godagari and Nachole) has shown in Table 7, 8 & 9. Major pests of Aphid and thrips can have a significant effect on the establishment, yield and longevity of grasspea crop. Aphid, *Aphis craccivora* Koch (Hemiptera: Aphididae) is a serious threat to the crop yield of *Lathyrus sativus* L. (Fabaceae), commonly known as grass pea. The aphid produces honeydew (a sweet and watery anal excrement), which serves as a medium for growth of sooty mould, causing blackening of leaves and thereby reducing photosynthesis (Table 7, 8 & 9).

Table 1. Insect population growth in lentil crops and monthly distribution of weather parameters from November 2021 to March 2022

Items	November 2020	December 2020	January 2021	February 2021	March 2021
Max. temp. **(°C)**	30.23	25.17	23.75	29.09	34.57
Min. temp. **(°C)**	17.39	13.01	11.44	12.85	19.27
RH (%)	85.50	88.18	87.13	76.23	73.14
Av. Rainfall (mm)	0.01	0	0	0	0
Sunshine(hours)	8.17	5.65	4.16	6.87	9.37
Cutworm* (mean ± SD)	3.87±1.54	5.93±1.56	3.23±0.67	0.67±0.12	0
Whitefly* (mean ± SD)	1.87±0.23	2.45±0.65	3.23±0.75	6.4±2.67	0
Green sting bug* (mean ± SD)	0	2.18±0.48	3.29±1.19	4.32±1.54	0
Pod borer* (mean ± SD)	0	0	0	6.45±2.39	2.65±1.48
Aphid* (mean ± SD)	0	1.64±0.31	4.87±1.45	10.65±2.52	0
Thrips* (mean ± SD)	1.76±0.64	3.89±0.39	5.72±2.45	8.27±2.67	1.58±0.71
Green Semilooper* (mean ± SD)	0.87±0.10	1.45±0.12	3.84±0.92	6.48±2.16	0.12±0.01

Note: 'Max. temp. **(°C)**, maximum temperature**(°C)**', 'Min. temp. **(°C)**, minimum temperature**(°C)**', 'RH (%), relative humidity (%)', 'Av. Rainfall (mm), average rainfall (mm)', '* = No. of insects/10 plants. Data are shown as mean ± standard deviation.

Table 2. Insect population growth in lentil crops and monthly distribution of weather parameters from November 2021 to March 2022

Items	November 2021	December 2021	January 2022	February 2022	March 2022
Max. temp. **(°C)**	29.42	26.37	23.41	25.96	34.85
Min. temp. **(°C)**	17.36	14.23	12.22	12.64	19.86
RH (%)	88.22	85.97	44.63	80.23	70.98
Av. Rainfall (mm)	0	0.02	0.10	1.40	0
Sunshine(hours)	7.49	5.95	4.80	6.78	11.28
Cutworm* (mean ± SD)	1.38±0.65	2.47±0.28	4.76±0.93	0.48±0.09	0
Whitefly* (mean ± SD)	0.97±0.11	1.48±0.21	2.43±0.29	4.87±1.46	0
Green sting bug* (mean ± SD)	0	1.18±0.26	4.76±1.98	5.34±2.96	0
Pod borer* (mean ± SD)	0	0	0	8.34±1.43	1.67±0.48
Aphid* (mean ± SD)	0	1.26±0.17	5.29±2.76	8.39±3.24	0
Thrips* (mean ± SD)	1.02±0.22	2.94±0.15	3.92±1.45	9.38±3.81	0.92±0.11
Green Semilooper* (mean ± SD)	0.32±0.09	2.73±0.14	4.89±1.14	5.92±1.27	0.21±0.05

Note: 'Max. temp. **(°C)**, maximum temperature**(°C)**', 'Min. temp. **(°C)**, minimum temperature**(°C)**', 'RH (%), relative humidity (%)', 'Av. Rainfall (mm), average rainfall (mm)', '* = No. of insects/10 plants. Data are shown as mean ± standard deviation.

Table 3. List of identified Insect pest of lentil at Godagari, Rajshahi and Nachole, Chapainawabganj in HBT during 2020-21 and 2021-22

SL. No.	Common Name	Scientific Name	Order: Family	Infested Parts	Status
1	Cutworm	*Agrotis ipsilon Hufnagel*	Lepidoptera: Noctuidae	Cut the leaves, stems and roots	Minor
2	Aphid	*Aphis Craccivora Koch*	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Major
3	Whitefly	*Bemisia tabaci*	Homoptera: Aleyrodidae	Suck sap from twigs, flowers and pods	Minor
4	Green Stink bug	*Nezara viridula Linn*	Homoptera: Pentatomidae	Suck sap from shoots and pods	Minor
5	Thrips	*Megalurothrips distalis Korny*	Thysanoptera: Thripidae	Suck sap from flowers	Major
6	Pod borer	*Helicoverpa armigera Hubner*	Lepidoptera: Noctuidae	Bore to the pod	Major
7	Green Semilooper	*Plusia Signata Fabricius*	Lepidoptera: Noctuidae	Feed on foliage and young plants	Minor

Table 4. Insect population growth in chickpea crops and monthly distribution of weather parameters from November 2021 to March 2022

Items	November 2020	December 2020	January 2021	February 2021	March 2021	April 2021
Max. temp. **(°C)**	30.23	25.17	23.75	29.09	34.57	37.52
Min. temp. **(°C)**	17.39	13.01	11.44	12.85	19.27	22.85
RH (%)	85.50	88.18	87.13	76.23	73.14	71.17
Av. Rainfall (mm)	0.01	0	0	0	0	0.51
Sunshine(hours)	8.17	5.65	4.16	6.87	9.37	7.69
Common Cutworm* (mean ± SD)	0	3.76±0.98	4.74±0.59	2.48±0.11	1.38±0.12	0
Black Cutworm* (mean ± SD)	0	6.28±1.38	3.86±1.35	2.19±0.20	0.83±0.09	0
Whitefly* (mean ± SD)	0	2.39±0.37	5.17±2.39	3.18±0.93	0.82±0.11	0
Green sting bug* (mean ± SD)	0	2.96±0.72	3.87±1.28	5.23±1.27	2.71±0.38	0
Pod borer* (mean ± SD)	0	0	1.56±0.73	10.32±3.96	3.87±1.12	0
Aphid* (mean ± SD)	0	2.79±0.67	5.18±1.69	8.25±3.83	2.76±0.86	0
Green Semilooper* (mean ± SD)	0	2.34±0.31	3.76±0.56	8.29±3.71	0.27±0.04	0

Note: 'Max. temp. **(°C)**, maximum temperature**(°C)**', 'Min. temp. **(°C)**, minimum temperature**(°C)**', 'RH (%), relative humidity (%)', 'Av. Rainfall (mm), average rainfall (mm)', '* = No. of insects/10 plants. Data are shown as mean ± standard deviation.

Table 5. Insect population growth in chickpea crops and monthly distribution of weather parmeters from November 2021 to March 2022

Items	November 2021	December 2021	January 2022	February 2022	March 2022	April 2022
Max. temp. **(°C)**	29.42	26.37	23.41	25.96	34.85	36.09
Min. temp. **(°C)**	17.36	14.23	12.22	12.64	19.86	25.56
RH (%)	88.22	85.97	44.63	80.23	70.98	79.57
Av. Rainfall (mm)	0	0.02	0.10	1.40	0	0.83
Sunshine(hours)	7.49	5.95	4.80	6.78	11.28	5.45
Common Cutworm* (mean ± SD)	0	2.87±0.23	3.56±0.45	2.17±0.19	1.12±0.18	0
Black Cutworm* (mean ± SD)	0	5.79±2.27	3.12±1.09	2.78±0.48	0.29±0.01	0
Whitefly* (mean ± SD)	0	1.96±0.36	3,74±1.36	2.28±0.57	0.62±0.08	0
Green sting bug* (mean ± SD)	0	1.43±0.14	2.54±0.67	3.26±0.87	1.47±0.13	0
Pod borer* (mean ± SD)	0	0	2.65±0.94	9.24±2.62	4.75±0.97	0
Aphid* (mean ± SD)	0	2.17±0.25	4.32±0.94	7.54±2.71	2.85±1.36	0
Green Semilooper* (mean ± SD)	0	1.98±0.46	2.67±0.91	9.63±3.15	0.21±0.06	0

Note: 'Max. temp. **(°C)**, maximum temperature**(°C)**', 'Min. temp. **(°C)**, minimum temperature**(°C)**', 'RH (%), relative humidity (%)', 'Av. Rainfall (mm), average rainfall (mm)', '* = No. of insects/10 plants. Data are shown as mean ± standard deviation.

Table 6. List of identified Insect pests of chickpea at Godagari, Rajshahi and Nachole, Chapainawabganj in HBT during 2020-21 and 2021-22

SL. No.	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
1	Black Cutworm	*Agrotis Ipsilon Hufnagel*	Lepidoptera: Noctuidae	Disconnect the base of seedlings	Minor
2	Common Cutworm	*Spodoptera litura Fabricius*	Lepidoptera: Noctuidae	Cut the seedlings roots	Minor
3	Green Semilooper	*Plusia Signata Fabricius*	Lepidoptera: Noctuidae	Feed on foliage and young plants	Minor
4	Green Stink bug	*Nezara viridula Linn*	Hemiptera: Pentatomidae	Suck sap from shoots and pods	Minor
5	Aphid	*Aphis craccivora Koch*	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Major
6	Whitefly	*Bemisia tabaci Gennadius*	Homoptera: Aleyrodidae	Suck sap from twigs, flowers and pods	Minor
7	Pod borer	*Helicoverpa armigera Hubner*	Lepidoptera: Noctuidae	Bore to the pod	Major

Table 7. Insect population growth in grasspea crops and monthly distribution of weather parameters from November 2021 to March 2022

Items	November 2020	December 2020	January 2021	February 2021	March 2021
Max. temp. **(°C)**	30.23	25.17	23.75	29.09	34.57
Min. temp. **(°C)**	17.39	13.01	11.44	12.85	19.27
RH (%)	85.50	88.18	87.13	76.23	73.14
Av. Rainfall (mm)	0.01	0	0	0	0
Sunshine(hours)	8.17	5.65	4.16	6.87	9.37
Green sting bug* (mean ± SD)	0	3.16±0.53	4.32±0.94	5.71±2.48	0
Aphid* (mean ± SD)	0	3.35±1.65	4.56±1.62	8.52±2.18	0
Thrips* (mean ± SD)	0	3.89±0.39	5.72±2.45	8.27±2.67	1.58±0.71
Cowpea weevil (mean ± SD)	0	1.13±0.14	2.37±0.85	5.37±1.62	0.7±0.06

Note: 'Max. temp. **(°C)**, maximum temperature**(°C)**', 'Min. temp. **(°C)**, minimum temperature**(°C)**', 'RH (%), relative humidity (%)', 'Av. Rainfall (mm), average rainfall (mm)', '* = No. of insects/10 plants. Data are shown as mean ± standard deviation.

Table 8. Insect population growth in grasspea crops and monthly distribution of weather parameters from November 2021 to March 2022

Items	November 2021	December 2021	January 2022	February 2022	March 2022
Max. temp. **(°C)**	29.42	26.37	23.41	25.96	34.85
Min. temp. **(°C)**	17.36	14.23	12.22	12.64	19.86
RH (%)	88.22	85.97	44.63	80.23	70.98
Av. Rainfall (mm)	0	0.02	0.10	1.40	0
Sunshine(hours)	7.49	5.95	4.80	6.78	11.28
Green sting bug* (mean ± SD)	0	2.14±0.24	3.16±0.45	4.13±1.46	0
Aphid* (mean ± SD)	0	3.35±1.65	4.51±1.43	7.42±2.56	0
Thrips* (mean ± SD)	0	3.18±0.49	4.76±1.34	6.54±2.11	0.98±0.11
Cowpea weevil (mean ± SD)	0	0.95±0.09	1.73±0.68	3.82±0.73	0.41±0.02

Note: 'Max. temp. **(°C)**, maximum temperature**(°C)**', 'Min. temp. **(°C)**, minimum temperature**(°C)**', 'RH (%), relative humidity (%)', 'Av. Rainfall (mm), average rainfall (mm)', '* = No. of insects/10 plants. Data are shown as mean ± standard deviation.

Table 9. List of identified Insect pests of grasspea at Godagari, Rajshahi and Nachole, Chapainawabgonj in HBT during 2020-21 and 2021-22

SL No	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
1	Aphid	*Aphis craccivora Koch*	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Major
2	Green Stink bug	*Nezara viridula Linn.*	Hemiptera: Pentatomidae	Suck sap from shoots and pods	Minor
3	Thrips	*Megalurothrips distalis Korny*	Thysanoptera: Thripidae	Suck sap from flowers	Major
4	Cowpea weevil/bruchid	*Callosobruchus maculatus Fabricius*	Coleoptera: Bruchidae	Boring on grain	Minor

SURVEY, MONITORING AND DOCUMENTATION OF MAJOR INSECT PESTS OF BETEL LEAF IN RAJSHAHI REGION

M.E.A. PRAMANIK AND J.C. BARMAN

Abstract

The current study was conducted in a betel leaf garden in the Rajshahi district of Bangladesh during 2020-21 and 2021-22 to track betel leaf insect infestations. During the research period, twelve insect pests were discovered. Various insect pests were observed during the study period, including betel vine blackfly, whitefly, semi looper, common cutworm, scale insects, mealy bug, snail, trips, red spider mite, betel vine bug, and betel vine termite. The betel vine blackfly, semi looper, scale insects, whitefly, and red spider mite were discovered to be the most harmful pests. The betel vine Blackfly, one of the insect pests, begins attacking in March and has its peak infestation in May and October. The average production cost for these betel farms in Bangladesh are about Tk 300,000 per hectare, and the farm owners can earn a profit of over Tk 100,000 per hectare. Pests damage the crop on the leaves and roots, resulting in significant losses. In order to design effective management techniques, it is vital to document the pests. The purpose of this study is to identify the pests that exist in the research locations.

Introduction

Bangladesh's main cash crop is the betel vine (*Piper betel* L.). It's a family Piperaceae perennial dioecious creeper. It's known as "Pan" in allover Bangladesh and also Malaysia, Sumatra, and maybe Java, and is assumed to have originated there. It's a vine with heart-shaped leaves that are lustrous and green. Many small adventitious roots help to climb the stem (Hassan and Shahadat, 2005). Masticators are made from the leaves of the betel vine and areca nut. Betel leaves are commonly chewed by people in South Asia, Southeast Asia, the Gulf States, and the Pacific Islands. In Bangladesh, betel vine is chewed by individuals of all classes as a habit as well as a part of traditions, etiquette, and manners. Bangladesh has over 14000 hectares of betel vine, making it the world's second largest producer. Bangladesh produces around 72,500 tons of the crop each year. The average yield per acre is 2.27 tons (Anonymous, 2006). Betel leaf has a significant position in our literature, song, society, and culture in people's daily lives. It is impossible to hold a social gathering in Bangladesh without serving betel leaf, especially in rural areas where 80 percent of the population resides. Apart from its sociocultural and ceremonial significance, it possesses antacid, carminative, and tranquilizing properties that aid digestion, eliminate bad breath, improve taste and appetite, and strengthen teeth (Islam et al. 2015). Bangladesh has been cultivating betel leaf for generations. Cox's Bazar, Chittagong, Greater Khulna, Greater Barisal, Greater Faridpur, and Greater Rajshahi are notable for betel leaf cultivation. Bagmara, Durgapur, and Mohanpur Upazilas in Rajshahi are particularly well-known for their production. Farmers are becoming increasingly interested in betel leaf cultivation, which has resulted in an increase in the area under cultivation. Betel leaf is in high demand because to its high quality and flavor, and Bangladesh exports high-grade betel leaves to many Asian and European countries. India, Saudi Arabia, Pakistan, the United Arab Emirates, the United Kingdom, Germany, and Italy are the top exporters of betel leaves (Banglapedia, 2015). Despite the fact that betel leaf cultivation is an economically viable commodity with significant-high market potential in both the domestic and international markets, very little research has been done in Bangladesh. Among these, (Islam and Matin, 2017) looked into the benefits and costs of betel leaf, while (Mridha et al. 2005) looked into the impact of production inputs on betel leaf return.

However, due to physical and social hurdles such as a lack of finance, an unorganized marketing system, and disease and pest infestation, betel vine acreage is rapidly declining (Islam 2005). One of several known limiting factors is disease damage to the crop. The betel vine is extremely vulnerable to diseases, pests, and natural disasters (Sayeeduzzaman, 1988). Betel vine growth is favored by humid and wet shady environments, which also favor the development of a range of root and foliage diseases (Goswami et al, 2002). After a few years, disease recurrence results in full devastation and crop loss. *Sclerotium rolfsii* causes foot and root rot in betel vines, which severely reduces betel leaf yield. In the year 2004, farmers producing Piper betel in three upazilas of Rajshahi lost 60 percent of their crop due to foot rot disease. Islam (2005) *Sclerotium rolfsii* Sacc. is a significant soil-borne pathogenic fungus that is detrimental to many economically important crops throughout much of the world's tropical and subtropical regions (Aycock, 1966). It has a wide spectrum of hosts and has been dubbed a "nearly omnipathogenic bacterium" (Talukder, 1974).

A variety of insect pests (Johri et al., 1984; Raut and Nandi, 1979; Raut and Bhattacharya, 1985a, b, 1986a, b, 1987a,b) and pathogenic fungi have a significant impact on this crop's cultivation (Maiti and Sen, 1979; Johri et al., 1984; Mehrotra, 1984). Dipteran, heteropteran, hymenopteran, and coleopteran insects, as well as spiders, mites, and harmful fungi, were all present at the same time as the pest species. We report the findings of field survey study on these organisms' interactions with pest species. Some of the findings, as revealed, are very interesting and point to the need for more detailed research. For example, the studies on optimal agro-climatic requirements, the role of soil reaction, agronomic norms, nutritional requirements, and quality components are all very important and should be pursued further. Diseases and pests are, of course, the most serious threats to betel farming. They are unprocessed in the most hospitable warm humid conditions of the boroj (local name for the betel vine yard). Taking into account the aforementioned research gap, this study attempted to identify the diseases and pests that affect betel leaf cultivation in Bangladesh, as well as to improve betel leaf cultivation.

Materials and Methods

Survey will be carried out in two upazilla of Bagmara and Durgapur, Rajshahi during September 2020 to April 2022. Ten betel vine growing areas of each upazilla and five samples will be selected per location. Ten plants will be selected from each sample and examined carefully to identify the pests and diseases of the study areas. The collected data will be processed and analyzed properly.

Results and Discussion

Tables 1 to 6 show the survey results in detail. During the study period, betel vine blackfly, whitefly, semi looper, scale insects, common cutworm, mealy bug, snail, thrips, red spider mite, betel vine bug, and betel vine termite were identified to attack betel leaf. Identified pests and their nature of damages show in Table 1. Pest populations with weather parameters is presented in Table 2, 3 and 4. Table 5 shows the relationship of correlation matrix with pest population and monthly distribution of meteorological parameters during October 2020 to April 2022. The incidence of pests was started from the first week of January and continued till to the complete growing period of betel vine plant. Population ranged reached its peak during May and October. Multiple linear regression models, along with coefficients of determination (R^2) regarding the impact of weather parameters on the seasonal abundance of different insect pest of betel leaf, are presented in Table 6.

It was evident from Table 6 that the combined effect of temperature, relative humidity, rainfall and sunshine (hours) was significant. The average monthly rainfall along with temperature and relative humidity contributed 71.5% abundance of blackfly, 46.3% of whitefly, 65.1% of red mite, 70.1% of mealy bug, 92.8% of aphid, 59.9% of Thrips and 89.9 % of betel vine bug (Table 6). Finally, the multiple linear regression analysis showed that all the weather parameters together contributed significant population abundance.

Table 1. List of identified pests of betel leaf in Durgapur and Bagmara upazila of Rajshahi district during 2021-22

Name of the pests	Scientific Name	Nature of damage
Blackfly	*Aleurocanthus spp* (Aleyrodidae: Hemiptera)	Adults of the insect species are crowded near the growing apex preferring ventral surface of apical leaves and suck sap. Elliptical nymphs also suck sap voraciously remaining on ventral aspect leaf. Curling, discolouration and reduced size of leaves, brown scars at the point of injury, stunted plant growth and development of sooty mould on dorsal leaf are some of the resultant effect of the insect damage. Injury results in reduced taste and texture of leaves and market value of the crop.
Whitefly	*Aleurocanthus spp.* (Aleurodidae: Hemiptera)	Both nymph and adults suck the sap from the tender leaves causing yellowing, chlorotic spots and shooty mould development on leaves.
Red spider mite	*Tetranichus neocaledonicas* (Tetranychidae: Trombidiformes)	Their mouths to suck the chlorophyll out of the leaves. A spider mite destroys about ten to 20 cells during one minute of feeding. Since they're sucking so much life out of your plant and destroying so many cells, there's going to be serious damage.
Mealy bug	*Ferrisia virgate* (Pseudococcidae: Hemiptera)	The insects, both nymph and adult suck the sap from leaves and tender shoots and reduce the vitality of vines. Affected leaves become deformed and vigour of the vine is reduced.
Aphid	*Aphis gossypii* (Aphididae: Hemiptera)	Both nymph and adults desap the tender shoot and leaves causing yellowing, curling and crinkling in leaves. Honey dew secreted by the aphids fall on the betelvine leaves and lead to the development of sooty mould which appear as black spots.
Thrips	*Thrips tabaci* (Thripidae: Thysanoptera)	The thrips rasp and pierce the surface of the plant with their mouthparts, mostly choosing young plant growth. They then add digestive juices and suck up the fluids that seep from the wounds. As the plant part grows, so do the damaged regions, leaving silvery streaks. The more thrips that are present, the greater the area of plant damaged, reducing the area of foliage available for photosynthesis. At the same time, more water is transpired and pathogens can find a way to gain entry.

Name of the pests	Scientific Name	Nature of damage
Betel vine bug	*Disphinctus politus* (Hemiptera: Miridae)	The eggs are laid in the tender tissues of the vines, and the young on hatching puncture the tender leaves. Badly attacked leaves curl and shrivel, serious loss being caused in severe cases. The adult bugs also similarly attack the leaves, and the bulk of the damage is traceable to the adults.
Semilooper	*Synegia spp.* (Geometridae: Lepidoptera)	Young larvae feed on young leaves, scraping the surface and leaving small holes. Mature larvae feed on the wole leaves, starting from the edges and moving towards the veins, leaving only the midrib and veins.
Leaf eating caterpillar	*Spodoptera litura* (Noctuidae: Lepidoptera)	The caterpillars feed voraciously on the leaves at night. They start feeding in newly planted betelvine causing irregular sides on leaves. It also damages the tip of the veins that results in failure of vein establishment.
Betel vine termite	*Odontotermes obesus* (Termitidae: Isoptera)	Cause damage on root of the vine
Linear scale pest	*Lepidosaphes cornutus* (Coccidae: Hemiptera)	Both the nymphs and adults suck the sap and the infested leaves loose colour, exhibit waxy, watery appearance, crinkle and dry up ultimately in case of severe damage. Damage severity found more in old gardens.
Giant African snail	*Achatina spp.* (Achatinidae)	The snails are found in betelvine gardens clinging to the lower and protected surface of the leaves of supporting plants. They feed on sprouted buds, leaves, outer layers of the stem of betelvine and supporting trees. Infestation is high during rainy and winter season.

Table 2. Insect population growth in betel leaf and monthly distribution of weather parameters from October 2021 to March 2022

Items	Oct. 2020	Nov. 2020	Dec. 2020	January 2021	February 2021	March 2021
Max. temp. **(°C)**	33.63	30.23	25.17	23.75	29.09	34.57
Min. temp. **(°C)**	25.01	17.39	13.01	11.44	12.85	19.27
RH (%)	90.56	85.50	88.18	87.13	76.23	73.14
Av. Rainfall (mm)	3.17	0.01	0	0	0	0
Sunshine(hours)	7.20	8.17	5.65	4.16	6.87	9.37
Blackfly* (mean ± SD)	24.76±2.45	21.89±4.54	6.36±1.56	4.3±0.67	4.9±0.89	6.2±1.36
Whitefly* (mean ± SD)	19.8±2.42	13.5±5.23	4.78±1.68	3.9±0.75	6.4±2.67	9.5±3.45
Red mite* (mean ± SD)	15.83±4.72	12.29±3.95	2.73±0.87	4.93±1.23	5.12±2.54	8.21±3.91
Mealy bug* (mean ± SD)	17.83±6.39	13.58±4.23	3.71±0.27	2.15±0.48	4.42±1.39	7.41±1.48
Aphid* (mean ± SD)	2.23±0.45	10.84±0.57	13.32±0.12	18.32±3.45	12.86±4.52	8.42±2.64
Thrips* (mean ± SD)	5.76±1.24	3.45±0.34	1.84±0.32	1.12±0.11	1.65±0.14	8.34±2.32
Betel vine bug* (mean ± SD)	7.34±2.43	4.62±0.18	3.76±0.61	2.65±0.26	1.54±0.46	1.12±0.13

Note: 'Max. temp. **(°C)**, maximum temperature**(°C)**', 'Min. temp. **(°C)**, minimum temperature**(°C)**', 'RH (%), relative humidity (%)', 'Av. Rainfall (mm), average rainfall (mm)', '* = Mean no. of insect population/vine. Data are shown as mean ± standard deviation.

Table 3. Insect population growth in betel leaf and monthly distribution of weather parameters from April to September 2021

Items	April 2021	May 2021	June 2021	July 2021	Aug. 2021	Sept. 2021
Max. temp. **(°C)**	37.52	34.63	34.22	34.22	44.35	34.15
Min. temp. **(°C)**	22.85	24.40	25.99	26.60	26.55	26.24
RH (%)	71.17	83.5	89.5	88.37	92.18	91.18
Av. Rainfall (mm)	0.51	6.34	8.84	10.49	17.04	4.96
Sunshine(hours)	7.69	6.22	4.60	4.21	3.89	5.23
Blackfly* (mean ± SD)	13.8±2.53	18.32±3.76	16.34±5.79	14.56±4.13	12.18±3.94	13.76±3.62
Whitefly* (mean ± SD)	14.6±3.87	20.2±2.79	15.8±4.65	8.6±2.37	5.2±1.74	5.2±1.74
Red mite* (mean ± SD)	12.38±4.42	14.36±2.67	7.18±1.38	4.13±1.21	3.11±0.98	6.25±2.62
Mealy bug* (mean ± SD)	12.46±5.27	15.78±5.71	11.46±3.93	7.29±2.51	2.58±0.31	9.58±3.21
Aphid* (mean ± SD)	4.39±0.59	2.58±0.41	1.43±0.23	1.11±0.12	1.25±0.21	1.67±0.67
Thrips* (mean ± SD)	12.32±3.45	14.32±3.21	7.21±2.31	5.43±1.12	4.87±1.49	3.62±0.41
Betel vine bug* (mean ± SD)	2.76±0.12	4.72±0.16	15.32±3.21	16.24±3.43	18.78±4.85	14.41±3.49

Note: 'Max. temp. **(°C)**, maximum temperature**(°C)**', 'Min. temp. **(°C)**, minimum temperature**(°C)**', 'RH (%), relative humidity (%)', 'Av. Rainfall (mm), average rainfall (mm)', '* = Mean no. of insect population/vine. Data are shown as mean ± standard deviation.

Table 4. Insect population growth in betel leaf and monthly distribution of weather parameters from October 2021 to April 2022

Items	Oct. 2021	Nov. 2021	Dec. 2021	Jan. 2022	Feb. 2022	Mar. 2022	April 2022
Max. temp. **(°C)**	32.99	29.42	26.37	23.41	25.96	34.85	36.09
Min. temp. **(°C)**	24.50	17.36	14.23	12.22	12.64	19.86	25.56
RH (%)	90.34	88.22	85.97	44.63	80.23	70.98	79.57
Av. Rainfall (mm)	3.72	0	0.02	0.10	1.40	0	0.83
Sunshine(hours)	7.12	7.49	5.95	4.80	6.78	11.28	5.45
Blackfly* (mean ± SD)	22.51±3.45	23.12±2.65	7.13±1.11	3.51±0.15	5.72±1.97	7.38±1.48	15.47±3.87
Whitefly* (mean ± SD)	20.23±5.38	14.87±3.98	5.32±2.75	4.76±0.67	7.8±1.37	10.32±4.21	15.25±4.37
Red mite* (mean ± SD)	16.23±5.29	13.72±4.35	3.51±0.93	5.57±0.71	4.24±1.28	9.68±1.85	14.59±5.39
Mealy bug* (mean ± SD)	19.72±6.98	14.43±5.68	4.18±0.82	3.19±0.79	5.97±0.87	8.64±2.16	13.96±3.28
Aphid* (mean ± SD)	2.98±0.76	11.12±1.87	12.87±3.76	17.32±6.87	13.23±5.34	9.28±4.29	5.26±1.39
Thrips* (mean ± SD)	6.12±2.21	4.28±1.56	2.87±0.58	1.76±.48	1.98±0.37	9.67±3.87	13.83±5.91
Betel vine bug* (mean ± SD)	8.24±2.49	5.73±2.19	4.89±1.39	2.82±0.78	2.32±0.37	1.84±0.23	3.52±0.42

Note: 'Max. temp. **(°C)**, maximum temperature**(°C)**', 'Min. temp. **(°C)**, minimum temperature**(°C)**', 'RH (%), relative humidity (%)', 'Av. Rainfall (mm), average rainfall (mm)', '* = Mean no. of insect population/vine. Data are shown as mean ± standard deviation.

Table 5. The effect of weather parameters on the seasonal occurrence of several insect pests of betel leaf was studied using correlation matrix.

	Blackfly	Whitefly	Red mite	Mealy bug	Aphid	Thrips	Betel vine bug	Avg. temp. (°C)	RH (%)	Av. Rainfal (mm)	Sunshine (hours)
Blackfly	100										
Whitefly	0.8076	100									
Red mite	0.7945	0.9101	100								
Mealy bug	0.8844	0.9378	0.9424	100							
Aphid	-0.4934	-0.4340	-0.2302	-0.4378	100						
Thrips	0.2956	0.6296	0.5040	0.4943	-0.5551	100					
Betel vine bug	0.2425	-0.0984	-0.3016	-0.0619	-0.7034	-0.0550	100				
Avg. temp. (°C)	0.4111	0.3301	0.1715	0.3122	-0.9494	0.5651	0.6987	100			
RH (%)	0.4059	081	-0.0698	0.1018	-0.2561	-0.4032	0.6687	0.1679	100		
Av. Rainfall (mm)	0.1252	-0.0526	-0.2980	-0.1403	-0.7065	0.1685	0.8901	0.7652	0.4921	100	
Sunshine(hours)	0.2427	0.4335	0.6172	0.4833	0.1728	0.2760	-0.6786	-0.1530	-0.6040	-0.6637	1

Table 6. Regarding the impact of meteorological conditions on the seasonal abundance of different insect pests of betel leaf, multiple linear regression models with coefficients of determination (R^2) were used.

Name of Insects	Regression equation	R^2	Adjusted R^2	Standard Error(SE)	F statistic
Blackfly	$Y=-99.360+14X_1+0.880X_2-0.661X_3+2.293X_4$ ($X_1=1.758$, $X_2=3.763$, $X_3=-0.886$, $X_4=1.510$)	0.715 (71.5%)	0.589 (58.9%)	4.548	$F_{4,9}=5.656$, $P<0.01$
Whitefly	$Y=-50.293+0.828X_1+0.364X_2-0.548X_3+1.72X_4$ ($X_1=1.225$, $X_2=1.315$, $X_3=-0.621$, $X_4=0.959$)	0.463 (46.3%)	0.224 (22.4%)	5.379	$F_{4,9}=1.938$, $P<0.10$
Red mite	$Y=-47.869+0.761X_1+0.357X_2-0.775X_3+1.437X_4$ ($X_1=1.742$, $X_2=1.995$, $X_3=-1.358$, $X_4=1.237$)	0.651 (65.1%)	0.497 (49.7%)	3.481	$F_{4,9}=4.206$, $P<0.05$
Mealy bug	$Y=-70.070+1.152X_1+0.537X_2-.1.100X_3+1.251X_4$ ($X_1=2.423$, $X_2=2.756$, $X_3=-1.771$, $X_4=0.991$)	0.701 (70.1%)	0.568 (56.8%)	3.785	$F_{4,9}=5.270$, $P<0.01$
Aphid	$Y=48.485-1.340X_1-0.127X_2+0.421X_3+0.514X_4$ ($X_1=-5.770$, $X_2=-1.331$, $X_3=1.389$, $X_4=0.833$)	0.928 (92.8%)	0.896 (89.6%)	1.850	$F_{4,9}=28.913$, $P<01$
Thrips	$Y=9.870+0.701X_1-0.237X_2-0.300X_3-0.244X_4$ ($X_1=1.910$, $X_2=-1.577$, $X_3=-0.626$, $X_4=-0.250$)	0.599 (59.9%)	0.421 (42.1%)	2.925	$F_{4,9}=3.361$, $P<0.06$
Betel Vine bug	$Y=-25.326+0.521X_1+0.284X_2-0.240X_3-0.981X_4$ ($X_1=1.815$, $X_2=2.411$, $X_3=0.639$, $X_4=-1.285$)	0.899 (89.9%)	0.855 (85.5%)	2.287	$F_{4,9}=20.115$, $P<01$

Note: Y= Insect population/Vine, X_1= average temperature (^{0}C), X_2= relative humidity (%), X_3= average rainfall (mm), X_4= Sunshine (hours)

MANAGEMENT OF GUMMOSIS DISEASE OF CITRUS IN NARSINGDI

M ASADUZZAMAN

Abstracts

The experiment was conducted with Colombo lebu at dattergaon and Joymongal, Shibpur, Norsingdi during 1st week of March, 2022. The experiment was laid out in randomized complete block design with three replications. Five to eight years-old 20 disease infected plants were selected for the experiment and five trees were considered as one replication. Treatments were: T_1= Redomil gold paste, T_2= Bordeaux mixture, T_3= Alkatra and T_4= Untreated control. Results revealed that application of different treatments reduced disease infected areas. The length and diameter were reduced by 82.31 and 82.81%, respectively, in Redomil gold treated plants followed by 64.27 and 65.22% respectively, in Bordeaux mixture treatment and, 72.14 and 75.34% respectively, in Alkatra treatment.

Introduction

Citrus is an important and popular fruit crop in Bangladesh. Citrus fruits are known as citron (Jaralebu), Colombo lebu, Lemon (Elachilebu), Pummelo, Satkara, Adazamir. It covers 20-25 percent of among the exported horticultural crops. Gummosis is a major fungal disease of citrus especially lemon and Colombo lebu. Gum formation on the trunk or branches is a characteristic symptom. Gum exudes from blisters containing gum pockets, usually located on the trunk. The wood beneath the blister shows a pink-orange color disease caused by *Phytophthoracitrophthora.* However *Diplodia* sp. also identified form infected disease areas. The disease can affect the root system, the trunk below and above ground, branches, leaves, blossoms and fruit. The infected area becomes cracked and gummy substances come out from the stem. It is especially troublesome during prolonged rainy periods. Trees with the bud union beneath or close to the soil and trees in poorly-drained locations are highly susceptible. Fungus of gummy stem blight can easily be transmitted to a new area with infected soil. Plants are more susceptible at older stage; chlorosis or necrosis symptoms appear in case of severe attack. The infected plant may be died due to the infection of gummy blight (Agrios, 1997; Kucharek and Schenck, 1999). Elaborate research work on gummosis not been undertaken yet. So this experiment will be conducted to develop appropriate technology for management of gummosis disease of citrus.

Materials and Methods

The experiment was conducted with Colombo lebu at datergaon and Joymongal, Shibpur, Norsingdi during 1st week of March, 2020. The experimental design laid out RCB with three replications. Five to eight years plants were selected for the experiment and five tree was considered one replication. Treatments were: T_1= Redomil gold paste, T_2= Bordeaux mixture [$Ca(OH)_2$:$CuSO_4$:H_2O=1:1:100], T_3= Alkatra and T_4= Untreated control. Disease area was scoped with sharp knife or chiseled and removed all infected plant parts. The scoped area was treated with Redomil gold, Bordeaux paste and Alkatra with covering the stem base. Redomil gold was sprayed on stem four times @ $2gL^{-1}$ at 15 days interval after removing the infected parts. The control treatment was maintained to keep the scoped area without any organic amendment or fungicide treatments. Area (length & diameter) was measured before and after treatment application. Treatment was applied at 30 days interval thrice times. Data on diseases area were recorded 15 days interval. Data were recorded and analyzed with CropStat analytical package.

Results and Discussion

Result revealed that application of different treatments reduced disease infected areas. Length and diameter of lesion reduced gradually in size after application of fungicide. The treatment application was significantly affected up to once or twice applications. However, after thrice application the lesion area recovered distinctly. In control treatment, disease area was not recovered compared to initial infection because of lack of treatment application (Table 1.). After thrice treatment application, lesion length and diameter reduced about 82.31 and 82.81%, respectively in Redomil gold paste treatment. While it reduced about 64.27 and 65.22%, respectively in Bordeaux paste treatment and 72.14 and 75.34% respectively in Alkatra (Table 2.).

Table 1. Effect of different treatment in controlling gummosis of Colombo lebu at dattergaon and Joymongal, Shibpur under OFRD Norsingdi

Treat-ment	Before treatment application		After once application		After twice application		After thrice application	
	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)
T_1	18.32	5.82	13.81	4.06	10.14	3.05	3.24	1
T_2	15.03	5.78	12.74	3.93	9.35	2.12	5.37	2.01
T_3	17.23	7.22	13.30	4.89	10.14	3.34	4.80	1.78
T_0	13.06	6.06	13.03	6.05	13.14	6.13	13.22	6
LSD	0.198	0.633	0.88	0.365	0.184	0.109	0.271	0.307
CV (%)	1.59	2.4	0.934	1.711	2.516	0.642	4.31	0.967

Table 2**.** Effect of different treatment on lesion size of gummosis of Colombo lebu at dattergaon and Joymongal, Shibpur under OFRD Norsingdi

Treatment	Lesion length reduced over control (%)	Lesion diameter reduced over control (%)
T_1	82.31	82.81
T_2	64.27	65.22
T_3	72.14	75.34
T_0	-	-

Conclusion

Redomil gold paste gave the best results. The experiment should be repeated in the next year

INTEGRATED MANAGEMENT APPROACH FOR CONTROLLING ROOT ROT (CAUSED BY *SCLEROTIUM ROLFSII*) OF SUNFLOWER

K N ISLAM, M M ISLAM AND M S I KHAN

Abstract

The experiment was conducted at FSRD site, Jamla, Dumki, Patuakhali during rabi season of 2021-22 to find out suitable management approach for controlling root rot disease and to reduce root rot disease incidence in sunflower field in southern region of Bangladesh. Five treatments namely: T_1: Seed treatment with Carboxin+Thiram (Provax 200WP) + three sprayings of Carbendazim (Autostin 50WDG), T_2: Seed treatment with Carboxin+Thiram (Provax 200WP) + three sprayings of Difenoconazole (Score 250EC), T_3: Seed treatment with Carboxin+Thiram (Provax 200WP) + three sprayings of Savlon, T_4: Seed treatment with Carboxin+Thiram (Provax 200WP) + three sprayings of Mancozeb + Metalaxyl (Metaril 72WP), T_5: Only seed treatment with Carboxin+Thiram (Provax 200WP) were evaluated. Statistically percent disease incidence (wilting) was the lowest (0.27%) at 30 DAS and 1.38% at 50 DAS in both T_1 while the highest disease incidence percentages were found at T_5 (Only seed treatment with Provax 200WP) in both 30 and 50 DAS. At 70 and 90 DAS, the percent disease incidence did not vary significantly. Among all the treatments, the highest yield was statistically observed at T_1 treated plot (2.01 t ha^{-1}) while T_5 showed the lowest result (1.72 t ha^{-1}). The maximum (1.21) marginal benefit cost ratio (MBCR) was returned from T_1 treated plot followed by (1.16) T_2. Overall, the research result revealed that, T_1 (Seed treatment with Provax 200WP + three sprayings of Autostin 50WDG) showed the lowest disease incidence percentages for wilt and also gave the highest yield.

Introduction

Sunflower (*Helianthus annuus* L.) popularly known as 'surajmukhi' is globally recognized as one of the fastest growing oilseed crop and is grown on over 22 million hectares worldwide, with a production of 26 million tonnes (Shirshikar, 2005; Skoric *et al.*, 2007). It is a high yielding oil crop which gives high return to the farmers (Shah *et al.*, 2005). Commercially available sunflower varieties contain from 39 to 49% oil in the seed (Irum Mukhtar, 2009). At present, it is a crop that fits well in the local cropping system and is considered the most important cash crop in all parts of the country. It is needed to increase sunflower production of the country (Haq *et al.*, 2006). Although sunflower is attacked by many diseases, which reduce the yield and quality significantly (Mirza and Beg, 1983). More than 90 sunflower diseases have been reported worldwide (Bai *et al.*, 1985). The crop is seriously affected by *Sclerotium rolfsii* and poses persistent problem to its production. *S. rolfsii* is a soil borne pathogen causing root rot disease (Agrios, 2005). Root rot pathogens cause some of the most important plant diseases worldwide impacting several crops (Gonzalez *et al.*, 2011; Nzungize *et al.*, 2011). In Morocco, the fungus has caused yield losses up to 50% on sugarcane and an incidence rate ranging from 60 to 80% on sunflower (Achbani and Tourvielle de Labrouhe, 2000). Root rot symptoms are a major threat because the damage starts below the ground, where the first symptoms are not apparent. Initial symptoms of the disease appear 40 days sowing. The infected plants can be identified by their sickly appearance. When the symptoms become apparent on the above ground part of the plant, yield is already compromised and plant survival is endangered. There are very few effective single approach is available to control the disease. Rather, integration of different treatments has been found to be effective in management of disease in comparison with individual treatments (Madhavi and Bhattiprolu, 2011). For example, *Trichoderma harzianum* accelerated composting and improved its disease suppressive effect (61.6%) (Morsy and El-Korany, 2007). Therefore, the experiment was undertaken to find out suitable management approach for controlling root rot disease and to reduce root rot disease incidence in sunflower field in southern region of Bangladesh.

Materials and Methods

The experiment was conducted at FSRD site, Jamla, Dumki, Patuakhali during rabi season of 2021-22. These approaches was integrated into several treatment combinations and tested to determine their efficacy for controlling root rot disease. Five treatment combinations were used to conduct this research. Those are as follows- T_1: Seed treatment with Carboxin+Thiram (Provax 200WP) + three sprayings of Carbendazim (Autostin 50WDG) @ 2 g/L of water at before 1st (30 DAS) 2nd (50 DAS) and 3rd (70 DAS) irrigation, T_2: Seed treatment with Carboxin+Thiram (Provax 200WP) + three sprayings of Difenoconazole (Score 250EC) @ 1 ml/L of water at before 1st (30 DAS) 2nd (50 DAS) and 3rd (70 DAS) irrigation, T_3: Seed treatment with Carboxin+Thiram (Provax 200WP) + three sprayings of Savlon @ 5 ml/L of water at before 1st (30 DAS) 2nd (50 DAS) and 3rd (70 DAS) irrigation, T_4: Seed treatment with Carboxin+Thiram (Provax 200WP) + three sprayings of Mancozeb + Metalaxyl (Metaril 72WP) @ 2 g/L of water at before 1st (30 DAS) 2nd (50 DAS) and 3rd (70 DAS) irrigation, T_5: Only Seed treatment with Carboxin+Thiram (Provax 200WP). BARI Surjomukhi-2 was used as test crop and was sown on 11 January 2022 at the rate of 15 kg ha^{-1} in rows maintaining spacing (50 cm x 25 cm). The experiment was laid out in RCB design with three replications. The unit plot size was 4m x 4m. The land was fertilized with N_{92}, P_{36}, K_{85} S_{30}, Zn_2 and B_2 in the field. Half of Urea and full doses of all other fertilizers were applied at final land preparation. The rest Urea was applied in two equal split at the first part 20-25 DAS after seedling emergence and the second part 40-45 DAS before flowering. All intercultural operations were done in proper time for better growth of the crop. Yield and yield attributing parameters were recorded properly from each plot of each replication. The experimental data were analyzed statistically through the analysis of variance (ANOVA) using WASP 1.0 software and means were separated by critical difference (CD) values at 5% level of significance. Collection of data on damping off of sunflower was recorded at 20 days after sowing (DAS). The incidence of wilting was recorded at 20 days interval up to its final harvesting. Data were also collected on plant height, head diameter, total no. of seeds/head and ultimate yield. Percent disease incidence was calculated by using following formula:

$$\%\text{ disease incidence} = \frac{\text{No. of infected plants by } Sclerotium\ rolfsii}{\text{Total no. of plants germinated}}\ x\ 100$$

Results and Discussion

Percent Disease Incidence (Wilting): Disease incidence increased almost uniformly along with time apparently independent of treatments. It has been noted throughout the growth periods, the percent disease incidence was highest at T_5 (Only seed treatment with Provax 200WP). So, the treatments effect differed significantly from only seed treatment with Provax 200WP and amongst them Table 1. At 30 DAS, the highest disease incidence occurred at T_5 (1.93%) followed by T_4 (1.39%), T_3 (1.11%) and the lowest showed at T_1 plot (0.27%) followed by T_2 (0.54%). There was statistical difference among results of those all treatments. Similarly, at 50 DAS, the highest disease incidence occurred at T_5 (2.75%) followed by T_4 (2.21%), T_3 (1.96%) and the lowest showed at T_1 plot (1.38%) followed by T_2 (1.63%). There was statistical difference among results of those all treatments. Only seed treatment with Provax 200WP (T_5) showed the highest disease incidence over all the treatments at 30 and 50 DAS. At 70 and 90 DAS, the percent disease incidence did not vary significantly.

The variation among yield of sunflower obtained from different plot was significant due to the different treatments Table 3. Among all the treatments, the highest yield was observed at T_1 (Seed treatment with Provax 200WP + three sprayings of Autostin 50WDG) treated plot (2.01 t ha^{-1}) and the lowest yield was found on T_5 (Only seed treatment with Provax 200WP) treated plot (1.72 t ha^{-1}). T_2 gave identical result (1.99 t ha^{-1}) as seed treatment with Provax 200WP + three sprayings of Score 250EC treated plot. Yield at T_3 (1.85 t ha^{-1}) and T_4 (1.83 t ha^{-1}) plot gave statistically similar result Table 3.

Table 1. Effect of different treatments on disease incidence (wilting) and yield of sunflower

Treatments	% Disease incidence (Wilting)				Yield (t ha^{-1})
	30 DAS	50 DAS	70 DAS	90 DAS	2.01 a
T_1	0.27 c	1.38 d	0.54	0	1.95 ab
T_2	0.54 bc	1.63 cd	0.81	0	1.85 bc
T_3	1.11 abc	1.96 bc	1.13	0.28	1.83 bc
T_4	1.39 ab	2.21 ab	1.37	0.27	1.72 c
T_5	1.93 a	2.75 a	1.65	0.83	4.36
CV (%)	50.42	15.17	36.04	115.55	0.16
CD (0.05)	0.99	0.56	-	-	

Return and marginal benefit cost ratio (MBCR)

Economic analysis is presented in Table 3. The net return and marginal benefit cost ratio (MBCR) varied depending on the cost of different application in treatments. The T_5 [Only Seed treatment with Provax 200WP] did not incur any pest management cost. The maximum net return (Tk. 121142 ha^{-1}) was recorded from T_1 [Seed treatment with Provax 200WP + three sprayings of Autostin 50WDG] plot followed by T_2 [Seed treatment with Provax 200WP + three sprayings of Score 250EC], T_3 [Seed treatment with Provax 200WP + three sprayings of Savlon] and T_4 [Seed treatment with Provax 200WP + three sprayings of Metaril 72WP]. The maximum marginal benefit cost ratio (1.21) was calculated from T_1 treated plot followed by (1.16) T_2.

Table 3. Cost analysis of different integrated management approach for controlling root rot of sunflower during 2021-22

Treatments	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Cost of management (Tk. ha^{-1})	Net return (Tk. ha^{-1})	Adjusted net return (Tk. ha^{-1})	Marginal benefit cost ratio (MBCR)
T_1	2.01	130650	9508	121142	11500	1.21
T_2	1.95	126750	7933	118817	9175	1.16
T_3	1.85	120250	5308	114942	5300	1
T_4	1.83	118950	7858	111092	1450	0.18
T_5	1.72	111800	2158	109642	-	-

For calculating benefit cost ratio, the following prices were used: Market price of sunflower seed @ Tk. 65/kg; Autostin (100 g) = 195 Tk.; Score (100 ml) = 285 Tk.; Savlon (1 L) = 220 Tk.; Metaryl (100 g) = 140 Tk.; Provax (100 g) = 350 Tk.; Labor wage for spraying fungicides @ Tk. 500/man/day (8 hours)

Conclusion

The incidence of wilting disease of sunflower caused by *Sclerotium rolfsii* was observed the highest at T_5 (Only Seed treatment with Provax 200WP) treated plot while the lowest incidence was under treatment T_1. T_5 (Only Seed treatment with Provax 200WP) treated plot resulted less yield than any other treatment. Among all the treatments, different integrated management approach had significantly given higher yield over only seed treatment with Provax 200WP. It also observed that integrated approach was found to be effective in management of disease in comparison with only seed treatment with Provax 200WP as well as eventual higher economic return. Therefore, the sunflower growers may be advised to take an integrated approach for reducing disease incidence of wilting of sunflower.

EVALUATION OF INTEGRATED CONTROLLING APPROACH AGAINST FLOWER THRIPS AND POD BORERS OF MUNGBEAN IN COASTAL AREA

K N ISLAM, M M ISLAM AND M S I KHAN

Abstract

The experiment was conducted at Keoyabunia, Amtoli, Borguna during late rabi season of 2021-22 to evaluate the efficacy of integrated controlling approach against flower thrips and pos leaves of mungbean based on their marginal benefit cost ratio in coastal area by various means, including blue sticky trap, bio and chemical insecticides. Five approaches namely: T_1 = Installing blue sticky trap + two sprayings of Success 2.5 SC and single spraying of Siena 6WG, T_2 = Installing blue sticky trap + two sprayings of Antario and single spraying of Coragen 20SC, T_3 = Installing blue sticky trap + two sprayings of Fytomax aza 3% and single spraying of Nitro 505EC, T_4 = Four sprayings of Imitaf 20SL, T_5 = Four sprayings of Voliam flexi 300SC were evaluated. The integrated management approaches showed significantly different performance against flower thrips and pod borer of mungbean. The highest percentage (65.73%) of reduction of thrips population was found in T_1 treated plot and the lowest percentage (9.79%) of pod infestation by pod borer observed by the same treatment followed by T_3. The highest yield (1.92 t ha^{-1}) was also obtained from T_1 as well as maximum gross return (Tk. 124800 ha^{-1}), gross margin (Tk. 74715 ha^{-1}) and BCR (2.49) was recorded from same treatment. The lowest economic return was recorded from T_2 (Tk. 95550 ha^{-1}) and BCR (1.83). Considering the overall eco-friendliness and profitability, integrated management approach 1 would be the best for controlling of flower thrips and pod borers of mungbean with higher yield in the insects' prone cropping areas.

Introduction

Mungbean (*Vigna radiata* L. Wilczek) is one of the most important pulse crops of Bangladesh. It is a rich source of protein and several essential micronutrients. In the field, mungbean crop is attacked by a number of insect pests from seedling to harvest stages. More than twelve species of insect pests were found to infest mungbean in Bangladesh (Rahman *et al.* 2000). Among insect pests, whitefly, leaf folder, flea beetles, flower thrips and pod borers are the most important. Flower thrips and Pod borers are considered as one of the major threats to the present-day to mungbean in the field. They cause significant damage to green gram including foliage, flowers, flower buds and developing or mature pods. Severe infestation of thrips resulted flower shedding causing significant yield loss (Lal, 1985). Heavy infestation of pod borer occurs at flowering and pod filling stages. Pod borer damages flowers, flower buds and developing or mature pods (Poehlman, 1991). It was reported that the yield reduction ranged from 30% to 70% due to thrips attack and 30% to 40% by pod borer in Bangladesh (Afzal *et al.*, 2004). In recent years populations of many pests have developed resistance to many commercially available pesticides. For this reasons, it is essential to search alternatives of pest control and develop an integrated approach for control of major insect pests of mungbean in coastal area. Keeping all these constraints in view, the experiment was undertaken to evaluate the appropriate integrated controlling approach against flower thrips and pod borers for mungbean production in coastal area of Bangladesh.

Materials and Methods

The experiment was conducted at Keoyabunia, Amtoli, Borguna during late rabi season of 2021-22. The experiment was laid out in RCB design with 3 replications. The unit plot size was 5 m x 4 m. BARI Mung-6 was used as experimental material and was sown on 23 January 2022 at the rate of 30 kg ha^{-1} in rows maintaining spacing (30cm x 10cm). The land was fertilized with N_{23}, P_{17} and $K_{17.5}$ kg ha^{-1} during the final land preparation. All intercultural operations were done as and when necessary to ensure normal growth and development of crops. Installing blue sticky trap, application of bio and synthetic insecticides considered as treatments of the experiment were assigned as follows: T_1 = Installing blue sticky trap + two sprayings of Spinosad (Success 2.5 SC) @ 1.3 ml l^{-1} of water at vegetative, flowering and single spraying of Abamectin + Emamectin benzoate (Siena 6WG) @ 1 g l^{-1} of water at podding stage, T_2 = Installing blue sticky trap + two sprayings of *Bacillus thuringiensis* + Abamectin (Antario) @ 1g l^{-1} of water at vegetative, flowering and single spraying of Chlorantraniliprol (Coragen 20SC) @ 0.5 ml l^{-1} of water at podding stage, T_3 = Installing blue sticky trap + two sprayings of Azadirachtin (Fytomax aza 3%) @ 1 ml l^{-1} of water at vegetative, flowering and single spraying of Chlorpyrifos+Cypermethrin (Nitro 505EC) @ 1 ml l^{-1} of water at podding stage, T_4 = Four sprayings of Imidacloprid (Imitaf 20SL) @ 0.5 ml l^{-1} of water at vegetative, flower initiation, peak flowering and podding stages, T_5 = Four sprayings of Thiamethoxam + Chlorantraniliprole (Voliam flexi 300SC) @ 0.5 ml l^{-1} of water at vegetative, flower initiation, peak flowering and podding stages. Blue sticky trap were installed (one trap/plot) at flower initiation stage and kept in the field upto harvest. Treatment wise bio and chemical insecticides were sprayed. The spray solutions at the pre-fixed concentration of the respective treatments were prepared in Knapsack sprayer by mixing with water as required just before spraying. The spray solutions were sprayed at vegetative, flowering and podding stages. The data on the population of thrips were collected before and after one day of each spraying. Thrips population was assessed from 15 open flowers which were randomly collected from two rows of each side of the plot avoiding border and central four rows. The collected flowers were immediately opened on the white paper and counted the adult and immature thrips.

For collecting data on the percentage of pod borer infested pods, the number of infested pods and the total number of pods from randomly selected 10 plants from central four rows of each unit plot were counted at ripening stage and recorded. The following formula was used for taking the infestation percentage:

$$\%\ Pod\ infestation = \frac{Total\ number\ of\ infested\ pods}{Total\ number\ of\ pods} \times 100$$

The selected 1m^2 (1m x 1m) area of the center of each unit plot was kept undisturbed for recording yield data. The pods of central four rows of each plot comprising area were harvested. Grains were recorded from 1m^2 area per plot wise and the yields were expressed in t ha^{-1}. The experimental data were recorded and analyzed statistically through the analysis of variance (ANOVA) using WASP 1.0 software. The population data were transformed to square root transformation for statistical analysis and mean comparisons were separated by critical difference (CD) values at 5% level of significance.

Results and Discussion

Effect of different integrated approaches on flower infestation and thrips population: The results are mean comparison of the data, regarding the treatment effect of integrated management approaches comprising installation of blue sticky trap and application of bio and chemical insecticides on flower infestation and thrips population in mungbean Table 1. Before spraying there was no significant difference on flower infestation and thrips population among the management approaches. After spraying, all the treatments significantly reduced flower infestation and thrips population. After 1 day of spray application, the highest reduction of flower infestation (72.39%) and thrips population (65.73%) was observed in T_1 [Installing blue sticky trap + two sprayings of Spinosad (Success 2.5 SC) and single spraying of Abamectin + Emamectin benzoate (Siena 6WG)] while the lowest reduction was found in T_4 [Four sprayings of Thiamethoxam + Chlorantraniliprole (Voliam flexi 300SC)]. The lowest number of thrips population (1.95/15 open flowers) was found in T_1 followed by T_3 (2.34/15 open flowers) while the highest thrips population (3.47/15 open flowers) were counted from T_2 treated plot. However, T_1 [Installing blue sticky trap + two sprayings of Spinosad (Success 2.5 SC) and single spraying of Abamectin + Emamectin benzoate (Siena 6WG)] was the most effective treatment against thrips infesting mungbean in field condition while T_3 [Installing blue sticky trap + two sprayings of Azadirachtin (Fytomax aza 3%) and single spraying of Chlorpyrifos+Cypermethrin (Nitro 505EC)] was the second most effective treatment.

Effect of different integrated approaches on pod borer infestation: Pod borer infestation varied depending on the effectiveness of different integrated management approaches and it ranged from 9.79 to 25.60% (Table 2). The lowest pod infestation was observed 9.79% in T_1 [Installing blue sticky trap + two sprayings of Spinosad (Success 2.5 SC) and single spraying of Abamectin + Emamectin benzoate (Siena 6WG)] followed by T_3 [Installing blue sticky trap + two sprayings of Azadirachtin (Fytomax aza 3%) and single spraying of Chlorpyrifos+Cypermethrin (Nitro 505EC). The highest pod infestation was 25.60% in T_2 [Installing blue sticky trap + two sprayings of *Bacillus thuringiensis* + Abamectin (Antario) and single spraying of Chlorantraniliprol (Coragen 20SC)].

Effect of different integrated approaches on yield: In respect of seed yield, statistically significant variation with the level of thrips and pod borer infestation was observed among the different integrated management approaches (Table 2). Seed yield ranged from 1.92-1.47 t ha^{-1}. The highest yield (1.92 t ha^{-1}) were recorded in T_1 [Installing blue sticky trap + two sprayings of Spinosad (Success 2.5 SC) and single spraying of Abamectin + Emamectin benzoate (Siena 6WG)] treated plot which was followed by T_3 [Installing blue sticky trap + two sprayings of Azadirachtin (Fytomax aza 3%) and single spraying of Chlorpyrifos+Cypermethrin (Nitro 505EC)]. The lowest yield (1.47 t ha^{-1}) was obtained on T_2 [Installing blue sticky trap + two sprayings of *Bacillus thuringiensis* + Abamectin (Antario) and single spraying of Chlorantraniliprol (Coragen 20SC)].

Economic return and benefit cost ratio (BCR): Economic analysis is presented in Table 3. The gross margin and benefit cost ratio (BCR) varied depending on the cost of different application in treatments. The maximum gross return (Tk. 124800 ha^{-1}), gross margin (Tk. 74715 ha^{-1}) and BCR (2.49) was recorded from T_1 [Installing blue sticky trap + two sprayings of Spinosad (Success 2.5 SC) and single spraying of Abamectin + Emamectin benzoate (Siena 6WG)], followed by T_3 [Installing blue sticky trap + two sprayings of Azadirachtin (Fytomax aza 3%) and single spraying of Chlorpyrifos+Cypermethrin (Nitro 505EC)]. The lowest economic return was recorded from T_2 [Installing blue sticky trap + two sprayings of *Bacillus thuringiensis* + Abamectin (Antario) and single spraying of Chlorantraniliprol (Coragen 20SC)] (Tk. 95550 ha^{-1}) and BCR (1.83).

Table 1. Effect of different integrated approaches on incidence of flower infestation and thrips population in mungbean during 2021-22

Treatments	No. of thrips infested flowers/15 open flowers			No. of thrips/15 open flowers		
	Spraying		Reduction of thrips infested flowers after 1 day of spray (%)	Spraying		Reduction of thrips population after 1 day of spray (%)
	Before	After 1 day		Before	After 1 day	
T_1	9.67	2.67 b	72.39	5.69	1.95 b	65.73
T_2	9	5.67 a	37	5.45	3.47 a	36.33
T_3	7.33	3 b	59.07	5.61	2.34 b	58.29
T_4	6.67	4 ab	40.03	5.01	2.72 ab	45.71
T_5	8.33	4 ab	54.13	5.08	2.67 ab	47.44
CV (%)	25.10	26.51	-	6.64	17.32	-
CD (0.05)	NS	1.92	-	NS	0.86	-

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV = Coefficient of Variation, CD = Critical Difference.

Table 2. Effectiveness of different integrated approaches on the incidence of pod borers and yield of mungbean during 2021-22

Treatments	Pod infestation by pod borers (%)	Yield (t ha^{-1})
T_1	9.79 c	1.92 a
T_2	25.60 a	1.47 c
T_3	16.44 bc	1.85 ab
T_4	23.72 ab	1.80 b
T_5	23.45 ab	1.81 b
CV (%)	23.19	2.28
CD (0.05)	8.64	0.08

Table 3. Cost analysis of different integrated approaches for the management of mungbean insect pests during 2021-22

Treatments	Yield (t ha^{-1})	Gross return (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Benefit cost ratio (BCR)
T_1	1.92	124800	50085	74715	2.49
T_2	1.47	95550	52355	43195	1.83
T_3	1.85	120250	49025	71225	2.45
T_4	1.80	117000	47705	69295	2.45
T_5	1.81	117650	49205	68445	2.39

For calculating marginal benefit cost ratio, the following prices were used: Market price of mungbean seed @ Tk. 65/kg. Installing blue sticky trap (two piece) = 90 Tk. (@40 ha^{-1}); Success 2.5 SC (100 ml) = 350 Tk.; Siena 6WG (50 g) = 178 Tk.; Antario (100 g) = 300 Tk.; Coragen (10 ml) = 210 Tk.; Fytomax aza 3% (100 ml) = 300 Tk. Nitro 505 EC (50 ml) = 92 Tk.; Imitaf 20 SL (50 ml) = 155 Tk.; Voliam flexi 300SC (50 ml) = 330 Tk.; Labor wage for spraying insecticides @ Tk. 500/man/day (8 hours)

Conclusion

From the study, it is observed that flower infestation, thrips population and pod borer infestation reduced significantly by using blue sticky trap, bio and chemical insecticides. Considering the overall eco-friendliness and profitability, it could be concluded that T_1 [Installing blue sticky trap + two sprayings of Spinosad (Success 2.5 SC) and single spraying of Abamectin + Emamectin benzoate (Siena 6WG)] would be the best package approach for mungbean's pest control with higher yield in the insects prone cropping areas followed by T_3 [Installing blue sticky trap + two sprayings of Azadirachtin (Fytomax aza 3%) and single spraying of Chlorpyrifos+Cypermethrin (Nitro 505EC)].

EVALUATION OF VARIOUS IPM TOOLS AGAINST POD BORERS ON MUNGBEAN IN SOUTHERN REGION OF BANGLADESH

KN ISLAM, MM. ISLAM AND MSI KHAN

Abstract

The experiment was conducted at FSRD site, Jamla, Dumki, Patuakhali during rabi season of 2021-22 to evaluate the efficacy of various IPM tools based on their marginal benefit cost ratio against pod borers on mungbean under southern region of Bangladesh by various means, including sex pheromone trap, blue sticky trap, bio and chemical insecticides. Five packages namely: T_1 = Installing sex pheromone trap + blue sticky trap + two sprayings of Success + single spraying of SNPV, T_2 = Installing sex pheromone trap + blue sticky trap + two sprayings of Antario + single spraying of SNPV, T_3 = Installing sex pheromone trap + blue sticky trap + two sprayings of Siena + single spraying of SNPV, T_4 = Farmer practice: four sprayings of Imitaf, T_5= Untreated control (water spray only) were evaluated. The insecticidal treatment options showed significantly different performance against pod borer (Spodoptera litura, Maruca vitrata and Helicoverpa armigera) on mungbean. The integrated management approaches showed significantly different performance against pod borers of mungbean. The highest percent reduction of pod borer population (52.32% at flowering and 45.77% at podding stage) was found in T_3 [IPM package 3: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of Abamectin + Emamectin benzoate (Siena 6WG) and single spraying of SNPV] and the highest (63.67%) reduction of pod infestation observed by the same package while the lowest (25.74) reduction of pod infestation was found in T_4 [Farmers practice: Four sprayings of imidacloprid (Imitaf 20 SL)]. The highest yield (1.84 t ha^{-1}) was also obtained from IPM package 3 which was statistically similar to all the IPM packages. The maximum (1.84) marginal benefit cost ratio (MBCR) was returned from IPM package 3 followed by (1.55) T_4 [Farmers practice (only chemical insecticide spray)]. Considering the overall eco-friendliness and profitability, IPM package 3 would be the best package approach for controlling of pod borers of mungbean with higher yield in the insects prone cropping areas.

Introduction

Mungbean (*Vigna radiata* L.) known as 'Moog' is important legume crop where contributes only about 11.53% of the total pulse production in Bangladesh (BARC, 2013). The crop is mostly sown under rainfed conditions. However, there are many constraints to pulses cultivation. The reasons of this low yield are numerous but yield losses due to insect pests are distinct one. More than twelve species of insect pests were found to infest mungbean in Bangladesh (Rahman *et al.* 2000). Among them, whitefly, flea beetles, flower thrips and pod borers are the most important. Pod borers (*Spodoptera litura*, *Maruca vitrata*, *Helicoverpa armigera*) are considered as one of the major threats to the present-day to mungbean in the field. Pod borers cause significant damage to green gram including foliage, flowers, flower buds and developing or mature pods. In recent years populations of many pests including pod borers have developed resistance to many commercially available pesticides. However, excessive insecticides has posed several adverse effects such as a buildup of pest resistance to insecticide, outbreak of secondary pests, harmful to non-target organisms, health hazards and other problems related to environmental pollution. Due the increasing concern of environmental awareness of pesticide hazards has evoked worldwide interest searching alternatives of pest control. Therefore, it is necessary to adopt various pest control techniques which reduce insecticide application significantly. Keeping all these constraints in view, the experiment was conducted to evaluate the efficacy of various IPM tools based on their marginal cost benefit ratio against pod borers in southern districts of Bangladesh.

Materials and Methods

The experiment was conducted at FSRD site, Jamla, Dumki during late rabi season of 2021-22. The experiment was laid out in RCB design with 3 dispersed replications. The unit plot size was 5 m x 4 m. BARI Mung-6 was used as experimental material and was sown on 15-17 February 2022 at the rate of 30 kg ha^{-1} in rows maintaining spacing (30cm x 10cm). The land was fertilized with N_{23}, P_{17} and $K_{17.5}$ during the final land preparation. All intercultural operations were done as and when necessary to ensure normal growth and development of crops. Installing sex pheromone trap & blue sticky trap and application of bio and synthetic insecticides considered as treatments of the experiment were assigned as follows: T_1 = IPM package 1: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of Spinosad (Success 2.5 SC) @ 1.3 ml/L of water at vegetative, flowering and single spraying of SNPV @ 0.2 g/L of water at podding stage, T_2 = IPM package 2: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of *Bacillus thuringiensis* + Abamectin (Antario) @ 1 g/L of water at vegetative, flowering and single spraying of SNPV @ 0.2 g/L of water at podding stage, T_3 = IPM package 3: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of Abamectin + Emamectin benzoate (Siena 6WG) @ 1 g/L of water at vegetative, flowering and single spraying of SNPV @ 0.2 g/L of water at podding stage, T_4 = Farmer practice: four sprayings of Imidacloprid (Imitaf 20SL) @ 0.5 ml/L of water at vegetative, flower initiation, peak flowering and podding stages, T_5= Untreated control (water spray only).

Sex pheromone trap and blue sticky trap were installed (one trap/plot) at vegetative and flower initiation stage, respectively and kept in the field upto harvest. Treatment wise bio and chemical insecticides were sprayed. The spray solutions at the pre-fixed concentration of the respective treatments were prepared in Knapsack sprayer by mixing with water as required just before spraying. The spray solutions were sprayed at vegetative, flowering and podding stages.

The data on the population of pod borers were collected before and after 1 day of spray application from each unit plot. Number of pod borers was recorded at vegetative, flowering and podding stage. For collecting data on the percentage of pod borers infested pods, the number of infested pods and the total number of pods from randomly selected 10 plants from central four rows of each unit plot were counted at ripening stage and recorded. The following formula was used for taking the infestation percentage:

$$\%\ Pod\ infestation = \frac{Total\ number\ of\ infested\ pods}{Total\ number\ of\ pods} \times 100$$

The selected 1m^2 (1m x 1m) area of the center of each unit plot was kept undisturbed for recording yield data. The pods of central four rows of each plot comprising area were harvested. Grains were recorded from 1m^2 area per plot wise and the yields were expressed in t ha^{-1}. The experimental data were recorded and analyzed statistically through the analysis of variance (ANOVA) using WASP 1.0 software. The population data were transformed to square root transformation for statistical analysis and mean comparisons were separated by critical difference (CD) values at 5% level of significance.

The marginal benefit cost ratio (MBCR) for each treatment was calculated on the basis of market prices of mungbean, cost of sex pheromone trap, blue sticky trap, bio & chemical insecticides and insecticidal spraying cost. Marginal benefit cost ratio was calculated by using the following formula:

$$MBCR = \frac{Benefit\ over\ control}{Cost\ of\ treatment}$$

Results and Discussion

Effect of various IPM packages on pod borers population at different growth stages: The results are mean comparison of the data, regarding the treatment effect of integrated management approaches comprising installation of sex pheromone (Spodo lure) trap and application of bio and chemical insecticides on pod borers population in mungbean which are prsented in Table 1. The treatments also showed significant influence on pod borers. After 1 day of spray application, all the IPM approaches significantly reduced pod borers population compared to untreated control. The highest reduction of pod borers over control (52.32% at flowering and 45.77% at podding stage) was observed in T_3 [IPM package 3: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of Abamectin + Emamectin benzoate (Siena 6WG) and single spraying of SNPV] while the lowest reduction was found in T_4 [Farmers practice: Four sprayings of imidacloprid (Imitaf 20 SL)]. The results revealed that all the insecticides significantly reduced pod borers infesting mungbean. The lowest number of pod borers population (2.26/plot at flowering and 1.86/plot at podding stage) was found in T_3 [IPM package 3]. Other IPM packages received significantly lower pod borers population compared to untreated control. In both flowering and podding stage, the highest pod borers population was counted from T_5 [untreated control].

Effect of various IPM packages on pod infestation by pod borers: Pod borers infestation varied depending on the effectiveness of **various** IPM packages and it ranged from 8.13 to 22.38% (Table 2). The lowest pod infestation was observed 8.13% in T_3 [IPM package 3: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of Abamectin + Emamectin benzoate (Siena 6WG) and single spraying of SNPV] followed by T_1 [IPM package 1: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of Spinosad (Success 2.5 SC) and single spraying of SNPV] and the highest pod infestation was 22.38% in T_5 [Untreated control]. Pod borer infestation reduction over control ranged from 25.74 to 63.67% (Table 2). The highest reduction of pod infestation (63.67) was observed in T_3 [IPM package 3] followed by T_1 [IPM package 1], T_2 [IPM package 2] and T_4 [Farmers practice].

Effect of various IPM packages on yield: In respect of seed yield, statistically significant variation with the level of pod borers infestation was observed among the various IPM packages (Table 2). Seed yield ranged from 1.83-1.07 t ha^{-1}. The highest yield (1.83 t ha^{-1}) were recorded in T_3 [IPM package 3: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of Abamectin + Emamectin benzoate (Siena 6WG) and single spraying of SNPV] treated plot which was statistically similar to T_2 [IPM package 2: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of *Bacillus thuringiensis* + Abamectin (Antario) and single spraying of SNPV] and T_1 [IPM package 1: Installing sex pheromone (Spodo lure) trap + blue sticky trap +

two sprayings of Spinosad (Success 2.5 SC) and single spraying of SNPV]. The lowest yield (1.07 t ha^{-1}) was obtained on T_5 [Untreated control] which was statistically similar to T_4 [Farmers practice]. Different IPM packages showed increase in yield of mungbean over control (Table 2). The maximum percent yield increase over control (71.03%) was recorded in T_3 [IPM package 3] followed by (57.01%) T_2 [IPM package 2], (56.07%) T_1 [IPM package 1] and (18.69%) T_4 [Farmers practice].

Pod borer (*Spodoptera litura*) moth catching in the sex pheromone traps: Pod borer (*Spodoptera litura*) were caught in the sex pheromone traps. Moth starts captured in the trap from 12 March when mungbean reached to 100% vegetative stage and the infestation of pod borer reached peak on 26 March when mungbean were in peak flowering and seed developing stage and then gradually decreased and the number of pod borer reached an indiscriminate level of damage on 23 April when the crops matured and suitable for harvesting. The number of pod borer was found consistently low in IPM package 3 followed by IPM package 1 and IPM package 2 (Figure 1, 2 & 3).

Return and Marginal benefit cost ratio (MBCR): Economic analysis is presented in Table 3. The net return and marginal benefit cost ratio (MBCR) varied depending on the cost of different application in treatments. The T_5 [Untreated control] did not incur any pest management cost. The maximum net return (Tk. 101564 ha^{-1}) was recorded from T_3 [IPM package 3] plot followed by T_2 [IPM package 2], T_1 [IPM package 1] and T_4 [Farmers practice]. The maximum marginal benefit cost ratio (1.84) was calculated from T_3 [IPM package 3] treated plot followed by (1.55) T_4 [Farmers practice (only chemical insecticide spray)].

Table 1. Effectiveness of various IPM packages on incidence of pod borer' population at different growth stages during rabi 2021-22

Treatments	Flowering stage			Podding stage		
	No. of pod borer/plot		Reduction of pod borer population over control (%)	No. of pod borer/plot		Reduction of pod borer population over control (%)
	Before spray	After 1 day of spray		Before spray	After 1 day of spray	
T_1	6.32 bc	3.07 bc	35.23	5.30 ab	2.18 bc	36.44
T_2	8.48 a	2.62 cd	44.73	5.74 a	2.58 b	24.78
T_3	5.52 c	2.26 d	52.32	3.82 c	1.86 c	45.77
T_4	6.19 c	3.51 b	25.95	4.35 bc	2.41 bc	29.74
T_5	7.36 ab	4.74 a	-	4.63 bc	3.43 a	-
CV(%)	8.91	12.56	-	10.65	13.51	-
CD (0.05)	1.13	0.77	-	0.95	0.64	-

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV = Coefficient of Variation, CD = Critical Difference.

Table 2. Effectiveness of various IPM packages on pod infestation by pod borers and yield of ungbean during rabi 2021-22

Treatments	Pod infestation by pod borers (%)	Pod infestation reduction over control (%)	Yield (t ha^{-1})	Yield increased over control (%)
T_1	12.58 bc	43.79	1.67 a	56.07
T_2	14.42 b	35.57	1.68 a	57.01
T_3	8.13 c	63.67	1.83 a	71.03
T_4	16.62 ab	25.74	1.27 b	18.69
T_5	22.38 a	-	1.07 b	-
CV (%)	21.61		9.28	
CD (0.05)	6.04		0.26	

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability.
CV = Coefficient of Variation, CD = Critical Difference.

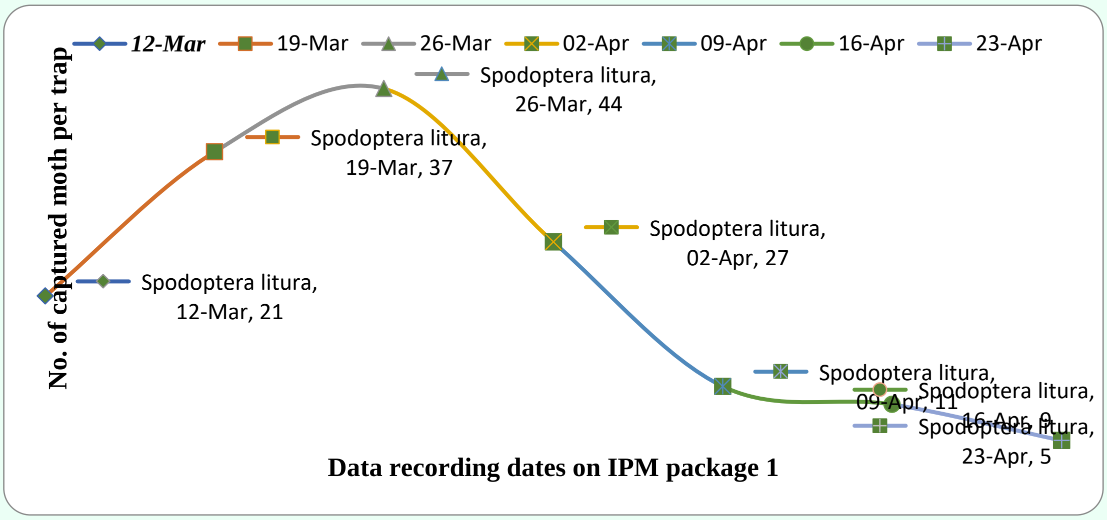

Figure 1: Weekly catches of pod borer (*Spodoptera litura)* in the sex pheromone trap of mungbean field in IPM package 1

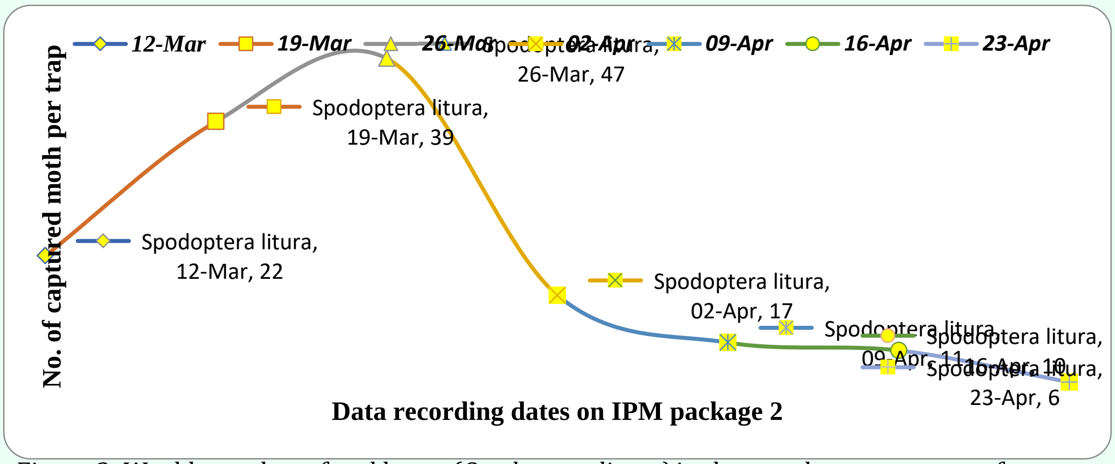

Figure 2: Weekly catches of pod borer (*Spodoptera litura)* in the sex pheromone trap of mungbean field in IPM package 2

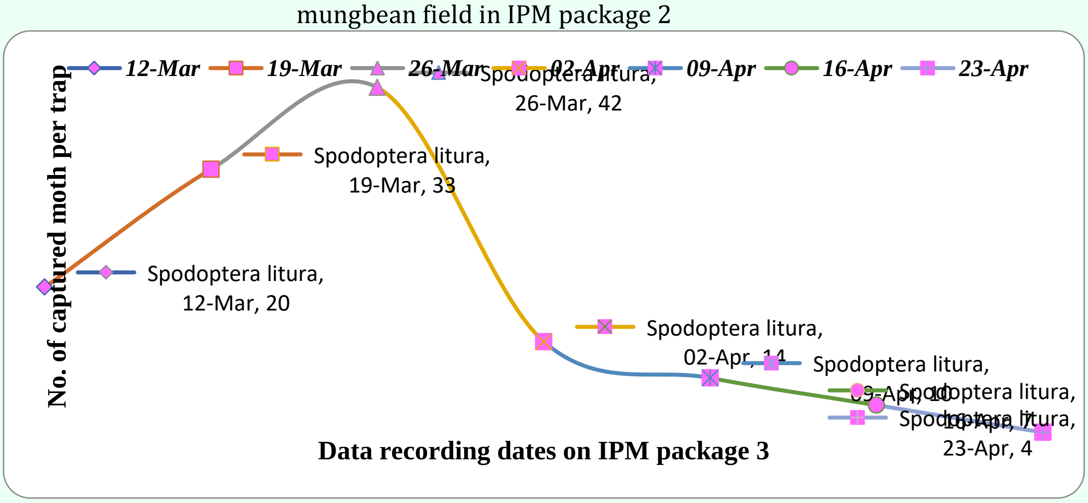

Figure 3: Weekly catches of pod borer (*Spodoptera litura)* in the sex pheromone trap of mungbean field in IPM package 3

Table 3. Cost benefit analysis of different IPM packages and farmers practice for the management of mungbean insect pests during rabi 2021-22

Treatments	Yield (t ha^{-1})	Gross return (Tk ha^{-1})	Cost of management (Tk ha^{-1})	Net return (Tk ha^{-1})	Adjusted net return (Tk ha^{-1})	Marginal benefit cost ratio (MBCR)
T_1	1.67 ab	108550	18026	90524	20974	1.16
T_2	1.68 ab	109200	16826	92374	22824	1.36
T_3	1.83 a	118950	17386	101564	32014	1.84
T_4	1.27 b	82550	5100	77450	7900	1.55
T_5	1.07 b	69550	0	69550	-	-

For calculating marginal benefit cost ratio, the following prices were used: Market price of mungbean seed @ Tk. 65/kg. Installing sex pheromone (*Spodoptera litura*) trap (two piece) with sex pheromone pot = 154 Tk. (@40 ha^{-1}); Installing blue sticky trap (two piece) = 50 Tk. (@40 ha^{-1}); Success 2.5 SC (100 ml) = 350 Tk.; SNPV (3 g) = 125 Tk.; Antario (100 g) = 300 Tk.; Siena 6 WG (50 g) = 178 Tk.; Imitaf 20 SL (50 ml) = 155 Tk.; Labor wage for spraying insecticides @ Tk. 500/man/day (8 hours)

Conclusion

From the study, it is observed that pod borers infestation reduced significantly by using sex pheromone trap, blue sticky trap, bio and chemical insecticides. Considering the overall eco-friendliness and profitability, it could be concluded that T_3 [IPM package 3: Installing sex pheromone (Spodo lure) trap + blue sticky trap + two sprayings of Abamectin + Emamectin benzoate (Siena 6WG) and single spraying of SNPV] would be the best package approach for mungbean's pest control in the insects prone cropping areas. It also observed that various IPM package was found to be effective in management of pod borers in comparison with only water spray (Untreated control) as well as eventual higher economic return. Therefore, the mungbean growers may be advised to take an IPM approach for reducing incidence of pod borers of mungbean.

CONTROLLING OF BIRD PESTS IN SUNFLOWER CROP USING DIFFERENT REPELLENT TOOLS AT COASTAL AREAS OF BANGLADESH

K N ISLAM, M M. ISLAM AND M S I KHAN

Abstract

The experiment for controlling of bird pests in sunflower production was conducted under farmer's field condition in Kuakata, Patuakhali during robi season of 2021-22 to evaluate the effectiveness of repellent tools against bird pests in sunflower. Four management techniques (MT) namely: MT_1 = Hanging red ribbon, MT_2 = Plastic bottle windmill, MT_3 = Bird repellent mechanical device and MT_4 = Control were evaluated. Among the using management techniques, Plastic bottle windmill as repellent tool having minimum (21.25%) % head damaged by bird and minimum (27.5%) % plant infested followed by Bird repellent mechanical device (23.13% and 30.0%) and Hanging red ribbon (29.38% and 32.5%) which was maximum in control. In respect of yield, the maximum yield (1.78 t ha^{-1}) and the maximum BCR (1.43) were obtained from Plastic bottle windmill used plot than all other repellent tools while the minimum was in control.

Introduction

Sunflower (*Helianthus annuus* L.) is a globally important oilseed and a high-value crop. It is very susceptible to birds. So susceptible, in fact, that bird damage can lead to the entire crop being destroyed and abandoned. Bird damage to sunflower is recognized as an international economic problem for sunflower producers. Bird attacks on sunflower crops occur from the sowing stage. Sometimes they occur later - in almost cases - affecting the flower head. Attacks can be very frequent and cause substantial damage to the sunflower crop. However, in order to limit the damage caused by these birds, measures have to be taken to protect the sunflower crop from its inception. Different repellents options may reduce the attacking of bird pests which may help in crop production. Therefore, the present experiment was undertaken to evaluate the appropriate repellent tools against bird pests for sunflower production and to enhance production of the farmers at coastal areas of Bangladesh.

Materials and Methods

The experiment was conducted under farmer's field condition at Kuakata, Patuakhali during Rabi season of 2021-22. Four management techniques (MT) namely: MT_1 = Hanging red ribbon, MT_2 = Plastic bottle windmill, MT_3 = Bird repellent mechanical device and MT_4 = Control were evaluated. BARI Surjomukhi-2 was used as test crop. The unit plot size was 33 decimal for each site. Seeds were sown on 10-15 January maintaining 50 cm x 25 cm spacing. The land was fertilized with N_{92}, P_{36}, K_{85} S_{30}, Zn_2 and B_2 kg ha^{-1} in the field. Half of Urea and full doses of all other fertilizers were applied at final land preparation. The rest Urea was applied in two equal split at 25 DAS and 45 DAS in the growing season. All intercultural operations were done in proper time for better growth of the crop. Yield data were recorded properly. Treatment wise bird repellent materials were put before flowering started.

In hanging red ribbon treatment, plastic rope was hanged along the length of the plot in 5 ft apart. Then 2 feet long red ribbon was tied at 2 feet intervals to the rope. Approximate Tk. 250 was spent for 10 decimal of land.

In plastic bottle windmill treatment, each device was put at a distance of 5m x 5m which would require approximate 500 windmills per hectare of land. Disposed plastic water bottle, red sticky tape, thin stiff stick etc. were required to prepare the windmill. Approximate Tk. 300 was spent for each 10 decimal of land for windmill.

In bird repellent mechanical device treatment, a device was installed for 33 decimal which would require 7 devices per hectare of land. Bell, battery, timer etc were required to prepare the device that costs approximately Tk. 4500. However, the device is usable of 3 (three) seasons, the cost of making the device can be economically analyzed at Tk. 1500 per season. One device was used for each 33 decimal of land. To calculate the percentage of head damaged, 10 representative heads were randomly selected from each demo plot at harvesting stage. The total number of infested plants was counted from randomly selected 1m^2 area of each demo plot to determine the level of infestation by bird. Data on the number of infected plants were recorded at reproductive stage.

Results and Discussion

The results presented in Table 2. Percent of head damage and plant infested varied by using different repellent tools. From the results, it was observed that the management techniques have different response to bird. The minimum percent (21.25%) of head damage was recorded in Plastic bottle windmill followed by Bird repellent mechanical device (23.13%) and Hanging red ribbon (29.38%). The maximum percent (44.38%) of infested plant was recorded in Control. Similar trends also found in percent of infested plant (Table 2). Among all the management techniques, the maximum seed yield (1.78 t ha^{-1}) was received from the plot where Plastic bottle windmill was used as repellent tool for controlling of bird pests which was followed by Bird repellent mechanical device (1.76 t ha^{-1}) and Hanging red ribbon (1.66 t ha^{-1}) as repellent tool and the minimum (1.40 t ha^{-1}) was in control. Different repellent tools showed increase in yield of sunflower over control. The maximum percent yield increase over control (27.14%) was recorded in Plastic bottle windmill used plot followed by Bird repellent mechanical device (25.71%), Hanging red ribbon (18.57%).

The gross margin and benefit cost ratio (BCR) varied depending on the cost of using different repellent tools in the experiment. The maximum gross margin (Tk. 34995 ha^{-1}) was recorded from Plastic bottle windmill used plot followed by Bird repellent mechanical device and Hanging red ribbon. Similarly the maximum benefit cost ratio (1.43) was calculated from Plastic bottle windmill used plot followed by Bird repellent mechanical device and Hanging red ribbon while the minimum (1.24) was in control (Table 3).

Farmers' opinion

Farmers are very interested in producing sunflower crop if proper measures are taken to control the bird pests. Among different repellent tools for controlling bird pests, the Plastic bottle windmill is an effective approach to saving, preparing and using. This device is wind dependent but even if there is no air, the birds don't come to the crop field in panic as there is red sticky tape with the Plastic bottle windmill. They hope to make this technique more effective and efficient in repelling birds.

Table 2. Performance of management techniques by using different repellent tools during Rabi season of 2021-22.

Management technique	BARI Surjomukhi-2			
	% head damaged	% plant infested	Seed yield (t ha^{-1})	Yield increased (%)
MT_1	29.38	32.5	1.66	18.57
MT_2	21.25	27.5	1.78	27.14
MT_3	23.13	30.0	1.76	25.71
MT_4	44.38	47.5	1.40	-

Table 3. Cost and return analysis as influenced by using different repellent tools during Rabi season of 2021-22.

Management techniques	Total yield (t ha-1)	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
MT_1	1.66	107900	79455	28445	1.36
MT_2	1.78	115700	80705	34995	1.43
MT_3	1.76	114400	81605	32795	1.40
MT_4	1.40	91000	73205	17795	1.24

Selling Price Sunflower= Tk 65/ kg

Conclusion

Considering effectiveness and profitability, it could be concluded that the using of Plastic bottle windmill is the most approach for the controlling of bird pests in sunflower production followed by Bird repellent mechanical device and hanging red ribbon.

ON-FARM VALIDATION OF INTEGRATED PEST AND DISEASE MANAGEMENT PACKAGES FOR QUALITY AND SAFE COUNTRY BEAN PRODUCTION IN SHERPUR REGION

M.S. RAHMAN, M.M. RAHMAN AND A.K.M.Z.U. NOOR

Abstract

Effect of different packages on aphid, pod borer infestation, Cercospora leaf spot and Anthracnose disease infections were studied on country bean at Nakla and Nalitabari upazilla under Sherpur district during summer 2021. Two packages ie. P_1 package (Seed treatment with Bordeaux mixture @10g per kg seed + Application of Tricho-compost in pit + Foliar spray of Tricho-leacete (Trichomax @10 ml L^{-1}) +Hand picking and destruction of infested flower pod^{-1} and shoot at 5 days interval + Installation of yellow sticky trap and sex pheromone trap for Maruca + Alternate spraying of Azadirachtin (Fytomax @ 1.5 ml L^{-1}) and Bt + Abamectin (Antario @ 1g L^{-1}) of water at weekly interval) and P_2 package (Farmers' practice: Spraying of Emamectin benzoate (Proclaim 5 SG) and Cloran traniliprole (Coragen18.5 SC) + Spraying of Amistertop 325 SC and Tilt 250 EC at weekly interval commencing from the first incidence) were tested in the experiment following Randomizes Complete Block Design with three dispersed replications. The lowest aphid (5.63%) and pod borer (8.02%) infestations, Cercospora leaf spot (6.91%) and Anthracnose (5.68%) disease infection were recorded in P_1 package followed by P_2 package aphid (7.83%), pod borer

(11.38%), cercospora leaf spot (9.13%) and Anthracnose (8.53%) disease infection. P_1 and P_2 packages were statistically at per. Per cent reduction of infestation over control also exhibited the same trend. On the contrary, maximum aphid (14.79%), pod borer (20.37%) infestation as well as cercospora leaf spot (20.39%) and Anthracnose (19.23%) disease was recorded in untreated control plot.

Introduction

Country bean (*Lablab purpureus* L. Sweet) is an ancient legume crop widely grown throughout the world as vegetable or pulse for human consumption or as animal forage or feed. But in spite of great potential, the bean yield is low and quality is poor due to insect pests' and disease attack. For controlling these above-mentioned pest and diseases, farmers still depend solely on the use of chemical pesticides at a very high frequency (19-21 times per season) to save the crop (Rahman and Rahman, 1988, Kabir, 2003), which have several limitations including ineffectiveness, killing of parasitoids and predators, resulting resurgence of other pest populations and develop resistant insect biotypes (Debach and Rosen, 1992; Pedigo, 1999; Irshad and Gilani, 1990). So far, no published reports are available on the amount of pesticide use for country bean production. But Mohiuddin *et al.* (2009) reported that on an average 4631 Taka are being incurred for pesticide per hectare (7% of total cost). Thus, alternative to sole reliance on chemical insecticides such as resistant variety, seed treatment, manipulation of planting time, mechanical control, biological control agents, use of pheromone and botanical pesticides deserve great demand. But no single approach had so far been proved to be completely successful and reliable in respect of quality crop and safer environment. Therefore, researchers have been trying combination of various components of integrated pest and disease management package for the control of pest and diseases of country bean. By the couple years' research BARI, other research organizations and Agricultural universities have developed a good number of Integrated Pest Management (IPM) and Integrated Disease Management (IDM) packages for safe and quality country bean production but these are rarely adopted by the farmers due to lack of on-farm validation, refinement and demonstration properly especially in Sherpur region.

Materials and Methods

During 2021 two experiments (i) On Farm validation of bio-rational integrated pest management (IPM) packages for quality and safe country bean production and (ii) On-Farm validation of bio-rational integrated disease management (IDM) packages for quality and safe country bean production were conducted separately. Two packages ie. P_1 package (Seed treatment with Bordeaux mixture @10g per kg seed + Application of Tricho-compost in pit + Foliar spray of Tricho-leacete (Trichomax @10 ml L^{-1}) +Hand picking and destruction of infested flower pod^{-1} and shoot at 5 days interval + Installation of yellow sticky trap and sex pheromone trap for Maruca + Alternate spraying of Azadirachtin (Fytomax @ 1.5 ml L^{-1}) and Bt + Abamectin (Antario @ 1g L^{-1}) of water at weekly interval) and P_2 package (Farmers' practice: Spraying of Emamectin benzoate (Proclaim 5 SG) and Cloran traniliprole (Coragen18.5 SC) + Spraying of Amistertop 325 SC and Tilt 250 EC at weekly interval commencing from the first incidence) irrespective of locations along with control were included in this experiment. As per the project proposal the best identified IPM and IDM packages from earlier study were evaluated with farmers' practices and untreated control in same experiment entitled "On Farm validation of bio-rational integrated insect pest and Disease management packages for quality and safe country bean production" with summer country bean variety, BARI Country Bean-7 in two upzillas of Sherpur District (Nalitabari and Nakla) under Mymensingh Division to validate the most effective IPM and IDM packages which ultimately would reduce yield losses caused by pests, raise farmers' incomes, and reduce environmental damage due to pesticides following RCB design with three dispersed replications. In all locations planting was done in April 2021 for summer season and August 2021 for winter season.

Data on numbers of healthy and infested/infected plant, leaf, and pod from whole plot were recorded weekly. Data were also recorded on the percent plant infestation, leaf infestation and pod damage (by visual estimation).

The monetary return from the yield was calculated on the basis of farm gate price during August-September, 2021.

The data recorded on different parameters were analyzed statistically by using MSTAT-c software for analysis of variance after necessary transformation. ANOVA was made by F-variance test and the differences between treatment means were compared by DMRT (Gomez and Gomez, 1984).

Results and Discussion

Effect of different packages on aphid and pod borer infestation is presented in Table 1 The lowest aphid (5.63%) and pod borer (8.02%) infestations were recorded in P_1 package followed by P_2 package aphid (7.83%) and pod borer (11.38%). P_1 and P_2 packages were statistically at per. Per cent reduction of infestation over control also exhibited the same trend. On the contrary, maximum aphid (14.79%) and pod borer (20.37%) infestation was recorded in untreated control plot.

Cercospora leaf spot and Anthracnose disease infection is presented in Table 2. The lowest infection on an average (6.91%) was recorded in package P_1 followed by P_2 package (9.13%) and, P_1 and P_2 packages were statistically at per. Per cent reduction of infection over control exhibited the same trend (66.12% and 58.33% reduction over untreated control. On the contrary, maximum cercospora leaf spot disease infection (20.39%) was recorded in untreated control plot. The lowest anthracnose disease infection on an average (5.68%) was recorded in package P_1 followed by P_2 package (8.53%) and P_1 and P_2 packages were statistically at per. Per cent reduction of infection over control exhibited the same trend (70.46% and 55.64% reduction over untreated control. On the contrary, maximum anthracnose disease infection (19.23%) was recorded in untreated control plot.

The results presented in Table-3 indicated that package P_1 provided the maximum marketable yield (9.16t ha^{-1}) followed by P_2 package (7.97t ha^{-1}). The same trend was found in same package in case of increased marketable yield over control.

Economic analysis of different packages for managing insect pests of country bean is presented in Table 4. The marginal benefit cost ratio (MBCR) was the highest (12.88) in package P_1 followed by P_2 package treated plots (6.95).

Table 1. Effect of different packages on percent aphid and pod borer infestation at different locations during summer season, 2021

Packages	% Aphid infestation		Avg. Infestation (%)	% Reduction over control	% Pod borer infestation		Av. infestation (%)	% Reduction over control
	Nakla	Nalitabari			Nakla	Nalitabari		
P_1	6.83 b (2.61)	6.5 b (2.55)	5.63	61.93	7.47 b (2.73)	6.83 c (2.61)	8.02	60.63
P_2	8.63 b (2.94)	8.4 b (2.9)	7.83	47.06	10.83 b (3.29)	10.67 b (3.26)	11.38	44.13
P_3	15.83 a (3.94)	16.2 a (4.02)	14.79		19.6 a (4.43)	20.73 a (4.55)	20.37	-
LS	**	**	-		**	**	-	-
CV%	4.65	7.92	-		9.72	4.99	-	-

Table 2. Effect of different packages on percent Cercospora leaf spot and anthracnose disease infection at different locations during summer season 2021

Packages	% Cercospora infection		Average Cercospora infection	%Reduction over control	% Anthracnose infection		Average Anthracnose (%)	%Reduction over control
	Nakla	Nalitabari			Nakla	Nalitabari		
P_1	6.67 b (2.58)	6.97 b (2.64)	6.91	66.12	5.7 b (2.39)	5.5 b (2.35)	5.68	70.46
P_2	8.53 b (2.92)	9.7 b (3.11)	9.13	55.22	8.83 b (2.97)	8.97 b (2.99)	8.53	55.64
P_3	20.67 a (4.55)	21.5 a (4.64)	20.39	-	19.3 a (4.39)	19.63 a (4.43)	19.23	-
LSD $_{(0.05)}$	**	**			**	**	-	-
CV%	8.76	9.35	-		16.91	6.01	-	-

Table 3. Effect of different IPM packages on marketable yield at different locations during summer season 2021

Packages	Marketable yield (t ha^{-1})		Average Yield (t ha^{-1})	% Increase over control
	Nakla	Nalitabari		
P_1	8.70a	9.03a	9.16	64.15
P_2	7.63a	8.06a	7.97	42.83
P_3	4.97b	5.27b	5.58	-
LS	**	**	-	
CV%	6.78	4.44	-	

Packages: Package1= Seed treatment with Bordeaux mixture+ Application of Tricho-compost in pit + Foliar spray of Tricho-leachate +Hand picking and destruction of infested flower/pods and shoot at 5 days interval + Installation of yellow sticky trap and sex pheromone trap + Alternate spraying of Azadirachtin (Phytomax) and Antario @ 1g/L of water at weekly interval, Package2 Farmers' practice: Spraying of Emamectin benzoate (Proclaim 5SG) and Clorantraniliprole (Coragen) + Spraying of Amistertop325SC and Tilt 250 EC, Package3= Untreated control]

Mean followed by the same letters in a column did not differ significantly by LSD at 1% level of probability

Table 4. Economic analysis of different packages against insect pests of country bean during summer season 2021.

Treatment	Cost of treatment (Tk. ha^{-1})	M. yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Net return (NR) (Tk. ha^{-1})	Adjusted net return (Tk. ha^{-1})	MBCR
1	2	3	4	5 (4-2)	6	7(6/2)
P_1	18050	9.16	641200	623150	232550	12.88
P_2	21050	7.97	557900	536850	146250	6.95
P_3	0	5.58	390600	390600	-	-

Cost of *Antario* biopesticide @ Tk. 3000 kg^{-1}, Cost of Phytomax @ Tk 2800/L, Cost of yellow sticky trap @ Tk 30/piece, Cost of *Maruca* Lure +trap @ Tk.110/piece, Cost of Spinosad @ Tk. 4000/ L, Cost of proclaim @ Tk. 2500 kg^{-1}, Wheel powder @ Tk. 130 kg^{-1}, Cost of hand picking (Two laborer ha^{-1}) @ Tk 400 day^{-1}, Cost of spray (Two laborer/spray ha^{-1}) @ Tk 400/day. Spray volume required 500L ha^{-1}

Price of country bean @ Tk 70 kg^{-1} (During Aug 2021 to Sept 2021)

Conclusion

package P_1 (Seed treatment with Bordeaux mixture @10g kg^{-1} seed + Application of Tricho-compost in pit + Foliar spray of Tricho-leacete (Trichomax @ 10 ml L^{-1}) + Hand picking and destruction of infested flower/pods and shoot at 5 days interval + Installation of yellow sticky trap and sex pheromone trap for Maruca + Alternate spraying of Azadirachtin (Fytomax @ 1.5 ml L^{-1}) and Bt + Abamectin (Antario @ 1g L^{-1}) of water at weekly interval) showed the best performance considering reduction of insect and disease infestation, increase of marketable yield and marginal benefit cost ratio

G. Agroforestry

PERFORMANCE OF INTERCROPPING CORIANDER LEAF WITH TURMERIC UNDER MANGO BASED AGROFORESTRY SYSTEM

M. M. BASHIR AND S. K. BHOWAL

Abstract

The experiment was conducted at the farmers' fields of Barura, Chandina of Cumilla during April 2021 to March 2022 to evaluate the performance of intercropping coriander leaf with BARI developed turmeric varieties under mango based agroforestry system. The results showed that intercropping of coriander with all varieties of turmeric exhibited better performance under mango based agroforestry system over open land condition. However, intercropping of coriander (var. . BARI Dhonia-2) with local variety of turmeric showed the best performance regarding mango equivalent yield and economic return.

Introduction

Climate change induced environmental hazards and demand for food, timber, fuel wood, fodder, fruits and poles etc. triggers sustainable land use system. Rapid increasing of fruit orchards in Cumilla region is opening new scope for agroforestry based production system. At the field level after transplanting of fruit trees, several years no output is obtained from the orchards. The ground layer of fruit orchards can be effectively utilized with suitable crops up to 7-8 years after plantation of fruit trees. In preliminary observation, turmeric and coriander is found suitable for growing under niches of mango trees. Recently DAE have some fruit garden establishment program to intensify the fruit garden and increase yield and return of the farmers bu using intercropping in agroforestry system. Agroforestry is a new name of an age old practice. If proper combination of tree and crops are selected, this technology would be stable and beneficial for fruit tree growers undoubtedly. Therefore, this study has been under taken with the following objectives.-

1. To observe the performance of intercropping jute leaf with turmeric varieties in the fruit tree based agroforestry system.
2. To select the suitable turmeric variety in the mango-based agroforestry system.
3. To increase production and economic return

Materials and Methods

The experiment was conducted at the farmers' mango fields of Barura, Chandina, Cumilla during April 2021 to March 2022. Around 6 years old mango orchards were selected for the study. Average spacing of mango trees was 4m×4m, clean bole height was 1.6m, canopy spread was 2.2m×2.2m and tree height was 4.7m. So, there was some gaps between the tree canopy in the garden, where direct sunlight may reach to the under storey crops. BARI developed turmeric varieties viz., BARI Halud-3, BARI Halud-4, and local turmeric variety was used as under storey crop. Coriander var. BARI Dhonia-2 was used in the whole experimental plot as intercrop with turmeric. The experiment was laid out in Randomized Complete Block (RCB) design with four dispersed replications. The unit plot size was 5m×4 m. The spacing of turmeric was 60cm×25cm. Coriander was broadcasted with turmeric in the same time. The land was prepared by three times ploughing followed by laddering. Soil test based fertilizer dose for every location were used. The rhizome of turmeric and seeds of coriander were sown on 25- 27 April 2020. Insecticide and fungicide were sprayed as and when necessary to control the pest and diseases. Coriander leaf was harvested during 23 May- 21June 2021. Turmeric was harvested during 2nd January to 10th March 2022. Necessary data were recorded and analyzed by using Statistix10 computer program.

Results and Discussion

Yield and yield contributing characters of turmeric at farmer's field of Barura, Chandina, Cumilla, is presented in Table 1. The maximum t plant height (153.9 cm) was observed in local turmeric , which was similar to var. BARI Halud-3 (151.4 cm) and BARI Halud-4 (148.9) in agroforestry system. The lowest plant height (129.5 cm) was recorded in Local turmeric in open field condition which was similar to BARI Halud. The highest no. of tiller plant^{-1}, no. of rhizome plant^{-1} and no. of secondary finger plant^{-1} were found in local variety in open field condition. The lowest tiller plant^{-1} (4.0) was observed in BARI Halud-3 in open field condition followed by agroforestry system. The lowest no. of rhizome plant^{-1} (1.13) was observed in BARI Halud-4 in agroforestry system. The highest rhizome weight plant^{-1} (141.9 g) was found in local turmeric which was identical to BARI Halud-3 in agroforestry system (141.5g) and the lowest rhizome weight (103.8g) in local one in open field condition. The highest no. and weight of primary finger (7.0 and 180.0g, respectively) and the lowest weight of primary finger (112.0g) was observed in local variety in open field condition. The highest weight of secondary finger was found in BARI Halud-3 which was identical to all the varieties in agroforestry system. The highest fresh turmeric yield (23.31t ha^{-1}) was found in local halud in agroforestry system and the lowest yield (16.01t ha^{-1}) in BARI Halud-4 in open field condition which was identical to BARI Halud-4 (17.36 t ha^{-1}) in agroforestry system and BARI Halud-3 in open field condition (17.36t ha^{-1} and 17.81t ha^{-1}, respectively).

The yield of coriander leaf showed variation with agroforestry system and open land condition. The result indicated that coriander leaf yield was relatively higher in open land condition as compared to agroforestry system (Table-2). However, maximum coriander leaf yield was attained from intercropping of coriander with local variety in open land condition which was similar to intercropping of coriander with all varieties under agroforestry system.

Mango yield was presented in Table-2. It was generally observed that mango yield was remarkably higher in agroforestry system as compared to sole mango. The reason behind this might be less care of sole mango orchard. The better management operation of associated crops and mango trees probably resulted in higher production of mango in agroforestry system. The result showed that agroforestry system gave higher mango equivalent yield than sole mango. The highest mango equivalent yield (Tk. 15.72 t ha^{-1}) was obtained from local one in agroforestry system and the lowest from sole mango (3.7t ha^{-1}). Local variety , BARI Halud-3 and BARI Halud-4 gave similar higher yield in mango based agroforestry system than sole turmeric/mango. Regarding economic benefit, gross return, gross margin and BCR were higher in local one (Tk. 786150 ha^{-1}, Tk. 660650 ha^{-1} and 6.26, respectively) under agroforestry system and the lowest from sole mango (Tk 185000 ha^{-1}, Tk. 122500 ha^{-1} and 2.96, respectively).

Table 1. Yield and yield contributing characters of turmeric in intercropping coriander leaf with turmeric under mango based agroforestry system during 2021-22

Variety	System	Plant height (cm)	Tiller plant^{-1} (No.)	No. of rhizome plant^{-1}	Weight of rhizome plant^{-1} (g)	No. of primary finger	Weight of primary finger (g)	No. of secondary finger	Weight of secondary finger (g)	Fresh turmeric yield (t ha^{-1})
BARI Halud-3	Agroforestry	151.4 a	4.6 d	1.48 bc	105.8 c	4.7 d	146.5 b	7.63 c	136.3 a	20.07 b
	Open land	138.6 b	4.0 e	1.58 b	141.5	6.8 a	139.0 bc	10.6 a	89.0 c	17.81 bcd
BARI Halud-4	Agroforestry	148.9 a	5.5 c	1.13 e	124.8 b	5.6 c	135.3 bc	8.0 c	135.0 a	17.36 cd
	Open land	134.5 b	5.2 c	1.33 cd	121.9 b	6.1 b	134.0 c	8.7 bc	96.0 c	16.01 d
Local (Lalmai)	Agroforestry	153.9 a	5.9 b	1.20 de	141.9 a	7.0 a	180.0 a	9.68 b	132.3 a	23.31 a
	Open land	129.5 b	6.6 a	1.80 a	103.8 c	5.7	112.0 d	11.6 a	107.5 b	19.72 bc
CV(%)		4.77	4.03	8.42	7.32	5.7	5.53	8.2	4.46	8.94
LSD(0.05)		10.27	0.321	0.179	13.60	0.513	11.75	1.15	7.797	2.567

Table 2: Yield and economic return of intercropping coriander leaf with turmeric under mango based agroforestry system during 2021-22

Variety	System	Fresh turmeric yield (t ha^{-1})	Coriander leaf yield (t ha^{-1})	Mango fruit yield (t ha^{-1})	Mango equivalent yield (t ha^{-1})	Gross return (Tk ha^{-1})	Cost of cultivation (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
BARI Halud-3	Agroforestry	20.07	1.40`	7.10	14.80	740050	126000	614050	5.87
	Open land	17.81	2.30	-	8.10	405150	80500	324650	5.03
BARI Halud-4	Agroforestry	17.36	1.30	7.23	14	699900	124800	575100	5.61
	Open land	16.01	2.20	-	7.44	372150	79300	292850	4.69
Local Halud	Agroforestry	23.31	1.30	7.17	15.72	786150	125500	660650	6.26
	Open land	19.72	2.50	-	8.92	445800	80000	365800	5.57
Sole Mango				3.70	3.70	185000	62500	122500	2.96

Price (Tk. kg^{-1}): Turmeric-15, Coriander-60 and Mango-50

Conclusion

The results showed that intercropping of coriander with all varieties of turmeric exhibited better performance under mango based agroforestry system over open land condition. However, intercropping of coriander (var. BARI Dhania-2) with local variety of turmeric showed the best performance regarding mango equivalent yield and economic return.

DEVELOPMENT OF GUAVA BASED AGROFORESTRY SYSTEM WITH HIGH VALUE CROPS

M.R. ALAM, M.A. ISLAM, M. MANIRUZZAMAN AND M.S.H. MOLLA

Abstract

The experiment was carried out at extrapolation areas of FSRD site Ganggarampur, Pabna during the Rabi season of 2021-22 to evaluate the performance of high value vegetable crops in guava-based agroforestry system and to increase productivity and farmers income. Different high value crops such as cauliflower, cabbage, broccoli, tomato, brinjal, chilly, onion, carrot and red amaranth were grown with existing guava orchard under guava-based agroforestry system. Maximum fruit equivalent yield was obtained from guava+ brinjal (31.95 t ha^{-1}) which was identical to guava + cauliflower (30.46 t ha^{-1}). Regarding economic benefit, higher gross return (Tk. 1278000 ha^{-1}) and gross margin (Tk. 1070200 ha^{-1}) was achieved from guava + brinjal followed by guava+ cauliflower. Considering total system productivity guava+ brinjal followed by guava+ cauliflower agroforestry system seems to be more promising at Pabna region.

Introduction

The arable land of Bangladesh is shrinking due to high population density and enormous pressure on natural resources. In addition, climate change accelerated the intensity and frequency of occurrences of salinity, storms, drought, irregular rainfall, high temperature, flash floods, etc. eventually pose serious threat on crop production and food security. In such situation, a comprehensive research and development effort is needed to increase production per unit arable land through agroforestry. Agroforestry system can contribute stable income, food and nutrition security, savings and insurance and a potential means of risk management under climate change induced stress (Akter et al. 1989; Evans 1988). The increasing trend of fruit tree orchard in Pabna area is opening good scope of agroforestry based production. Guava is now a popular fruit and its off season fruiting and handsome market price encourage the farmers to establish more guava orchards. For this reason, many farmers have established guava orchards. Guava trees have small canopy structure which favors more sunlight to the ground as compared to other dense canopy fruits. In some cases, farmers grow some perennial spices crops in association with fruit trees which requires long time for income generation. Many orchards are not under this practice.

Growing high value vegetable crops in fruits orchards can be better options for higher productivity and income generation.

Materials and Methods

The experiment was carried out at extrapolation areas of FSRD site Ganggarampur, Pabna Sadar, Pabna during 2021-22 to evaluate the performance of high value vegetable crops in agroforestry system and to increase productivity and farmers income. Different high value crops such as tomato, cauliflower and cabbage were selected for guava-based agroforestry system in this study. Thirty days old seedlings of cauliflower (var. Snow white), cabbage (var. Atlas 70), broccoli (var. BARI Broccoli-1), tomato (var. BARI Tomato-19), brinjal (var. BARI Begun-12), chili (var. BARI Morich-2), onion (var.BARI Piaz-4), carrot (var. New Korada) and seeds of red amaranth were planted on 24-28 November, 2021 with maintaining recommended spacing for all the crops. Application of fertilizers and other intercultural operation were made as per recommendation of individual crops. The harvesting of cauliflower was initiated on 12 February and continued up to 5 March, 2022. The harvesting of cabbage was initiated on 15 February and continued up to 12 March, 2022.The harvesting of tomato was initiated on February 20 and continued up to March 25, 2022. The harvesting of brinjal was initiated on 25 February and continued up to 25 March, 2022. The harvesting of chili was initiated on 5 March and continued up to 30 March, 2022. The harvesting of onion was done on 8 April, 2022. The harvesting of carrot was initiated on 15 March and continued up to 25 March, 2022. The harvesting of red amaranth was initiated on 5 March and continued up to 10 March, 2022.The harvesting of guava was initiated on February 15 and continued up to March 14, 2022. Data on yield of vegetables and guava fruits were recorded and necessary table were prepared with mean values.

Results and Discussion

The performance of different high value vegetable crops and fruits under guava-based agroforestry system are presented in Table-1. Maximum fruit equivalent yield was obtained from guava+ brinjal (31.95 t ha^{-1}) which was at par with guava + cauliflower (30.46 t ha^{-1}) and followed by guava+ carrot (20.05 t ha^{-1}). Minimum fruit equivalent yield was recorded in sole guava (7.80 t ha^{-1}). Regarding economic benefit, higher gross return (Tk. 1278000 ha^{-1}) and gross margin (Tk. 1070200 ha^{-1}) was achieved from guava + brinjal followed by guava+ cauliflower. The results revealed that guava-based agroforestry system with high value crops demonstrated very encouraging results in view of total system productivity and economic return. All the tested vegetables in agroforestry system exhibited three to four time's higher production and economic return as compared with sole guava. However, considering total system productivity guava + brinjal and guava + cauliflower agroforestry system exhibited relatively better performance.

Farmers' opinion

Farmers expressed their satisfaction to this agroforestry technology because-

- Increased production and economic benefit as compared to their sole guava cultivation
- More time harvesting and marketing generate cash income
- Intensive labour utilization
- Less pest and disease infestation
- Feel proud due to visit of neighboring farmers and govt. officials

Conclusion

The results revealed that guava-based agroforestry system with high value crops showed very encouraging results in view of total system productivity and economic return. All the tested vegetables in agroforestry system exhibited three to four time's higher production and economic return as compared with sole guava. However, considering total system productivity guava+ brinjal and guava+ cauliflower agroforestry system seems more promising at Pabna region. However, this study needs to continue at least another year to get comprehensive findings.

Table 1. Performance of yield of vegetables and fruits in guava-based agroforestry system at FSRD site Ganggarampur, Pabna during the *rabi* season 2021-22.

Treatment	Vegetables yield ($t\ ha^{-1}$)	Fruit yield ($t\ ha^{-1}$)	Fruit equivalent yield ($t\ ha^{-1}$)
Guava + Cauliflower	35.30	8.10	30.46
Guava+ Cabbage	42.50	7.25	17.87
Guava+ Brocolli	11.50	7.20	17.26
Guava + Tomato	22.40	7.45	15.85
Guava + Brinjal	49.50	7.20	31.95
Guava + Chilli	5.50	7	15.25
Guava + Onion	10.75	7.25	13.97
Guava + Carrot	15.40	8.50	20.05
Guava + Red amaranth	9.75	8.75	17.28
Guava	-	7.80	7.80
CV (%)	7.36	7.82	7.12
Level of significance	*	ns	*

Table 2. Cost and return of vegetables and fruits in guava-based agroforestry system at FSRD site Ganggarampur, Pabna during the *rabi* season of 2021-22.

Treatment	Gross return ($Tk.\ ha^{-1}$)	Total variable cost ($Tk.\ ha^{-1}$)	Gross margin ($Tk.\ ha^{-1}$)
Guava + Cauliflower	1206400	176800	1029600
Guava+ Cabbage	714800	180800	534000
Guava+ Broccoli	690400	170800	513600
Guava + Tomato	634000	182800	451200
Guava + Brinjal	1278000	207800	1070200
Guava + Chilli	610000	187800	422200
Guava + Onion	558800	180800	378000
Guava + Carrot	802000	170800	631200
Guava + Red amaranth	691200	77300	613900
Guava	312000	42300	269700

Price: Cauliflower 25 Tk kg^{-1}, Cabbage-18 Tk kg^{-1}, Broccoli- 35 Tk kg^{-1}, Tomato-15 Tk kg^{-1}, Brinjal-20 Tk kg^{-1}, Chilli-60 Tk kg^{-1}, Onion-25 Tk kg^{-1}, Carrot-30 Tk kg^{-1}, Red amaranth-35 Tk kg^{-1}, Guava- 40 Tk kg^{-1}.

UPSCALING MANGO BASED AGROFORESTRY WITH ELEPHANT FOOT YAM AT FARMERS FIELD

M.R. ALAM, M. MANIRUZZAMAN, M.A. ISLAM AND M.S.H. MOLLA

Abstract

The research program was carried out at FSRD site, Ganggarampur; Pabna during 2021 to assess the performance of mango based agroforestry system with elephant foot yam over sole mango cultivation. The higher system productivity in terms of fruit equivalent yield (16.41 t ha^{-1}) was obtained from the mango based agroforestry system with elephant foot yam as compared with sole mango cultivation (6.60 t ha^{-1}). Regarding economic benefit, remarkably higher gross return (Tk. 984600 ha^{-1}) and gross margin (Tk. 743285 ha^{-1}) and satisfactory MBCR (3.33) was also obtained from agroforestry system.

Introduction

Establishment of fruit orchard is rapidly expanded in Pabna region. High land and medium high land is being brought under fruit cultivation. Development of high yield potential fruits varieties with dwarf canopy structure enhance increasing trend of fruit cultivation in rural areas. Development of agroforestry-based production is deemed important for raising sustainable total production per unit area of land. Elephant foot yam is a popular high value vegetable and can be grown easily under partial shady areas. In previous farming systems research, elephant foot yam grown under niches of existing mango trees performed better regarding yield and economic return. In this regard, upscaling the agroforestry technology with elephant foot yam may result in increased total system productivity and satisfactory income generation. Therefore, the present production program was carried out to scale up farm productivity through production program of mango-based agroforestry system and to increase farmers' income.

Materials and Methods

The production program was carried out at FSRD site, Ganggarampur, Pabna during 2020-21. An existing 8 years aged unutilized mango orchard (var. BARI Aam-4) with an area of 30 decimal was selected for this study. Local variety (var. Madrazi) of elephant foot yam was used for this production program. The corms of elephant foot yam were planted in well prepared pit maintaining 100 cm x 75 cm spacing between the unutilized spaces of existing mango fruits on April 24, 2021 (Table 1). The spacing of mango fruit trees in the existing orchard was more or less 4m x 4m. Recommended fertilizer management was followed for fruits and elephant foot yam. Other management practices for fruits and elephant foot yam were done when required. Mango was harvested on July 15-25, 2021. Elephant foot yam was harvested on October 10-20, 2021. The yield and economic analysis are presented in Table-2.

Results and Discussion

The results reveal that agroforestry system with elephant foot yam showed remarkably higher productivity as compare to sole mango cultivation. The higher system productivity in terms of fruit equivalent yield (FEY) of the agroforestry system with elephant foot yam was 16.41 t ha^{-1} while relatively much lower FEY (6.60) was noted in sole mango cultivation. Higher gross return (Tk. 984600 ha^{-1}) and gross margin (Tk.743285 ha^{-1}) and satisfactory MBCR (3.33) was also obtained from agroforestry system. The results suggest that this agroforestry technology with mango and elephant foot yam found more profitable and contributed to the higher production and economic return as compared to famers' traditional sole mango cultivation.

Farmers reaction

Farmers were highly motivated to see the performance of mango-based agroforestry system. Additional production of elephant foot yam under the niches of relatively old mango orchard and their good market price attracted the neighboring farmers to adopt the technology. Farmers were also motivated to this agroforestry technology due to handsome economic return over sole mango cultivation.

Table 1: Details of crop management under existing fruit (Mango) orchard and agroforestry system

Topic	Existing fruit orchard	Agroforestry system with existing fruit orchard	
Crop	Mango	Elephant foot yam	Mango
Variety	BARI Aam-4	Local (var. Madrazi)	BARI Aam-4
Spacing	4m x 4m	100 cm x 75 cm	4m x 4m
Plot size (Dec.)	30	30	30
Fertilizer dose (N-P-K-S-Zn-B Kg ha^{-1})	115-50-62-45-4.5-2.3	160-50-100-36-4.0-2.0	115-50-62-45-4.5-2.3
Date of sowing/planting	July, 2012	24.04.21	July, 2012
Date of harvesting	July 15-25, 2021	10-20.10.2021	July 15-25, 2021

Table 2. Yield and economic performance of existing fruit orchard and agroforestry system

Production system	Crop yield ($t\ ha^{-1}$)		Fruit equivalent yield ($t\ ha^{-1}$)	Economic analysis			
	Elephant foot yam	Mango		Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
Existing sole fruits	-	6.60	6.60	396000	64305	331695	-
Agroforestry system	15.71	5.94	16.41	984600	241315	743285	3.33

Price (Tk. kg^{-1}) = Urea-16, TSP-24, MP-16, Gypsum-10, Zinc Sulphate-230, Boric acid-460, Mango: 60, Elephant foot yam: 40.

Conclusion

The study demonstrated encouraging results in terms of total system productivity and economic return. The higher system productivity in terms of fruit equivalent yield (16.41 t ha^{-1}) was obtained from the mango based agroforestry system with elephant foot yam as compared with sole mango cultivation (6.60 t ha^{-1}). Regarding economic benefit, remarkably higher gross return (Tk. 984600 ha^{-1}) and gross margin (Tk. 743285 ha^{-1}) and satisfactory marginal benefit cost ratio (MBCR) (3.33) was also obtained from agroforestry system. Therefore, mango based agroforestry system with elephant foot yam can be recommended for wider scale extension at the similar extrapolation areas of the country.

Project III:

On-Farm Trials with Advanced lines and Technologies

- Pulse Crops
- Oilseed Crops
- Horticultural Crops
- Tuber Crops
- Spices Crops
- Minor Cereal Crops

Pulse Crops

PARTICIPATORY VARIETY SELECTION OF BLACKGRAM

J.C. BARMAN, M.S. ALAM, A.A. MAHMUD, M. J. ALAM, M.A. ISLAM, S. HOSSAIN AND E.A. PRAMANIK

Abstract

The field trial was carried out at the farmer's field of FSRD site, Basantopur, Godagari, Rajshahi (High Barind Tract-HBT), Sonatola Upazila under Bogura and Saghata under Gaibandha during kharif-2 season 2021 to select suitable blackgram variety under drought prone area. Six genotypes of blackgram viz. BBLXK2-12005-5, BBLXK2-12002-4, BBLXK2-12005-6, BBLXK2-04001-1, BBLXK2-08008-2, BBLXK2-12002-2 and two check varieties BARI Mash-3 and BARI Mash-4 were tested in the farmer's field. At HBT, among the tested genotypes BBLXK2-12002-4 gave the maximum seed yield (1.28 t ha^{-1}) followed by BBLXK2-12005-5 (1.24 t ha^{-1}) and minimum seed yield obtained from BARI Mash-4 (0.93 t ha^{-1}) and BBLXK2-12005-6 (0.95 t ha^{-1}). At Bogura, the maximum seed yield (2.11 t ha^{-1}) was obtained from c BARI Mash-4 followed by BBLXK2-12002-2. Other accessions like BBLXK2-12005-5, BBLXK2-12002-4, BBLXK2-12002-2 and BARI Mash-4 have statistically similar yield potentials. The lowest yield (1.05 t ha^{-1}) was recorded from BBLXK2-04001-1. At Gaibandha, the highest yield (1.54 t ha-1) was obtained from E5 (BBLXK2-04001-1) lines similar to the line E6 (BBLXK2-08008-2-1) with seed yield of 1.49 t ha^{-1} whereas the lowest yield was observed from the check varieties. However, among the 6 new lines, E5 (BBLXK2-04001-1) and E6 (BBLXK2-08008-2-1) showed the best yield performance as well as a greater number of pods plant-1 (41 to 42) and 100- seed weight (4.87 g).

Introduction

Blackgram [*Vigna mungo* (L.)] is one of the important pulse crops grown in Bangladesh. It provides grain for human consumption and the plants fix nitrogen addition of organic matter to the soil. It supplies a substantial amount of nitrogen to the succeeding non- legume crops (i.e., rice) grown in rotation (Sharma and Prasad, 1999). Blackgram is cultivated in the area of 0.188 million hectares contributing 9.5% of total pulse production (BBS 2011). Maximum grown of blackgram found in western part of Bangladesh. High Barind Tract is different from other parts of the country due to its undulating topography having compact and low fertile soils. The region experienced high temperature with limited soil moisture storage along with low and erratic rainfall (BMDA, 2006). The area of High Barind Tract (HBT) is covering about 1,600 km^2 in north-western Bangladesh between the floodplains of the Padma and the Jamuna rivers. The area is characterized by very low soil organic matter content. The rainfall in this area is erratic and the lowest for Bangladesh (average 1300-1400 mm per annum). So, HBTt is called drought prone area in our country. There is huge area remain fallow in charland of Bogura and Gaibandha. Some crossing materials/lines have to be selected through screening process by PRC in drought and charland condition. If these lines grow well with high yield, it could l be helpful to develop new variety.

Materials and Method

An experiment of participatory variety selection of blackgram was conducted at farmer's field of FSRD site, Basantopur, Godagari, Rajshahi (HBT), Charland of Sonatola Upazila under Bogura and Charland of Saghata, Gaibnadha during kharif-2 in 2021. The experiment was conducted in randomized complete block design (RCBD) with three dispersed replications. The unit plot size was 4m x 8 rows. Line to line distance 30 cm plant to plant distance 10 cm. Weeds, stubble and crop residues were removed. The land was fertilized with 20-20-20-10-1 N-P-K-S-B kg ha^{-1} (BARC, 2018) in the form of urea, triple super phosphate, muriate of potash and gypsum, respectively at the time of final land preparation. Blackgram seeds were sown on 13 September 2021 in HBT, on 12 October 2021 in Bogura and 2 September 2021 in Gaibandha. Weeding and thinning were done at 20 days after planting of blackgram seeds. First weeding was done at the time of first thinning and second weeding and thinning were done at 35 days after planting of blackgram seeds. No irrigation was applied during the experimental period. When 80% of the pods turned brown in colour, the crop was assessed to attain maturity. Blackgram was harvested on 06 December in HBT, 28 December in Bogura and 25 November 2021 at Gaibandha. The seed yield and yield components of blackgram were recorded and analyzed statistically using STAR and open-source software R (R Core Team, 2018).

Results and Discussion

Days to flowering, days to maturity, plant height and plants/m^2 of blackgram lines at High Barind Tract, Bogura and Gaibandha are presented in Table 1 and pods/plant, seeds/pod, 1000-seed weight and plants/m^2 of blackgram lines at High Barind Tract, Bogura and Gaibandha in Table 2. At HBT, the yield andyield contributing characters like days to maturity, plant height (cm), number of plant/ m^{-2} number of pods/plant, seeds/pod, thousand Grain Weight (g), seed yield showed significant variation except days of flowering. Among the genotypes, BBLXK2-12002-4 showed the maximum number of pods plant^{-1} (36.57) followed by BBLXK2-12002-2 (36.23) and the minimum number of pods plant^{-1} (22.53) from BBLXK2-04001-1. The maximum1000- seed weight (44.53 g) was found in BBLXK2-12002-4 followed by BBLXK2-12005-5 (43.43g), BBLXK2-04001-1 (43.28 g). whereas the line, BBLXK2-08008-2-1 gave the minimum 1000- seeds weight (39.63 g). BBLXK2-12002-4 gave the maximum seed yield (1.28 t ha^{-1}) identically followed by BBLXK2-12005-5 (1.24 t ha^{-1}) and BBLXK2-12002-2 (1.23 t ha^{-1}). The lowest seed yield was obtained from BARI Mash-4 (0.93 t ha^{-1}) followed by BBLXK2-12005-6 (0.95 t ha^{-1}) .

At Bogura, Plant height differed significantly among the genotypes. The maximum plant height (55.50 cm) was recorded from E10 germplasm followed by E7 and E6 and the minimum (40.05 cm) from E1. Maximum pod number/plant (21.25 and 21.14) was recorded from both E4 followed by lines E4 and E9, the lowest number (15.25) was obtained from E1. The number of seeds per pod was ranged from 4.31 in E4 to 6.36 in E10. The maximum seed weight/plant (7.37 g) was recorded from E10 followed by E9 (5.96 g) and the lowest (3.65 g) from E5. The higher 1000- seed weight (33.50 and 33.10 g) was recorded from E10 followed byE9, E1 and E6 which were statistically similar with E2, E4, E7, and E8 and the lowest (29.62 g) from E5. The highest yield (2.11 t ha^{-1}) was obtained from the E10 as the number of seeds/pods, seed weight/plant and 1000 seed weight seemed higher in this line. The lowest yield (1.05 t ha^{-1}) was recorded from E5as t yield parameters were found lower in the respective line.

At Gaibandha, there was a significant effect on days to maturity, plant height, pods plant^{-1}, and seed yield among the different entries. The advance line E5 (BBLXK2-04001-1) showed maturity in 74 days, about 8 days longer than the BARI Mash-3. The maximum plant height (49.7 cm) was recorded in E7 followed by E8 and E3 with a value of 43.1 to 44.9 cm. The highest seed yield (1.54 t ha^{-1}) produced by E5 , which was 19% higher than E1 followed by E6 with a yield of 1.49 t ha^{-1} whereas the lowest yield (1.25 t ha^{-1}) was recorded in E8 . The reason for the highest crop yield in E5 (BBLXK2-04001-1) and E6 (BBLXK2-08008-2-1) is due to the highest no. of pods plant^{-1} (41 to 42) as well as 100-seed weight (4.87 g).

Farmer's reaction

Farmers are happy to get higher yield from selected lines/variety: line, BBLXK2-12002-4 and BBLXK2-12005-5 and var. BARI Mash-3. They also observed that pest attack was lowest in selected lines/variety.

At Bogura, farmers preferred E1, E2, E4, E6, and E10 genotypes for high seed yield in Charland conditions.

At Gaibandha, considering the performances of the genotypes regarding yield, farmers preferred E5 (BBLXK2-04001-1) and E6 (BBLXK2-08008-2-1) genotypes for Charland in Gaibandha.

Table 1. Days to flowering, days to maturity, plant height and plants/m^2 of blackgram lines at High Barind Tract, Bogura and Gaibandha during 2021-2022.

Treat.	Days to Flowering			Days to Maturity			Plant height			Plants/m^2		
	HBT	Bogura	Gaibandha	HBT	Bogura	Gaibandha	HBT	Bogura	Gaibandha	HBT	Bogura	Gaibandha
E_1	35	-	33	71bc	-	66b	29bc	40de	42b	31.5ab	-	28
E_2	35	-	33	74a	-	74a	28bc	43 e	43b	30.6b	-	28
E_3	36	-	31	73ab	-	75a	37a	46c	43ab	33.8ab	-	28
E_4	35	-	35	72abc	-	74a	28bc	46 c	40b	31.7ab	-	31
E_5	36	-	33	71bc	-	74a	25c	47c	42b	22.4c	-	29
E_6	35	-	34	70c	-	72ab	31b	50b	41b	34.4ab	-	30
E_7	35	-	33	72bc	-	74a	28bc	52a	50a	36.3a	-	31
E_8	35	-	33	73ab	-	70ab	28bc	43e	45ab	29.4b	-	29
CV(%)	4.1	-	4.0	1.7	-	3.4	9.4	4.5	5.5	10.0	-	3.4

Legend: HBT = High Barind Tract; E_1 = BARI Mash-3; E_2 = BBLXk2-12005-5; E_3 = BBLXk2-12002-4; E_4 = BBLXk2-12005-6; E_5 = BBLXk2-04001-1; E_6 = BBlXk2-08008-2-1; E_7 = BBLXk2-12002-2; E_8 = BARI Mash-4

Table 2. Pods/plant, seeds/pod, 1000-seed weight and seed yield of blackgram lines at High Barind Tract, Bogura and Gaibandha during 2021-2022.

Treat.	Pods/plant			Seeds/pod			1000 seed wt. (g)			Seed yield t ha^{-1}		
	HBT	Bogura	Gaibandha	HBT	Bogura	Gaibandha	HBT	Bogura	Gaibandha	HBT	Bogura	Gaibandha
E_1	24c	15 f	37ab	5.5cd	4.7def	-	41.43bc	32.0b	4.6	1.2a	1.5cd	1.3c
E_2	27c	17 e	37ab	5.5cd	5.5b	-	43.43ab	31.5bc	4.7	1.2a	1.5cd	1.4bc
E_3	37a	19d	40a	6.3a	4.9de	-	44.53a	30.3c	4.7	1.3a	1.4d	1.4c
E_4	26c	21a	39ab	5.6bc	4.3f	-	42.29ab	31.6 bc	4.7	1.0b	1.5cd	1.4c
E_5	23c	18d	42a	5.0d	5.2bcd	-	43.28ab	29.6d	4.9	1.2a	1.1e	1.5a
E_6	30abc	20c	41a	6.0abc	5.0cd	-	39.63c	32.2b	4.9	1.2a	1.6c	1.5ab
E_7	36ab	20bc	39ab	5.7abc	4.6ef	-	42.89ab	31.2c	4.5	1.2a	1.4d	1.4bc
E_8	29bc	16e	31b	6.2ab	4.5ef	-	43.10ab	30.8bc	4.5	1.0b	1.4 cd	1.3c
CV(%)	15.10	5.5	7.9	6.3	4.6	-	3.31	4.7	6.5	9.1	7.1	3.3

Conclusion

The performance of blachgram var. BARI Mash-3, line BBLXK2-12002-4 and BBLXK2-12005-5 appeared to be promising among the lines at Godagari, Rajshahi . For Bogura, considering overall performances, the genotypes E1, E2, E4, E6, and E10 was suggested for next year trial due to had higher yield. At Gaibandha, considering the performances of the genotypes regarding yield, farmers preferred E5 (BBLXK2-04001-1) and E6 (BBLXK2-08008-2-1) genotypes for Charland in Gaibandha. However, the experiment may be repeated for further evaluation in the next year.

YIELD PERFORMANCE OF BARI RELEASED BLACKGRAM VARIETIES IN CHAR LAND AREAS OF RAJSHAHI REGION

J.C. BARMAN, S. HOSSAIN AND E.A. PRAMANIK

Abstract

During the kharif-2 season of 2021, a field trial was conducted in the char land area of charkhari jagati, premtoli, Godagari, Rajshahi to find out the suitable blackgram varieties. Two blackgram varieties viz. BARI Mash-3 and BARI Mash-4, as well as a local check were used. BARI Mash-3 produced the maximum seed yield (1.58 t ha-1), followed by BARI Mash-4 (1.31 t ha-1) and Local (thakri) (1.14 t ha-1).

Introduction

Char Land stands out from the rest of the country because of its undulating topography and compact, low-fertility soils. High temperatures, little soil moisture storage, and low, irregular rainfall were all factors in the region's climate (BMDA, 2006). One of the most significant pulse crops in Bangladesh is blackgram [Vignamungo (L.)]. It produces grain for human use, and the plants fix nitrogen in the soil through the addition of organic matter. It provides a significant quantity of nitrogen to the non-legume crops that follow in the rotation (such as rice) (Sharma and Prasad, 1999). Blackgram is cultivated in the area of 0.188 million hectares contributing 9.5% of total pulse production (BBS, 2011). Maximum grown of blackgram found in western part of Bangladesh. The area is characterized by very low soil organic matter content. The rainfall in this area is erratic and the lowest for Bangladesh (average 1300-1400 mm per annum). So, it is called drought prone area in our country. Some crossing materials / lines selected through screening process by PRC in drought condition. If these lines grow well with high yield, it could be helpful to develop new variety.

Materials and Method

An experiment was conducted at farmer's field of FSRD site, char land area named charkhari jagati, premtoli, Godagari, Rajshahi during kharif-2 season of 2021.The experiment was conducted in randomized complete block design with three replications. The unit plot size was 10m x 5 rows. Line to line distance 30 cm plant to plant distance 10 cm. Treatment combinations were randomly assigned in each replication. Weeds, stubble and crop residues were removed. The land was fertilized with 20-20-20-10-1 N-P-K-S-B kg ha^{-1} (BARC, 2018) in the form of urea, triple super phosphate, muriate of potash and gypsum, respectively at the time of final land preparation. Blackgram seeds were sown on 16 September 2021. Weeding and thinning were done at 20 days after planting of blackgram seeds. First weeding was done at the time of first thinning and second weeding and thinning were done at 35 days after planting of blackgram seeds. No irrigation was applied during the experimental. When 80% of the pods turned brown in colour, the crop was assessed to attain maturity. Blackgram trail was harvested on 12 December 2021. The seed yield and yield components of blackgram were recorded and analyzed statistically following open-source software R (R Core Team, 2018).

Results and Discussion

Days to flowering, days to maturity, plant height (cm), number of pods/plants, thousand grain weight (g), and seed yield exhibited significant variation. Among the cultivars, BARI Mash-3 had the maximum number of pods $plant^{-1}$ (41.33), followed by BARI Mash-4 (33.67 while . BARI Mash-4 had the maximum 1000- seed weight (44.53 g) followed by BARI Mash-3 (43.17 g) . Local variety produced the lowestpods/plant (22.00), thousand seed weight (38.28 g). The highest seed yield (1.58 tha^{-1}) was achieved by BARI Mash-3 followed by BARI Mash-4 (1.31 tha^{-1}).

Farmer's reaction

Farmers obtained some promising variety of blackgram for Barind condition e.g., BARI Mash-3 and BARI Mash-4. Farmers are happy to get higher yield from variety. They also observed that pest attack was lowest in selected variety.

Table 1. Yield Performance of mlackgram varieties in Char land area 2021-22

Treatment	Days of Flowering	Days of Maturity	Plant height (cm)	Plant/m^2	Pods/ plant	Seeds/ pod	1000- seed wt. (g)	Seed yield (t ha^{-1})
BARI Mash-3	35b	78b	35.17b	36.33	41.33a	5.00	43.17a	1.58a
BARI Mash-4	37b	75b	32.38b	30.00	33.67ab	4.70	44.53a	1.31b
Local	60a	103a	39.43a	36.67	22.00b	4.52	38.28b	1.14c
CV (%)	2.58	1.64	4.17	8.57	22.34	12.76	4.71	3.04

Conclusion

The performance of blackgram var. BARI Mash-3 and BARI Mash-4 appeared to be promising among the varieties tested at Char land, Premtoli, Godagari, Rajshahi . But the experiment may be repeated for further evaluation in the next year.

ADAPTIVE TRIAL OF DIFFERENT VARIETIES OF MUNGBEAN IN COASTAL AREA

M.S. ISLAM, M. ISLAM AND K. N. ISLAM

Abstract

The experiment was conducted at Keoyabunia, Amtoli, Borguna during late Rabi season of 2021-22 to evaluate the performance of some mungbean varieties in coastal area. Four mungbean var. BARI Mung-6, BARI Mung-8, BINA Mung-7 and BINA Mung-8 were evaluated . The growth parameters and yield contributing characters of mungbean plant was found significantly different among the varieties. The maximum seed yield (1.71 t ha^{-1}) was obtained from BARI Mung-6 followed by BINA Moog-8 (1.21 t ha^{-1}) and BINA Moog-7 (1.18 t ha^{-1}. The lowest seed yield (1.06 t ha^{-1}) was obtained by BARI Mung-8. The maximum gross return (Tk. 110500 ha^{-1}) was obtained from BARI Mung-6 as well as gross margin (Tk. 68950 ha^{-1}) and BCR (2.65) from same variety. The lowest economic return was recorded from BARI Mung-8 (Tk. 68900 ha^{-1}) and BCR (1.66). BARI Mung-6 was found the most productive variety under the coastal area.

Introduction

Mungbean (*Vigna radiata*) is one of the most important pulse crops of Bangladesh. It is a rich source of nutrient and is considered healthy food. Its seeds are a good source of dietary protein nd contains higher levels of folate and iron than most other legumes (Keatinge *et al.*, 2011). On dry weight basis, mungbean contains 22-28% protein, 1.0-1.5% fat, 3.5-4.5% fiber, 4.5- 5.5% ash and 60-65% carbohydrate. It is also a rich source of essential amino acids like isoleucine, leucine, lysine and phenylalanine (Lambrides and Godwin, 2007). On an average, it fixes @ 300 kg ha^{-1} of atmospheric nitrogen annually (Sharar *et al.*, 2001), which not only meet its own nitrogen need, but also benefits following crops (Ali and Gupta, 2012). Mungbean is usually grown in low to medium altitudes in the tropics as a rainfed crop. Farmers commonly grow mungbean by one ploughing and scarcely use fertilizer as a resuly low yield achieved. Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have released a good number of improved varieties of mungbean, which have been tested in the different areas, and performance was highly satisfactory over local varieties. But the improved varieties are not yet introduced to farmers in coastal area. Therefore, the experiment was undertaken to evaluate the performance of released mungbean varieties and to increase yield in coastal area.

Materials and Methods

Adaptive trial program with four released varieties e.g., BARI Mung-6, BARI Mung-8, BINA Mung-7 and BINA Mung-8 were conducted at Keoyabunia, Amtoli, Borguna in coastal area during late rabi season of 2021-22. The seeds of variety @ 30 kg ha^{-1} were used. The experiment was laid out in RCB design with 3 replications having unit plot size 8 m x 5 m. Seeds were sown on 22 January, 2022 according to plots in line 30 cm apart. The land was fertilized with N_{23}, P_{17} and $K_{17.5}$ kg ha^{-1} at the time of final land preparation. Weeding was done at 15 days after sowing followed by thinning to keep plant to plant distance of 10 cm. Other intercultural operations were done as and when necessary to ensure normal growth and development of crops. Plant protection measures were taken as required. In addition, Imitaf and Coragen was sprayed @ 0.5 ml/l to control insect pests such thrips and pod borers, respectively. The crops were harvested by hand picking of pods at different dates as per maturity. Seed yield was recorded at 10-12% moisture content. The yield and other relevant data were recorded and analyzed statistically.

Results and Discussion

Growth and phenological parameter: Days to maturity: The highest days to maturity were observed in variety BINA Moog-7 (73 days) followed by (67 days) BINA Moog-8 and the lowest in BARI Mung-6 (63 days) followed by BARI Mung-8 (63 days).

Plant height (cm): Plant height ranged from 21.60 to 28.80 cm. The maximum plant height (28.80 cm) was obtained at BARI Mung-6 followed by BINA Moog-8 (27.50 cm) and BINA Moog-7 (26.67 cm) while the lower plant height from BARI Mung-8 (21.60 cm).

Number of branches/plants: The higher number of branches/plant (2.20) was obtained at BINA Moog-7 and the lower from BARI Mung-8 which is 2.07.

Yield components:

Number of pods/plants: The maximum (31.67) number of pods per plant was obtained at BARI Mung-6 variety followed by BINA Moog-8 (23.00) and BINA Moog-7(21.33). But the lowest (19.00) number of pods per plant was obtained at BARI Mung-8 (Table 2).

Number of seeds/pods: The variety BARI Mung-6 (9.07) produced the higher number of seeds per pod followed by BINA Moog-8 (8.63)and BINA Moog-7 (8.40). The lowest number of seeds per pod was recorded in BARI Mung-8 (8.07).

1000-seed weight (g): The 1000- seed weight under different variety ranged from 35.33 g to 50.67 g while the maximum weight was recorded in BARI Mung-6 (50.67 g) followed by BINA Moog-8 (39.33 g) and BINA Moog-7 (36.33 g). In contrast, the lowest weight of 1000-seed (g) was found in BARI Mung-8 (35.33 g).

Seed yield: Results revealed that BARI Mung-6 produced the highest seed yield, which resulted from the highest number of pods/plants, seeds/pod and 1000-seed weight than the other variety (Table 2). Seed was maximum with BARI Mung-6 (1.71 t ha^{-1}) followed by BINA Moog-8 (1.21 t ha^{-1}) and BINA Moog-7 (1.18 t ha^{-1}) while the var. BARI Mung-8 (1.06 t ha^{-1}) gave the lowest seed yield contributing characters.

Stover yield: Stover yield was significantly influenced by variety. The highest stover yield (2.39 t ha^{-1}) was recorded from BARI Mung-6 and the lowest from BARI Mung-8which is 1.97 t ha^{-1}.

Harvest index: The maximum value of harvest index (41.62%) was obtained with the var. BARI Mung-6. The minimum harvest index value (34.99%) was obtained from variety BARI Mung-8.

Economic return and benefit cost ratio (BCR)

Economic analysis is presented in Table 3. The maximum gross return (Tk. 110500 ha^{-1}), gross margin (Tk. 68950 ha^{-1}) and BCR (2.65) was recorded from BARI Mung-6 followed by BINA Moog-8 and BINA Moog-7. The minimum economic return was recorded from BARI Mung-8 (Tk. 68900 ha^{-1}) and BCR (1.66).

Farmers' opinion

Farmers are very interested in producing variety BARI Mung-6 and they were happy to see the performance of mungbean varieties. Among the varieties they preferred BARI Mung-6> BINA Moog-8> BINA Moog-7> BARI Mung-8 in coastal area in terms of yield and economic return.

Table 1. Growth and phenological parameter of mungbean varieties during late Rabi 2021-22.

Varieties	Days to maturity	Plant height (cm)	Number of branches/plants
BARI Mung-6	62.67 c	28.80 a	2.17
BARI Mung-8	63.33 c	21.60 c	2.07
BINA Moog-7	72.67 a	26.67 b	2.20
BINA Moog-8	67.33 b	27.50 ab	2.13
CV (%)	1.52	2.93	10.93
CD (0.05)	2.03	1.54	NS

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV = Coefficient of Variation, CD = Critical Difference.

Table 2. Performance of varieties on the yield and yield components of mungbean during late Rabi 2021-22.

Varieties	Number of pods/plants	Number of seeds/pods	1000-seed weight (g)	Seed Yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
BARI Mung-6	31.67 a	9.07 a	50.67 a	1.71 a	2.39 a	41.62 a
BARI Mung-8	19.00 c	8.07 c	35.33 c	1.06 b	1.97 b	34.99 b
BINA Moog-7	21.33 bc	8.40 b	36.33 bc	1.18 b	2.12 b	35.73 b
BINA Moog-8	23.00 b	8.63 b	39.33 b	1.21 b	2.17 b	35.58 b
CV (%)	5.79	1.50	3.84	7.28	4.87	4.25
CD (0.05)	2.75	0.26	3.11	0.18	0.22	3.14

Table 3. Cost and returns of the mungbean varieties during Rabi 2021-22.

Varieties		Gross return (Tk. ha^{-1})	Variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
BARI Mung-6		110500	41550	68950	2.65
BARI Mung-8		68900	41550	27350	1.66
BINA Moog-7		76700	41550	35150	1.85
BINA Moog-8		78650	41550	37100	1.89

Conclusion

From the studies it can be concluded that e mungbean var. BARI Mung-6 out yielded the other varieties in farmer’s field condition. This variety could be appeard to be well adapted to the agro-ecological conditions of the coastal area of Bangladesh.

ON FARM TRIAL OF LENTIL VARIETIES IN DINAJPUR

M.S. HUDA AND A. HOSSAIN

Abstract

The experiment was conducted at farmer's field of MLT site, Raniganj, sadar, Dinajpur during the Rabi season of 2021-2022 to observe the performance of BARI released lentil variety in Dinajpur region. Four BARI released lentil varieties viz. BARI Masur-5, BARI Masur-7, BARI Masur-8, BARI Masur-9 were tested. Among the tested varieties, BARI Masur-8 performed better and gave the highest seed yield and economic return in Dinajpur.

Introduction

Lentil ranks first position in respect of consumers’ preference and second in terms of area and production in Bangladesh. It is an important protein source in the daily diet of most of the people of the country. It is grown in Bangladesh after harvest of upland rice and jute and transplanted lowland monsoon rice. Lentil is traditionally grown during the dry winter months (rabi season) on residual soil moisture under rainfed conditions or particularly where irrigation is available. Bangladeshis consumes about 10.5 g of pulses per capita per day, far below the 45 g per day recommended by FAO/WHO (Islam and Ali, 2002). In respect of food security of our large population, now it is essential to increase the production of the crops. Recently Pulse Research Center BARI has developed some high yielding disease resistant lentil varieties which have higher yield as well as short lived. For this reason, the present study was undertaken to observe the performance of the new varieties under farmer's field condition and popularize among the farmers and promote their adoption in this area.

Materials and Methods

The experiment was conducted at MLT site *of MLT site of Raniganj, sadarDinajpur* during the Rabi season of 2021-22. The unit plot size was 5m×4 m with 30 cm×5 cm plant spacing. The trial was laid out in a RCB design with three dispersed replications. Fertilizers were applied @ 20-17-17.5-9-1 kgha^{-1} of N-P-K-S-B, respectively. All fertilizers were applied as basal dose during final land preparation. Necessary data were recorded as per objectives. Sowing and harvesting date were 11 November, 2020 and 15 February (var. BARI Masur-9) respectively.

Results and Discussion

The results and cost analysis were shown in Table-1 and Table-2, respectively.Days to maturity of BARI Masur-5, BARI Masur-7, BARI Masur-8, BARI Masur-9 were 110,113,116, 95 days, respectively. The highest plant height (68 cm) was recorded in BARI Masur-6, but the highest thousand grain weight was obtained from BARI Masur-8 (22.10 g). The highest seed yield (1.88 t ha$^{-1)}$ was obtained from BARI Masur-8 and the lowest in BARI Masur-5 (1.58 t ha^{-1}).

Cost and return

Total variable cost was calculated at Tk. 62500 ha^{-1} for all varieties. The maximum return (Tk. 150400 ha^{-1}) and gross margin (Tk. 87900 ha^{-1}) were obtained from BARI Masur-8 as a result higher BCR (2.40) and the lowest in BARI Masur-7 (Tk. 62300 ha^{-1}).

Farmers were pleased to see the high yielding variety of lentil var. BARI Masur-8. They have chosen BARI Masur-8 due to its comparatively higher yield. They have stored good amount seed for next year sowing.

Table 2. Seed yield and yield attributes of lentil varieties during the Rabi season of 2021-22

Variety	Population/ m2	Plant Height (cm)	Days to Maturity	Number of Pod/ Plant	Number of Seeds/ Pod	1000-seed weight (g)		Seed Yield (t ha^{-1})
BARI Masur-5	121	62.7	110	16.3	1.73	18.6		1.58
BARI Masur-7	144	59.1	113	18.3	1.73	20.0		1.56
BARI Masur-8	174	68.0	116	19.4	1.67	22.1		1.88
BARI Masur-9	114	66.4	95	19.2	1.53	21.4		1.63
$LSD_{0.05}$		3.91	2.85			1.94		0.18
CV (%)	16.85	3.05	1.31	19.47	6.93	4.74		5.49

Table 3. Economics analysis of different lentil varieties at different locations during the Rabi season of 2021-22.

Treatment	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
BARI Masur-5	126400	62500	63900	2.0
BARI Masur-7	124800	62500	62300	2.0
BARI Masur-8	150400	62500	87900	2.4
BARI Masur-9	130400	62500	67900	2.1

Conclusion

Based on the findings, it can be concluded that lentil var. BARI Masur-8 and BARI Masur-9 were more profitable to the farmers than other varieties. So, this variety should be expanded to Dinajpur region of Bangladesh.

ON-FARM TRIAL OF CHICKPEA VARIETIES

A.A. MAHMUD, M.J. ALAM, A.H. TALUKDER, Z. FERDOUS, M.S. ALAM, M.S. HUDA AND A. HOSSAIN

Abstract

A field trial was conducted in the farmer's field of MLT site, Saghata, Gaibandh; stable Charland of Bonogram, Chilmari, Kurigram and and at the ARS, Dinajpur during 2021-22 to evaluate the performance of Chickpea varieties. Three chickpea var. BARI Chola-9, BARI Chola-10, and BARI Chola-11 were evaluated at Dinajpour whereas four varieties of chickpea, e.g., BARI Chhola-5, BARI Chhola-9, BARI Chhola-10, and BARI Chhola-11 were tested in Rangpur and Dinajpur. At Gaiband, var. BARI Chola-9 produced the maximum seed yield (1.96 t ha-1) followed by BARI Chola-10 (1.80 t ha-1) due to the maximum 100-seed weight (21.4 g) and number of pods plant-1 (57). The lowest seed yield (1.15 t ha-1) was produced by BARI Chola-11 due to the smaller number of pod plant-1 (43) as well as 100-seed weight (18.2 g). At Rangpur,var. BARI Chhola-9 (1.38 t ha-1) gave maximum seed yield followed by BARI Chhola-10 (1.29 t ha-1) and BARI Chhola-5 (1.25 t ha-1), respectively. The maximum gross return (105750 Tk. ha-1) and gross margin (56535 Tk. ha-1) was obtained from BARI Chhola-9. At Dinajpur, BARI Chickpea 9 gave maximum seed yield (2.43 t ha-1) followed by BARI Chickpea 5 (1.82 t ha-1) and minimum seed yield from BARI Chola-10 (0.97 t ha-1) among the tested varieties.

Introduction

Chickpea (*Cicer arietinum* L.) is a popular and profitable pulse crop grown in Bangladesh during the winter season. It is a good source of protein, energy, vitamins, minerals, fiber, and also some potentially health-beneficial phytochemicals (Wood and Grusak, 2007). Chickpea is a common source of carbohydrates and protein, so it makes it more economical and affordable for developing countries without compromising on nutritional quality (Malunga et al., 2014). The average yield of chickpea is low (600-700 kg ha^{-1}) in Bangladesh compared to the south Asian countries (1.46 t ha^{-1}) (ICRISAT, 1990). Its yield is probably the most unstable among pulses due to its sensitivity to the microenvironment. The average daily temperature of less than 15°C has been shown to cause abortion in flowers (Clarke and Siddique, 2010). The area under Chickpea cultivation has been decreasing gradually because of the increasing demand for staple grains like rice and wheat (BBS, 2020). Currently, about 4942 t of Chickpea is being produced from an area of 4635 ha of land with an average seed yield of 1.07 t ha^{-1} (BBS, 2020).

The major constraints responsible for the low yield of Chickpea include low yield potential, sensitivity to high water and fertilizer application, and sensitive to climatic factors such as excess soil moisture/humidity and rainfall. Chickpea is found to be a very suitable dry land *rabi* crop with less soil moisture condition like char land areas. Bangladesh Agricultural Research Institute (BARI) has developed some high-yielding and disease-resistant/tolerant varieties of chickpea. Yield potentialities of those varieties are 2-3 times higher than national average yields under research station/researchers managed trial. The yield gap between the research center and the farmer's field is due to multiple reasons such as knowledge gap, quality seed, and environmental resource constraints of farmers. However, suitable variety needs to identify the suitable chickpea variety for Charland Gaibandha and Dinajpur area.

Materials and Methods

The field trial was conducted at MLT site, Saghata, Gaibandha; stable Charland of Bonogram, Chilmari, Kurigram and at ARS, Dinajpur during 2021-22 *rabi* season. The experiment was laid out in a randomized complete design with six dispersed replications at Gaibandha and three replications at Rangpur and Dinajpur. The crop management of chickpea are given in Table 1.

Weeding and thinning were done at 20 days after planting of chickpea seeds. First weeding was done at the time of first thinning and second weeding and thinning was done at 35 days after planting of chickpea seeds. No irrigation was applied during the experimental period as there was no symptom of moisture stress. To identify any change in plant characters and attack of pests and disease the crop plots were frequently observed. When 80% of the pods turned brown in colour, the crop was assessed to attain maturity. All fertilizers were applied as basal during final land preparation. The seed yield and yield components of chickpea were recorded and analyzed statistically using STAR software at Gaibandha, open-source software R (R Core Team, 2018) at Dinajpur.

Table 1. Crop management of chickpea at different locations.

Locations	Date of sowing	Date of harvesting	Tested varieties	Plot size	Fertilizer dose (N-P-K-S-B kg ha^{-1})
Gaibandha	30 November 2021	8 April 2022	BARI Chola-9 BARI Chola-10 BARI Chola-11	50 m x 25 m	20-20-20-10-1
Rangpur	12November 2021	28-30 March 2022	BARI Chola-5 BARI Chola-9 BARI Chola-10 BARI Chola-11	5 m x 8 m	20-20-20-10-1
Dinajpur	22 November 2021	5 April 2022	BARI Chola-5 BARI Chola-9 BARI Chola-10 BARI Chola-11	4 m × 5 m	20-20-20-10-1

Results and Discussion

The seed yield and yield contributing parameters of chickpea are presented in Table 2. At Gaibandha, BARI Chola-9 produced the maximum seed yield (1.96 t ha^{-1}) followed by var. BARI Chola-10 (1.80 t ha^{-1}). The reason for more yield in BARI Chola-9 is mainly due to the more 100-seed weight (21.4 g) and satisfactory pods plant^{-1} (57) but maximum pods plant^{-1} (70) in BARI Chola-10. BARI Chola-11 produced the lowest seed yield (1.15 t ha^{-1}) due to the smaller number of pod plant^{-1} (43) as well as 100-seed weight (18.2 g). In terms of economic analysis, BARI Chola-9 produced the highest gross margin (98863 Tk. ha^{-1}) due to higher seed yield as well as good market price, whereas lowest in var. BARI Chola-11 (50263 Tk. ha^{-1}) (Table 3).

At Rangpur, among the tested entries, BARI Chhola-9 (1.38 t ha^{-1}) gave maximum seed yield followed by BARI Chhola-10 (1.29 t ha^{-1}) and BARI Chhola-5 (1.25 t ha^{-1}), respectively (Table 2) while BARI Chola-11gave minimum yield (1.13 t ha^{-1}). Maximum number of pods plant^{-1} (58.76) was recorded from BARI Chhola-9 followed by BARI Chhola-5. The maximum 1000- seeds weight (15.43 g) was recorded from BARI Chhola-9 followed BARI Chhola-11 (13.89 g). The maximum gross return (105750 Tk. ha^{-1}) and gross margin (56535 Tk. ha^{-1}) was obtained from BARI Chhola-9 (Table 3).

At Dinajpur, the highest plant height (44.4cm at 50DAS) was recorded from BARI Chola 11 and the lowest plant height (30.33 cm at 50DAS) from BARI Chola 9. (Table 2). The maximum time (77 DAS) for flowering was recorded from BARI Chola 9 and the minimum (43DAS) from BARI Chola-11. Maximum 1000- seed weight (23.07 g) was found in BARI Chola-9 while BARI Chola-5 (12.96 g) gave minimum weight. BARI Chola-9 gave maximum seed yield (2.43 t ha^{-1}) followed by BARI Chola-9 (1.82 t ha^{-1}) and minimum seed yield from BARI Chola-10 (0.97 t ha^{-1}) followed by BARI Chola-11 (1.25 t ha^{-1}) The maximum gross return (TK 121500 ha^{-1}) and gross margin (Tk. 62000 ha^{-1}) were obtained from BARI Chola 9 and the lowest in BARI Chola 10 where negative gross margin was obtained from BARChola-10.

Farmer's reaction

Farmers in the char areas of Gaibandha preferred var. BARI Chola-9 and BARI Chola-10 for their higher seed yield as well as good economic return. Farmers of Rangpur are opined that that BARI Chhola-9 is high yielder variety for Charland area. They also observed that pest attack was relatively minimum under charland condition.

Farmers of Dinajpur preferred BARI Chola-5 and BARI Chola-9 for their higher seed yield and proft.

Table 2. Seed yield and yield attributes of Chickpea varieties at Gaibandha, Rangpur and Dinajpur during 2021-22

	Treatment	Days to flowering	Days to maturity	Plant height (cm)	Pods plant^{-1}	100-seed wt. (g)	Seed yield (t ha^{-1})
Saghata, Gaibandha	BARI Chola-9	74 a	125 a	63.3 a	57 b	21.4	1.96 a
	BARI Chola-10	70 a	114 ab	55.0 ab	70 a	20.5	1.80 a
	BARI Chola-11	56 b	105 b	51.2 b	43 c	18.2	1.15 b
	$LSD_{0.05}$	4.43	14.21	9.16	12.26	ns	0.34
	CV (%)	6.71	5.47	7.15	9.57	7.71	9.08
Charland of Chilmari, Rangpur	BARI Chhola-5			56.57c	56.44a	12.01c	1.25b
	BARI Chhola-9			62.07b	58.76a	14.67a	1.38a
	BARI Chhola-10			60.73b	51.88b	12.77bc	1.29b
	BARI Chhola-11			79.87a	47.21c	13.89b	1.13c
	$LSD_{0.05}$			2.37	5.67	1.49	0.06
Dinajpur	BARI Chhola-5	74	133	82.63	57.6	12.96	1.82
	BARI Chhola-9	77	135	71.13	45.16	23.07	2.43
	BARI Chhola-10	44	127	87.27	43.76	20.57	0.97
	BARI Chhola-11	43	123	94.93	49.78	19.96	1.25
	$LSD_{0.05}$	2.6	-	ns	6.51	0.9	0.69

Table 3. Economic performance of Chickpea varieties at Gaibandha, Rangpur and Dinajpur during 2021-22

Location	Crop variety	Gross Return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Gaibandha	BARI Chola-9	117600	18737	98863
	BARI Chola-10	108000	18737	89263
	BARI Chola-11	69000	18737	50263
Rangpur	BARI Chhola-5	93750	46965	46785
	BARI Chhola-9	103500	46965	56535
	BARI Chhola-10	96750	46965	49785
	BARI Chhola-11	84750	46965	37785
Dinajpur	BARI Chhola-5	91000	59500	31500
	BARI Chhola-9	121500	59500	62000
	BARI Chhola-10	48500	59500	-1100
	BARI Chhola-11	62500	59500	3000

Conclusion

The performance of chickpea var. BARI Chola-9 and BARI Chola-10 at Gaibandha; BARI Chhola-9 at Charland area of Rangpur; and BARI Chola-9 and BARI Chola-5 at Dinajpur appeared promising in terms of yield and economic performance. The experiment may be repeated for further investigation in the next year.

REGIONAL YIELD TRIAL OF CHICKPEA

J.C. BARMAN, S. HOSSAIN AND E.A. PRAMANIK

Abstract

The field trial was carried out at the farmer's field of FSRD site, Basantopur, Godagari, Rajshahi during rabi season 2021-22 to select suitable chickpea variety through regional yield trial (RYT) under drought prone area. Four genotypes of chickpea viz. BCX-09010-9, BCX-13005-8, BCX-13005-3, BCX-13002-2, and two varieties BARI Chola-5 and BARI Chola-10 as a check were tested . Among the tested genotypes, BCX-13002-2 gave the maximum seed yield (1.86 t ha-1) followed by BCX-13005-3 (1.79 t ha-1) and the minimum seed yield was obtained from BARI Chola-10 (1.13 t ha-1).

Introduction

Chickpea (*Cicer arietinum* L) is an important pulse crop in Barind area. Traditionally, the farmers of Barind area cultivate chickpea after harvest of T. aman rice in residual soil moisture condition. The long duration T. aman rice affect the proper sowing time of chickpea that causes lower seed yield. Therefore, development of suitable chickpea variety is necessary for improving chickpea productivity in Barind area. Its yield is probably most unstable among pulses due to its more sensitivity to microenvironment. Chickpea is found to be a very suitable dry land *rabi* crop with residual soil moisture condition. Under Barind stress situation it can be successfully grown after harvesting of short duration T. aman rice. The average yield of chickpea is low (600-700 kg ha^{-1}) compared to other neighboring countries (ICRISAT, 1990). Bangladesh has been developing a good number of varieties of chickpea. BARI has released high yielding and disease resistant/tolerant varieties of chickpea. Yield potentialities of those varieties are 2-3 times higher than national average yields under research station/researchers managed trial. It is assumed that this yield gap between research station and farmers field is due to manifold reasons viz. i) knowledge gap, ii) resources constraints of farmers including quality seed, iii) environmental hazard. In relation to the above situation the present trial was undertaken with a view to develop variety(s) through farmer's selection under Barind environments.

Materials and Method

An experiment on regional yield trial (RYT) of chickpea was conducted at farmer's field of FSRD site, Basantopur, Godagari, Rajshahi during Rabi 2021-22. The experiment was conducted in randomized complete block design with three replications. The unit plot size was 8 rows x 4m. Line to line distance 50 cm and plant to plant distance 10 cm. Weeds, stubble and crop residues were removed. The land was fertilized with 20-20-20-10-1 N-P-K-S-B kg ha^{-1} (BARC, 2018) in the form of urea, triple super phosphate, muriate of potash and gypsum, respectively at the time of final land preparation. Chickpea seeds were sown on 02 November, 2021. Weeding and thinning were done at 30 days after planting of chickpea seeds. First weeding was done at the time of first thinning and second weeding and thinning were done at 45 days after planting of chickpea seeds. No irrigation was applied during the experimental period as . When 80% of the pods turned brown in colour, the crop was assessed to attain maturity. Chickpea was harvested on 17 March, 2022. The seed yield and yield components of chickpea were recorded and analyzed statistically following open-source software R (R Core Team, 2018).

Result and Discussion

The performance of yield and yield parameters of chickpea were presented in Table 1. The yield and most of the yield contributing characters like days to flower, days to maturity, plant height (cm), and thousand Grain Weight (g) showed significant variation except number of pods per plant and number of seeds per pod . Among the genotypes, BCX-13002-2 showed the maximum number of pods plant^{-1} (115.33) followed by BARI Chola-5(111.67) and the minimum number of pods plant^{-1} (66.77) from BARI Chola-10. The maximum100- seed weight (20.67 g) was found in BCX-13002-2 whereas BARI Chola-5 gave the lowest 12.77g. The line BCX-13002-2 gave the maximum seed yield (1.86 t ha^{-1}) followed by line BCX-13005-3 (1.79 t ha^{-1}) followed by BARI Chola-5 (1.64 t ha$^{-1)}$ and minimum from BARI Chola-10 (1.13 t ha^{-1}).

Farmer's reaction

Farmers obtained some promising cultivars for Barind condition e.g., BCX-13002-2 and BCX BCX-13005-3 and BARI **C**hola-5. Farmers are happy to get higher yield from selected lines/variety. They also observed that pest attack was lowest in selected lines/variety.

Table1. Seed yield and yield attributes of Chickpea genotypes at Basantopur under FSRD site, Godagari, Rajshahi during 2021-2022.

Entry Names	Days to Flowering	Days of maturity	Plant height (cm)	Plant/m 2	Pod /plant	Seeds /pod	100-Seed wt. (g)	Seed yield (tha^{-1})	Straw yield (tha^{-1})
E_1	75a	134d	55c	25abc	112	1.60	12.77c	1.64c	1.87c
E_2	73ab	136b	81a	33a	101	1.67	18.00ac	1.60c	2.08ab
E_3	68d	135c	59bc	23abc	94	1.47	18.00ab	1.72bc	2.07ab
E_4	68d	136b	65b	16c	109	1.47	19.33ab	1.79ab	2.07ab
E_5	71bc	134d	59bc	22bc	115	1.60	20.67a	1.86a	2.18a
E_6	69cd	139a	61bc	29ab	67	1.67	16.67b	1.13bc	1.95bc
CV (%)	2.1	0.17	7.51	14.3	30.0	13.82	9.09	4.17	5.25

Legend: E_1= BARI Cholla-5; E_2= BCX-09010-9; E_3= BCX-13005-8; E_4= BCX-13005-3; E_5= BCX-13002-2; E_6= BARI Cholla-10

Conclusion

The performance of chickpea var. BARI **C**hola-5, line -13002-2 and BCX-13005-3 appeared to be promising at FSRD site, Basantopur, Godagari, Rajshahi during the study period. So, it can be concluded that the experiment may be repeated for further evaluation in the next year.

PRELIMINARY YIELD TRIAL OF CHICKPEA

J.C. BARMAN, S. HOSSAIN AND E.A. PRAMANIK

Abstract

The field trial was carried out at the farmer's field of FSRD site, Basantopur, Godagari, Rajshahi during rabi season 2021-22 to select suitable chickpea variety through regional yield trial (RYT) under drought prone area. Ten genotypes of chickpea viz. ICCV-181632, ICCV-181633, ICCV-181635, ICCV-181636, ICCV-181634, ICCV-181650, ICCV-181652, ICCV-181630, ICCV-181624, ICCV-181627 and two BARI released varieties BARI Chola-5 and BARI Chola-10 as check were tested in the farmer's field. Among the tested genotypes, ICCV-181635 gave the maximum seed yield (1.67 t ha-1) followed by BARI Chola-5 (1.56 t ha-1) and minimum seed yield from ICCV-181650 (0.71 t ha-1) due to minimum pods per plants. Among other genotypes, ICCV-181624 gave the seed yield 1.54 t ha-1, BARI Chola-10 gave 1.52 t ha-1, ICCV-181634 gave 1.50 t ha-1, ICCV-181636 gave 1.47 t ha-1, ICCV-181627 gave 1.43 t ha-1, ICCV-181633 gave 1.34 t ha-1 and ICCV-181630 gave 1.26 t ha-1. The maximum straw yield was found from ICCV-181635 (2.05 t ha-1) followed by BARI Chola-10 (1.97 t ha-1) and the minimum straw yield (1.03) by ICCV-181650.

Introduction

Chickpea (*Cicer arietinum* L) is an important pulse crop in Barind area. Traditionally, the farmers of Barind area cultivate chickpea after harvest of T. aman rice in residual soil moisture condition. The long duration T. aman rice affect the proper sowing time of chickpea that causes lower seed yield. Therefore, development of suitable chickpea variety is necessary for improving chickpea productivity in Barind area. Its yield is probably most unstable among pulses due to its more sensitivity to microenvironment. Chickpea is found to be a very suitable dry land *rabi* crop with residual soil moisture condition. Under Barind stress situation it can be successfully grown after harvesting of short duration T. aman rice. The average yield of chickpea is low (600-700 kg ha^{-1}) compared to other neighboring countries (ICRISAT, 1990). Bangladesh has been developing a good number of varieties of chickpea. BARI has released high yielding and disease resistant/tolerant varieties of chickpea. Yield potentialities of those varieties are 2-3 times higher than national average yields under research station/researchers managed trial. It is assumed that this yield gap between research station and farmers field is due to manifold reasons viz. i) knowledge gap, ii) resources constraints of farmers including quality seed, iii) environmental hazard. In relation to the above situation the present trial was undertaken with a view to develop variety(s) through farmer's selection under Barind environments.

Materials and Method

An experiment on Preliminary yield trial (PYT) of chickpea was conducted at farmer's field of FSRD site, Basantopur, Godagari, Rajshahi during Rabi 2021-22. The experiment was conducted in randomized complete block design with three replications. The unit plot size was 3-meter x 8lines. Line to line distance 40 cm plant to plant distance 10 cm. Treatment combinations were randomly assigned in each replication. Weeds, stubble and crop residues were removed. The land was fertilized with 20-20-20-10-1 N-P-K-S-B kg ha^{-1} (BARC, 2018) in the form of urea, triple super phosphate, muriate of potash and gypsum, respectively at the time of final land preparation. Chickpea seeds were sown on 30 November, 2021. Weeding and thinning were done at 20 days after planting of chickpea seeds. First weeding was done at the time of first thinning and second weeding and thinning were done at 35 days after planting of chickpea seeds. No irrigation was applied during the experimental periodWhen 80% of the pods turned brown in colour, the crop was assessed to attain maturity. Chickpea was harvested on 04 April 2022. The seed yield and yield components of chickpea were recorded and analyzed statistically following open-source software R (R Core Team, 2018).

Results and Discussion

The performance of yield and yield parameters of chickpea were presented in Table 1. The seed yield and yield contributing characters like days to flower, days to maturity, plant height (cm), and thousand seed weight (g) showed significant variations. Among the tested genotypes, ICCV-181635 gave the maximum seed yield (1.67 t ha^{-1}) followed by BARI Chola-5 (1.56 t ha^{-1}) and minimum seed yield from ICCV-181650 (0.71 t ha^{-1}) due to lower pods per plants. Among other genotypes, ICCV-181624 gave the seed yield 1.54 t ha^{-1}, BARI Chola-10 gave 1.52 t ha^{-1}, ICCV-181634 gave 1.50 t ha^{-1}, ICCV-181636 gave 1.47 t ha^{-1}, ICCV-181627 gave 1.43 t ha^{-1}, ICCV-181633 gave 1.34 t ha^{-1} and ICCV-181630 gave 1.26 t ha^{-1}. The maximum straw yield was found from ICCV-181635 (2.05 t ha^{-1}) followed by BARI Chola-10 (1.97 t ha^{-1}) and the minimum straw yield (1.03) by ICCV-181650.

Farmer's reaction

Farmers obtained some promising variety/ line for Barind condition e.g.,line, ICCV-181635, var. BARI **c**hola-5 and line, ICCV-181624. Farmers are happy to get higher yield from selected lines/variety. They also observed that pest attack was lowest in selected lines/variety.

Table 1. Yield and yield attributes of Chickpea genotypes at Basantopur under FSRD site, Godagari, Rajshahi during 2021-2022.

Entry Names	Days to Flowering	Days to maturity	Plant height (cm)	Plant /m2	Pods /Plant	Seeds /pod	100-seed wt. (g)	Seeds yield (t ha^{-1})	Straw yield (t ha^{-1})
E_1	76cbe	116fg	42c	19b	89a	1.60a	12.2f	1.56ab	1.73cd
E_2	78bc	119cd	61ab	24ab	51def	1.33bcd	20.1de	1.23d	1.85bc
E_3	81a	121b	61a	22ab	47ef	1.27bcd	24.4a	1.34cd	1.69d
E_4	80ab	118cde	59ab	23ab	83ab	1.27bcd	19.4de	1.67a	2.05a
E_5	81a	119c	62a	27a	68bc	1.47bcd	18.9de	1.47bc	1.91b
E_6	81a	119cde	62a	24ab	67bcd	1.20cd	19.4de	1.50b	1.76cd
E_7	74e	116g	41c	20b	28g	1.33bcd	23.5ab	0.71f	1.03f
E_8	75de	116efg	55b	23ab	35fg	1.60a	23.1ab	0.90e	1.08f
E_9	81a	123a	57ab	20.0b	58cde	1.40abc	21.8bc	1.26d	1.55e
E_{10}	77c	119c	61ab	24ab	65cd	1.20cd	20.6cd	1.54b	1.93b
E_{11}	77c	117def	62a	23ab	54cde	1.13d	19.6de	1.43bc	1.89b
E_{12}	77cd	116g	44c	19b	57cde	1.47ab	18.7e	1.52b	1.97b
CV(%)	1.99	1.45	6.51	6.2	7.10	11.61	5.1	5.79	4.09

Legend: E_1= BARI Cholla-5; E_2 = ICCV-181632; E_3= ICCV-181633; E_4= ICCV-181635; E_5= ICCV-181636; E_6= ICCV-181634; E_7= ICCV-181650; E_8= ICCV-181652; E_9= ICCV-181630; E_{10}=ICCV-181624; E_{11}= ICCV-181627; E_{12}= BARI Cholla-10

Conclusion

The performance of Chickpea genotypes ICCV-181635, var. BARI **C**hola-5 and line, ICCV-181624 appeared to be promising among the lines tested at FSRD site, Basantopur, Godagari, Rajshahi during the study period. So, it can be concluded that the experiment may be repeated for further evaluation in the next year.

EVALUATION OF GRASSPEA GENOTYPES FOR CHAR AREAS OF GAIBANDHA

A.A. MAHMUD AND M.J. ALAM

Abstract

The trial was conducted with nine promising lines: E2 (114509), E3 (116610), E4 (116820), E5 (114585), E6 (66054), E7 (114505), E8 (116755), E9 (11506) and E10 (11690) along with two checks var. BARI Khesari-3) and var. BARI Khesari-5) of Grasspea in charland of Saghata, Gaibandha during 2021-22. The maximum seed yield (1.56 t ha-1) was obtained from the E7 (114505) genotype followed by E9 (1.53 t ha-1) and E6 (1.51 t ha-1). The lowest yield (1.26 t ha-1) was recorded from E3 (116610). However, out of the 9 advanced lines, three lines such as, E7 , E9 and E6 showed similar yield performance compared to both the checks var. BARI Khesari-3 and BARI Khesari-5.

Introduction

Grasspea (*Lathyrus sativus* L) is an important pulse crop in Bangladesh, and it stands first position according to the area and production. Currently, about 119548 metric ton of grass pea is being produced from an area of 110323 ha of land (BBS, 2020). Grasspea is mostly grown in the southern part of Bangladesh as a sole or relay crop with aman rice. Nowadays, Grasspea cultivation is introducing in the char areas of Bangladesh and popularized among the farmers. The grass pea can be grown in drought, rainfed areas where soil is less fertile. It has a very hardy and deep root system, can be grown on a wide range of soil types, including very poor soil and heavy clays. Besides, grass pea is also resistant to many diseases and insects including storage pest compared to other legumes.

Participatory Varietal Selection is a method of selection where the farmers involved in the selection process and the trial must be grown in the farmers' field. In this selection process, the farmers would get a chance to select the best materials for the cultivation in their own region. It is the latest selection process to identify the best material with the direct involvement of the farmers for the specific area or region.

Materials and Methods

The trial was conducted at charland of Saghata, Gaibnadha during 2021-22. The trial was conducted with nine promising grasspea genotypes,viz., E2 (114509), E3 (116610), E4 (116820), E5 (114585), E6 (66054), E7 (114505), E8 (116755), E9 (11506) and E10 (11690) with two checks i.e., E1 (BARI Khesari-3) and E11 (BARI Khesari-5). The trial was laid out in RCB design with three dispersed replications. The spacing was 50 cm rowx 10 cm spacing. Seeds were sown on 22 November 2021. Plants were thinned at 15-20 days after sowing (DAS). Each plot was fertilized with N, P, K, S fertilizers @ 20, 40, 20, 10 kg ha^{-1}. All the fertilizers were applied during the final land preparation. Single weeding was done at 25-30 DAS. Three times spay with Karate 55 EC@ 2ml/L was made at 7 days intervals as precautionary measures for controlling insects like leaf feeders, thrips, hairy caterpillars. Harvesting was done on 31 March 2022. Data on different parameters were recorded. The data were analyzed using STAR software by LSD (0.05) test .

Results and Discussion

Morphological, yield, and yield contributing characters are presented in Table 1 and Table 2. There was a significant effect on plant height, no. of pods plant^{-1}, 100 -seed weight and seed yield among the different entries. The maximum seed yield (1.56 t ha^{-1}) was produced by E7 (114505), followed by E9 (1.53 t ha^{-1}), E6 (1.51 t ha^{-1}), E1 (1.49 t ha^{-1}), and E11 (1.46 t ha^{-1}) whereas the lowest seed yield (1.26 t ha^{-1}) from E3 (116610). The entries of E7 (114505), E9 (11506) and E6 (66054) produced a good yield mainly due to highest number of pods plant^{-1} (33-37) as well as 100-seed weight (g) with a value of 5.00-5.13 g.

Farmers' opinion: Considering the performances of the genotypes regarding yield, farmers preferred E7 (114505), E9 (11506) and E6 (66054) genotypes for charland in Gaibandha.

Table 1. Crop performances of eight Grasspea advance lines with two checks in char areas of Gaibandha during 2021-22

Treatment	Initial plant population m^{-2}	Final plant population m^{-2}	Days to 50% flowering	Days to maturity
E1 (BARI Khesari-3)	40	22	70	125
E2 (114509)	39	21	70	122
E3 (116610)	39	22	74	125
E4 (116820)	40	23	73	120
E5 (114585)	38	22	70	120
E6 (66054)	38	21	70	125
E7 (114505)	39	22	70	124
E8 (116755)	40	21	68	122
E9 (11506)	40	22	71	125
E10 (11690)	41	20	74	122
E11 (BARI Khesari-5)	40	22	71	123
$LSD_{0.05}$	ns	ns	ns	ns
CV (%)	3.67	5.15	4.98	3.74

Table 2. See yield and yield contributing parameters of eight Grasspea advance lines with two checks in char areas of Gaibandha during 2021-22

Treatment	Plant height (cm)	Pod plant^{-1}	100 seed wt. (g)	Seed yield (t ha^{-1})
E1 (BARI Khesari-3)	62.4 g	36ab	4.97 a	1.49 ab
E2 (114509)	74.4 bc	34 abc	4.50 ab	1.40 bcd
E3 (116610)	64.5 g	31 c	3.80 c	1.26 e
E4 (116820)	67.7 e	32 bc	4.00 bc	1.31 de
E5 (114585)	74.8 b	31 c	4.00 bc	1.41 bcd
E6 (66054)	71.9 cd	34 abc	5.00 a	1.51 ab
E7 (114505)	69.5 de	37 a	5.13 a	1.56 a
E8 (116755)	65.0 fg	34 abc	4.00 bc	1.31 de
E9 (11506)	67.2 ef	33 abc	5.10 a	1.53 a
E10 (11690)	70.8 d	30 c	4.50 ab	1.36 cde
E11 (BARI Khesari-5)	77.9 a	34 abc	4.93 a	1.46 abc
$LSD_{0.05}$	2.59	4.49	0.66	0.12
CV (%)	4.26	4.58	4.93	5.97

Conclusion

Considering the overall performance, The genotypes: E7 (114505), E9 (11506) and E6 (66054) was found promising but close to check varieties. However, the experiment needs further trial for final recommendation.

ADAPTIVE TRIAL OF DIFFERENT GENOTYPES OF COWPEA IN COASTAL AREA

M.S. ISLAM, M. ISLAM AND K.N. ISLAM

Abstract

The experiment was conducted at Keoyabunia, Amtoli, Borguna during Rabi season of 2021-22 to evaluate the performance of cowpea genotypes in coastal area. Two cowpea genotype/variety viz. BARI Felon-1 and Local Felon (Bhola) were evaluated as planting materials . BARI Felon-1 gave the better performance in respect of all growth and yield parameters. Higher seed yield (1.72 t ha^{-1}) was obtained from var. BARI Felon-1 whereas lower seed yield value (1.08 t ha^{-1}) by var. Local Felon (Bhola). The maximum gross return (Tk. 86000 ha^{-1}) was obtained from BARI Felon-1 as well as gross margin (Tk. 41625 ha^{-1}) and BCR (1.94) from same variety. Lower economic return was recorded from Local Felon (Bhola) (Tk. 64800 ha^{-1}) and BCR (1.46). On basis of these findings, cowpea var. BARI Felon-1 was the most productive variety under the coastal area.

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp] belongs to the family Fabaceae which is one of the oldest crops known to man. It was domesticated from a wild plant to a cultivated plant (Ng and Marechal, 1985). Its grain and fresh leaves are important sources of protein, minerals and vitamins, and thus helps to address malnutrition (Nielsen *et al.*, 1997; Santos *et al.*, 2012). Additionally, it fixes atmosphere nitrogen through symbiosis with nodule bacteria (Shiringani and Shimeles, 2011). It is often referred to as the poor man's meat because it is a significant source of protein, minerals and vitamins (Tharanathan and Mahadevamma, 2003) for the rural poor who have limited access to protein from animal sources such as meat and fish. It is also known as 'vegetable meat' (Singh and Mehndiratta, 1970). This crop is a highly resilient crop and can be cultivated under some of the most extreme agricultural conditions in the world (Muoneke *et al*., 2012). Farmers commonly grow cowpea by one ploughing and scarcely use fertilizer due to its low yield and lack of proper information. Thus, the yield becomes low. With this background the present study was conducted to determine and compare the physical properties of new cowpea genotype against BARI Felon-1. Therefore, this trial was carried out to evaluate the performance of cowpea genotypes and to increase yield in coastal area.

Materials and Methods

Adaptive trial program with two varieties e.g., BARI Felon-1 and Local variety (Bhola) were conducted at Keoyabunia, Amtoli, Borguna in coastal area during rabi season of 2021-22. The seeds of variety @ 50 kg ha^{-1} were used having unit plot size 10 m x 10 m. Seeds were sown on 28 January, 2022 in line 30 cm apart. The land was fertilized with $N_{13.82}$, P_9 and K_{15} kg ha^{-1} at the time of final land preparation. Weeding was done at 25 days after sowing followed by thinning to keep plant to plant distance of 10 cm. Other intercultural operations were done as and when necessary to ensure normal growth and development of crops. Plant protection measures were taken as required. In addition, Imitaf and Coragen was sprayed @ 0.5 ml L^{-1} to control insect pests such thrips and pod borers, respectively. . Seed yield was recorded at 10-12% moisture content. The yield and other relevant data were recorded.

Results and Discussion

The performance of two varieties of cowpea in terms of plant height, number of branches per plant, number of leaves per plant and yield and yield components are presented in Table 1 and 2, respectively. Lower days to maturity (103 days) was found in Local Felon (Bhola) and maximum (115 days) in BARI Felon-1. Among the two varieties, higher seed yield was recorded from BARI Felon-1 (1.72 t ha^{-1}) and lower yield 1.80 t ha^{-1} was found in Local Felon (Bhola). Therefore, out of two varieties, BARI Felon-1 performed better on the basis of yield and yield contributing characters than Local var. Felon (Bhola).

Economic analysis is presented in Table 2. The maximum gross return (Tk. 86000 ha^{-1}), gross margin (Tk. 41625 ha^{-1}) and BCR (1.94) was recorded from BARI Felon-1 whereas the minimum from Local Felon (Bhola) (Tk. 68900 ha^{-1}) and BCR (1.46).

Farmers' opinion

Farmers are very interested in producing cowpea var. BARI Felon-1 in coastal area in terms of yield and economic return and they were happy to see the performance of cowpea varieties.

Table 1: Growth and phenological parameter of cowpea varieties during Rabi 2021-22

Varieties	Days to maturity	Plant height (cm)	Number of branches/plants	Number of leaves/plants	Number of pods/plants	Number of seeds/pod	1000-seed weight (g)
BARI Felon-1	115	23.93	2.8	27.6	11.93	13.8	100
Local Felon (Bhola)	103	20.33	2	19.07	9.13	10.1	120

Table 2. Seed yield and economic return as influenced by sowing date during Rabi 2021-2**2**

Varieties	Seed Yield (t ha^{-1})	Gross return (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
BARI Felon-1	1.72	86000	44375	41625	1.94
Local Felon (Bhola)	1.08	64800	44375	20425	1.46

Conclusion

From the studies, it can be concluded that the cowpea var. BARI Felon-1 out yielded the local variety in farmer's field condition. This variety appears to be well adapted to the agro-ecological conditions of the coastal area of Bangladesh.

Oilseed Crops

ON FARM TRIAL OF ADVANCED LINES OF RAPESEED

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Abstract

An adaptive trial was conducted in the farmer's field of Pabna, Tangail and Mymensingh during the Rabi season of 2021-22 with a view to evaluate the yield performance of some advanced lines of short duration mustard which could fit in the existing cropping pattern. The experiment was laid out in RCB design with three replications. In Pabna areas, three lines viz. BC-100614(3)-1, BC-100614(8)-4 and BC-100614(4)-7 along with BARI Sarisha-14 as check were evaluated in this study. Among the tested lines BC-100614(4)-7 exhibited significantly higher seed yield (1.22 t ha^{-1}) while the lowest seed yield (1.01 t ha^{-1}) in BARI Sarisha-14. Regarding economic benefit, higher gross return (Tk. 125280 ha^{-1}) and gross margin (Tk. 66550 ha^{-1}) was also attained from BC-100614(4)-7. In Tangail regions, three advanced lines viz. BC-100614(3)-1, BC-100614(4)-7, BC-100614(8)-4, with one variety as check viz. BARI Sarisha-14. The maximum seed yield was obtained in BC-100614(8)-4 (1.43 t ha^{-1}) followed by BC-100614(4)-7 (1.41 t ha^{-1}), and BARI Sarisha-14 (1.40 t ha^{-1}) whereas lowest seed yield in BC-100614(3)-1 (1.37 t ha^{-1}). The highest stover yield (2.72 t ha^{-1}) was also observed from BC-100614(8)-4 and the lowest from BC-100614(4)-7 (2.52 t ha^{-1}). The highest gross return and gross margin (Tk.109970 ha^{-1} and Tk.62650 ha^{-1}) were obtained from BC-100614(8)-4 and the lowest gross return and gross margin (Tk. 105280 ha^{-1} and Tk. 57960 ha^{-1}) from BC-100614(3)-1. On the contrary, in Mymensingh areas, the advanced lines those were used in this trial are BC-100614(3)-1, BC-100614(8)-4, BC-100614(4)-7 and a check variety as BARI Sarisha-14. The highest seed yield (2050 kg ha^{-1}) was obtained from BC-100614(4)-7(which was statistically similar with BC-100614(8)- 4 (1925 kg ha^{-1}). The lowest seed yield was obtained from BARI Sarisha-14 (1600 kg ha^{-1}) followed by BC-100614(3)-1 (1675 kg ha^{-1}). The economic performance of four treatments showed that the highest gross return (Tk.164000 ha^{-1}) and gross margin (Tk.119650 ha^{-1}) was recorded from BC-100614(4)-7.

Introduction

Edible oil plays a key role as a source of high energy component of food in human nutrition. Bangladesh is facing acute shortage of edible oil for several decades. A huge amount of edible oil is imported annually from foreign countries to meet up the national demand. Rapeseed and Mustard are the major oilseed crop of Bangladesh on the basis of its total cultivated area and production. The area under mustard cultivation during 2020-21 was 329 thousand hectares with the production of 396 thousand metric tons (BBS, 2020). The average yield of mustard in our country is very low (1200 kg ha^{-1}) compared to world context. The major reasons for low yield of mustard in Bangladesh are lack of high yielding variety, appropriate population density and inadequate knowledge of sowing time, sowing methods and proper management practices (Mamun *et al.,* 2014). Besides, genetically low yield potential of local varieties grown from farmers own sources, susceptible to disease and insect to the cultivar and low soil moisture due to insufficient precipitation when the crops are grown under rain-fed conditions. The per cent per capita oil consumption is only 10 g day^{-1}, when total need is 22 g day^{-1} (Wahab *et al*., 2002) and the mustard production can only meet 33% of national demand. There is a great scope of increasing yield of mustard by selecting high yielding varieties and improving management practices (Bhuiyan *et al.,* 2008). Farmers' mostly grow the traditional variety Tori-7 for short duration with minimum input and low yield with an average 750 kg ha^{-1} from the long past. This variety is advantageous to grow as catch crop between T.aman and Boro rice with minimum input use and tillage practices. On the contrary, BARI has developed a number of mustard and rapeseed varieties with high yield potentials suitable for cultivation in between T.aman and Boro rice with improved package of management practices. The short duration yellow seeded variety, BARI Sarisha-14 and BARI Sarisha-15 having yield capacity of 1.50-1.65 t ha^{-1} with 2-3% increased oil content than Tori-7 that can easily be grown in the T.*aman*-Mustard-*Boro* cropping pattern. Hence, the present study was undertaken to see the performance of the tested lines and variety at farmers' field as well as to develop a high yielding rapeseed variety.

Materials and Methods

The experiment was conducted in the farmer's field of FSRD site, Ganggarampur, Pabna, Atia, Tangail, Karli, Challisha under Netrokona district (AEZ-9) during the rabi season of 2021-22 with a view to evaluate the yield performance of some advanced lines of short duration mustard which could fit in the existing cropping pattern. Three lines viz. BC-100614(3)-1, BC-100614(8)-4 and BC-100614(4)-7 along with BARI Sarisha-14 as check were selected for the trial. The experiment was laid out in RCB design with four dispersed replications having a unit plot size 4m x 3m. The seeds of the tested lines and variety was sown on November 24, 2021. The land was fertilized with 120-34-45-29-1.8-1.2 kg ha^{-1} N-P-K-S-Zn-B respectively. Half of N and the entire amount of P, K, S, Zn and B were applied as basal during final land preparation. Remaining half of N was applied as top dress at the time of flower initiation stage on 16 December, 2021 followed by an irrigation. Weeding was done on 16 December, 2021 to control dry land weeds. Insecticide (Impel 20 SL) was applied two times on 20 and 30 January, 2022 to control Aphid infestation. Fungicide Rovral 50 WP was applied on 10 and 25 January and 10 February, 2022 to control *Alternaria* leaf spot disease. The harvesting of crops was started on 21 February and continued up to 26 February, 2022. In Tangail, Seeds were sown on 24 November 2021 and pods harvested 6 to 18 February, 2022. Necessary measures were taken for controlling the pest. Cost and return analysis of different lines and variety were computed on the basis of the prevailing market price.

In Mymensingh, the seeds were sown on 09 November, 2021 and seed rate was 8 kg ha^{-1}. Each unit plot was uniformly fertilized at the rate of 260, 170, 90, 160, 5 and 10 kg ha^{-1} of Urea, TSP, MoP, Gypsum, Zinc-oxide and Boric acid, respectively. Entire fertilizers and half of urea were applied as basal during final land preparation. The rest urea was top dressed just before flowering. The spacing was maintained as line to line 30 cm and plant to plant 4-5 cm after thinning out at 22 days after sowing. To prevent as well as to control the crops from Alternaria leaf spot disease, fungicide Rovral @ 0.2% was sprayed twice at 10 days' interval from 45 DAS. To collect the data on yield and yield component, 10 plants were randomly selected from each plot prior to harvest. The lines BC-100614(3)-1 and BARI Sarisha-14 were harvested on 26 January, 2022, line BC-100614(8)-4 was harvested on 29 January, 2022 and line BC-100614(4)-7 was harvested on 30 January, 2022, respectively. All the relevant data were recorded carefully and analyzed statistically with CropStat analytical package.

Results and Discussion

Pabna: Data on yield contributing characters and yield are presented in Table-1. Yield, thousand seed weight and days to maturity varied significantly among the tested lines/variety but other parameters were found non-significant. The advanced line BC-100614(8)-4 and BC-100614(4)-7 demonstrated maximum days for attaining its maturity whereas BARI Sarisha-14 showed minimum days for maturity. Maximum weight of 1000 seeds (3.28 g) were found in BARI Sarisha-14 which is statistically similar with BC-100614(4)-7. The minimum weight of 1000 seeds (3.08 g) were recorded in BC-100614(8)-4 which is identical to BC-100614(3)-1. The maximum seed yield (1.22 t ha^{-1}) was obtained from BC-100614(4)-7 which is statistically similar to BC-100614(8)-4 and followed by BC-100614(3)-1. However, the lowest seed yield (1.01 t ha^{-1}) was recorded in BARI Sarisha-14. The yield of mustard is low due to the rainfall occurred for "Jawad" during the growing period. The tested lines of mustard did not exert significant influence on stover yield. Cost and return analysis are presented in Table 2. Regarding economic benefit, maximum gross return (Tk. 121500 ha^{-1}) and gross margin (Tk. 66550 ha^{-1}) was obtained from BC-100614(4)-7 which was followed by BC-100614(8)-4. However, minimum gross return (Tk. 100500 ha^{-1}) and gross margin (Tk. 44980 ha^{-1}) was noted in BARI Sarisha-14 (Table 1 & 2).

Tangail: Yield and yield contributing characters were not varied significantly among pod length, the number of effective pods plant^{-1}, 1000 seed weight, grain yield, and stover yield (Table 1). The shortest days to maturity were observed in BARI Sarisha-14 (76 days) followed by BC-100614 (4)-7 (77 days) and the longest in BC-100614(8)-4 (84 days). The longest plant was BC-100614(8)-4 (104 cm) while the shortest plant in BARI Sarisha-14 (83.00 cm). The maximum effective pods plant^{-1} was found in BARI Sarisha-14 (24.96) followed by BC-100614(8)-4 (24.29) and BC-100614(3)-1 (24.21). The highest thousand grain weight was found in BC-100614(8)-4 (3.30 g) and the lowest in BARI Sarisha-14 (3.17 g). The highest seed yield (1.43 t ha^{-1}) was observed in BC-100614(8)-4 which may be contributed by the highest effective pod plant^{-1} (24.29) and 1000- seed weight (3.37 g). The maximum seed yield was observed in BC-100614(8)-4 (1.43 t ha^{-1}) followed by BC-100614(4)-7 (1.41 t ha^{-1}), BARI Sarisha-14 (1.40 t ha^{-1}) whereas the lowest seed yield in BC-100614(3)-1 (1.37 t ha^{-1}). In addition, the highest stover yield (2.72 t ha^{-1}) was also observed from BC-100614(8)-4 and the lowest from BC-100614(4)-7. The highest gross return and gross margin (Tk.109970 ha^{-1} and Tk.61650 ha^{-1}) were obtained from BC-100614(8)-4 and the lowest gross return and gross margin (Tk. 105280 ha^{-1} and Tk. 57960 ha^{-1}) from BC-100614(3)-1 (Table 1 & 2).

Mymensingh: The yield and yield attributes of tested materials were differed significantly except siliqua per plant and 1000- seed weight (Table 1). The highest maturity showed by the line BC-100614(4)-7 (82 days) which was followed by BC-100614(8)-4 (81 days) and shortest by BARI Sarisha-14 (78 days). The maximum plant height was obtained from the line BC-100614(4)-7 (124 cm) which was followed by BC-100614(8)-4 (117 cm) and BC-100614(3)-1 (114 cm) whereas the shortest from BARI Sarisha-14 (101 cm). Higher number of branch was found from line the line BC-100614(4)-7 (4.72) which was followed by BC-100614(8)-4 (3.95) and BC-100614(3)-1 (3.10) while the lowest in BARI Sarisha-14 (2.90). The Maximum siliqua per plant was in 100614(4)-7 (108.1) followed by BARI Sarisha-14 (91.25) and BC-100614(8)-4 (89.1) while lowest from BC-100614(3)-1 (87.53). The line BC-100614(4)-7 was produced the highest seeds per siliqua (33.27) followed by BC-100614(8)-4 (31.95) . The the lowest number of seeds per siliqua was obtained from BC-100614(3)-1(28.07) which was statistically similar with BARI Sarisha-14 (28.15). The 1000- seed weight were not differed significantlyThe maximum seed yield was recorded from BC-100614(4)-7(2050 kg ha^{-1}) which was statistically similar with BC-100614(8)-4 (1925 kg ha^{-1}) and the lowest seed yield was obtained from BARI Sarisha-14 (1600 kg ha^{-1}) followed by BC-100614(3)-1 (1675 kg ha^{-1}). Branch per plant, siliqua per plant, seed per siliqua per and 1000 -grain weight might be contributed on yield (Table 1 & 2).

Cost and return analysis

Economic return differed significantly over the locations due to yield variation and prevailing market price of produce (Table 2). Higher gross margin was obtained from BARI developed Mustard varieties than local varieties grown by the farmers in the tested locations.

Disease and pest incidence: Rovral 50 WP @ .02% was applied to control Alternaria blight. For controlling aphids, Impel 20 SL @ 0.02% were used.

Farmer's opinion

Farmers of Pabna expressed their satisfaction to see higher yield performance of the tested lines: BC-100614(4)-7 over BARI Sarisha-14. They also preferred the lines BC-100614(3)-1, BC-100614(8)-4 because of short life cycle as BARI Sarisha-14.

Farmers' of Tangail opined that the grain size and price are much higher than local mustard cultivars grain. Farmers showed their interest to cultivate BC-100614(8)-4 for better yield performance.Farmers' of Mymensingh are happy with advanced lines and variety due to higher yield potentiality and short duration to be fitted in Mustard-*Boro*-T.*aman* cropping pattern. They showed their keen interest in growing BC-100614(4)-7 and BC-100614(8)-4 for its higher seed (yield potentiality and economic return.

Table 1. Yield and yield contributing characters of mustard lines and variety at Pabna, Tangail and Mymensingh during the Rabi season of 2021-22.

Lines/varieties	Days to maturity	Plant height (cm)	Siliqua $plant^{-1}$	Seeds $siliqua^{-1}$	1000 seed wt. (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Pabna							
BC-100614(3)-1	90 b	85.5	31.3	31.4	3.13 b	1.11 b	1.69
BC-100614(8)-4	92 a	87.8	31.7	31.1	3.08 b	1.15 ab	1.82
BC-100614(4)-7	91 a	86.7	33.2	32.0	3.15 ab	1.22 a	1.89
BARI Sarisha-14	88 c	84.9	30.2	31.0	3.28 a	1.01 c	1.61
CV (%)	3.87	4.02	10.8	8.86	2.90	4.76	11.6
LSD $_{(0.05)}$	1.26	5.55	5.45	4.45	0.15	0.09	0.32
Tangail							
BC-100614(3)-1	77	97.33	24.21	24.72	3.27	1.37	2.53
BC-100614(8)-4	84	104.00	24.29	23.63	3.30	1.43	2.72
BC-100614(4)-7	77.33	86	24.17	24.62	3.20	1.41	2.52
BARI Sarisha-14	75.67	83	24.96	23.99	3.17	1.40	2.61
CV (%)	2.90	7.20	3.80	1.70	3.10	5.60	9.30
LSD $_{(0.05)}$	4.46	13.33	1.85	0.83	0.20	-	-
Mymensingh							
BC-100614(3)-1	78	114	87.53	28.07	3.48	1.68	0.98
BC-100614(8)-4	81	117	89.1	31.95	3.45	1.93	1.10
BC-100614(4)-7	82	124	108.1	33.27	3.55	2.05	1.25
BARI Sarisha-14	78	101	91.25	28.15	3.35	1.60	0.90
CV (%)	6.28	7.48	0.30	10.68	5.91	12.81	2.67
LSD $_{(0.05)}$	2.83	13.67	0.65	-	2.87	-	3.54

Means with the same letter are not significantly different.

Table 2. Cost and return analysis of different Mustard varieties at different locations during the year of 2021-22.

Location	Variety	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Pabna	BC-100614(3)-1	113885	58730	55155
	BC-100614(8)-4	118635		59905
	BC-100614(4)-7	125280		66550
	BARI Sarisha-14	103710		44980
Tangail	BC-100614(3)-1	105280	47320	57960
	BC-100614(4)-7	108270		60950
	BC-100614(8)-4	109970		62650
	BARI Sarisha-14	107610		60290
Mymensingh	BC-100614(3)-1	134000	44350	89650
	BC-100614(8)-4	154000		109650
	BC-100614(4)-7	164000		119650
	BARI Sarisha-14	128000		83650

Price of input and output: Urea: 20.00 Tk. kg^{-1}, TSP: 25.00 Tk. kg^{-1}, MOP: 22.00 Tk. kg^{-1}, Gypsum: 13.00 Tk. kg^{-1}, Zinc sulphate: 160.00 Tk. kg^{-1}, Boric acid: 240.00 Tk. kg^{-1}, mustard seed: 80.00 Tk. kg^{-1} and Market price of mustard 80 Tk. kg^{-1}

Conclusion

Farmers expressed their satisfaction to see higher yield performance of the tested lines: BC-100614(4)-7 over BARI Sarisha-14. They also preferred the lines BC-100614(3)-1, BC-100614(8)-4 because of short life cycle as BARI Sarisha-14. Therefore, suitable advanced lines and varieties to be extended in the tested locations according to yield performance, field duration and farmers choice.

PERFORMANCE OF SELECTED MUSTARD VARIETIES UNDER SALINITY CONDITION IN COASTAL AREA

M.H. RASHID, K. ISLAM; M.K. SHAHADAT AND M. RAHMAN

Abstract

The experiment was conducted in the farmer's field at MLT site Koyra and Dacope, Khulna during rabi season in 2021-2022 to evaluate the performance of mustard varieties against salinity. Seven mustard varieties viz. BARI Sarisha-11, BARI Sarisha-14, BARI Sarisha-16, BARI Sarisha-18 (canola variety), BAU Sarisha-1 (canola variety), BAU Sarisha-2 and BAU Sarisha-3 were tested under this study. The experiment was laid out in a randomized complete block design with three replications. Dacope site has been omitted because of damaged by heavy rainfall at vegetative stage. However, the results from the Koyra location showed that maximum seed yield was obtained from BARI Sarisha-11 (1.72 t ha^{-1}), which was statistically similar to BARI Sarisha-16 (1.65 t ha^{-1}), and lowest from BARI Sarisha-14 (1.32 t ha^{-1}). Highest stover yield was recorded from BARI Sarisha-16 (3.06 t ha^{-1}) and lowest from BARI Sarisha-14 (2.06 t ha^{-1}), (Table 2). Farmers preferred both BARI Sarisha-11 and 16 for their higher seed and stover yield. But due to longer duration of these varieties they chose mustard var. BARI Sarisha-14.

Keywords: Mustard, salinity, growth, yield, Bangladesh.

Introduction

In Bangladesh, about 1.06 million hectare of the cultivated lands area is affected by varying degrees of salinity. Multiple types of soluble salts are available in saline soils and each of them has different impact on growth of plants. In saline soils, soluble salt compositions differ among the locations. Oilseed Research Centre of BARI has already developed 18 varieties of rapeseed-mustard including one canola variety. From previous results, some of them showed salt tolerant varieties of rapeseed-mustard including one canola variety. The experiment has been undertaken to observe the performance of BARI and BAU developed rapeseed-mustard varieties in saline affected areas of Bangladesh.

Materials and Methods

The trial was conducted at MLT site, Koyra and Dacope of Khulna during *rabi* season 2021-2022. Seven mustard varieties viz. BARI Sarisha-11, BARI Sarisha-14, BARI Sarisha-16, BARI Sarisha-18 (canola variety), BAU Sarisha-1 (canola variety), BAU Sarisha-2 and BAU Sarisha-3 were tested. . A randomized complete block design with three dispersed replication was followed. The unit plot size was 5 m X 5m. Seeds were sown in rows of 30 apart and continuous sowing in rows. After thinning plant to plant distance was maintained around 5 cm. Seeds were sown on 29 November, 2021 at Koyra and 30 November 2021 at Dacope. Fertilizers were applied at the rate of 260-170-90-160-5-10 kg ha^{-1} as urea-TSP-MoP-Gypsum-Zinc Sulphate- Boric acid, respectively. Half urea and all other fertilizer were applied as basal and remaining urea was top dressed at vegetative stage (22 Days after Emergence). All the intercultural operations were done as and when necessary. Salinity data was recorded at 15 days interval during the crop growing period with harvested date. The salinity of experiment field was 2.82-7.85 dS/m (Fig.1). The crop was harvested on 17 February 2022 to 10 March 2022 at Koyra and 17 February 2022 to 15 March 2022 at Dacope. But at Dacope crop performance was damaged by heavy rainfall in January 2022.

Results and Discussion

A significant variation was found the tested varieties with respect to most of the studied parameters except plant population and number of branches per plant (Table 1). Significantly highest plant height was recorded (175.0 cm) from BARI Sarisha-16 and lowest was (108.07 cm) from BARI Sarisha-14.. BARI Sarisha-18 took maximum of 44 days for 50% flowering and BARI Sarisha-14 took only about 30 days to 50% flowering. Similarly, BARI Sarisha-18 took maximum 100 days for maturity while BARI Sarisha-14 about 75 days.

Higher number of siliqua plant^{-1} was found from BAU Sarisha-3 (272.43), which was statistically identical to BARI Sarisha-11 (266.17) followed by BARI Sarisha-18 (240.0), and lowest from BARI Sarisha-14 (107.08). The maximum seed siliqua^{-1} was recorded from BARI Sarisha-18 (23.65), and lower seeds per silique was recorded from BAU Sarisha-2 (15.85) followed by BAU Sarisha-3 (16.14), BAU Sarisha-1 (17.29), BARI Sarisha-16 (16.6) and BARI Sarisha-11 (17.03). The highest 1000 -seed weight was recorded from BARI Sarisha-14 (4.67 g). . The maximum seed yield was obtained from BARI Sarisha-11 (1.72 t ha^{-1}), which was statistically similar to BARI Sarisha-16 (1.65 t ha^{-1}), and lowest from BARI Sarisha-14 (1.32 t ha^{-1}). Highest stover yield was recorded from BARI Sarisha-16 (3.06 t ha^{-1}) and lowest from BARI Sarisha-14 (2.06 t ha^{-1}), (Table 2).

Farmers and the neighbors were encouraged about the yield performance BARI Sarisha-11 and 16. They preferred not only seed yield but also for their stover yield which could be used as fueld wood. However, they were concerned about their longer duration. In that case, they preferred BARI Sarisha-14 for its shorter duration but relatively higher yield than local varieties.

Table 1. Agronomic performance of mustard varieties at Koyra, Khulna during 2021-22

Treatment	Plant Population (m^2)	Plant height (cm)	Branch Plant^{-1} (No.)	Days to 50% flowering	Days to maturity
BARISarisha-11	525.0	160.20 ab	8.9	38 b	93 bc
BARISarisha-14	565.0	108.07 c	6.6	30 c	74 d
BARISarisha-16	528.3	175.00 a	7.8	38 b	93 bc
BARISarisha-18	513.3	145.50 b	7.6	44 a	100 a
BAUSarisha-1	491.7	151.01 b	8.5	37 b	92 c
BAUSarisha-2	520.0	152.57 b	6.4	38 b	94 bc
BAUSarisha-3	501.7	153.75 b	8.1	38 b	95 b
$LSD_{0.05}$	NS	17.99	NS	1.81	2.35
CV(%)	6.44	6.77	19.55	2.72	1.44

Table 2. Yield and yield contribution characters of mustard varieties at Koyra, Khulna during 2021-22

Treatment	Siliqua plant^{-1} (No.)	Seed silique^{-1} (No.)	Thousand seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
BARISarisha-11	266.17 a	17.03 bc	4.00 b	1.72 a	2.82 b
BARISarisha-14	107.08 c	19.47 b	4.67 a	1.32 d	2.06 d
BARISarisha-16	209.13 b	16.60 bc	4.00 b	1.65 ab	3.06 a
BARISarisha-18	240.00 ab	23.65 a	4.00 b	1.60 abc	2.49 c
BAUSarisha-1	203.95 b	17.29 bc	4.33 ab	1.55 bc	2.70 b
BAUSarisha-2	185.31 b	15.85 c	4.00 b	1.57 bc	2.77 b
BAUSarisha-3	272.43 a	16.14 c	4.00 b	1.48 c	2.77 b
$LSD_{0.05}$	54.76	2.98	0.53	0.14	0.17
CV%	14.52	9.29	7.13	4.89	3.63

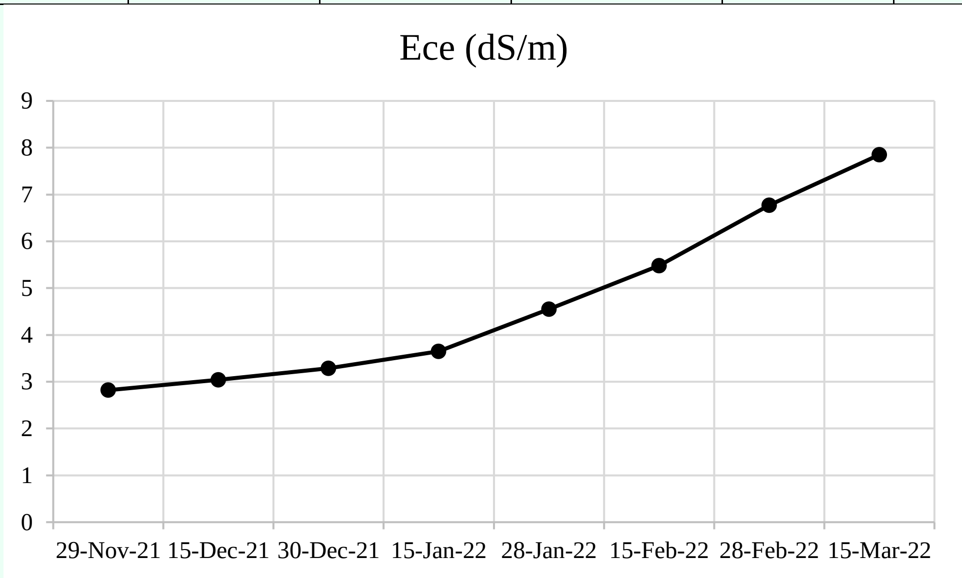

Fig.1. Salinity during crop growing period at Koyra, Khulna

Conclusion

From the study it was revealed that mustar var. BARI Sarisha-11 and 16 produced highest seed yield and stover yield under saline soil of Koyra, Khulna. However, for confirmation of the results the experiment should be repeated in more saline soil of coastal region.

ON-FARM TRIAL OF SOYBEAN VARIETIES UNDER RAINFED CONDITION

G.N. HASAN AND R. HASAN

Abstract

The experimental trail was conducted in the farmer's field at Bhola sadar and Doulatkhan upazilla in Bhola district during Rabi season of 2021-2022 to select suitable soybean variety/varieties for char lands under rainfed condition. Among the tested varieties, the maximum seed yield (1.92 t ha^{-1}) was obtained in BARI Soybean-6 which was statistically identical with BARI Soybean-5 (1.78 t ha^{-1}) while the lowest yield (1.25 t ha^{-1}) in local variety. The highest gross margin was recorded in BARI Soybean-6 (Tk.. 62920 ha^{-1}) followed by BARI Soybean-5 (Tk.. 55220 ha^{-1}) and the lowest gross margin from local (Tk. 26078 ha^{-1}).

Introduction

About 0.82 million hectares of lands are estimated as Char lands in Bangladesh and is highly dynamic as it is disappeared or reappeared due to river erosion or accretion. Cultivated soils of chars are mostly sandy loam to silty loam with slightly acidic to slightly alkaline in reaction and deficient in plant nutrients as well as organic matter content. Generally, topsoils of charland are dried quickly but sub-soils remain wet for longer time. Soybean has a fairly wide range of adaptation involving a wide array of climatic, soil, and growth conditions though it is mostly grown on rain-fed land (Fageria, 1997). Soybean (Glycine max L.) is the most important oil seed crop of the world in terms of its use in human foods and livestock. Farmers of char areas grow soybean after receding flood water. Therefore, present trial was undertaken to select suitable soybean variety for charland under rainfed condition.

Materials and Methods

The experimental trail was conducted in the farmer's field at Bhola sadar and Daulatkhan upazilla in Bhola district during Rabi season of 2021-2022 to select suitable soybean variety/varieties for char lands under rainfed condition. The experiment was laid out in RCB design with five dispersed replications. The soil was sandy clay loam to silty clay loam belonging to Young Meghna Estuarine Flood plain of Bangladesh (AEZ 18). Four (04) soybean varieties namely: BARI Soybean-5, BARI Soybean-6, BARI Soybean-7 and local variety as check were included in the trial. The unit plot size was 8m x 5m. The seeds were sown @ 50 kg ha^{-1} from 25 December, 2021 to 22 January 2022 in line with the spacing of 30 x 5 cm. The crop was fertilized with 25, 25, 55 and 10 kg ha^{-1}of N, P, K and S respectively. Except Urea, all other fertilizers were applied at the final land preparation as basal dose. Urea was applied at two equal splits- once during first weeding 24 DAS and another 45 DAS during second weeding. Different intercultural operations and plant protection measures were taken as and when necessary to raise healthy crops. Harvesting was done from 20 April to 08 May, 2022 Data on different plant, yield and yield contributing characters were recorded. The collected data were analyzed statistically using Crop Stat analytical package.

Results and Discussions

Days to 50 % flowering and maturity were recorded in all varieties (Table 1). BARI Soybean -6 and 5 required 104 and 108 days to mature followed by Local (110 days). The maximum plant height was found in BARI Soybean-6 (56.5 cm) which was statistically identical with BARI Soybean-5. Higher number of branch plant^{-1} was found in BARI Soybean-6 (2.7) followed by BARI Soybean-5 (2.5) and the minimum in local variety (2.2). The maximum number of pods plant^{-1} (44.5) was recorded in BARI Soybean-6 which was statistically similar with BARI Soybean-5 (43.8) while minimum in Local variety (35.8). The maximum number of seeds pod^{-1} (2.3) was recorded in BARI Soybean-6 which was statistically different with BARI Soybean-5 and 7. The maximum 100- seeds weight (11.85 g) was recorded in BARI Soybean-5 which was statistically similar with BARI Soybean-6 (11.76 g). The maximum seed yield (1.92 t ha^{-1}) was obtained in BARI Soybean-6 which was statistically identical with BARI Soybean-5 (1.78 t ha^{-1}) while the lowest yield (1.25 t ha^{-1}) in local variety. In Table 2, the maximum gross margin was recorded in BARI Soybean-6 (TK. 62920 ha^{-1}) followed by BARI Soybean-5 (TK. 55220 ha^{-1}) and the lowest gross margin from local (Tk. 26078 ha^{-1}).

Farmers' Opinion

Soybean var. BARI Soybean-6 is highly accepted by the farmers for its early maturity and higher yield. Sometimes farmers are disabled to collect seeds for the next season when heavy rainfall occurred during maturity stage of soybean.

Table 1. Seed yield and yield contributing characters of Soybean varieties in Bhola district during Rabi season of 2021-2022

Varieties	Plants m^{-2}	Days to 50% flowering	Days to Maturity	Plant height (cm)	Branches $plant^{-1}$	Pods $plant^{-1}$	Seeds pod^{-1}	100- seeds weight (g)	Seed yield (t ha^{-1})
BARI Soybean-5	21.9	58	104	54.0	2.5	43.8	2.1	11.85	1.78
BARI Soybean-6	21.5	57	108	56.5	2.7	44.5	2.3	11.76	1.92
BARI Soybean-7	22.7	56	106	52.6	2.6	38.1	2.0	10.87	1.54
Local	20	59	110	53	2.2	35.8	1.9	10.54	1.25
LSD (0.05)	NS	NS	NS	3.76	NS	3.56	0.32	0.78	0.49
CV (%)	4.43	3.89	6.83	7.42	2.49	6.02	5.91	5.47	6.39

Table 2. Cost and return analysis of soybean varieties in Bhola district during Rabi season of 2021-2022

Varieties	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Soybean-5	97900	42680	55220
BARI Soybean-6	105600		62920
BARI Soybean-7	84700		42020
Local	68750		26078

Price of Soybean per kg = TK. 55.0

Conclusion

Among the BARI released soybean varieties, BARI Soybean-5 and BARI Soybean-6 were much popular at the farmer's level of Bhola. These varieties should be disseminated in larger area including char .

ON FARM TRIAL OF MUSTARD GENOTYPE IN HIGH BARIND TRACT (HBT) AND LEVEL BARIND TRACT

Abstract

A field trial was conducted in the farmer's field at FSRD site, Basantapur, Godagari, Rajshahi under High Baring Tract (HBT) and at MLT site, Joypurhat under Level Barind Tract (LBT) during the Rabi 2021-22 cropping season to assess the performance of mustard genotypes/ variety . In HBT, two lines and one check variety of mustard viz. BJDH-12, JUN-536 and BARI Sharisha-16 were tested . Among the tested genotypes, BJDH-12 gave the maximum seed yield (1.86 t ha^{-1}) followed by var. BARI Sarisha-16 (1.66 t ha^{-1}) while JUN-536 produced the lowest seed yield (1.63 t ha^{-1}). In LBT, three promising mustard genotypes, i.e., BJDH-11, BJDH-12 and Jun-536 and one var. BARI Sarisha-16 was used as check. The maximum seed yield of 2.19 t ha^{-1} was recorded from BARI Sarisha-16, followed by Jun-536 (1.91 t ha^{-1}), BJDH-11 (1.75t ha^{-1}), and the lower seed yield of 1.63 t ha^{-1} from BJDH-12. The highest yield contributed to the highest gross return (Tk. 201780 ha^{-1}) and gross margin (Tk. 156437ha^{-1}) in BARI Sarisha-16, followed by Jun-536, whereas the lowest gross return Tk. 150670 ha^{-1} and gross margin Tk. 105327 ha^{-1} d in BJDH-12.

Introduction

High Barind Tract is different from other parts of the country due to its undulating topography having compact and low fertile soils. The region experienced high temperature with limited soil moisture storage along with low and erratic rainfall (BMDA, 2006). Moisture holding capacity of HBT soil is poor due to critical organic matter contents and low infiltration of water (Adham *et al.,* 2010; Ali, 2000). The area also has acute deficit of fuel wood. Thus, farmers normally used cowdung as a cooking fuel. Boro-T. Aman rice is one of the popular cropping patterns in Rajshahi region. There is a big scope to introduce short or semi-long duration mustard variety between T.

Aman and Boro rice. Farmers mostly used Tori-7 due to its short duration. The old variety give very low seed yield as well as stover. Oilseed Research Centre of BARI has developed some mustard varieties and also have some promising lines those should test their performance in Barind condition. Among the mustard varieties, BARI Sharisha-11 and 16 *(B. juncea type)* are high yielding, long-duration (105-115 days) suitable for late planting where Boro rice cannot be grown to lack of irrigation facilities. *The B. juncea type is more popular, especially in the Barind region, for its* higher yield and fuel purposes. Therefore, the experiment was conducted to screen out high yield potential long-duration mustard genotype capable of giving yield with minimum exploitation of water in level Barind areas of Joypurhat and to evaluate the field performance of some mustard genotypes to fit in Mustard-Boro-T. Aman rice cropping pattern in farmer's field in High Barind Tract.

Materials and Methods

An experiment on mustard genotypes was conducted at farmer's field of FSRD site, Basantapur, Godagari, Rajshahi under High Baring Tract (HBT) and at MLT site, Joypurhat under Level Barind Tract (LBT)during the Rabi 2021-22 cropping season. The experiment was conducted in randomized complete block design with three dispersed replications. The unit plot size was 30 m^2. In HBT, two lines viz. BJDH-12, JUN-536 along with BARI Sharisha-16 (check) were tested . Mustard seed was shown on 03 November 2021. The land was fertilized with 115-35-35-30-1 kg N-P-K-S-B ha^{-1} + CD 05 t ha^{-1} (FRG, 2018). Full doses of cowdung, half of the urea and all other inorganic fertilizers were applied according to individual plot and mixed with soil at the time of final land preparation. The rest urea was top dressed after 1st irrigation. First weeding was done at the time of first thinning and second weeding and thinning were done at 20 days after planting of mustard seeds. The lines/ variety viz. BJDH-12, JUN-536 and var. BARI Sharisha-16 were harvested on 20 February 2022.On the other hand, In LBT, it consisted of four variety/ genotype , i.e., T_1= BARI Sarisha-16, T_2=Jun-536, T_3=. BJDH-11 and T_4= BJDH-12. The unit plot size was 20 m^2. Seeds of each variety/genotype were sown continuously in the field, maintaining a distance of 30 cm from row to row on 30 November, 2021. The fields were fertilized with 120-34-45-30-1.8 kg N-P-K-S-B ha^{-1} respectively. The total amount and half of the urea fertilizers were applied during the final land preparation. The rest half urea was applied as a top dress at 26 DAS, followed by irrigation. Single weeding to control dryland weeds alongwith thinning were done before irrigation to keep the optimum plant population on the field. The fields were infested with aphids and *Alternaria* leaf spots. Insecticide Sobicron and fungicide Rovral 50wp were applied three times at 7 to 10 days, depending on pest incidence. The crops were harvested on 15 March 2022. Data were collected on different yield and yield components and analyzed statistically with open-source software R (R Core Team, 2019).

Results and Discussion

High Barind Tract: The yield and yield attributes of mustard genotypes were presented in Table 1. The maximum days to maturity were found in line BJDH-12 (108 days) ; and minimum and similar days were required for BARI Sharisha-16 (106 days) and JUN-536 (107 days). The maximum plant height was found in line JUN-536 (180.27 cm) and minimum in BJDH-12 (165.80 cm). The maximum siliqua plant^{-1} (183.73), seeds siliqua^{-1} (13.53), 1000-seed weight (3.34 g) and seed yield (1.86 t ha^{-1}) were found in line BJDH-12 . The lowest number of siliqua plant^{-1} (151.03) and seeds siliqua^{-1} (11.80) were recorded from line JUN-536 . The seed yields of mustard genotypes were identical for BARI Sarisaha-16 (1.66 t ha^{-1}) and JUN-536 (1.63 t ha^{-1}). The maximum straw yield was found in BARI Sharisha-16 (4.85 t ha^{-1}) and minimum in JUN-536 (3.88 t ha^{-1}). It was found that BJDH-12 mustard line gave better performance in the farmer's field.

Level Barind Tract: From table 1, it has been shown that all the plant and yield contributing characters varied significantly among the treatments. The maximum plant height (168.07cm) was observed in BARI Sarisha-16 followed by BJDH-12 (161.47 cm), BJDH-11 (16140 cm), and the lowest in Jun-536 (151.60 cm). Higher branch/plant (4.26) was recorded from BARI Sarisha-16 followed by Jun-536 (3.63), and the lowest in BJDH-11 (3.20) followed by BJDH-12 (3.23).

The plants m- was non-significant among the treatments, ranging from 91 to 95 [2]. The maximum nos. of siliqua plant^{-1} were obtained from BARI Sarisha-16 (52.40) while the lowest in BJDH-12 (39.33) followed by line Jun-536 and BJDH-11. The highest seeds siliqua^{-1}were also found in BARI Sarisha-16 (12.83) and the lowest from BJDH-11 (8.87). The maximum 1000- seeds weight was obtained from BARI Sarisha-16 (4.40 g), and the minimum in BJDH-11 (3.40 g), followed by f BJDH-12 (3.50 g) and Jun-536 (3.43 g). The maximum seed yield was observed in BARI Sarisha-16 (2.19 t ha^{-1}) followed by Jun-536 (1.91 t ha^{-1}), and the minimum from BJDH-12 (1.63 t ha^{-1}). Higher yield contributing characters viz., siliqua plant^{-1}, seeds siliqua^{-1}, and thousand seed weight resulted in higher seed yield in BARI Sarisha-16. The maximum stover yield was found from BARI Sarisha-16 (3.02 t ha^{-1}) followed by Jun-536 (2.92 t ha^{-1}), and the lowest in BJDH-12 (2.41 t ha^{-1}).

Cost and return analysis from table 2 indicated the highest gross return (Tk. 201780 ha^{-1}) was obtained from BARI Sarisha-16, followed by Jun-536 (Tk. 176840 ha^{-1}), BJDH-11 (Tk. 162160 ha^{-1}), and the lowest gross return, Tk. 150670 ha^{-1} was from line BJDH-12. Higher gross return contributed to the higher gross margin in mustard var. BARI Sarisha-16 (Tk. 156437 ha^{-1}) and lower in BJDH-12 (Tk. 105327 ha^{-1}) against the cultivation cost Tk. 45343 ha^{-1}(Table 1 & 2).

Farmer's reaction

Farmers of HBT were happy to get higher yield from the line BJDH-12 while pest attack was lowest . However, farmers of Level Barind Tract were happy to get higher yield both from the mustard var. BARI Sharisha-16 and line Jun-536. Pest attack was lowest in that line also.

Table 1. Yield and yield attributes of Mustard genotypes at High Barind Tract and Level Barind Tract during Rabi 2021-22.

Variety/ line	Days to flower	Days to maturity	Plant height (cm)	Plant m^{-2}	Siliqua plant^{-1}	Seeds Siliqua^{-1}	1000 Grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
High Barind Tract									
BARI Sharisha-16	37	106	172.93b	63.00	159.40	13.00	3.32a	1.66b	4.85 c
BJDH-12	36	108	165.80c	65.67	183.73	13.53	3.34a	1.86a	4.01a
JUN-536	37	107	180.27a	69.00	151.02	11.80	3.17b	1.63b	3.88b
CV (%)	1.11	1.42	1.57	6.09	10.34	6.38	0.37	1.13	0.36
Level Barind Tract									
T_1= BARI Sarisha-16			168.07 a	90.86	52.40 a	12.83a	4.40a	2.19 a	3.02 a
T_2=Jun-536			151.60 b	92.83	43.93 b	11.03 b	3.43 b	1.91 b	2.92 b
T_3= BJDH-11			16140 b	95.40	43.53 b	8.87 d	3.40 b	1.75 c	2.72 c
T_4= BJDH-12			161.47 b	93.97	39.33 b	10.00 c	3.50 b	1.63 c	2.41 d
CV (%)			4.57	NS	6.95	3.40	2.57	4.56	5.69

Table 2. Cost and return analysis of different mustard genotypes obtained from experimentation conducted during the Rabi season, 2021-22 at MLT site, Joypurhat (Level Barind Tract)

Variety/ line	Total return (Tk ha^{-1})			Total cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})
	Grain	Straw	Total		
T_1= BARI Sarisha-16	192720	9060	201780	45343	156437
T_2=Jun-536	168080	8760	176840	45343	131497
T_3= BJDH-11	154000	8160	162160	45343	116817
T_4= BJDH-12	143440	7230	150670	45343	105327

*Grain= 88.0 Tk kg^{-1} *Straw= 3.0 Tk kg^{-1}

Conclusion

The performance of mustard line BJDH-12 was better than other BARI mustard genotypes tested at Basantapur, Godagari, Rajshahi . In Level Barind Tract, it can be concluded that the tested mustard var. BARI Sarisha-16 and line Jun-536 were higher yielders than BJDH-11 and BJDH-12.

ON FARM TRIAL INTERCROPPING OF CHILI WITH GROUNDNUT IN HAOR AREAS

M.I. NAZRUL AND M. AKHTAR HOSSAIN

Abstract

A field experiment was conducted at farmer's field during winter 2021-22 under MLT site, Moulvibazar. Three intercrop combinations such as T_1 = Groundnut sole, T_2 = Groundnut (100%) + 1 row of chilli at 40 cm spacing and T_3 = Groundnut + 1 row of chilli at 60 cm spacing were considered. The variety BARI Chinabadamm-8 and locally populay chilli cultivar was used in this trial. The experiment was setup in randomized complete block design with three dispersed replications. The highest groundnut pod yield (2.62 t ha^{-1}) was observed in T_2 (groundnut+ 1 row chilli at 40 cm spacing). On the contrary, in intercrop situation the pod yields of chilli 6.48 and 5.97 t ha^{-1} were obtained in T_2 (groundnut+ 1 row of chilli at 40 cm spacing) and T_3 (groundnut + 1 row of chilli at 60 cm spacing), respectively. The highest groundnut equivalent yield (10.84 t ha^{-1}) was also recorded in T_2 (groundnut+ 1 row of chilli at 40 cm spacing) with gross return of Tk. 650400 ha^{-1} and gross margin of Tk. 509500 ha^{-1}, respectively. Finally, T_3 combination (groundnut + 1 row of chilli at 60 cm spacing) provided higher BCR (4.95) compared to that of T_2 (groundnut+ 1 row of chilli at 40 cm spacing) and sole ground nut.

Introduction

Haors with their unique hydro-ecological characteristics are large bowl-shaped floodplain depressions located in the north-eastern region of Bangladesh covering about 1.99 million ha of area and accommodating about 19.37 million people. Total 373 haors cover an area of about 858,000 ha which is around 43% of the total area of the haor region. Agriculture and fisheries are the main base of the diversified economic resources of the area. A total of about 0.71 million ha of net cultivable land is available in this area, which produces more than 5.25 million tons of paddy each year. However, sudden intrusion of flash flood may destroy agricultural production from about 0.33million ha, worth Tk. 3,486 million or 3% of the national agricultural contribution to the GDP (UNDP, 2012). Agriculture is the principal livelihood of the farmers who practice mono-agriculture. This single crop remains under the constant threat of partial to complete damage from the early onrush of flash floods. Such a situation intercropping might be an option to minimize the sudden loss of farmers doing monoculture. Groundnut (*Arachis hypogaea* L.) is the second important oilseed crop that covered a considerable area in Bangladesh, and it is a long durated crop. On the other hand, chili is a very important and valuable spices crop which is usually grown as sole and in some cases as intercrop in farmer's field in various parts of Bangladesh. As the spacing for groundnut cultivation is 40 cm X 15 cm, so there is a scope to intercrop chili with groundnut. This might be economically beneficial for the farmers. Hence this experiment was undertaken to find out the optimum row arrangement of chili for intercropping with groundnut for higher productivity and return.

Materials and Methods

The experiment was conducted at MLT site, Moulvibazer during the year 2021-22. Three intercrop combinations, $T_{1:}$ Groundnut sole, $T_{2:}$ Groundnut (100%) + 1 row of chilli at 40 cm spacing and $T_{3:}$ Groundnut + 1 row of chilli at 60 cm spacing were considered. The groun nut variety BARI Chinabadamm-8 and local chilli was used . The experiment was set up in randomized complete block design with three dispersed replications. The seed of groundnut were sown with maintaining the spacing of 40 cm × 15 cm. The crop was fertilized as per fertilizer recommendation guide (FRG, 2018). The seeds and seedlings of groundnut and chilli were sown and transplanted on 5-9 December, 2021. Intercultural operations were done as and when necessary. There was no remarkable disease and pest attack. The chilli harvest duration was 15 February to 20 April 2022 and groundnut was harvested during 10-15 May, 2022. Data on yield components were collected from 10 plants selected at random in each plot and seed yield was recorded plot wise. The collected data were analyzed statistically using "STAR" software package and means were separated by LSD test.

Results and Discussion

Nut Yield and yield attributes of groundnut: There was not statistically difference in seeds per pod and shelling per cent of groundnut during intercropping.Numerically higher pods plant^{-1} (41.50). and seeds pod^{-1} (2.66) was recorded in sole ground nut and lowest (2.00) in T_3 (groundnut + 1 row of chilli) at 60 cm spacing. The sole groundnut cultivation practice also provided the highest 100- kernel weight (48.40 g) with highest pod yield (2.92 t ha^{-1}) followed by T_2 (groundnut+ 1 row chilli at 40 cm spacing). On the contrary, the lowest pod yield (2.31t ha^{-1}) was obtained from the combination of groundnut + 1 row chilli at 60 cm spacing.

Pod Yield of chilli : On an average, in intercrop situation the yields of chilli were 6.48 and 5.97 t ha^{-1} in T_2 (groundnut+ 1 row of chilli at 40 cm spacing) and T_3 (groundnut + 1 row of chilli at 60 cm spacing), respectively (Table 2). Results showed that T_2 produced higher yield of chilli over T_3, it might be due to higher number plant population accumodated in T_2 at 40 cm spacing.

Groundnut Equivalent Yield (GEY): Groundnut equivalent yields were higher in intercrops (10.84 and 10.27 t ha^{-1}) than sole crop of ground nut (2.92 t ha^{-1}). The maximum groundnut equivalent yield (10.84 t ha^{-1}) was recorded in T_2 (groundnut+ 1 row of chilli at 40 cm spacing) intercropped combination which was followed by T_3 (10.27 t ha^{-1}), and the total productivity also increase of 271 and 251 percent over sole bush bean (Table 2).

Cost benefit analysis

Intercrop combination of groundnut with chilli showed higher monetary return than sole crop (Table 3). The highest gross return (Tk. 650400 ha^{-1}) was recorded from T_2 (groundnut+ 1 row of chilli at 40 cm spacing) intercrop combination which was more than 271 percent higher over sole groundnut. On the contrary, T_3 (groundnut + 1 row of chilli at 60 cm spacing) combination gave gross return of Tk. 616200 ha^{-1} and gross margin of Tk. 491767 ha^{-1} with higher BCR (4.95).

Farmer's opinions

Farmers cultivating groundnut in Hakaluki area mainly as sole crop but through the experimentation they learned a profitable intercropping practice. As such farmers can earn extra income easily without hampering the main crop and also boost up their family nutrition.

Table 1. PodyYield and yield attributes of groundnut intercropped with chilli at farmer's field under MLT site, Moulvibazer during 2021-22

Treatment	Pods plant^{-1}	Seeds pod^{-1}	100 kernel wt.(g)	Shelling (%)	Pod yield (t ha^{-1})
T_1: Groundnut sole	41.50	2.66	48.40	74.71	2.92
T_2: Groundnut+ 1 row chilli (40 cm)	34.48	2.15	44.90	71.12	2.20
T_3: Groundnut + 1 row chilli (60 cm)	31.72	2.00	44.03	7.56	2.31
CV (%)	10.28	5.57	2.86	2.32.	5.46
LSD $_{(0.05\%)}$	NS	0.29	2.97	NS	0.21

Table 2. Pod yield of chilli and groundnut equivalent yield (GEY) in intercropping system 2021-22

Treatments	Pod yield of chilli (t ha^{-1})	GEY (t ha^{-1})	% increase of GEY over sole groundnut
T_1: Groundnut sole	-	2.92	-
T_2: Groundnut+ 1 row chilli (40 cm)	6.48	10.84	271
T_3: Groundnut+ 1 row chilli (60 cm)	5.97	10.27	251

GEY: Groundnut equivalent yield; Price (Tk. Kg^{-1}): groundnut- 60, chilli- 80

Table 3: Cost benefit analysis of groundnut intercropped with chilli, 2021-22

Treatments	Gross return ($Tk.ha^{-1}$)	Total cost ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)	BCR
T_1: Groundnut sole	175200	91500	83700	2.91
T_2: Groundnut+ 1 row chilli (40 cm)	650400	140900	509500	4.61
T_3: Groundnut+ 1 row chilli (60 cm)	616200	124433	491767	4.95

Price ($Tk. Kg^{-1}$): groundnut- 60, chilli- 80

Conclusion

From the result it was found that intercrop combinations were better than sole crop in terms of yield and economic return. The intercrop combination T_3 (groundnut + 1 row of chilli at 60 cm spacing) performed better and contributed higher benefit cost ratio (4.95). It can be a good option to haor farmers for cultivating groundnut with chilli intercropping system.

ADAPTIVE TRIAL OF ADVANCED LINES OF SESAME IN FARIDPUR

S. AHMED, R. QUDDUS AND M. AKHTAR HOSSAIN

Abstract

A trial was conducted at the FSRD site Faridpur during Kharif I, 2021 to evaluate the performance of advanced lines of sesame in the farmer's field and to develop high yielding variety of sesame. Three advanced lines viz. Ses MR-20, Ses FR-20, Ses 2010-01R along with two check varieties viz. BARI Til-4 and Binatil-1 were evaluated. The experiment was laid out in RCB design with four replications. The highest seed yield (1.63 t ha^{-1}) was obtained from BARI Til-4 due to maximum number of siliqua $plant^{-1}$ and 1000- seed weight which was similar with Ses MR-20 (1.56 t ha^{-1}) and Ses FR-20 (1.55 t ha^{-1}). The lowest seed yield (1.32 t ha^{-1}) was calculated from Binatil-1 due to the lowest number of seed $siliqua^{-1}$. The seed yield of BARI Til-4 was (1.63 tha^{-1}) 5% higher than that of Ses MR-20 (1.56 tha^{-1}) and Ses FR-20 (01.55 th^{-1}).

Introduction

Sesame is one of the important oil crops in Bangladesh. Farmers mostly grow the traditional variety T-6 from long past with minimum input and low yielding type with average yield of 850kg ha^{-1}. There is ample scope of replacing the traditional cultivar T-6 by the modern sesame varieties having yield capacity of around 1.3-1.5 ton per hectare. Some advanced lines of sesame showed better performance during the previous years. But before releasing these lines as varieties, performance should be tested in the farmers' field. The present study was undertaken to find out the performance of the advance lines in farmers' field condition.

Materials and Methods

The trial was conducted at the FSRD site Faridpur during Kharif I 2021 to evaluate the performance of some advanced lines of sesame under the farmers' field condition. Three advanced lines viz. Ses MR-20 (black coated seed), Ses FR-20 (black coated seed), Ses 2010-01R (white coated seed) along with two check varieties viz. BARI Til-4 (brown coated seed) and Binatil-1(white coated seed) were evaluated in the study. The experiment was laid out in RCB design with four dispersed replications having plot size 4 m x 3 m. Seeds of Ses MR-20, Ses FR-20 and BARI Til-4 were sown at row to row spacing of 30 cm. The rest seeds were sown at 20 cm line to line spacing with continuous seeding 22 March, 2021. Different crop management practices were shown in Table 1. All fertilizers: 100-40-40-20-3-2 N-P-K-S-Zn-B $kgha^{-1}$ were applied as basal during final land preparation. Two times irrigation was applied at immediately after sowing and 33-41 DAS. Top dressing was done at 33-41 DAS. A total of 500 mm rainfall was recorder during growing period and about 300 mm rainfall was occurred at the harvesting month.The crop harvested from 17-21 June, 2021. Data on different yield and yield contributing characters were recorded and were analyzed statistically with the "R" software.

Results and Discussion

The maximum days to maturity (87 days) was found from Ses MR-20, Ses FR-20 and BARI Til-4 whereas the minimum (84 days) in Ses 2010-01R and Binatil-1 (Table 1). The highest plant height (138.50 cm) was observed in Ses MR-20 and the lowest in Ses 2010-01R (125.35 cm). The plant population m^{-2} ranged from 36.50 to 43.50. The maximum (35.10) number of siliqua $plant^{-1}$ was obtained from BARI Til-4 followed by Ses MR-20 and Binatil-1 (34.17) and the lowest in Ses 2010-01R (29.02). The maximum number of seeds $siliqua^{-1}$ was found from Ses FR-20 (83.17) followed by BARI Til-4 (81.67) while lowest in Binatil-1 (66.90). 1000-seed weight was the highest in Binatil-1 (2.80 g) and the lowest in Ses 2010-01R (2.45g). The maximum seed yield (1.63 t ha^{-1}) was obtained from BARI Til-4 due to highest siliqua $plant^{-1}$ and 1000- seed weight which was followed by Ses MR-20 (1.56 t ha^{-1}) and Ses FR-20 (1.55 t ha^{-1}). The lowest seed yield (1.32 t ha^{-1}) was calculated from Binatil-1 due to lowest number of seed $siliqua^{-1}$. The seed yield of BARI Til-4 was 5% higher than that of Ses MR-20 and Ses FR-20.

Farmers' opinion

Farmers expressed their positive opinion on two lines: Ses MR-20 and Ses FR-20 due to its black coated seed and comparatively higher yield. They were interested to grow these lines as variety in next time.

Table 1. Seed yield and yield attributes of sesame lines/variety at the FSRD site, Faridpur

Variety/Line	Plant height (cm)	Plants (m^{-2})	Siliqua $plant^{-1}$ (no.)	seed $siliqua^{-1}$ (no.)	1000- seed wt. (g)	Seed yield (t ha^{-1})
Ses MR-20	138.50 a	36.50 b	34.17 a	73.07 b	2.60 b	1.56 ab
Ses FR-20	134.67 a	38.75 b	33.30 a	83.17 a	2.70 ab	1.55 ab
Ses 2010-01R	125.35 b	43.50 a	29.02 b	73.75 b	2.45 c	1.43 bc
BARI Til-4	130.95 ab	38.00 b	35.10 a	81.67 a	2.75 a	1.63 a
Binatil-1	131.35 ab	39.50 b	34.17 a	66.90 c	2.80 a	1.32 c
CV (%)	3.87	5.16	7.87	4.66	2.65	7.33

Conclusion

The seed yield of two advance lines (MR-20 & FR-20) are promising in terms of yield especially MR-20 has capacity to live in water submerged condition (7-10 days). So, sesame line MR-20 may release as a variety.

ON FARM TRIAL OF BARI SUNFLOWER VARIETIES

M.R. AMIN, M.M. BASHIR AND S.K. BHOWAL

Abstract

The experiment was conducted at Sharashing village under Shibaloya upazila of Manikganj district and MLT site Barura and Chandina of Cumilla, Kasba of B. Baria and Shahrasti of Chandpur district under OFRD, BARI,Cumilla during the Rabi seasons of 2021-22 in the farmers' field to select suitable variety of Sunflower and to increase production and farmers income. In manikganj areas, three sunflower varieties viz. BARI Surjomukhi-2, BARI Surjomukhi-3 with a commercial variety Hysan-33. The seeds of Hysan-33 failed to germinate in the field, but the performance of BARI varieties was quite good. BARI Surjomukhi-2 gave the highest seed yield (2.10 t ha^{-1}) compared to BARI Surjomukhi-3 (1.85 t ha^{-1}). Higher gross margin (Tk. 26735 ha^{-1}) and BCR (1.18) was also obtained from BARI Surjomukhi-2. Moreover, in Cumilla region, BARI Surjamukhi-2, BARI Surjamukhi-3 and

Hybrid RDS-275 were used l. The result i revealed that seed yield of BARI Surjamukhi-2 (2.18t ha^{-1}) was the highest than the other varieties. The major problem of BARI Surjamukhi-2 and RDS-275 was lodging tendency at the maturity stage when hailstorm was occurred. As the productivity of BARI Surjamukhi-2 is higher it produces higher gross return (Tk. 218000.00 ha^{-1}) and gross margin (Tk. 177500.00 ha^{-1}) among the tested varieties.

Introduction

Sunflower (*Helianthus annuus*) is the second most important oil crop in the world after Soybean in terms of acreage and production. Sunflower contains 42-44% oil. It also contains 40-50% linoleic acid and 20-22% protein. One kg Sunflower seed brings 500-600 ml oil which is greater than any other oil seeds.. Sunflower in Bangladesh is cultivated since 1975 and cultivated in limited area of Patuakhali, Jashore, Kushtia, Natore, Pabna, Gazipur and Tangail district. Some farmers in Manikganj district also cultivate this crop occasionally collected the seeds from unknown sources.BARI varieties need to be tested in the farmers' field at Manikganj. BARI has already release 03 Sunflower varieties of which BARI Surjamukhi-2 and BARI Surjamukhi-3 high yielder ability. So, this trial was undertaken to show the performance and popularize the sunflower among the farmers at this Cumilla and Manikganj regions.

Materials and Method

The experiment was conducted at Sharashing village under Shibaloya upazila of Manikganj district and MLT site Barura and Chandina of Cumilla, Kasba of B. Baria and Shahrasti of Chandpur district under OFRD, BARI, Cumilla during the Rabi seasons of 2021-22. In Manikganj, three sunflower varieties viz. BARI Surjomukhi-2, BARI Surjomukhi-3 and Hysan-33 were included . The experiment was conducted in RCB design with three dispersed replications. The fertilizers applied @ 90-40-75-24-3.5-2 kg ha^{-1} of N-P-K-S-Zn-B. Half urea and all other fertilizers were applied during final land preparation. Rest half of urea was applied in two equal splits at 20-25 DAS and 40-45 DAS before flowering. The seeds of sunflower were sown on 03 November, 2021. Unit plot size was 40m × 20m with spacing of 50cm × 25cm. Nitro @ 2 ml L^{-1} water was sprayed 3 times at vegetative stage to control insect. Nativo @ 2 g L^{-1} was sprayed 2 times to control fungal disease. Weeding, irrigation and other intercultural operations were done as and when necessary. The head was harvested on 15 February, 2022. Data on yield and yield characters were collected and analyzed statistically.

In Cumilla areas, BARI developed Sunflower varieties such as BARI Surjamukhi-2, BARI Surjamukhi-3 and Hybrid Sunflower variety RDS-275 were used . The varieties were evaluated in RCB design with four dispersed replications. Chemical fertilizer was applied @ 100-30-60-20-1.5 kg ha-1 N, P, K, S and B in the form of Urea, TSP, Mop, Gypsum, Boric acid in the field. Half of Urea and full doses of all other fertilizers were applied during final land preparation. Rest amount of Urea were top dressed at 25 & 45 days after sowing. The unit plot size was 5decimals. Seeds were sown on 02-31 December, 2021 with a spacing of 50 cm × 25 cm, respectively. The seeds were treated with Provax-200 at the rate of 2.5 mg Kg^{-1} of seeds. To control caterpillar (*Admire* and *Cortan Plus*) Nitro 505 EC at the rate of 2ml L^{-1}was sprayed twice at flowering and grain filling stage. For controlling blight and root rot diseases of sunflower Autostin 72 Wp and Rovral-50 Wp @ 1 mg L^{-1}of water were sprayed at disease initiation stage. The crops were harvested 27 March-06 April, 2022. Yield and Yield attributes were recorded properly.

Result and Discussion

Manikganj: The commercial variety Hysan-33 failed to germinate in the field. BARI Surjomukhi-3 (104.20 cm) was significantly shorter compared to BARI Surjomukhi-2 (154.20 cm). The number of seeds plant^{-1} was maximum (423) in BARI Surjomukhi-2 and minimum in BARI Surjomukhi-3 (398). The highest seed yield was obtained from BARI Surjomukhi-2 (2.10 t ha^{-1}) and the lowest in BARI Surjomukhi-3 (1.85 t ha^{-1}). The maximum gross return (Tk. 168000 ha^{-1}) and gross margin (Tk. 26735 ha^{-1}) was obtained from BARI Surjumukhi-2 with higher BCR (1.18). Lowest gross return (Tk. 148000 ha^{-1}) and gross margin (Tk. 6735 ha^{-1}) was obtained from BARI

Surjumukhi-3 with lower BCR (1.04). Nitro @ 2ml L^{-1} water was sprayed three times to control leaf feeding caterpillar insect. Nativo 2g L^{-1} water was sprayed to control leaf rot disease (Table 1 & 3).

Cumilla: Seed yield and yield contributing characters of BARI developed sunflower varieties are presented in the Table 1. All the characters were varied statistically except seeds head^{-1} among the varieties. It was revealed that minimum days to maturity (98) was found from BARI Surjamukhi-3 and maximum from RDS-275. The highest plant height (182.35cm) was recorded from RDS-275 and the lowest (85.15cm). from BARI Surjomukhi-3. Higher head diameter (56.03 cm) was recorded from the variety BARI Surjamukhi-2and lower fromRDS-275 followed by BARI Surjomukhi-3 (52.12 cm). There was no significant difference in number of seeds per head. Seeds wt. head^{-1}, 1000-seed wt. and seed yield were the highest in BARI Surjamukhi-2 and the lowest in RDS-275. Thus, gross return and gross margin were also the highest in BARI Surjamukhi-2 and the lowest in hybrid sunflower variety RDS-275 (Table 2 & 3).

Farmer's reaction

In Manikganj district, Sunflower var. BARI Surjumukhi-2 and BARI Surjumukhi-3 were found promising . In Cumilla, farmers were very much impressed and cabe fitted in the existing cropping pattern: Rabi- Fallow-T. Aman. BARI Surjomukhi-3 is shorter, uniform in size, big head. They want to cultivate BARI Surjomukhi-3 if seeds are available.

Table 1. Seed yield and yield attributes of BARI Sunflower varieties at Shibaloya, Manikganj during *Rab*i season of 2021-22.

Variety	Plant height (cm)	No. of seed plant^{-1}	Fruit yield (t ha^{-1})
BARI Surjomukhi-2	154.20	423.00	2.10
BARI Surjomukhi-3	104.20	398.00	1.85
t- value	0.02*	0.04*	0.05*
CV (%)	4.36	6.80	10.41

Table 2. Seed yield and yield contributing characters of BARI Surjomukhi varieties at different location of Cumilla region during Rabi season of 2021-22

Varieties/lines	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed's head^{-1} (no.)	Seeds wt. head^{-1} (gm)	1000-seed wt. (g)	Seed yield (t ha^{-1})
BARI Surjomukhi-2	100.	163.52 b	56.03 a	428.55	30.25 a	64.68 a	2.18
BARI Surjomukhi-3	98	85.15 c	52.12 b	481.75	28.00 ab	62.13 a	2.07
RDS-275	102.	182.35 a	52.12 b	484.43	24.00 b	45.18 b	1.87
CV (%)	3.36	2.56	2.98	8.04	9.16	4.17	6.27
LSD (0.05)	5.85	6.36	2.753	NS	4.34	4.14	0.22

Table 3. Economic return of Sunflower at different locations during the rabi season of 2021-22.

Locations	Varieties/lines	Gross return (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Manikganj	BARI Surjomukhi-2	168000	26735
	BARI Surjomukhi-3	148000	6735
Cumilla	BARI Surjomukhi-2	218000	177500
	BARI Surjomukhi-3	207000	166500
	RDS-275	187000	144000

Market price of Sunflower at Manikganj @ Tk. 80 kg^{-1} and at Cumilla @ Tk. 100 kg^{-1}

Conclusion

Sunflower var. BARI Surjumukhi-2 was found promising in the farmers' field at Manikganj. But in Cumilla, BARI Surjamukhi-2 gave the highest yield, but farmers want to cultivate BARI surjomukhi-3, due to dwarf plants and a new crop.

ON-FARM TRIAL OF BARI GROUNDNUT VARIETIES

M.A.H. KHAN, S. ROY, T. TASMIMA, G.N. HASAN AND R. HASAN

Abstract

The experiment was conducted under Charland situation at the MLT site Bhuapur, Tangail AEZ-8 and Daulatkhan and Bhola sadar upazilla under Bhola district during the Rabi season of 2021-22 to find out the suitable groundnut variety for the charlands and to popularize the varieties among the farmers. In Tangail areas, five improved lines/ varieties of groundnut viz., ICGV-07219, ICGV 36-1, ICGV-06285, BARI Chinabadam-8, and BARI Chinabadam-9 were used.. The highest pod yield (2.50 t ha^{-1}) was recorded in ICGv-072019 whereas the lowest pod yield (1.80 t ha^{-1}) from BARI Chinabadam-8. Higher gross return (Tk. 162500 ha^{-1}) and gross margin (Tk. 114370 ha^{-1}) were observed from ICGV-072019 and the lowest gross return (Tk. 117000 ha^{-1}) and gross margin (Tk. 65870 ha^{-1}) from BARI Chinabadam-8. Moreover, in Bhola region, four BARI improved Groundnut varieties viz., BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10, BARI Chinabadam-11 and one local variety were used as check. The highest 100- kernel weight was recorded from BARI Chinabadam-8 (102.0 g) followed by BARI Chinabadam-10 (99.5 g). The maximum average nut yield (2.14 t ha^{-1}) was recorded in BARI Chinabadam-9 which was significantly similar among the tested varieties except local which produced lowest nut yield (1.37 t ha^{-1}) . The yield was 56% higher in BARI Chinabadam-9 over Local variety.

Introduction

Groundnut (*Arachis hypogaea*) is an important leguminous oilseed crop. It is cultivated both in rabi and kharif seasons in Bangladesh. This crop is an important source of oil (43-55%) and protein (25-28%), hence used as food and feed (Din *et al.*, 2009). It is a good source of edible oil as it contains about 50% oil of good quality. It is also an excellent source of vitamins and contains high levels of thiamine, riboflavin and niacin. Groundnut, being a drought tolerant crop, it requires low input and produces high output for the farmer. Since it is a leguminous crop it can fix atmospheric nitrogen enhancing soil health by adding nitrogen to soil. Farmers of charland areas of Bangladesh usually grow Groundnut with local variety which produce lower yield and susceptible to pest and diseases. BARI has developed some modern varieties of Groundnut, which are supposed to be higher yielder and less susceptible to pest and diseases. Therefore, an adaptive trial with BARI developed high yielding Groundnut varieties was conducted for higher yield and economic return and to popularize BARI varieties among the farmers.

Materials and Method

The experiment was conducted under Charland situation at the MLT site Bhuapur, Tangail AEZ-8 and Daulatkhan and Bhola sadar upazilla under Bhola district during the Rabi season of 2021-22 following RCB design. In Tangail, three improved lines/variety of groundnut viz. ICGV-07219, ICGV-36-1, ICGV-06285, and BARI Chinabadam-8 and BARI Chinabadam-9 were used with four dispersed replications. Seeds were sown on 18 November, 2021 and harvested from 20 April to 8 May, 2022. Before sowing, seeds were treated with Provax @ 0.2% to prevent seed and soil borne diseases. Plots were fertilized with 12-32-43-54-0-1-5000 kg NPKSZnB and Cowdung ha^{-1}. The half urea and entire amount of TSP, MP, gypsum, and boric acid were applied during the final land preparation. The rest half urea was top-dressed at the initial stage of peg development. All intercultural operations were done properly. The cost and return were calculated on the basis of the prevailing market price of the commodities. At the harvesting stage, different data were collected properly and analyzed statistically using the CropStat analytical package.

In Bhola region, improved Groundnut varieties viz., BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10, BARI Chinabadam-11 and one local variety were used as check with six dispersed replications. The unit plot size was 8m x 5m. Seeds were sown maintaining a spacing of 30 cm × 15 cm. Before sowing, seeds were treated with Provax @ 0.2 % to prevent seed and soil borne diseases. Sowing time on 24 December, 2021 – 19 January, 2022 and harvesting in27April-08May,2022.Fertilizerdose(kgha^{-1}) N-P-K-S-Zn-B was 50-50-30-35-2-1.5. Half amount of urea and whole amount of TSP, MP, gypsum and boric acid were applied during final land preparation. The rest half urea was top dressed at the initial stage of peg developments. One hand weeding was done at 45 DAS. Other intercultural operations and plant protection measures were done as and when required. The cost and return were calculated on the basis of prevailing market price of the commodities. Data on yield and yield characters were collected and analyzed statistically.

Results and Discussion

Tangail: Days to maturity, plant height, effective pod plant^{-1}, thousand seed weight, and shelling percentage showed insignificant (Table 1). The lowest days to maturity were observed in ICGV-07219 (153) and the highest in ICGV-06285 (160). The longest plant was observed in ICGV 36-1 (43.77 cm) and the shortest in BARI Chinabadam-8 (35.93 cm). The highest number of effective pod plant^{-1} (22) was recorded in ICGV-07219 and the lowest number of effective pod plant^{-1} (17) was recorded in BARI Chinabadam-8 followed by BARI Chinabadam-9. The highest 1000- seed weight (685 g) was recorded in ICGV-07219 whereas the lowest in BARI Chinabadam-8 (601 g). The highest pod yield (2.50 t ha^{-1}) was recorded in ICGV-07219 which was significantly different among the tested lines and varieties. The higher number of pods plant^{-1} and seed weight were closely associated with higher pod yield ha^{-1}. The lowest pod yield (1.80 t ha^{-1}) was obtained from BARI Chinabdam-8. Higher gross return (Tk. 162500 ha^{-1}) and gross margin (Tk. 114370 ha^{-1}) were observed from ICGV-07219 and the lowest gross return (Tk. 117000 ha^{-1}) and gross margin (Tk. 65870 ha^{-1}) from BARI Chinabadam-8 (Table 1 & 3).

Bhola: All the yield and yield contributing characters showed significant difference among the tested varieties (Table 2). The highest plant height (50.02 cm) was obtained from BARI Chinabadam-10 and the lowest from local (46.78 cm). The maximum number of mature pods plant^{-1} (18.2) was recorded in local followed by BARI Chinabadam-9 (17.5) and the lowest number of mature pods plant^{-1} (14.9) from BARI Chinabadam-10. The maximum 100- kernel weight was recorded from BARI Chinabadam-8 (102.0 g) followed by BARI Chinabadam-10 (99.5 g). The highest average nut yield (2.14 t ha^{-1}) was recorded in BARI Chinabadam-9 which was significantly similar among the tested varieties except local which produced lowest nut yield (1.37 t ha^{-1}). Higher gross margin was obtained from BARI Chinabadam-9 (Tk.139500 ha^{-1}) followed by BARI Chinabadam-8 (Tk.11500 ha^{-1}) and lowest from the local variety (Tk.62500 ha^{-1}) (Table 2 & 3).

Conclusion

Results from Tangail indicated that line ICGV-07219 had more potentiality than other lines and variety. HYV groundnut lines are less susceptible to pest infestation. In Bhola areas, all the high yielding varieties provided higher yield over the farmer's variety. Therefore, Groundnut var. BARI Chinabadam-8, BARI Chinabadam-9, BARI Chinabadam-10 could be extended in the tested locations according to farmer's choice and local market price.

Table 1. Yield and yield contributing characters of groundnut varieties at the MLT Site, Bhuapur, Tangail during rabi, 2021-22

Treatment	Days to maturity	Plant height (cm)	Effective pod plant^{-1}	1000- seed wt. (g)	Nut yield (t ha^{-1})
ICGV-07219	153	43.53	22.60	685.00	2.50
ICGV 36-1	159	43.77	22.27	679.33	2.40
ICGV-06285	160	40.00	19.00	622.67	2.13
BARI Chinabadam-8	154	38.27	16.67	601.00	1.80
BARI Chinabadam-9	156	35.93	16.60	614.33	1.97
$LSD_{0.05}$	1.50	2.62	2.22	45.48	0.31
CV (%)	2.10	3.50	6.10	3.70	7.50

Table 2. Nut yield and yield contributing characters of Groundnut varieties at different locations in Bhola district during the rabi season of 2021-22.

Location	Variety	Plant height (cm)	Mature pods plant^{-1}	100-seed weight (g)	Nut yield (t ha^{-1})
Bhola	BARI Chinabadam-8	47.66	15.8	102.0	1.94
	BARI Chinabadam-9	46.78	17.5	99.5	2.14
	BARI Chinabadam-10	50.02	14.9	97.5	1.71
	BARI Chinabadam-11	47.35	15.6	94.3	1.52
	Local (Check)	48.12	18.2	93.0	1.37
	LSD (0.05)	5.16	3.43	1.76	2.49
	CV (%)	6.21	7.02	3.87	3.43

Table 3. Economic return of Groundnut at different locations during the rabi season 2021-22.

Locations	Varieties/lines	GR (Tk. ha^{-1})	GM (Tk. ha^{-1})
Tangail	ICGV-07219	162500	114370
	ICGV 36-1	156000	104870
	ICGV-06285	138450	87320
	BARI Chinabadam-8	117000	65870
	BARI Chinabadam-9	128050	76920
Bhola	BARI Chinabadam-8	194000	119500
	BARI Chinabadam-9	214000	139500
	BARI Chinabadam-10	171000	96500
	BARI Chinabadam-11	152000	77500
	Local (Check)	137000	62500

Market price of Groundnut at Tangail @ Tk. 65 kg^{-1} and Bhola @ Tk. 100 kg^{-1}

Horticultural Crops

ON-FARM TRIAL OF BARI BRINJAL VARIETIES

M.R. AMIN, A.A. MAHMUD AND J. ALAM

Abstract

The adaptive trial was conducted at Ghior upazila of Manikganj, and Sadar, Sadullahpur and Saghata Upazilla of Gaibandha district during *Rabi* season of 2021-22 to evaluate the performance of BARI released brinjal varieties against local variety. Three brinjal varieties viz. BARI Begun-4, BARI Begun-10 and a farmer's variety were tested. . The experiment was conducted in RCB design with 4 dispersed replications. Out of the tested varieties, local variety Lalteer hybrid gave higher yield (40.13 t ha^{-1}) followed by BARI Begun-4 (30.15 t ha^{-1}) and BARI Begun-10 (19.22 t ha^{-1}) in Manikganj. But in Gaibandha, the maximum fruit yield (26.6 t ha^{-1}) was obtained from BARI Begun-10 followed by BARI Begun-8 (18.2 t ha^{-1}). The higher gross return Tk. 328100.00 ha^{-1} and gross margin (Tk. 199559.00 ha^{-1}) was also obtained from Lalteer hybrid followed by BARI Begun-4 (Tk. 328100.00 ha^{-1} and Tk.99559ha^{-1}) in Manikganj, and the maximum gross margin (Tk. 116300 ha^{-1}) and highest MBCR (3.7) were recorded from BARI Begun-10 followed by BARI Begun-8 (Tk. 32400 ha^{-1} and 1.0, respectively) in Gaibandha with the lowest gross margin (Tk. 31200 ha^{-1}) from local variety.

Introduction

Brinjal (*Solanum melongena*) is widely cultivated in Bangladesh and is considered as the second most important vegetable crop after Potato in relation to its total production. Average yield of Brinjal in Bangladesh is low compared to other Brinjal growing countries of the world. The acreage of Rabi Brinjal in Manikganj district was 1564 acres and production 8788 metric tons in 2016-17 (BBS, 2017). This low yield may be due to the cultivation of the low yielding local varieties, incidence of diseases and insects, lack of technical know-how etc. During the recent years, BARI has developed some high yielding varieties of Brinjal which are supposed to be high yielder and less susceptible to pest and diseases. The present study was undertaken to evaluate the performance of BARI released Brinjal varieties under farmer's field condition and popularize those varieties among the farmers to promote their adoption.

Materials and Methods

The adaptive trials with different BARI brinjal varieties were conducted in the farmers' field at Ghior upazilla of Manikganj, and Sadar, Sadullahpur and Saghata Upazilla of Gaibandha district during *Rabi* season of 2021-22 to evaluate the performance of BARI released brinjal varieties against local brinjal varieties. The trial was laid out in RCB design with 3-6 dispersed replications.

Half of the urea and full of other fertilizers were applied as a basal dose. The rest of the urea was applied as top dress at 30 days after planting (DAP). Irrigation and other intercultural operations like weeding, top dressing of urea and plant protection measures were taken as and when required. Nitro @ 2ml L^{-1} water was sprayed to control aphid, Jassid and leaf miner insect. The crop was harvested and data on different plant characters and yield were collected and analyzed statistically. The economic return was calculated on the basis of prevailing market price of the commodities.

Detailed materials and methods are given in the table below:

Location	Variety	Plot size	Spacing	Fertilizers	Planting time	Harvesting time
Manikganj	BARI Begun-4, BARI Begun-10 & Lalteer hybrid (as check)	10m x 10m	100 cm x 70 cm	140-50-100-20-1-1.5 kg N- P- K-S-Zn-B & cowdung @ 5.0 t ha^{-1}	07-11 Nov. 2021	10 Mar. to 15 April, 2022
Gaibandha	BARI Begun-8, BARI Begun-10 & local variety (as check)	10m × 7m	100 cm ×70 cm	300-250-200-100-10-10 kg ha^{-1} of Urea-TSP-MP-Gyp-$ZnSo_4$-Boric acid, & Cowdung @ 10 t ha^{-1}	12-15 Nov. 2021	25 Feb. to 7 May 2022

Results and Discussion

Yield and yield attributes of BARI developed brinjal varieties at Manikganj are shown in Table 1. The plant height of eggplant varieties did not differ significantly between Lalteer hybrid (57.40cm) and BARI Begun-10 (57.10 cm) but the shortest (38.00cm) in BARI Begun-4. The fruit size ranged from 15.60 cm to 20.20 cm in length. The fruit size was longer in BARI Begun-10 (20.20 cm) but similar to Lalteer hybrid variety (18.30 cm) and the smallest in BARI Begun-4 (15.60 cm). The diameter of fruits was maximum in BARI Begun-10 (4.10 cm) followed by BARI Begun-4 (3.90 cm) and Lalteer hybrid (3.70 cm). Profuse bearing of fruits (74.90) was observed in Lalteer hybrid followed by BARI Begun-4 (62.30) and lower in BARI Begun-10 (32.30). The fruit yield varied significantly among the brinjal varieties. The maximum fruit yield was obtained from Lalteer hybrid (40.13 t ha^{-1}) followed by BARI Begun-4 (30.15 t ha^{-1}). The lower yield was recorded in BARI Begun-10 (19.22 t ha^{-1}).

In Gaibandha, the yield and yield attributes were differed significantly among the crop varieties except plant height (Table 2). The maximum fruit yield (26.6 t ha^{-1}) was obtained from BARI Begun-10 followed by BARI Begun-8 (18.2 t ha^{-1}) due to the more fruits $plant^{-1}$ (23) as well as individual fruit weight (84.5g). On the contrary, the local variety gave the minimum fruit yield with a value of 14.6 t ha^{-1}.

Cost and return

Manikganj: The cost and return analysis is shown in Table 3. Gross return (Tk. 802600 ha^{-1}) was higher in Lalteer hybrid with higher gross margin (Tk. 662559 ha^{-1}) and benefit-cost ratio (5.73). Gross return (Tk. 603000 ha^{-1}) and gross margin (Tk. 466459 ha^{-1}) with BCR 4.41 was recorded in BARI Hybrid Begun-4. The lower gross return (Tk. 384400 ha^{-1}) and gross margin (Tk. 247859.00 ha^{-1}) was obtained from BARI Begun-10 with lower benefit-cost ratio (2.81).

Gainandha: The maximum gross margin (Tk. 116300 ha^{-1}) and highest MBCR (3.7) were recorded from BARI Begun-10 followed by BARI Begun-8 (Tk. 32400 ha^{-1} and 1.0, respectively) and the lowest gross margin (Tk. 31200 ha^{-1}) from local variety (Table 4).

Disease and pest incidence: Whitefly, Jasid, aphid, and brinjal fruit and shoot borer infestation was observed that was well controlled by spraying of insecticides at both the locations.

Farmer's opinion

Farmers of Manikganj chose Lalteer hybrid for higher yield but they opined that BARI Begun-4 is tastier than hybrid varieties and fruit yield was also satisfactory compared to commercial hybrid. On the contrary, farmers of Gaibandha were quite happy with BARI brinjal varieties as they exhibited higher yields than the local variety. Farmers from both locations reacted about the BSFB infection in all BARI varieties. The cost of production increased to a great extent due to regular spraying of insecticides.

Table 1. Fruit yield and yield attributes of eggplant varieties grown at Ghior, Manikganj during *Rabi* season of 2021-22.

Treatments	Plant height (cm)	Length of fruits (cm)	Diameter of fruit (cm)	Fruit $plant^{-1}$ (no.)	Fruit yield (t ha^{-1})
BARI Begun-4	38.00 b	15.60 a	3.90 a	62.30 b	30.15 b
BARI Begun-10	57.10 a	20.20 a	4.10 a	32.30 c	19.22 c
Local variety (Lalteer hybrid)	57.40 a	18.30 a	3.70 a	74.90 a	40.13 a
$LSD_{(0.05)}$	9.435	7.467	2.98	4.712	9.732
CV (%)	8.19	9.70	8.26	3.68	8.39

Table 2. Fruit yield and yield attributes of brinjal varieties at Gaibandha during *Rabi* season 2021-22

Varieties	Plant height (cm)	Fruits $plant^{-1}$ (no.)	Individual fruit weight (g)	Fruit yield (t ha^{-1})
BARI Begun-8	70.3	24 a	68.2 ab	18.2 b
BARI Begun-10	66.7	23 a	84.5 a	26.6 a
Local variety	62.7	18 b	53.2 b	14.6 b
CV (%)	5.79	9.21	14.8	12.7
$LSD_{0.05}$	ns	4.5	22.9	5.7

Table 3. Cost and return of BARI hybrid brinjal varieties grown at Ghior, Manikgaj during *Rabi* season of 2021-22.

Variety	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
BARI Begun-4	603000	136541	466459.00	4.41
BARI Begun-10	384400	136541	247859.00	2.81
Local variety (Lalteer hybrid)	802600	140041	662559.00	5.73

Market price of brinjal Tk. 20.00 kg^{-1}

Table 4. Economic performance of brinjal varieties at Gaibandha during 2021-22

Variety	Gross Return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
BARI Begun-8	182400	150000	32400	1.0
BARI Begun-10	266300	150000	116300	3.7
Local variety	146200	115000	31200	-

Farm gate price of brinjal Tk. 10.00 kg^{-1}

Conclusion

Considering the results of both locations, local brinjal variety (Lalteer hybrid) produced the highest Gross return and BCR in Manikganj while BARI Begun-10 was satisfactory to the farmers in terms of yield and economic return in Gaibandha.

ON-FARM TRAIL OF BARI HYBRID BRINJAL VARIETIES

M.A.H. KHAN, S. ROY, T. TASMIMA, M.H. RASHID, K. ISLAM, M.K. SHAHADAT AND M. RAHMAN

Abstract

The trial was conducted at the FSRD site, Atia of BARI, Tangail and MLT site, Koyra of Khulna district during *Rabi* season of 2021-2022. Two hybrid brinjal varieties i.e., BARI Hybrid Begun-3 and BARI Hybrid Begun-4 were evaluated against a local hybrid (Purple King) in Tangail while BARI Hybrid Begun-5, BARI Hybrid Begun-6 & BARI Begun-12 were evaluated in Khulna. The maximum t fruit yield was obtained from local variety, Purple King (42.88 t ha^{-1}) very closely followed by BARI Hybrid Begun-3 (42.24 t ha^{-1}). In Khulna, the maximum fruit yield (50.20 t ha^{-1}) was recorded from the variety BARI Hybrid begun-6 followed by BARI Hybrid Begun-5 (48.80 t ha^{-1}) and the lowest (38.6 t ha^{-1}) in the BARI Begun-12.

Introduction

Brinjal (*Solanum melongena*) is one of the most important and popular vegetables in Bangladesh. Eggplant is widely cultivated in Bangladesh and is considered as the second major important vegetable crop after potato in relation to its total production. It's grown widely round the year throughout the country. The average yield of brinjal is 5.91 t ha^{-1} in Kharif and 7.02 t ha^{-1} in Rabi which is lower than the other brinjal growing countries of the world. This low yield may be due to the cultivation of low yielding local varieties, incidence of pest and diseases, lack of technical knowledge etc. During the recent years, Horticulture Research Centre (HRC) of BARI has developed some hybrid brinjal varieties i.e., BARI Hybrid Begun-4 which is high yielding and tolerant to pest and diseases (Azad *et. al.* 2017). So, a trial was conducted to evaluate the adaptability and performance of BARI developed hybrid brinjal varieties under farmer's field conditions and to popularize the variety among the farmers in different areas of Bangladesh.

Materials and Methods

The trial was conducted at the FSRD site, Atia of BARI, Tangail and MLT site, Koyra of Khulna district during the Rabi season of 2021-2022. Two hybrid brinjal varieties i.e., BARI Hybrid Begun-3 and BARI Hybrid Begun-4 were evaluated against a local hybrid (Purple King) in Tangail while BARI Hybrid Begun-5, BARI Hybrid Begun-6 and BARI Begun-12 were evaluated in Khulna. The trial was laid out in RCB design with 3-6 dispersed replications under farmer's field condition. The detailed materials and methods are given in the table below:

Location	Variety	Plot size	Spacing	Fertilizers	Planting time	Harvesting time
Tangail	BARI Hybrid Begun-3, BARI Hybrid Begun-4 and a local hybrid (Purple King) as check	8 m × 5 m	100 cm × 75 cm	140-50-40-16-1.7-5000 N-P-K-S-B-Cowdung, respectively	1st Dec. 2021	25 Feb. to 27 April 2022
Khulna	BARI Hybrid Begun-5, BARI Hybrid Begun-6 and BARI Begun-12	3.5 m x 1.5 m	100 cm×70 cm	Cowdung, Urea, TSP, MP and Gypsum @ 10000, 550, 450, 250 & 111 kg ha^{-1}, respectively	29 Dec. 2021	

Half of the urea and full of other fertilizers were applied as a basal dose. The rest of the urea was applied as top dress at 30 days after planting (DAP). Irrigation and other intercultural operations like weeding, top dressing of urea and plant protection measures were taken as and when required. Nitro @ 2ml L^{-1} water was sprayed to control aphid, Jassid and leaf miner insect. The crop was harvested and data on different plant characters and yield were collected and analyzed statistically. The economic return was calculated on the basis of prevailing market price of the commodities.

Results and Discussion

Tangail: Yield and yield contributing characters varied significantly among the tested varieties. The maximum plant height was observed in Purple King (93.67 cm) followed by BARI Hybrid Begun-4 (80 cm) and the lowest one in BARI Hybrid Begun-3 (72.33 cm). The maximum number of fruits $plant^{-1}$ was found in BARI Hybrid Begun-4 (55) followed by BARI Hybrid Begun-3 (43) whereas the lowest number of fruits in BARI Hybrid Begun-4 (30). The highest individual fruits weight $plant^{-1}$ was observed in Purple King (77 g) whereas the lowest in BARI Hybrid Begun-4 (64 g). The maximum weight of fruit $plant^{-1}$ (3.69 kg) in BARI hybrid Begun-3 followed by Purple King (3.57 kg) whereas the lowest was in BARI Hybrid Begun-4 (2.67 kg). The highest number of fruits $plant^{-1}$ and individual fruit weight results in maximum yield in Purple King (42.88 t ha^{-1}) followed by BARI Hybrid Begun-3 (42.24 t ha^{-1}) (Table 1). The highest gross return (Tk. 1072000 ha^{-1}) and gross margin (Tk. 823430 ha^{-1}) were observed from Purple King followed by BARI Hybrid Begun-3 (Table 2).

Khulna: Yield and yield contributing characters are presented in the Table 3. Among the varieties number of fruits per plant were varied significantly as the highest number of fruits produced by the variety BARI Hybrid begun-6 (33) and the lowest from BARI Begun-12 (8). The highest friut yield (50.20 t ha^{-1}) was recorded from the variety BARI Hybrid begun-6 followed by BARI Hybrid Begun-5 (48.80 t ha^{-1}) and the lowest (38.6 t ha^{-1}) in BARI Begun-12.

Farmers' Opinion

In Tangail, though local hybrid Purple King produced the maximum yield, BARI Hybrid Begun-3 provided a satisfactory yield with tastier. Farmers of Koyra, Khulna became interested to cultivate all tested brinjal varieties especially BARI Hybrid Begun-6 for its highest yield production and BARI Begun-12 for its larger size fruits.

Table 1. Yield and yield attributes of hybrid brinjal varieties at FSRD site, Atia, Tangail during *Rabi* season of 2021-22

Variety	Plant height (cm)	Fruits $plant^{-1}$ (no.)	Individual fruit weight (g)	Weight of fruits $plant^{-1}$ (kg)	Fruit Yield (t ha^{-1})
BARI Hybrid Begun-3	72.33	42.67	69.33	3.69	42.24
BARI Hybrid Begun-4	80.00	30.00	64.00	2.67	30.10
Purple King	93.67	54.67	77.00	3.57	42.88
$LSD_{0.05}$	7.09	9.59	7.87	0.69	8.31
CV (%)	3.80	10.00	5.00	11.60	11.20

Table 2. Cost and return analysis of hybrid brinjal varieties at FSRD site, Atia, during *Rabi* season of 2021-22

Variety	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Hybrid Begun-3	1056000	248570	807430
BARI Hybrid Begun-4	602000	248570	353430
Purple King	1072000	248570	823430

The sale price of brinjal: BARI Hybrid Begun-3: Tk 25 kg^{-1}, BARI Hybrid Begun-4: Tk. 20 kg^{-1}, Purple King: Tk. 25 kg^{-1}.

Table 3. Average Yield of different Brinjal varieties at Koyra, Khulna during 2021-22

Location	Yield (t ha^{-1})		
	BARI Hybrid Begun-5	BARI Hybrid Begun-6	BARI Begun-12
Koyra, Khulna	48.8	50.20	38.60

Conclusion

Local brinjal variety Purple King produced the highest fruit yield and gross margin in Tangail while BARI Hybrid Begun-6 produced the highest yield in Khulna. BARI Hybrid Begun-12 I and popular for its bigger size and economically profitable.

ON-FARM TRIAL OF BARI COUNTRY BEAN VARIETIES IN FARIDPUR

SELIM AHMED AND AFM RUHUL QUDDUS

Abstract

A field experiment was carried out at the FSRD site, Faridpur during Kharif II season of 2021 to evaluate the performance of BARI developed country bean varieties and to popularize the varieties among the farmers. Brinjal var. BARI Sheem-1, BARI Sheem-6 and BARI Sheem-8 were evaluated against local variety (Hybrid Rupban). The trial was laid out in RCB design with six dispersed replications. The highest fruit yield (20.35 t ha^{-1}) was recorded in BARI Sheem-6 due to a greater number of pod $plant^{-1}$ which was statistically similar with BARI Sheem-1 (19.15 t ha^{-1}) and the lowest in local variety (16.15 t ha^{-1}). The maximum gross margin (Tk. 371700.00 ha^{-1}) and BCR (2.09) was achieved from BARI Sheem-6 because of higher market price than that of local cultivar (about Tk.10 kg^{-1} difference). The lowest gross margin was calculated from local (Tk. 82150.00 ha^{-1}).

Introduction

Country bean (*Lablab purpureas*) is one of the important vegetables of Bangladesh. BARI has already developed some high yielding country bean varieties with good quality. The varieties have been popularized in some areas of the country. The country bean grows well in Faridpur. Farmers normally use local imported variety. BARI has developed some winter varieties. BARI Sheem-6" named ``Noldoc'' type is soft, fleshy, less fibrous pods and it has been released in 2011 for higher yield and pod quality. BARI Sheem-8 is another winter variety for early harvesting. Therefore, the trial was conducted observe the adaptability and evaluate the performance of BARI Sheem-1, BARI Sheem-6 and 8 at Faridpur region.

Materials and Methods

A field experiment was carried out at the FSRD site, Faridpur during Kharif II season of 2021 to evaluate the performance of BARI developed country bean varieties and to popularize the varieties among the farmers. The trial was laid out in RCB design with six dispersed replications. BRinjal var. BARI Sheem-1, BARI Sheem-6 and BARI Sheem-8 were evaluated against local variety. The unit plot size was 4m x 2.2m. The pit was prepared by maintaining spacing of 2.2m × 2m. The seed was sown on 30 August 2021. The crop was fertilized with 60-40-30-10-2-0 kg ha^{-1} N-P-K-S-Zn-B, respectively with cow dung @ 4 tha^{-1}. Half of cowdung were applied during final land preparation. The remaining half of cowdung, full amount of P and half of N and K were applied during pit preparation. The rest of N and K were applied as top dress at 23, 71, 103 and 138 days after sowing (DAS). The crop was irrigated four times after top dressing. Weeding was done thrice at 21, 55 and 103 DAS. Necessary management practices were done for the control of insects and diseases. Harvesting of fruit started from 94 DAS to 201 DAS. Yield data was calculated based on total plots. The gross economic return was calculated on the basis of prevailing market price of the commodities. Yellow mosaic virus infestation was observed in some plants at later stage. Pod borer insect was also recorded but it was successfully controlled.

The data on yield and yield attributes were analyzed statistically using R program and the means were separated by DMRT.

Results and Discussion

Table 1 revealed that, early flowering was observed in BARI Sheem-1 (66 DAS) followed by local (68 DAS) and BARI Sheem-6 (76 DAS). In BARI Sheem-8, flowering was happened on 82 DAS and appeared as late flowering. Accordingly, early harvest was started from BARI Sheem-1 (94 DAS) and BARI Sheem-8 showed delayed (110 DAS). Days to last harvest ranged between 193 to 201 DAS. Harvest duration was highest in local sheem (13 times) followed by BARI Sheem-1 and 6 (12 times) and lowest in BARI Sheem-8 (11 times). Total harvesting period ranged between 92 to 102 days.

Yield and yield contributing characters of country bean showed significant variation due to varietal difference (Table 2). The maximum number of pod plant^{-1} was observed from local cultivar (361.50) followed by BARI Sheem-1 (345.33) and BARI Sheem-8 (343.33) The lowest pod plant^{-1}was found from BARI Sheem-6 (294.50). Single pod weight was ranged between 7.02 (BARI Sheem-8) to 9.74 (BARI Sheem-6). The highest fruit yield (20.37 t ha^{-1}) was recorded in BARI Sheem-6 due to highernumber of pod plant^{-1}which was followed by BARI Sheem-1 and BARI Sheem-8 and the lowest in local variety (16.15 t ha^{-1}).

The maximum gross margin (Tk. 371700.00 ha^{-1}) was achieved from BARI Sheem-6 because of higher market price than that of local cultivar (about Tk. 10 kg^{-1} difference). The lowest gross margin was calculated from local (Tk. 82150.00 ha^{-1}) (Table 3).

Farmers were happy with brinjal var. BARI Sheem-6 as it exhibited higher yield and gross margin for the highest market price than other varieties. For early variety, BARI Sheem-1 was also preferred. But dislike local variety due to pest infestation is lower market price and taste is not good.

Table 1. Days to flowering, 1st and last harvest with harvest duration of country bean varieties at Faridpur during 2021-22

Treatments	Days to flowering (DAS)	Days to 1st harvest (DAS)	Days to last harvest (DAS)	Harvest duration (times)	Harvesting period (days)
BARI Sheem-1	66	94	193	12	100
BARI Sheem-6	76	104	196	12	92
BARI Sheem-8	82	110	201	11	92
Local Sheem	68	100	201	13	102

Table 2. Fruit yield and yield attributes of country bean varieties at Faridpur during 2021-22

Varieties	Plant population m^{-2} (nos.)	Pod plant^{-1} (nos.)	Single pod weight (g)	Fruit yield (t ha^{-1})
BARI Sheem-1	0.71 a	345.33 a	7.81 c	19.15 b
BARI Sheem-6	0.71 a	294.50 b	9.74 a	20.37 ab
BARI Sheem-8	0.71 a	343.33 a	7.02 d	17.00 c
Local Sheem	0.71 a	361.50 a	8.59 b	16.15 c
CV (%)	1.56e-14	7.31	3.23	6.98

Table 3. Cost and return analysis of different country bean varieties at Faridpur

Variety		Gross return (Tk. ha^{-1})	Variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Sheem-1		537040	335300	201740
BARI Sheem-6		712950	341250	371700
BARI Sheem-8		425000	324000	101000
Local variety		404000	321850	82150

Price of output (Tk kg^{-1}): BARI Sheem-1= 28.0, BARI Sheem-6= 35.0, BARI Sheem-8= 25.0 and Local= 20.00

Price of input (Tk kg^{-1}): Urea=16.0, TSP=22.0, MoP=15.0, Gypsum=10.0, Zinc Sulphate mono hydrate=220.0, cowdung=2.5 and seed of country bean=1000.0

Conclusion

The BARI released country bean variety BARI Sheem-6 (20.37 t ha^{-1}) and BARI Sheem-1 (19.15 tha^{-1}) performed better compared to local variety due to higher yield and gross margin. It is the result of one year only. For concrete/final decision, the experiment may be repeated in next year.

ON-FARM TRIAL OF BARI HYBRID PUMPKIN VARIETIES

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Abstract

The trial was conducted at Dhamrai, Manikganj, Satkhira, Cumilla, Mymensingh and Sherpur during *Rabi* season of 2021-22 to evaluate the performance of BARI developed pumpkin varieties in farmers' field. Three BARI pumpkin varieties viz. BARI Hybrid Mistikumra-1, BARI Hybrid Mistikumra-2, BARI Hybrid Mistikumra-3 were evaluated against their respective local hybrid variety used as check. The fruit yield of BARI Hybrid Mistikumra-1 (37.78-39.30 t ha^{-1}), Hybrid Mistikumra-2 (18.01-48.60 t ha^{-1}) and BARI Hybrid Mistikumra-3 (24.80-46.20 t ha^{-1}) showed better performance over local hybrid varieties in all the tested locations except at Dhamrai where check variety Sweety hybrid gave higher fruit yield (47.72 t ha^{-1}). BARI hybrid varieties gave higher yield at Manikganj and Satkhira while lower yield was observed at Mymensingh and Sherpur. BARI hybrid varieties provided higher gross margin over local hybrids. Market demand of BARI Mistikumra-2 and 3 was higher due to their good taste and medium fruit size.

Introduction

Pumpkin (*Cucurbita moschata* Duch. ex Poir) is a cucurbitaceous vegetable grown throughout the sub-tropical and tropical regions of the world. In our country, farmers cultivate local varieties of pumpkin.. In Bangladesh it is a common vegetable crop fulfill a major portion of vegetable demanded of the peoples of the country. It is grown round the year having the longest storage capability and high nutrition value. The main nutrients of sweet gourd are lutein and both alpha and beta carotene, the latter of which generates vitamin A in the body. Pumpkin is relatively high in energy and carbohydrates and a good source of vitamins, especially high carotenoid pigments and minerals (Bose and Som, 1998; Tindall, 2001). It may certainly contribute to improve nutritional status of the people, particularly the vulnerable groups in respect of vitamin A requirement. The total area under cultivation of sweet gourd is 42622 acre and total production is 177899 ton (BBS, 2015) in the year 2014-15. In most cases sweet gourd growers tend to use older fresh market varieties. Recently, BARI has developed high yielding hybrid pumpkin varieties with a remarked family sized but their performances in different growing regions have not been well studied. The performances of these varieties need to be evaluated at the farmers' field condition. Therefore, the present trial was undertaken to popularize and disseminate BARI Hybrid Mistikumra varieties to the farmers' level in the tested location and to increase farmers' income.

Materials and Methods

A trial on pumpkin varieties was conducted at Dhamrai, Manikganj, Satkhira, Cumilla, Mymensingh and Sherpur during Rabi season of 2021-22. Three BARI pumpkin varieties viz. BARI Hybrid Mistikumra-1, BARI Hybrid Mistikumra-2 and BARI Hybrid Mistikumra-3 were evaluated against a local hybrid variety (check). The seeds of pumpkin were sown in in time and the seedlings were transplanted during last week of November to 3rd week of December in different locations. The experiment was laid out in a randomized complete block (RCB) design with dispersed replications. The spacing was 1.5-2.5m × 1.5-2.5m. The experimental plots were fertilized with recommended doses. The whole amount of cowdung, TSP, MOP, Zinc sulphate, Boric acid and half of urea were applied during final land preparation. The remaining urea was applied in two equal splits at 30 and 45 DAS. Weeding, irrigation, split application of fertilizers, plant protection measures and other intercultural operations were done as and when necessary. Harvesting of fruits was started from February April 2022. Data on yield and yield attributes were taken and analyzed statistically.

Results and Discussion

Fruit yield and yield characters differed significantly among the pumpkin varieties but fruits plant^{-1} (5.3 to 6.1) insignificant. . The weight of single fruit was maximum t in Sweety hybrid (2.55 to 3.06 kg) followed by BARI Mistikumra-3 (2.50 to 2.78 kg) and BARI Mistikumra-2 (2.76 to 2.90 kg) and BARI Mistikumra-1 (2.60 to 2.82 kg). Farmers' variety Sweety hybrid gave higher fruit yield (47.72 t ha^{-1}) which was at par with BARI Hybrid Mistikumra-2 (44.56 t ha^{-1}) and BARI Hybrid Mistikumra-3(40.83 t ha^{-1}) at Dhamrai. The lowest yield was obtained from BARI Mistikumra-1 (38.64 t ha^{-1}).

On the other hand, at Saturia, BARI Hybrid Mistikumra-1 (37.78 t ha^{-1}) gave higher fruit yield which was identical with BARI Hybrid Mistikumra-3 (35.36 t ha^{-1}) and BARI Hybrid Mistikumra-2 (35.51 t ha^{-1}) but the lowest in Sweety hybrid (30.65 t ha^{-1} due to lower number of fruit setting plant^{-1}. Higher gross margin (Tk. 370440 ha^{-1}) was obtained from Sweety hybrid followed by BARI Hybrid Mistikumra-2 (Tk. 339340 ha^{-1}) at Dhamrai while the maximum gross margin (Tk. 271540 ha^{-1}) was found from BARI Hybrid Mistikumra-1 followed by BARI Hybrid Mistikumra-3 (Tk. 247340 ha^{-1}) but the lowest was in Sweety hybrid (Tk.199740 ha^{-1}) at Saturia. Market demand was higher in all BARI sweet gourd varieties due to its medium fruit size. Considering number of fruits plants^{-1}, single fruit weight and fruit yield, BARI Hybrid Mistikumra-3 performed better producing higher gross margin in Cumilla, Brahmanbaria and Chandpur.

At Satkhira, the maximum fruit yield was found from BARI Hybrid Mistikumra-2 (48.6 t ha^{-1}) followed by BARI Hybrid Mistikumra-3 (46.2 t ha^{-1}) and lowest yieldfrom BARI Hybrid Mistikumra-1 (39.3 t ha^{-1}).

At Mymensingh, the maximum number of fruit plant^{-1} (6.7) was obtained from BARI Hybrid Mistikumra-3 while the local check variety gave the minimum number of fruits (5.9). Single fruit weight showed to be highest in local hybrid (3.04 kg) when lowest weight from BARI Hybrid Mistikumra-3(2.62 kg). The fruit yield of BARI Hybrid Mistikumra-3 was found 26 t ha^{-1} while local check variety produced the lowest yield 22 t ha^{-1}. BARI Hybrid Mistikumra-3 produced the highest individual fruit weight (2.98 kg) and highest fruit yield (19.44 t ha^{-1}) in Sherpur district while the local hybrid produced the lowest fruit yield (17.08 t ha^{-1}).

Cost and return

In the farmers' field of Dhamrai, Sweety hybrid provided the maximum gross return (Tk.477200 ha^{-1} and maximum gross margin Tk.370440 ha^{-1}) followed by BARI Hybrid Mistikumra-2 (Tk.445600 and Tk. 339340 ha^{-1}), respectively.

At Saturia, the maximum gross return (Tk. 353600 ha^{-1} and maximum gross margin Tk.247340 ha^{-1}) was obtained from BARI Hybrid Mistikumra-3 while the lowest in Sweety hybrid (Tk.306500 ha^{-1} and Tk.199740 ha^{-1}).

In Mymensingh, the maximum gross return (Tk.338000 ha^{-1}) and maximum gross margin (Tk.250018 ha^{-1}) was obtained from BARI Hybrid Mistikumra-3 while the lowest gross return (Tk. 286000 ha^{-1}) and gross margin (Tk.198018 ha^{-1}) in local variety .

In Comilla region, BARI Hybrid Mistikumra-3 produced the higher gross return (Tk.347200 ha^{-1}) as well as maximum gross margin (Tk.257200 ha^{-1})..

In Sherpur, the highest gross return was found Tk.253141 ha^{-1} and gross margin Tk.145732 ha^{-1} from BARI hybrid Mistikumra-3 due to higher yield. The lowest gross return and gross margin were found Tk.219289 ha^{-1} and Tk.111889 ha^{-1} was found from local hybrid.

In Mymensingh, BARI Hybrid Mistikumra-3 gave the maximum gross return (Tk. 338000 ha^{-1}) and gross margin (Tk. 250018 ha^{-1}) over local hybrid.

Disease and pest incidence: Fruit fly infestation was observed in all the locations. Powdery mildew disease was also observed in the plots and Thiovit powder @ 5 g $L^{-1}$was sprayed twice to control this disease. Nitro @ 2 gL^{-1} water, and Confidor @ 2 g/10 L water was sprayed three times to control insects. The crop was infested with white fly insect in some places and Malataf @ 2 ml L^{-1} water was applied to control the insect. Pheromone trap was also set at 12 m after to control the cucurbit fruit fly.

Farmers' opinion

Farmers were satisfied with the yield of BARI varieties especially BARI Mistikumra-2 and 3 as the size of this variety is medium and has good demand in the market. Now a days, young green fruits are of great demand in the market. Therefore, farmers were not interested to harvest mature fruit as young fruits can be harvested earlier and farmers get higher economic return.

Table 1.Fruit yield and yield characters of BARI sweet gourd varieties grown at different regions of Bangladesh during *Rabi* season of 2021-22

Location	Variety	Fruit $plant^{-1}$ (No.)	Wt. of single fruit (kg)	Fruit Yield (t ha^{-1})
Dhamrai, Dhaka	BARI Hybrid Mistikumra-1	5.53 a	2.82 ab	38.64 c
	BARI Hybrid Mistikumra-2	6.00 a	2.90 ab	44.56 a
	BARI Hybrid Mistikumra-3	5.70 a	2.78 b	40.83 a
	Sweety hybrid	6.10 a	3.06 a	47.72 a
	LSD $_{(0.05)}$	1.340	0.2364	8.67
	CV (%)	8.61	4.16	10.12
Saturia, Manikganj	BARI Hybrid Mistikumra-1	5.80 a	2.60 c	37.78 a
	BARI Hybrid Mistikumra-2	5.40 a	2.76 a	35.51 a
	BARI Hybrid Mistikumra-3	5.80 a	2.50 a	35.36 a
	Sweety hybrid	4.80 a	2.55 a	30.65 c
	LSD $_{(0.05)}$	1.325	0.423	8.671
	CV (%)	10.17	7.94	10.25
Cumilla, Brahmanbaria and Chandpur	BARI Hybrid Mistikumra-3	4.16	2.33	24.8
	Hybrid Mistikumra (Asha)	3.91	1.89	21.5
	T test (0.05)	*	*	*
Tala, Satkhira	BARI Hybrid Mistikumra-1	-	-	39.30
	BARI Hybrid Mistikumra-2	-	-	48.60
	BARI Hybrid Mistikumra-3	-	-	46.20
Muktagacha and Trishal, Mymensingh	BARI Hybrid Mistikumra-3	6.7	2.62	26.00
	Check (local hybrid)	5.9	3.04	22.00
	t-value	0.818	-3.135	0.093
Sreebordi, Sherpur	BARI hybrid Mistikumra-2	3.40	2.12	18.01
	BARI hybrid Mistikumra-3	2.60	2.98	19.44
	Local hybrid (Sweety)	2.29	2.98	17.08
	Put LSD Value			
	CV %	3.72	3.48	4.14

Table 2. Cost and return of BARI sweet gourd varieties grown at at different regions of Bangladesh during *Rabi* season of 2021-22

Locations	Variety	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
Sreerampur, Dhamrai, Dhaka	BARI Hybrid Mistikumra-1	386400	106260	280140	3.64
	BARI Hybrid Mistikumra-2	445600	106260	339340	4.19
	BARI Hybrid Mistikumra-3	408300	106260	302040	3.84
	Sweety hybrid	477200	106760	370440	4.47
Saturia, Manikganj	BARI Hybrid Mistikumra-1	377800	106260	271540	3.55
	BARI Hybrid Mistikumra-2	325100	106260	218840	3.05
	BARI Hybrid Mistikumra-3	353600	106260	247340	3.32
	Sweety hybrid	306500	106760	199740	2.87

Locations	Variety	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
Cumilla, Brahmanbaria and Chandpur	BARI Hybrid Mistikumra-3	347200	90000	257200	-
	Hybrid Mistikumra (Asha)	301000	90000	211000	-
Muktagacha and Trishal, Mymensingh	BARI Hybrid Mistikumra-3	338000	87982	250018	-
	Local hybrid	286000	87982	198018	-
Sreebordi, Sherpur	BARI hybrid Mistikumra-2	232153	107400	124753	-
	BARI hybrid Mistikumra-3	253141	107400	145732	-
	Local hybrid (Sweety)	219289	107400	111889	-

Market price of sweet gourd @ Tk. 10.00 kg^{-1} Seed price of BARI Hybrid variety: Tk. 1000.00 kg^{-1} and Sweety hybrid Tk. 1400.00 kg^{-1}.

Conclusion

Sweet gourd var. BARI Hybrid Mistikumra-2 and 3 showed better performance regarding yield in the study areas. Therefore, these two varieties can be recommended for large scale extension in the farmer's field at sweet gourd producing areas of Bangladesh.

ON-FARM TRIAL OF BARI WINTER TOMATO VARIETIES

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Abstract

The trial was conducted at Manikganj, Cumilla, Khulna, Gaibandha, Dinajpur and Noakhali during *Rabi* season of 2021-22 to evaluate the performance of BARI developed winter Tomato varieties. Eight BARI Tomato varieties viz. BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, BARI Tomato-17, BARI Tomato-18, BARI Tomato-19, BARI Tomato-20 and BARI Tomato-21 were evaluated against local hybrid varieties as check. BARI developed Tomato varieties performed better in different locations compared to local varieties. BARI Tomato-14 (54.57 t ha^{-1}) and BARI Tomato-15 (52.29 t ha^{-1}) gave statistically similar yields, but BARI Tomato-19 produced significantly higher fruit yield (80.15 t ha^{-1}) at Dinajpur. Higher yields from BARI Tomato-16 were found at Manikganj (75.76 t ha^{-1}) and Dinajpur (62.27 t ha^{-1}) whereas BARI Tomato-17 gave higher yield at Gaibandha (71.60 t ha^{-1}) but lower at Dinajpur (54.20 t ha^{-1}). The maximum fruit yield from BARI Tomato-18 was obtained at Dinajpur (76.68 t ha^{-1}) followed by Gaibandha (72.40 t ha^{-1}) and Manikganj (68.65 t ha^{-1}). The fruit yield of BARI Tomato-20 was comparatively lower than other BARI varieties viz. 49.00 t ha^{-1} at Noakhali, 47.10 t ha^{-1} at Khulna, 39.60 t ha^{-1} at Cumilla and 34.05 t ha^{-1} at Dinajpur. The maximum fruit yield of BARI Tomato-21 was recorded at Manikganj (78.24 t ha^{-1}) followed by Gaibandha (76.50 t ha^{-1}), Dinajpur (75.03 t ha^{-1}), Khulna (73.30 t ha^{-1}), Cumilla (51.90 t ha^{-1}) and Patuakhali (42.59 t ha^{-1}) but the lowest at Noakhali (23.10 t ha^{-1}). The yield of commercial hybrids ranged from 41.40 to 80.12 t ha^{-1} where Lalteer hybrid (80.12 t ha^{-1}) at Manikganj produced the maximum yield followed by Bahoboly (41.40 t ha^{-1}) at Cumilla , Local variety (57.40 t ha^{-1}) at Gaibandha, Bizli Super at Patuakhali (54.71 t ha^{-1}), Rani hybrid (50.65 t ha^{-1}) at Dinajpur and Mintu hybrid (43.20 t ha^{-1}). Higher gross margin was obtained from BARI winter tomato varieties in all locations compared to local varieties except at Patuakhali where local hybrid gave higher gross margin over BARI varieties.

Introduction

Tomato (*Solanum lycopersicum*) is the most important vegetables crop in Bangladesh cultivated during the *Rabi* season. It is a good source of vitamins and minerals. This average yield of Tomato is very low compared to other tomato growing countries of the world. Farmers use the traditional varieties those are low yielding and susceptible to diseases and pests. As a result, yield is decreasing day by day. Horticulture Research Centre of BARI has developed some tomato varieties those are supposed to be high yielding and less susceptible to pest and diseases. The present study was undertaken to evaluate the performance of BARI developed tomato varieties at different locations and to increase production and economic return of farmers.

Materials and Methods

The experiment was conducted at Manikganj, Cumilla, Khulna, Gaibandha, Dinajpur, Noakhali and Patuakhali during *Rabi* season of 2021-22. Tomato var. BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, BARI Tomato-17, BARI Tomato-18, BARI Tomato-19, BARI Tomato-20 and BARI Tomato-21 at Dinajpur; BARI Tomato-16, BARI Tomato-18 and BARI Tomato-21 at Manikganj; BARI Tomato-17, BARI Tomato-15, BARI Tomato-18 and BARI Tomato-21 at Gaibandha; BARI Tomato-20, BARI Tomato-21 and BARI Hybrid Tomato-9 at Cumilla, Khulna and Noakhali were evaluated against locally available hybrid varieties. At Patuakhali, BARI Tomato-15 and BARI Tomato-21 were tested against a local hybrid. The experiment was laid out in RCB design with six dispersed replications. The unit plot size 5m × 4m and spacing was 60 cm × 40cm. Crop management practices used in different locations shown in Table 1. The whole amount of cowdung, TSP, MOP, Gypsum, Zinc sulphate, Boric acid and half of urea were applied during final land preparation. The remaining urea was applied in two equal splits at 30 and 45 days after transplanting. Other intercultural operations were done as and when required. Data on yield and yield attributes were taken and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Transplanting time	Harvesting time	Fertilizer dose (kg ha^{-1}) N-P-K-S-Zn-B-Cowdung
Manikganj	20 October to 13 November, 2021	16 January to 20 February, 2022	250-90-125-22-1-1-5000
Cumilla	25 November to 05 December, 2021	23 February to 20 April, 2022	210-50-75-0-0-0-5000
Khulna	Satkhira: 02.12.2021 Koyra: 10 November to 16 December, 2021	Satkhira: 25 February to 26 March 2022 Koyra: 12 February to -22 April 2022	253-90-125-22-5.4-2-5000
Gaibandha	10-15 November 2021	15 January to 20 February 2022	195-180-90-93-12-7.5-5000
Dinajpur	12 January, 2022	10 April, 2022	195-180-90-93-12-7.5-5000
Noakhali	29 December to 06 January, 2022	25 March to 05 April, 2022	253-90-125-22-5.40-2-5000
Patuakhali	29 December, 2021	25 February to 15 April, 2022	90-75-45-45-5.40-2-5000

Results and Discussion

All BARI developed Tomato varieties performed better in the farmer's field of Manikganj, Gaibandha, Khulna and Dinajpur whereas lower yields were obtained at Cumilla, Noakhali and Patuakhali (Table 1). Yield characters such as number of fruits plant^{-1} and single fruit weight contributed to produce higher yield in different tomato varieties. The fruit yield varied in different location depended on the yield potentiality, crop management, soil and agro climatic characteristics. The fruit yields from BARI Tomato-16 at Dinajpur (62.27 t ha^{-1}) and Manikganj (75.76 t ha^{-1}) was comparatively higher. BARI Tomato-17 gave lower yield at Dinajpur (54.20 t ha^{-1}) but higher in Gaibandha (71.60 t ha^{-1}). The fruit yield of BARI Tomato-18 at Manikganj was 68.65 t ha^{-1} followed by Gaibandha (72.40 t ha^{-1}) and Dinajpur (76.68 t ha^{-1}). BARI Tomato-20 produced lower yield at Dinajpur (34.05 t ha^{-1}), Cumilla (39.60 t ha^{-1}), Khulna (47.10 t ha^{-1}) and Noakhali (49.00 t ha^{-1}).The yield performance of BARI Tomato-21 at Noakhali (23.10 t ha^{-1}) was lower but this varieties produced higher yields at Patuakhali (42.59 t ha^{-1}), Cumilla (51.90 t ha^{-1}), Khulna (73.30 t ha^{-1}), Dinajpur (75.03 t ha^{-1}), Gaibandha (76.50 t ha^{-1}) and Manikganj (78.24 t ha^{-1}). In the farmers field of Dinajpur, the fruit yield of BARI Tomato-14 (54.57 t ha^{-1}) and BARI Tomato-15 (52.29 t ha^{-1}) were low, but BARI Tomato-19 produced significantly higher yield (80.15 t ha^{-1}) at the same location. The yield of commercial hybrids varied at different testing locations. The yield ranged from 41.40 to 80.12 t ha^{-1} where Lalteer hybrid (80.12 t ha^{-1}) at Manikganj, Bahoboly (41.40 t ha^{-1}) at Cumilla, Local variety (57.40 t ha^{-1}) at Gaibandha, Bizli Super at Patuakhali (54.71 t ha^{-1}), Rani hybrid (50.65 t ha^{-1}) at Dinajpur and Mintu hybrid (43.20 t ha^{-1}) at Noakhali was recorded.

Cost and return: Economic return differed significantly over the locations due to yield variation and prevailing market price of produce. Higher gross margin was obtained from BARI developed tomato varieties than local varieties at all the tested locations.

Pest and disease infestation: Autostin @ 2g L^{-1} water was sprayed to control root rot disease of seedlings and Confidor @ 2g/10L water was sprayed to control small insects. Pyrifen @ 2 ml L^{-1} water was sprayed to control white fly insect. Some plants were infected by leaf curl virus and were uprooted from the plot. At Cumilla, to control the fungal disease and insect Rovral @ 2 g L^{-1}, Indofil @ 2 g L^{-1}, Dithane M-45 @ 4.5 g L^{-1}, Secure @ 2 g L^{-1}, Ridomil Gold @ 2.5 g $L^{-1}$and Admire @ 1 ml L^{-1}, Desis @ 2 ml L^{-1}, respectively were applied. Virus infestation rate at Cumila was 2.1 to 12.4% in different varieties. The lower infestation was observed in BARI Varieties viz. BARI Hybrid Tomato-9 (2.1%), BARI Tomato-20 (4.0%), BARI Tomato-21 (5.10%) but higher in commercial hybrid Bahoboly (12.4%). At Gaibandha, Rovral @ 2 g L^{-1}, Indofil @ 2 g L^{-1}, Dithane M-45 @ 4.5 g L^{-1}, Pegasus 50 SC @ 1 ml L^{-1} and Desis @ 2 ml L^{-1}, respectively were applied to control the disease and insect.

Farmers Opinion

- Farmers at Manikganj were very much interested to grow the BARI Tomato-16 and BARI Tomato-18 for their higher yield, uniform size, attractive color and economic benefit. Farmers commented that market demand of BARI Tomaro-21 was lower due to its round shape.
- Farmers at Cumilla were very much impressive to grow BARI developed tomato varieties *i.e.,* BARI Hybrid Tomato-9 and BARI Tomato-21. They are willing to grow the varieties in the next year if seeds are available.
- Farmers at Khulna became interested to cultivate BARI Hybrid Tomato-9 and BARI Tomato-21 for its larger fruit and longer shelf life.
- Farmers at Gaibandha became interested to cultivate BARI Tomato-17 and BARI tomato-21 for their higher yield, attractive color, shape, size, higher market price and longer shelf life.
- Farmers choose BARI Tomato-19, BARI Tomato-18 and BARI Tomato-21 due to better yield performed at Dinajpur.
- Farmers' of Noakhali choose BARI Hybrid Tomato-9 and BARI Tomato-20 for better yield.
- Farmers at Patukhali showed their interest to grow hybrid varieties in the following year due to their attractive shape, size, color and higher yield. They also opined that pest and disease attack was less in BARI varieties.

Table 2. Fruit yield and yield attributes of Tomato varieties at different locations during *Rabi* season of 2021-22.

Location	Variety	Fruits $plant^{-1}$ (no)	Single fruit wt. (g)	Fruit yield (t ha^{-1})	Gross Margin (Tk. ha^{-1})
Manikganj	BARI Tomato-16	45.53	76.00	75.76	1264904
	BARI Tomato-18	35.70	60.33	68.65	1122704
	BARI Tomato-21	45.53	51.00	78.24	1314504
	Lalteer hybrid	60.27	70.00	80.12	1347104
	LSD $_{(0.05)}$	13..33	9.01	5.92	
	CV (%)	10.57	6.18	3.83	
Cumilla	BARI Tomato-20	51.40	20.30	39.60	205500.00
	BARI Tomato-21	36.90	52.30	51.90	328500.00
	BARI Hybrid Tomato-9	52.10	83.30	55.80	367500.00
	Hybrid Bahoboly	31.50	57.20	41.40	223500.00
	LSD $_{(0.05)}$	5.98	6.98	4.95	
	CV (%)	9.98	3.85	12.48	
Khulna	BARI Tomato-20	20.30	65.50	47.10	706500.00
	BARI Tomato-21	45.53	76.00	73.30	1099500.00
	BARI Hybrid Tomato-9	61.27	71.00	81.46	1221900.00
	LSD $_{(0.05)}$	14..43	8.98	5.92	
	CV (%)	7.88	5.66	9.45	

Location	Variety	Fruits plant^{-1} (no)	Single fruit wt. (g)	Fruit yield (t ha^{-1})	Gross Margin (Tk. ha^{-1})
Gaibandha	BARI Tomato-17	22.00	132.30	71.60	433250.00
	BARI Tomato-18	35.00	64.70	72.40	441250.00
	BARI Tomato-21	39.00	83.80	76.50	482250.00
	Local variety	36.00	58.90	57.40	291250.00
	LSD $_{(0.05)}$	9.40	28.70	8.90	
	CV (%)	14.40	16.90	6.40	
Dinajpur	BARI Tomato-14	51.60	29.22	54.57	280200
	BARI Tomato-15	40.30	37.81	52.29	257399
	BARI Tomato-16	61.70	25.78	62.27	357198
	BARI Tomato-17	16.60	92.81	54.20	276497
	BARI Tomato-18	57.30	34.74	76.68	501296
	BARI Tomato-19	55.50	69.94	80.15	535995
	BARI Tomato-20	34.80	19.83	34.05	74994
	BARI Tomato-21	33.50	47.81	75.03	484793
	Rani (Local hybrid)	43.60	36.42	50.65	240992
	LSD$_{(0.05)}$	10.16	11.70	18.63	
	CV%	7.97	5.68	10.69	
Noakhali	BARI hybrid tomato-9	34.60	42.50	56.70	726850
	BARI tomato-20	27.40	45.90	49.00	572850
	BARI tomato-21	31.30	19.40	23.10	54850
	Hybrid tomato (Mintu)	18.30	62.50	43.20	456850
	LSD $_{(0.05)}$	2.11	6.21	7.20	
	CV (%)	13.05	12.04	12.66	
Patukhali	BARI Tomato-15	30.13	51.83	37.86	317400
	BARI Tomato-21	34.96	51.16	42.59	388350
	Bizli Super	33.73	68.93	54.71	570150
	LSD $_{(0.05)}$	1.97	6.07	6.14	
	CV (%)	2.65	4.68	6.02	

Market price of Tomato- Manikganj: Tk. 20 kg^{-1}, Cumilla: Tk.10 kg^{-1}, Khulna: 15.00 kg^{-1}, Gaibandha: Tk.10 kg^{-1}, Dinajpur: Tk.10 kg^{-1}, Noakhali: Tk. 20 kg^{-1} and Patukhali: Tk. 15.00 kg^{-1}

Conclusion

Considering yield and economics analysis,it revealed that BARI released different varieties of tomato performed better in different locations. Therefore, these varieties could be extended in the farmers' field in the tested locations according to yield performance and farmers choice.

ON-FARM TRIAL OF BARI WINTER HYBRID TOMATO VARIETIES

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Abstract

The field experiment was conducted at Tangail, Manikganj, Gopalganj, Patuakhali, Munshiganj and Gazipur during Rabi season of 2021-22 to evaluate the performance of BARI winter hybrid Tomato varieties and to popularize the varieties among the farmers. The experiment was laid out in RCB design with six dispersed replications. BARI Hybrid Tomato-5 and BARI Hybrid Tomato-7 and BARI Hybrid Tomato-9 against Bipul Plus hybrid at Tangail and Gopalgonj. BARI hybrid Tomato-7 and 9 were evaluated with commercial hybrids as check at Manikganj, Munshiganj and Gazipur. BARI Hybrid Tomato-7, BARI Hybrid Tomato-9 were compared with two locally available hybrids viz. Unnayan and Lalpakri at Patuakhali. BARI Hybrid Tomato-7 gave the highest fruit yield at Atia (89.00 t ha^{-1}) and Madhupur (88.00 t ha^{-1}) of Tangail while the lowest (75.00 and 76.00 t ha^{-1}) from Bipul Plus hybrid at both the tested locations of Tangail. At Gopalgonj, Bipul plus hybrid gave higher yield (81.41t ha^{-1}) which was statistically similar to BARI Hybrid Tomato-9 (78.69 t ha^{-1})) but the lowest (69.58 t ha^{-1}) in

BARI Hybrid Tomato-5. BARI winter hybrid Tomato-7 produced higher yields (87.73 and 92.03 t ha^{-1}) at Saturia and Shibaloya compared to Unnayan hybrid 75.50 and 89.52 t ha^{-1}, respectively. BARI winter hybrid Tomato-9 gave fruit yields 72.23, 79.20 and 87.53 t ha^{-1} at Ghior, Saturia and Shibaloya, respectively whereas the maximum yield (91.28 t ha^{-1}) was obtained from Bipul Plus hybrid at Shibaloya of Manikganj. BARI Hybrid Tomato-9 at Patuakhali produced the maximum fruit yield (104.73 t ha^{-1}) followed by BARI Hybrid Tomato-7 (85.60 t ha^{-1}) but lower yields were obtained from Unnayan hybrid (72.44 t ha^{-1}) and Lalpakri hybrid (69.16 t ha^{-1}) at the same location. BARI hybrid tomato-9 produced higher fruit yields both at Munshiganj (87.00 t ha^{-1}) and Gazipur (70.3 t ha^{-1}) followed by BARI hybrid tomato-7 producing 69.4 t ha^{-1}at Munshiganj and 58.00 t ha^{-1} at Gazipur but lowest from local variety 62.2 t ha^{-1} at Munshiganj and 31.3 t ha^{-1} at Gazipur. Higher gross margin was also obtained from BARI varieties due to higher fruit yields and lower price of seed at all the tested locations.

Introduction

Tomato (*Solanum lycopersicum*) is the most important vegetable crop in our country cultivated during winter season. It is cultivated throughout the country due to its adaptability to wide range of soil and climate (Ahmed, 1976). Its food value is very rich because of higher contents of vitamins A, B and C including calcium and carotene (Bose and Som, 1990). The area of winter hybrid tomato at the tested locations are low as a result total production is also low. Farmers use the traditional varieties which is low yielding and susceptible to diseases and pests. As a result, yield is decreasing day by day. This declining is probably associated with variety, climatic change, decreasing soil fertility, deficiency of micronutrient and unavailability of quality seeds during the sowing time and also and improper management. Some advance farmers grow commercial hybrid varieties, but the seeds are very costly that causes economic loss of the farmers. Horticulture Research Centre, BARI has developed some winter hybrid Tomato varieties those are supposed to be high yielder and less susceptible to pest and diseases. The present study was undertaken to evaluate the performance of BARI winter hybrid Tomato varieties in the farmers' field and to popularize the varieties among the farmers to promote their adoption.

Materials and Methods

The experiment was conducted in farmers' field at FSRD site, Delduar and MLT site, Modhupur of Tangail district; Saturia, Ghior and Shibaloya upazila of Manikganj district; Pirojpur and Gopalganj district and Bauphal, Patuakhali; at MLT site, Munshiganj and MLT site, Gazipur during *Rabi* season of 2021-22. Three BARI developed hybrid tomato varieties viz. BARI Hybrid Tomato-5, BARI Hybrid Tomato-7 and BARI Hybrid Tomato-9 were evaluated against locally available commercial tomato hybrids. The experiment was laid out in RCB design with six dispersed replications. The unit plot size was 5m × 4m with spacing of 60cm × 40cm. Thirty days old seedlings were planted in the main field. Crop management practices used in different locations shown in Table 1. Intercultural operations were done as and when required. Data on yield and yield contributing characters were recorded and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Transplanting time	Harvesting time	Fertilizer dose (kg ha^{-1}) N-P-K-S-Zn-B-Cowdung
Tangail	20 November, 2020	12 February to 30 March, 2021	253-90-125-22-5.4-2-5000
Manikganj	18 October to 05 November, 2021	16 January to 25 February, 2022	250-90-125-22-1-1-5000
Gopalganj	27 November to 03 December, 2021	10 February to 30 March, 2022	250-90-125-22-5-2-5000
Patuakhali	23 to 29 December, 2021	18 March to 14 April 2022	90-75-45-45-1-1-5000
Munshiganj	13-15 December 2021	28 February to 5 April 2022	250-90-125-22-2-2-10000
Gazipur	1-5 December 2021	14 February to 4 April 2022	250-90-125-22-2-2-10000

Results and Discussion

BARI winter hybrid Tomato varieties performed better than those of local hybrid tomato varieties cultivated in different locations of Tangail, Manikganj, Gopalganj, Patuakhali, Munshiganj and Gazipur (Table 2). Fruit yield of BARI Hybrid Tomato-5 ranged from 69.58 to 88.00 t ha^{-1} at Tangail and Gopalganj. The higher fruit yields were obtained at Atia (87.00 t ha^{-1}) and Modhupur (86.00 t ha^{-1}) of Tangail and lower at Gopalganj (69.58 t ha^{-1}). On the other hand, BARI Hybrid Tomato-7 ranged from 71.18 to 92.03 t ha^{-1} at different locations. BARI Hybrid Tomato-7 gave yield 85.60 t ha^{-1} at Patuakhali but the yield at Ghior (87.00 t ha^{-1}) and Saturia of Manikganj were almost similar (87.73 t ha^{-1}). Simialr trend was also observed in Modhupur (88.00 t ha^{-1}) and Atia (89.00 t ha^{-1}) of Tangail. Lower yields were observed at Munshiganj (69.4 t ha^{-1}) and Gazipur (58.00 t ha^{-1}), but the maximum yield (92.03 t ha^{-1}) was recorded at Shibaloya of Maniganj. The fruit yield of BARI Hybrid Tomato-9 ranged from 72.23 to 104.73 t ha^{-1} in the tested locations. The fruit yield at Modhupur (74.00 t ha^{-1}) and Atia (75.00 t ha^{-1}) of Tangail were statistically similar but differ significantly at Ghior (72.23 t ha^{-1}) and Saturia (79.20 t ha^{-1}) of Manikganj. The maximum fruit yield of BARI Hybrid Tomato-9 at Patuakhali was recorded 104.73 t ha^{-1}. The yield of BARI Hybrid Tomato-9 at Munshiganj gave 87.00 t ha^{-1} but 70.30 t ha^{-1} at Gazipur. At Gopalganj, BARI Hybrid Tomato-9 gave 78.69 t ha^{-1}. The yield obtained from commercial hybrids at different tested locations were lower than BARI varieties. Commercial hybrid Bipul Plus at Atia (79.00 t ha^{-1}) and Modhupur (76.00 t ha^{-1}) of Tangail produced about 10 to 15% lower yields than BARI varieties, respectively. Similarly, BARI Hybrid Tomato-7 and BARI Hybrid Tomato-9 at Saturia gave about 5 to 16% higher yields than Unnayan hybrid. Bipul plus (91.28 t ha^{-1}) at Shibaloya of Maniganj gave 0.82% lower yield than BARI Hybrid Tomato-9 (92.03 t ha^{-1}) but in the farmers field of Gopalganj Bipul Plus (81.41 t ha^{-1}) gave higher yield compared to BARI Hybrid Tomato-9 (78.69 t ha^{-1}) and BARI Hybrid Tomato-7 (71.18 t ha^{-1}). The yields of commercial hybrids Unnayan hybrid (72.44 t ha^{-1}) and Lalpakri hybrid (69.16 t ha^{-1}) at Patuakhali were statistically identical and produced about 35% lower yields compared to BARI hybrid tomatoes. Local hybrid (Jhalmol) at Munshiganj (62.20 t ha^{-1}) and Ruma hybrid at Gazipur (41.30 t ha^{-1}) gave about 25and 51% lower yields than BARI hybrid varieties.

Cost and return analysis

Economic return differed significantly over the locations due to yield variation and prevailing market price of produce. Higher gross margin was obtained from both BARI winter hybrid tomato varieties at all the locations and lower from the farmers varieties.

Pest Infestation

In the farmers' field at Tangail, plants were infected by leaf blight and successfully controlled by applying Ridomil Gold @ 2 gL^{-1} water. White fly infestation was controlled by spraying subicron @ 2ml L^{-1} water. Experimental plots at Manikganj were sprayed with Autostin @ 2g L^{-1} water to control root rot disease of seedling and Confidor @ 2g /10L water was sprayed to control small insects. Pyrifen @ 2 ml L^{-1} water was sprayed to control white fly insect. Some plants were infected by leaf curl virus and were uprooted from the plot.

Farmers' opinion

Farmers of Tangail were interested to grow BARI Hybrid tomato varieties for their higher yield, uniform size, attractive color and higher economic return. Framers opined that keeping quality of BARI varieties were better than locally available hybrid Tomato varieties. They demanded seeds of BARI hybrid varieties for next growing season.

Farmers at Saturia of Manikganj choose BARI Hybrid Tomato-9 due to its late yield potentiality and longer shelf life than other hybrid varieties.

Farmers at Ghior, preferred BARI Hybrid Tomato-7 due to its higher yield and higher market demand.

At Shibaloya, farmers choose BARI Hybrid Tomato-7 due to its higher yield but keeping quality was low compared to BARI Hybrid Tomato-9.

Farmers at Gopalganj became interested to cultivate BARI Hybrid Tomato-9 and Bipul Plus hybrid for oval fruit size, higher yield and return.

Farmers at Patuakhali showed their interest in growing BARI improved varieties the following year due to their higher yield. They also opined to make available seeds of BARI hybrid tomato varieties in local market.

Farmers at Gazipur showed their interest on BARI Hybrid Tomato-9 due to higher yield and large fruit size. They demanded the seeds of BARI Hybrid Tomato to cultivate in the next year.

Table 2. Fruit yield, yield attributes and gross margin of winter hybrid tomato varieties at different locations during the *Rabi* season of 2021-22.

Location	Variety	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit yield (t ha^{-1})	Gross margin (Tk. ha^{-1})
Tangail (Atia)	BARI Hybrid Tomato-5	34.00	72.00	87.00	1150563
	BARI Hybrid Tomato-7	39.00	64.00	89.00	1188563
	BARI Hybrid Tomato-9	44.00	48.00	79.00	922563
	Local hybrid (Bipul Plus)	36.00	68.00	75.00	979563
	LSD $_{(0.05)}$	3.65	7.04	8.53	
	CV (%)	4.80	5.10	4.60	
Tangail (Modhupur)	BARI Hybrid Tomato-5	35.00	74.00	86.00	1150563
	BARI Hybrid Tomato-7	35.00	67.00	88.00	1188563
	BARI Hybrid Tomato-9	38.00	46.00	74.00	922563
	Local hybrid (Bipul Plus)	34.00	67.00	76.00	979563
	LSD $_{(0.05)}$	4.79	3.02	12.63	
	CV (%)	6.70	2.10	7.40	
Manikganj (Saturia)	BARI Hybrid Tomato-7	54.80	51.80	87.73	1505669
	BARI Hybrid Tomato-9	28.60	94.40	79.20	1335069
	Local variety (Unnayan hybrid)	43.40	62.80	75.50	1246069
	LSD $_{(0.05)}$	3.433	10.19	7.69	
	CV (%)	3.58	6.45	3.96	
Manikganj (Ghior)	BARI Hybrid Tomato-7	103.40	42.00	87.00	1482704
	BARI Hybrid Tomato-9	59.00	81.25	72.23	1187304
	Local variety (Unnayan hybrid)	178.50	57.20	89.52	1503104
	LSD $_{(0.05)}$	14.10	11.54	12.02	
	CV (%)	5.47	5.45	6.03	
Manikganj (Shibaloya)	BARI Hybrid Tomato-7	68.40	42.60	92.03	1591669
	BARI Hybrid Tomato-9	33.40	83.26	87.53	1501669
	Local hybrid (Bipul Plus)	57.60	50.24	91.28	1501669
	LSD $_{(0.05)}$	10.20	12.37	25.34	
	CV (%)	8.47	9.29	11.73	
Gopalganj	BARI Hybrid Tomato-5	38.10	60.20	69.58	859950
	BARI Hybrid Tomato-7	39.50	62.60	71.18	891950
	BARI Hybrid Tomato-9	44.70	64.80	78.69	1042150
	Local hybrid (Bipul Plus)	46.30	65.40	81.41	1096550
	LSD $_{(0.05)}$	6.20	4.90	6.90	
	CV (%)	12.90	8.34	8.20	
Patuakhali	BARI Hybrid Tomato-7	48.00	53.00	85.60	595500
	BARI Hybrid Tomato-9	59.00	71.70	104.73	786800
	Local hybrid (Unnayan)	42.00	48.50	72.44	453900

Location	Variety	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit yield (t ha^{-1})	Gross margin (Tk. ha^{-1})
	Local hybrid (Lalpakri)	38.00	49.70	69.16	421100
	LSD $_{(0.05)}$	4.56	7.85	11.32	
	CV (%)	8.69	6.45	9.76	
MLT site Munshiganj	BARI Hybrid Tomato-7	36.00	56.50	69.40	1198800
	BARI Hybrid Tomato-9	79.00	89.20	87.00	1550000
	Local variety (Ruma hybrid)	34.00	48.20	62.20	1054000
	LSD $_{(0.05)}$	4.33	5.76	6.89	
	CV (%)	9.64	5.88	10.22	
MLT site Gazipur	BARI Hybrid Tomato-7	18.00	47.60	58.00	973500
	BARI Hybrid Tomato-9	26.00	86.20	70.30	1219500
	Local variety (Ruma hybrid)	15.00	44.90	41.30	578200
	LSD $_{(0.05)}$	3.29	3.67	6.42	
	CV (%)	11.27	6.93	9.71	

Market price of winter hybrid Tomato-Tangail: Tk.19.00 kg^{-1} and Manikganj and Gopalganj: Tk. 20.00 kg^{-1}, Patuakhali: Tk. 10.00 kg^{-1}

Conclusion

Winter hybrid Tomato var. BARI Hybrid Tomato-5, 7 and 9 showed better performance regarding yield potentiality and economic return. Therefore, these varieties could be extended in the farmers' field in the study areas.

ON-FARM TRIAL OF BARI BOTTLE GOURD VARIETIES

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Abstract

The trial was conducted at Satkhira and Bandarban during Rabi season of 2021-22 to evaluate the performance of BARI developed high yielding bottle gourd varieties in the farmer's field. Bottle gourd var. BARI Lau-4, BARI Lau-5 and local variety were included at Sathkhira and BARI Lau-3, 4 and 5 were tested against local variety (Hybrid Lau) in the hill valleys of Bandarban. The experiment was laid out in RCB design with six dispersed replications. At both the locations, BARI Lau-4 gave the highest fruit yield (49.00 t ha^{-1}) followed by produced BARI Lau-5 (39.17 t ha^{-1}) and the lowest from local variety (26.65 t ha^{-1}) at Satkhira. In the hill valleys of Bandarban, the highest fruit yield was obtained from BARI Lau-4 (34.66 t ha^{-1}) followed by local variety (32.98 ha^{-1})), BARI Lau-5 (22.88 t ha^{-1}) and the lowest from BARI Lau-3 (21.34 t ha^{-1}). The maximum gross margin was also obtained from BARI Lau-4 at all the tested locations.

Introduction

Bottle gourd (*Lagenaria vulgaris*) is one of the most common popular cucurbits grown in Bangladesh. It contains 83.1% water, 0.6% minerals, 0.6% fiber, 1.1% protein, 0.1% fat and 15.1% carbohydrate per 100 g edible protein. It can play an important role in supplying vegetables throughout the year and can solve the nutritional problem for the low-income earning people round the year. In our country, farmers cultivate local varieties of bottle gourd. Yield potentiality of local variety is very poor and susceptible to pest and diseases. BARI has developed a good number of winter bottle gourd varieties which are high yielding, tolerant to different pest and diseases and seed producing potentiality. Farmers' can cultivate BARI Lau-3, BARI Lau-4 and BARI Lau-5 in winter season which possess high yield and attractive colour. The experiment was undertaken to evaluate the performance of BARI Lau-3, BARI Lau-4 and BARI Lau-5 under farmer's field condition and popularize the varieties among the farmers to promote their adoption.

Materials and Methods

The experiment was carried out at MLT site, Satkhira and Bikricchara hill valleys of Bandarban during *Rabi* season of 2021-22 under farmers' field condition. BARI released three bottle gourd varieties such as BARI Lau-3, BARI Lau-4, BARI Lau-5 were evaluated against local variety in different locations. The trial was laid out in Randomized Complete Block design with six dispersed replications. The unit plot size was 10m x 2.5m. Twenty-five days old seedlings were planted with a spacing of 3m x 2m. Crop management practices used in different locations are shown in Table 1. Full amount of cowdung, P, S, Zn, B and 2/6th of K was applied during pit preparation at least 7 days before transplanting. N and the remaining K were applied in 4 equal installments at 20, 40, 60 and 80 days after transplanting. Irrigation, plant protection measures and other intercultural operations were done as and when necessary. Data on yield and yield attributes were collected and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Planting time	Harvesting time	Fertilizer dose (kg ha^{-1}) N-P-K-S-Zn-B-Cowdung
Satkhira	15 May 2021	20 August to 25 Septt. 2021	80-30-85-18-4-1.5-5000
Bandarban	15-17 November, 2021	01 March to 18 April 2022	81-30-87-19-4-2-5000

Results and Discussion

Fruit yield of BARI Lau-4 ranged from 49.00 t ha^{-1} to 34.66 t ha^{-1} with a mean yield 41.83 t ha^{-1}. On the other hand, the yield of local variety ranged from 26.65 to 32.98 t ha^{-1} with an average yield of 29.81t ha^{-1} (Table 2). BARI Lau-4 at Satkhira gave 49.00 t ha^{-1} yields whereas local variety produced 26.65 t ha^{-1}. Fruit yield in local variety decreased due to lower number of fruits plant^{-1} (8.95). Fruit size of BARI Lau-4 was longer (42.10cm) than local variety (32.12cm). The highest yield of BARI Lau-4 recorded in the hill valleys of Bandarban (34.66 t ha^{-1}) followed by Local hybrid (32.98 t ha^{-1}) and BARI Lau-5 (22.88 t ha^{-1}). All the yield characters differ significantly among the varieties and fruit length of local variety were longer than BARI variety.

Farmers' opinion

Bandarban: Farmers expressed their satisfaction with higher yield and individual fruit weight and attractive color of BARI Lau- 4 and Khet Lau. They also preferred the size and shape of BARI Lau-3 because of market demand but bottle shape of BARI Lau-5 was not so much appreciated.

Satkhira: Farmers were highly satisfied to see the performance of BARI Varieties due to its higher yield, market price and better taste.

Table 2. Fruit yield and yield attributes of Bottle gourd at different locations during the *Rabi* season of 2021-22.

Location	Variety	Fruit length (cm)	Fruit diameter (cm)	Single fruit wt. (kg)	Fruits plant^{-1} (no.)	Fruit yield (t ha^{-1})	Gross margin (Tk. ha^{-1})
Sathkhira	BARI Lau-4	42.10	17.30	2.54	11.65	49.00	438000
	BARI Lau-5	38.10	16.23	2.13	10.45	39.17	320040
	Local variety	32.12	14.76	1.84	8.95	26.65	169800
	CV (%)	6.62	8.34	13.51	6.24	18.43	-
	LSD (0.05)	3.65	2.27	1.26	0.86	4.21	-
Bandarban	BARI Lau-3	32.02	14.61	1.99	6.35	21.34	212000
	BARI Lau-4	39.96	15.60	2.15	9.68	34.66	411800
	BARI Lau-5	38.20	14.01	1.73	7.83	22.88	235100
	Hybrid Lau	41.97	15.14	1.95	10.00	32.98	386600
	CV (%)	6.62	8.34	13.51	6.24	16.39	-
	LSD (0.05)	1.78	0.88	0.19	0.37	3.24	-

Market price of Bottle gourd at Satkhira @ Tk.12 kg^{-1} and Bandarban: @ Tk.15 kg^{-1}

Conclusion

The Bottle gourd var. BARI Lau-4 performed better in both locations than local variety regarding yield potentiality. Therefore, these varieties could be cultivated widely in the tested locations.

ON-FARM ADAPTIVE TRIAL OF BARI CAPSICUM VARIETIES

G.N. HASAN, R. HASAN, Q. NAHER, M. M. BASHIR AND S. K. BHAWAL

Abstract

The experiment was carried out at charland of Bhola sadar and Daulatkhan under Bhola district and at MLT site, Chandina and Barura of Cumilla and Saharasti of Chandpur during Rabi season of 2021-22 to evaluate the performance of BARI developed capsicum varieties. Three capsicum varieties were tested viz. BARI Mishtimorich-1, BARI Mishtimorich-2 and locally popular hybrid Maria for Bhola and Dream for Cumilla. Among the tested varieties, Hybrid Maria gave the maximum fruit yield (14.42 t ha^{-1}) followed by BARI Mishtimorich-2 (12.97t ha^{-1}) and lowest fruit yield from BARI Mishtimorich-1 (9.21 t ha^{-1}) at Bhola and the highest yield (22.06 t ha^{-1}) was obtained from BARI Mistimorich-2 compared to Local capsicum and BARI Capsicum-1 at Cumilla region. The highest gross return (Tk. 1009400 ha^{-1}), gross margin (Tk. 680900 ha^{-1}) was found from hybrid variety Maria due to higher yield, but BCR (3.15) were obtained from BARI Mishtimorich-2 due to low cost of seed. At Cumilla, higher gross return (Tk. 1544200 ha^{-1}), gross margin (Tk. 1314200 ha^{-1}) and BCR (6.7) were obtained from BARI Mistimorich-2.

Introduction

Capsicum peppers (*Capsicum annuum* L.) is a popular vegetable all over the world and have a significant importance in international market. Their attributes such as pungency, color, aroma, and flavor are desirable in a variety of culinary dishes around the world, which make them widely appreciated. So, its popularity is increasing day by day in Bangladesh. Sweet pepper is a very valuable vegetable in terms of nutrition. Capsicum is rich in vitamin C, vitamin A, carbohydrates, proteins, fiber, unsaturated fatty acid (Lal *et al*., 2014; Zende, 2008) and also known as medicinal plants due to having capsaicin, capsanthin, carotenoids and antioxidant properties (Aminifard *et al*., 2012). Although sweet pepper is not our traditional vegetable, its cultivation is expanding lately. It is cultivated by a limited number of farmers, especially in the vicinity of big cities and sold in elite hotels and various big markets. Loam or sandy loam soil is much better for cultivating capsicums or sweet pepper. None of the sweet peppers can tolerate drought and early water accumulation. Therefore, the best time to sow sweet pepper seeds is from October to November. In last year, 70 ha area has been covered under capsicum cultivation at charland in Bhola sadar and Dawlatkhan. Farmer use locally available hybrids. BARI has developed two capsicum var: BARI Misti Morich-1 and BARI Mistri Morich-2. Hence the trial was undertaken to evaluate the performance of BARI capsicum variety and to popularize the variety among the farmers at Cumilla region at char area of Bhola.

Materials and Methods

On-farm trial was carried out at MLT site, Barura and Chandina of Cumilla and Saharasti of Chandpur and at char area of Bhola sadar and Daulatkhan under Bhola district during Rabi season of 2021-22 to evaluate the performance of BARI Mishtimorich-1 and BARI Mishtimorich-2 with local popular hybrid and to popularize the BARI released capsicum varieties among the farmers. The trial was laid out in RCB design with three dispersed replications. The unit plot size was 3.0 m × 1.2 m and spacing was 60cm×40cm. Transplanting, harvesting and fertilizer doses are mentioned in table-1. TSP, 1/5th urea and MP, full gypsum, ZnSO4 and cowdung were applied during land preparation. Rest 4/5th of Urea and MP were applied as top dress. Irrigation, plant protection measures and other intercultural operations were done as and when necessary. Data on different plant characters and yield were collected and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Planting time	Harvesting time	Fertilizer dose (kg ha-1) N-P-K-S-Zn-B-Cowdung
Cumilla	01-12 December 2021	01 March to 10 April, 2022	115-70-125-47-1.8-1.5 and 10000
Bhola	06-28 December 2021	08 March to 12 April, 2022	120-80-120-45-4.0-1.5 and 5000

Results and Discussion

The yield and yield contributing characters of capsicum during 2021-22 is presented in Table-2. Single fruit weight, field duration and yields were significantly differing The highest single fruit weight (104.3g) was found in local variety but the lowest in BARI Mistimorich-1 (87.7g). Higher plant height (59.53cm), branch plant^{-1}(4.13) were found in local variety but number of fruits plant^{-1} (7.60), fruit length (8.58cm), diameter (7.05cm) and the highest fruit yield (22.06 t ha^{-1}) were found from BARI Capsicum-2.

At Bhola, the height plant height (56.4cm), branch plant^{-1} (4.6), fruit plant^{-1} (5.46), single fruit weight (78.36g), fruit diameter (7.93cm) were obtained from hybrid Maria except fruit length that was higher in BARI Mistimorich-2 (7.27). The fruit yield (14.42 t ha^{-1}) was found from hybrid Maria followed by BARI Capsicum-2 (12.97 t ha^{-1}) and the lowest in Mistimorich-1 (9.21 t ha^{-1}).

Cost and return

Cumilla: Gross return, total cost, net return and BCR of capsicum varieties were presented in Table-2. Higher gross return (Tk. 1544200 ha^{-1}), gross margin (Tk. 1314200 ha^{-1}) and BCR (6.7) were obtained from BARI Capsicum-2 and the lowest from BARI Capsicum-1.

Bhola: Gross return, total cost, gross margin and BCR of capsicum varieties were presented in Table-2. Higher gross return (Tk. 1009400 ha^{-1}), and gross margin (Tk. 680900 ha^{-1}) were found from hybrid variety Maria due to higher yield, but BCR (3.15) were obtained from BARI Capsicum-2 due to low cost of seed.

Pest incidence: Plants were infected by leaf blight and root rot disease which were controlled by spraying with Ridomil Gold and Amistar Top @ 2 g L^{-1} water. White fly infestation was controlled by spraying three times with confider @ 1gm L^{-1} water at 15 days interval.

Farmers' opinion

Farmers expressed their satisfaction on capsicum var. BARI Mishtimorich-2 for its keeping quality and high yield potentiality in both locations. They said that the seeds of BARI Capsicum varieties are not available in the market.

Table 2. Friut yield and yield contributing characters of BARI released capsicum varieties during 2021-22

Location	Variety	Plant height (cm)	Branch plant^{-1} (No.)	Fruits plant^{-1} (No.)	Single fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit Yield (t ha^{-1})
Cumilla	BARI Mishtimorich-1	52.77	3.77	6.12	87.7	7.75	7.76	18.03
	BARI Mishtimorich-2	59.47	3.50	7.60	98.5	8.58	8.58	22.06
	Hybrid (Dream)	59.53	4.13	6.47	104.3	8.34	8.34	20.23
	LSD $_{(0.05)}$	NS	NS	NS	2.44	NS	NS	Put value
	CV (%)	8.54	8.99	12.28	1.11	4.48	4.38	4.82
Bhola	BARI Mishtimorich-1	54.1	3.56	4.42	67.45	7.12	6.90	9.21
	BARI Mishtimorich-2	56.8	4.20	5.25	76.81	7.27	7.11	12.97
	Hybrid (Maria)	58.4	4.60	5.46	78.36	6.25	7.93	14.42
	LSD$_{(0.05)}$	1.03	2.89	1.23	4.74	2.04	1.97	1.38
	CV %	6.34	6.72	8.37	2.52	0.89	1.08	9.47

Table 3. Cost and return analysis of BARI released capsicum varieties during 2021-22

Location	Variety	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
Cumilla	BARI Mishtimorich-1	1262100	230000	1032100	5.5
	BARI Mishtimorich-2	1544200	230000	1314200	6.7
	Hybrid (Dream)	1416100	234000	1182100	6.1
Bhola	BARI Mishtimorich-1	644700	288500	356200	2.23
	BARI Mishtimorich-2	907900	288500	619400	3.15
	Hybrid (Maria)	1009400	328500	680900	3.10

Average price of capsicum=Tk. 70 kg^{-1}

Conclusion

Capsicum var. BARI Mishtimorich-2 gave higher yield and economic return than local and BARI Capsicum-1 in both the locations. So, capsicum var. BARI Mistimorich-2 can be recommended to disseminate in larger area of tested locations.

ON-FARM TRIAL OF BARI BROCCOLI VARIETY

T. ISLAM AND M.U. CHOUDHURY

Abstract

An on-farm trial was conducted at Bikrichhara hill valleys of Bandarban sadar and FSRD site, Dharmapur, Subornachar which belong to AEZ 18c (non-saline medium high land adjacent to farmers homestead) during the Rabi season,2021-22 to evaluate the performance of BARI Broccoli-1 in farmers' field. A hybrid variety (Early you) of broccoli was used as check at Banadarban and green magic at Noakhali. The experiment was laid out in RCB design with three dispersed replications. BARI Broccoli-1 gave higher single head weight (228.47 g) and curd yield (11.16 t ha^{-1}) than hybrid variety (222.27 g and 10.20 t ha^{-1}). The highest gross margin and BCR (Tk. 341400 ha^{-1} and 4.25) was found from BARI Broccoli-1 than hybrid variety (Tk. 303000 ha^{-1} and 3.89). At Noakhali, significant variation was observed in single curd weight between Hybrid variety (431.8 g) and BARI Broccoli-1(394.6 g). Hybrid variety produced the maximum curd yield (16.5 t ha^{-1}) while 15.3 t ha^{-1} was obtained from BARI Broccoli-1. Higher gross margin (Tk. 355600 ha^{-1}) obtained from Hybrid variety compared to BARI Broccoli-1 variety (Tk. 309500 ha^{-1}).

Introduction

Broccoli (*Brassica oleracea* L. var. *italica*) is a cruciferous vegetable, originated from west Europe (Prasad and Kumar, 1999) has now been distributed in both the sub-tropical and tropical areas like Bangladesh. Broccoli heads are rich in minerals and vitamins together with fiber and health related secondary metabolites such as flavonoids, carotenoids and glucosinolates (Bjorkman *et al.* 2011). Broccoli is planted in the winter season in Bangladesh especially at the northern part where the ambient temperature was prevailed (15-20 ^{0}C). At Noakhali districts, cauliflower and cabbage frequently saturated the market and farmers face the problem of marketing due to low price at the final stage. Traditionally farmers have to pay a lot of money for buying hybrid broccoli seeds from the market, but farmers can keep the seeds of BARI Broccoli-1 as it is an open pollinated variety. Cultivation of broccoli is gaining popularity among the farmers in our country as well as in hilly areas of Bandarban. Many farmers are cultivating this seasonal cash crop in the area as they are getting a higher market price compared to other vegetables. BARI has released a broccoli variety in Bangladesh. The trial was therefore undertaken to evaluate the performance of BARI variety in hilly area and coastal area. .

Materials and Methods

The trial was conducted in the three farmer's field of Bikrichhara hill valleys of Bandarban sadar and FSRD site, Dharmapur, Subornachar which belong to AEZ 18c (non-saline medium high land adjacent to farmers homestead) during the Rabi season of 2021-2022. BARI Broccoli-1 was compared with a hybrid variety as check. The experiment was laid out in RCB design with three dispersed replications. Crop was planted with the spacing 50cm × 45cm and 30 days aged seedlings were transplanted. Unit plot size was 10m x 8m. Crop management practices used in different locations is shown in Table 1. Total amount of cowdung, TSP, gypsum, zinc sulphate and boric acid were applied during final land preparation. Urea and MoP were applied in three equal splits at 15, 30 and 45 days after transplanting. Irrigation, weeding and other plant protection measures were done as and when necessary. Data related to yield characters were recorded and analyzed statistically.

Table 1. Crop management practices used in different locations

Location	Planting time	Harvesting time	Fertilizer dose (kg ha^{-1}) N-P-K-S-Zn-B-Cowdung
Bandarban	10-12 November, 2021	20 to 30 January 2022	120-30-50-15-1.8-2 and 10000
Noakhali	06-28 December 2021	08 March to 12 April, 2022	111-30-110-20-2.0-1.5 and 10000

Result and Discussions

At Noakhali, card harvesting of BARI Broccoli-1 required 70 days after planting whereas 65 days required for Green Magic hybrid. Curd length and breadth showed non-significant variation between the varieties. Significant variation in single curd weight was observed between Hybrid variety (431.8g) and BARI Broccoli-1 (394.6g). The curd yield varied significantly between the varieties and hybrid variety produced the maximum curd yield (16.5 t ha^{-1}) followed by BARI Broccoli-1(15.3 t ha^{-1}). At Bandarban, BARI Broccoli-1 gave higher head length (18.30 cm) and diameter (14.83 cm) than local broccoli variety (10.87 cm and 13.05 cm) while BARI Broccoli-1 produced maximum head (228.47 g) than local variety (222.27g) BARI Broccoli-1 produced higher curd yield (11.16 t ha^{-1}) than local variety (10.20 t ha^{-1}). BARI Broccoli-1 took less time to harvest (63.20 days) than hybrid variety (64.20) (Table 2).

Cost and return:

Bandarban: BARI Broccoli-1 gave higher gross return (Tk. 446400 ha^{-1}), gross margin (Tk. 341400 ha^{-1}) and BCR (4.25) over local broccoli variety with lower gross return (Tk. 408000 ha^{-1}), gross margin (Tk. 303000 ha^{-1}) and BCR (3.89).

Noakhali: Higher gross margin (Tk. 355600 ha^{-1}) obtained from Green Magic due to higher card yield comparison to BARI Broccoli-1variety with (Tk. 309500 ha^{-1}).

Farmers' opinion

Bandarban: Farmers expressed their satisfaction with higher yield and market price, but they expected a variety which is very compact.

Noakhali: Farmers are interested to grow Broccoli, but they sometimes worried about the marketing because people of the coastal area are yet not familiar with this new cool crop. Farmers opined that broccoli cultivation is more profitable because higher price (Tk.40 kg^{-1}) than cauliflower and cabbage.

Table 2. Performance of BARI developed broccoli variety during Rabi season of 2021-22

Locations	Treatment	Days to card harvest	Curd length (cm)	Card diameter (cm)	Single card wt. (g)	Curd Yield (t ha^{-1})
Bandarban	BARI Broccoli-1	63.2	18.30	14.83	228.47	11.16
	Local Hybrid	64.2	10.87	13.05	222.27	10.20
	LSD $_{(0.05)}$	1.57	0.49	0.54	11.69	0.60
	CV (%)	3.02	4.18	4.79	6.35	6.88
Noakhali	BARI Broccoli-1	70.00	13.3	12.8	394.6	15.3
	Hybrid (Magic)	65.00	12.7	12.8	431.8	16.5
	t-Test	NS	NS	NS	**	*

Table 3. Cost and return of BARI developed broccoli variety during *Rabi* season of 2021-22

Location	Treatment	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
Bandarban	BARI Broccoli-1	446400	105000	341400	4.25
	Hybrid Broccoli	408000	105000	303000	3.89
Noakhali	BARI Broccoli-1	612000	302500	309500	2.02
	Hybrid Broccoli	660000	304400	355600	2.17

Price of Broccoli = Tk. 40 ha^{-1}

Conclusion

The performance of broccoli var. BARI Broccoli-1 in the hill valleys of Bandarban and in Noakhali was found promising in respect of yield and profit.Therefore, BARI Broccoli-1 could be recommended to cultivate in the tested locations.

ON-FARM TRIAL OF BARI HYBRID BITTER GOURD VARIETIES

M. M. BASHIR AND S. K. BHOWAL

Abstract

An on-farm trial was conducted at MLT site, Chandina and Debidwer of Cumilla, Saharasti of Chandpur and Kasba of B. Baria during *Kharif* -1 season of 2021 to evaluate the performance of BARI developed newly released high yielding hybrid bitter gourd varieties BARI Hybrid Korola-2 and BARI Hybrid Korola-3 against commercial Hybrid bitter gourd (Tia). The highest fruit yield (18.42 t ha^{-1}) was obtained from Hybrid Koroa-Tia compared to BARI Hybrid Korola-2 and BARI Hybrid Korola-3 at Cumilla region. The highest gross return (Tk. 1105200.00 ha^{-1}) and gross margin (Tk. 980200.00 ha^{-1}) were also found in hybrid Korola-Tia compared to BARI Hybrid Korola-2 and BARI Hybrid Korola-3.

Introduction

Bitter gourd is one of the popular vegetables in our country. Bitter gourd is a good source of nutrients like fiber, vitamin C, folate and vitamin A. It is reported that this crop helps to improve several markers of long-term blood sugar control, including levels of fructosamine and hemoglobin etc., more high-quality research is needed. Bitter melon is low in calories but high in fiber. BARI has released some new high yielding varieties of bitter gourd viz. BARI Hybrid Korala-2 and BARI Hybrid Korala-3 which needs to be popularizes among the farmers. The present experiment was therefore undertaken to popularize and disseminate BARI Hybrid Korola-2 and BARI Hybrid Korola-3 among the farmers of Cumilla region.

Materials and Methods

On-farm trial was carried out at MLT site, Debidwer of Cumilla, Saharasti of Chandpur and Kasba of B. Baria during Kharif-1 season of 2021 to evaluate the performance of BARI Hybrid Korola-2 and BARI Hybrid Korola-3. Hybrid Korola (Tia) was used as check variety. The trial was laid out in RCB design with two dispersed replications. The unit plot size was 6.0m × 1.2m. Seeds were sown in poly bag on 20-27April, 2021 and seedlings were transplanted in main plot during 06-18June, 2021 in a pit maintaining a distance of 1.50m × 1.50m. Fertilizer dose N-P-K-S-Zn-B-Cowdung was applied @ 76-40-70-14-2-2-5000 kg ha^{-1}. Whole amount of Cowdung, 1/3rd of TSP, 1/3rd of MP, full amount of gypsum, $ZnSO_4$ and boric acid were applied during pit preparation. Total amount of Urea, 2/3rd of TSP, and 2/3rd of MP was applied as top dress. Irrigation, protection measures and other intercultural operations were done as and when required. Harvesting of fruits was started at 20 June, 2021 and continued up to 10 August, 2021. Data on yield and yield characters were collected and analyzed statistically.

Results and Discussion

Significant variations were observed in all the characters of hybrid bitter gourd varieties (Table 1). The minimum field duration (106 days) was needed for BARI Hybrid Korola-3 and the maximum (110.5 days) in Hybrid Korola-Tia. The highest number of fruits $plant^{-1}$ (24.58) was observed in BARI Hybrid Korola-3 and the lowest (20.50) in Hybrid Korola-Tia. The longer fruit (21.9cm) was observed in Hybrid Korola-Tia and the shortest (13.16cm) in BARI Hybrid Korola-3. The maximum fruit diameter (4.82cm) was observed in Hybrid Korola-Tia and the minimum (4.05cm) in BARI Hybrid Korola-3. The weight of single fruit was maximum (175.1g) in Hybrid Korola-Tia and the minimum (85.0g) in BARI Hybrid Korola-3. The highest fruit yield (18.42 t ha^{-1}) was recorded in Hybrid Korola-Tia but the yields of BARI Hybrid Korola-2 (15.21 t ha^{-1}) and BARI Hybrid Korola-3 (14.17 t ha^{-1}) a bit lower but statistically identical. The maximum gross margin (Tk. 980200.00 ha^{-1}) was found in Hybrid Korola-Tia than BARI Hybrid Korola-2 (Tk. 578462.50 ha^{-1}) and BARI Hybrid Korola-3 (Tk. 530362.50 ha^{-1}).

Table1. Fruit yield and yield attributes of BARI hybrid bitter gourd varieties and commercial Hybrid (Tia) at different locations of Cumilla and Chandpur during *Kharif-1* season of 2021

Variety	Field duration	Fruits $plant^{-1}$ (no.)	Fruit length (cm)	Fruit diameter (cm)	Single fruit weight (kg)	Fruit yield (t ha^{-1})
BARI Hybrid Korola-2	108.	23.83	13.85	4.56	104.70	15.21
BARI Hybrid Korola-3	106	24.58	13.16	4.05	85.00	14.17
Hybrid Korola (Tia)	110	20.50	21.90	4.82	175.10	18.42
$LSD_{(0.05)}$	0.86	3.22	1.71	0.65	19.95	1.28
CV (%)	0.46	8.11	6.06	8.52	9.48	4.63

Table 2. Cost and Return analysis of Hybrid bitter gourd varieties at different locations of Cumilla, Brahmanbaria and Chandpur during Kharif-1 season of 2021

Varieties	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Hybrid Korola-2	703462.50	125000	578462.50
BARI Hybrid Korola-3	655362.50	125000	530362.50
Hybrid Korola (Tia)	1105200.00	125000	980200.00

The price of BARI Hybrid Korola-2 and BARI Hybrid Korola-3 is Tk. 46.25 and Hybrid Tia is Tk. 60.0 kg^{-1}

Conclusion

Considering the yield and economic return, Hybrid Korola (Tia), Bitter gourd var. BARI Hybrid Korola-2 and BARI Hybrid Korola-3 could be extended in the tested locations.

ON-FARM TRIAL OF BARI SPONGE GOURD VARIETY

M. M. BASHIR AND S. K. BHOWAL

Abstract

An on-farm trial was conducted at MLT site, Debidwer of Cumilla during *Kharif-1* season of 2021-22 to evaluate the performance of BARI developed high yielding sponge gourd variety. BARI Dhundul-2 was tested against commercial Dhundul (Mahi) in farmer's field condition. Commercial hybrid Mahi gave the higher fruit yield (25.44 t ha^{-1}) compared to BARI Dhundol-2 (23.65 t ha^{-1}). The gross return (Tk. 356160.00 ha^{-1}) and gross margin (Tk. 269160 ha^{-1}) were also higher in Mahi compared to than BARI Dhundol-2 (Tk. 331100.00 and Tk. 246100.00 ha^{-1}).

Introduction

Sponge gourd (*Luffa aegyptica)* is one of the vegetables people eat today known as Vietnamese luffa and Egyptian cucumber. It is usually added to various meal recipes for added taste and nutrition. Sponge gourd is rich in vitamin A, which is responsible for promoting vision and integrity of the skin and the mucus membranes. BARI has released numerous sponge gourd varieties with higher yield potentials. So, the production of BARI sponge gourd varieties needs to be evaluated at farmer's field. Therefore, the present on farm trial was undertaken to popularize and disseminate BARI sponge gourd variety in Cumilla region.

Materials and Methods

On-farm trial was carried out at MLT site, Debidwer of Cumilla, Shahrasti of Chandpur and Kosba of B. Baria during *Kharif* season of 202. Sponge var. BARI Dhundol-2 was evaluated with a commercial hybrid Mahi as check . The unit plot size was 4.0 m ×2.5 m. Seeds were sown on 06-18 May, 2021 in pit maintaining a distance of 2.50m × 1.50m. Fertilizer N-P-K-S-Zn-B-Cowdung was applied @ 106-46-96-6-1.4-0.7-5000 kg ha^{-1}. Whole amount of cowdung, 1/3rd of TSP, 1/5th of MP, full amount of gypsum, ZnSO4 and boric acid were applied during pit preparation. Total amount of Urea, 2/3rd of TSP, and 4/5th of MoP was applied as top dress. Irrigation, plant protection measures and other intercultural operations were done as and when necessary. Harvesting of fruits was started at 07 July, 2021 and continued up to 22 September, 2021. Data on different yield and yield characters were collected and analyzed statistically.

Results and Discussion

Fruit yield and yield contributing characters of sponge gourd varieties are presented in (Table 1). The number of fruits plant^{-1} between BARI Dhundol-2 (65.1) and Mahi (64.7) did not differ significantly. Fruit length and single fruit weight were higher (23.9cm, and 220.9g, respectively) in Mahi and lower in BARI Dhundol-2 (17.7cm and 197.1g, respectively). The fruit yield was higher in Mahi (25.44 t ha^{-1}) than BARI Dhundol-2 (23.65). Gross return (Tk. 356160.00 ha^{-1}) and gross margin (Tk. 269160.00 ha^{-1}) were also higher in Mahi than BARI Dhundol-2 (Tk. 331100 and 246100 ha^{-1}, respectively).

Farmers' opinion

Spongegourd var. BARI Dhundol-2 is an open pollinated variety. Farmers opined that they would keep the seeds of BARI Dhundol-2 for the next growing season.

Conclusion

Sponge gourd var. Mahi produced the higher yield as well as higher economic return over BARI Dhundol-2. It was first year trial. So, it may be repeated next year for more precise result.

Table 1. Fruit yield and yield attributes of BARI Dhundol-2 and commercial variety (Mahi) at different locations of Cumilla region, during Kharif season of 2021

Variety	Harvest duration (days)	Field duration (days)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit Yield (t ha^{-1})
BARI Dhundul-2	57	111.0	65.1	197.1	17.7	4.9	23.65
Hybrid (Mahi)	51	103.3	64.7	220.9	23.9	4.8	25.44
$LSD_{(0.05)}$	2.48	NS	NS	10.33	3.63	NS	1.72
CV (%)	1.32	3.63	0.27	1.41	4.97	4.15	1.99

Table2. Cost and return of sponge gourd varieties at different locations of Cumilla, Brahmanbaria and Chandpur during *Kharif* season of 2021

Varieties	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Dhundul-2	331100	85000	246100
Hybrid (Mahi)	356160	87000	269160

Price of sponge gourd: Tk.14 kg^{-1}

ON-FARM TRIAL OF BARI LEMON VARIETIES IN THE HILLY AREAS OF BANDARBAN

M. T. ISLAM

Abstract

An on-farm trial was conducted at farmer's field of hill slopes of Bandarban sadar during Rabi season of 2021-22 to evaluate the performance of BARI lemon varieties and to select suitable variety for hilly areas of Bandarban. Vegetative data were collected immediate after planting on 27 September, 2021 and 18 May, 2022 to evaluate annual increment. The investigation revealed that vegetative growth of mango varieties varied significantly. Overall tree volume was found high in Chaina-3 seedless Lebu throughout the year (921.33%) followed by BARI Lebu-1 (751.81%) and BARI Kagaji Lebu-1 showed the least increment (289.23%) in the first year. The highest increment percentage in plant height was observed in BARI Lebu-2 (61.41%) followed by Chaina-3 seedless lebu (107.82%) and lowest increment in BARI Kagaji Lebu-1 (68.23). Flower initiation just have started in different lemon varieties. First flowering in BARI Lebu-3 and BARI Lebu-4 was observed on 1st May followed by Chaina-3 seedless Lebu and Thai seedless Lebu on 2nd week of May. Reproductive parameters and yield data will be collected as the growth progress.

Introduction

Lemon (*Citrus limon*) are grown all over in Bangladesh, though their production is concentrated in Sylhet, Chittagong, and the Chittagong Hill Tracts; cultivated in homestead as well as in orchard, mainly from grafts and cuttings. Plants are medium-sized, spreading types. Leaves are pale green, long ovate and pointed at the tip. Petioles are narrowly winged and margined. Flowers are reddish tinted in the bud; petals are white above and purplish below. Fruits are ovate to elliptical or oblong with thick skin; become pale yellow on ripening. Lemon fruits are sour and juicy containing high vitamin C. They are consumed fresh for juice and used in making pickles and beverages. Lemon oil is also used for flavoring the soft drinks and confectionery products. BARI released some lemon varieties named BARI Lebu-1, BARI Lebu-2, BARI Lebu-3, BARI Lebu-4, BARI Lebu-5 and BARI Kagaji Lebu-1. These varieties are popular for their distinct characters and high yielding nature. Recently other seedless lebu viz. China-3 seedless Lebu, Thai seedless Lebu etc. varieties getting popular because of their year-round production and high bearing. Citrus fruit production at Bandarban is getting popular because of good climatic and soil condition for lemon production. Information regarding the performance of BARI lemon varieties and other commercial varieties are not well known in Bandarban hill tract. The experiment was therefore undertaken to observe the performance of BARI Lemon varieties in hilly areas of Bandarban.

Materials and Methods

The trial was conducted at Tankabati hill slopes of Bandarban sadar during 2021-22. Six BARI lemon varieties viz. BARI Lebu-1, BARI Lebu-2, BARI Lebu-3, BARI Lebu-4, BARI Lebu-5, BARI Kagaji Lebu-1 and two other popular commercial lemon varieties viz. China-3 seedless Lebu and Thai seedless Lebu along with one local deshi Kagaji lebu were evaluated. The experiment was laid out in RCB design with six replications. The saplings were planted on 27 September, 2021 in pit of 60cm × 60cm × 60cm with paired row system where spacing between row to row and plant to plant was 8 feet and in between two paired rows there were 12 feet distance. Six (06) plants from twenty plants of each variety were randomly selected where a single tree constituted the unit of replication. Manure and fertilizers were applied during pit preparation at post monsoon on 20 October 2021. Other intercultural operations, such as weeding, and mulching were done as and when necessary. Tree volume was calculated following formula by Castle (1983) with some modifications, such as $\pi/6 \times \text{height} \times (2r)^2$ where, 2r = (Eastwest + Northsouth canopy spread)/2. Data on vegetative growth viz. plant height and canopy of the tree were recorded after planting and on 18 May, 2022 to observe percent increment in one year. Flowering and yield attributes will be recorded when they will be available. Data on insect pest and diseases were also recorded time to time. The collected vegetative data were analyzed, and percent annual increment were calculated.

Lemon butterfly attack was observed after new leaf emergence of each variety. Leaf minor and mite infestation was also very common. Sumithion 50 EC @ 2 ml along with Dithane M- 45 @ 2 g L^{-1} of water was sprayed after every new shoot emergence. Imitaf @ 0.5 ml and Vertimac @1.5 ml were sprayed for leaf minor and mite infestation.

Results and Discussion

Plant height (% increment): BARI Lebu-2 showed the highest annual height increment (113.33%) over other varieties followed by China-3 seedless lebu (107.82%) and lowest increment observed in BARI Kagaji Lebu-1 (68.23) (Table 1).

1st Flowering: BARI Lebu-3 and BARI Lebu-4 flowered on 1st week of May where Chaina-3 seedless Lebu and Thai seedless Lebu flowered on 2nd week of May (Table 1).

Volume (% increment): Overall tree volume was found high in China-3 seedless Lebu throughout the year (921.33%) followed by BARI Lebu-1 (751.81%) and BARI Lebu-4 (734.22%) whereas BARI Kagaji Lebu-1 showed the least increment (289.23%) in first year (Table 1).

Table 1. Annual vegetative growth of different lemon varieties in Bandarban during 2021-22

Treatment	Plant height (% increment)	1st Flowering date	Tree volume (% increment)
T_1= BARI Lebu-1	94.34	-	751.81
T_2= BARI Lebu-2	113.33	-	513.14
T_3= BARI Lebu-3	73.79	1st week of May	485.18
T_4= BARI Lebu-4	102.00	1st week of May	734.22
T_5= BARI Lebu-5	95.38	-	702.28
T_6= BARI Kagaji Lebu-1	68.23	-	289.23
T_7=Chaina-3 seedless Lebu	107.82	2nd week of May	921.33
T_8= Thai seedless Lebu	68.78	2nd week of May	546.20
T_9=Deshi Kagaji Lebu	87.92	-	328.42

Conclusion

Vegetative data will be collected every year to analyze the growth pattern and flowering and yield data will be collected from this year.

PERFORMANCE OF BARI MANGO VARIETIES IN THE HILLY AREAS OF BANDARBAN

M. T. ISLAM

Abstract

A trial was conducted at farmer's field of hill slopes of Bandarban sadar during *Rabi* season of 2021-22 to evaluate the performance of BARI mango varieties along with other popular commercial varieties to find out suitable variety for hilly areas of Bandarban. Mango saplings were planted on 11 July, 2021 with a spacing of 6m×6m. Vegetative data were collected immediate after planting on 11 July, 2021 and 18 May, 2022 to evaluate annual increment. The investigation revealed that vegetative growth of mango varieties varied significantly for all the parameters. Overall tree volume rises more in BARI Aam-4 throughout the year (776.92%) followed by BARI Aam-11 (707.69%) whereas BARI Aam-10 showed the least increment (90.91%) in first year. Highest increment percentage in plant height, stem girth and canopy were observed in BARI Aam-4 (61.41%), BARI Aam-3 (135.60%) and BARI Aam-11 (140.23% in North-South and 156.38% in East-West direction), respectively. Reproductive parameters and yield data will be collected from the following year.

Introduction

Mango (*Mangifera indica*) is an important tropical cash crop in the world (Jahurul *et al.,* 2015) and the fifth most important fruit species worldwide (together with bananas, oranges, grapes, and apples). Mango is widely planted in the tropics and subtropics (Perez *et al.* 2016). It is the most popular fruit in Bangladesh and occupies an area of 32011 hectares of land with an annual production of 1047849 metric tons (BBS, 2011). Although it grows well in all parts of Bangladesh, the grafted mango plants are concentrated in a few places in the northwestern region and seedling mangoes are grown in the southern and other parts of Bangladesh (Bhuyan, 1995). But nowadays most of the commercial mango orchard in southern region, especially in the hilly areas and Chittagong Hill Tracts are establishing by means of grafted mango seedlings. In general, the cultivars are location specific and the commercial varieties of one region may not do well in another areas (Majumder *et al*., 2001). BARI has already released 18 mango varieties with variable quality. Other popular mango varieties of the country are also being disseminated by public and private initiatives. Information regarding the performances of the released mango varieties is scanty under Chittagong condition. Therefore, the present investigation was undertaken to evaluate the performance of BARI mango varieties and other commercial varieties under hot and humid climatic condition of Bandarban.

Materials and Methods

The experiment was conducted at the hill slopes of Tankabati union, Bandarban sadar during 2021-2022. BARI released seven mango varieties namely BARI Aam-1, BARI Aam-2, BARI Aam-3, BARI Aam-4 (Hybrid), and BARI Aam-8 and five other popular commercial mango varieties namely Katimon, Gouramoti, Banana, Himsagar and Govindavog were included in this study. The experiment was laid out in RCB design with six replications. The saplings were planted on 11 July, 2021 with a spacing of 6m×6m. A single tree of each variety constituted the unit of replication. The trees were fertilized as per schedule described by Hossain (1989). Ripcord 10 EC @ 1 ml along with Dithane M- 45 @ 2 g L^{-1} of water was sprayed with the help of a hand sprayer at new flush emergence to control mango leaf cutting weevil and anthracnose as per recommendation of Hossain (1989). Manure and fertilizers were applied during pit preparation and post monsoon on 25 June and 20 October 2021. Other intercultural operations, such as weeding, and mulching were done as and when necessary. Girth of the trunk was measured at a height of 30 cm from ground level and tree volume was calculated following formula by Castle (1983) with some modifications, such as π/6 X height X (2r) 2 where, 2r = (East – West + North – South canopy spread)/2. Data on vegetative growth viz. plant height, trunk girth and canopy of the tree were recorded after planting and on 18 May, 2022 to observe percent increment in one year. Flowering and yield attributes viz. harvesting, fruit weight, number of fruits per tree, TSS content, edible portion, fruit size, stone size and stone weight will be recorded from third year. All the data will be recorded following mango descriptor recommended by IBPGR (2006). Organoleptic evaluation will also be done and for this, a panel of five members will be selected to determine the pulp colour, sweetness, aroma, texture, juiciness, fibrousness, peeling quality, eye appeal, and general quality of fruits of different genotypes based on the criteria of the score card as follows : a) Pulp colour: 1- light yellow, 2- yellow, 3- bright yellow; b) Sweetness/Taste: 1- insipid, 2- sweet, 3- very sweet; c) Aroma: 1- very slight, 2- pleasant, 3- delightful; d) Texture: 1- firm, 2- medium, 3- soft; e) Juiciness: 1- scantly, 2- much, 3- abundant; f) Fibrousness: 1- abundant, 2- much, 3- scanty; g) Peeling quality: 1- hard, 2- medium, 3- easy, and h) Eye appeal: 1- poor, 2- good, 3- very good (Uddin et al., 1998). Data on insect pest and diseases were also recorded at fruit harvest. The collected data were analyzed statistically, and the means were separated by LSD.

Leaf cutting weevil and anthracnose was very common after new leaf emergence. Ripcord 10 EC @ 1 ml along with Dithane M- 45 @ 2 g L^{-1} of water was sprayed after every new shoot emergence.

Results and Discussion

Plant height (% increment): BARI Aam-4 showed the highest annual height increment (78.27%) over other varieties followed by BARI Aam-1 (61.41%) and the least increment observed in BARI Aam-11 (Table 1).

Stem girth (% increment): Most girth increment found at BARI Aam-3 (135.60%), BARI Aam-1 (123.32%) and BARI Aam-4 (122.22%) where the lowest was found from Katimon Aam (65.93%) in a year (Table 1).

Canopy (N-S) and (E-W) (% increment): BARI Aam-11 develops canopy more in both direction (140.23% and 156.38% respectively) than other varieties and canopy spread was minimum in banana mango variety (44.29% and 64.43% respectively). (Table 1).

Volume (% increment): Overall tree volume rises more in BARI Aam-4 throughout the year (776.92%) followed by BARI Aam-11 (707.69%) whereas BARI Aam-10 showed the least increment (90.91%) in first year (Table 1).

Table 1. Annual vegetative growth of different mango varieties in Bandarban during 2021-22

Treatment	Plant height (% increment)	Stem girth (% increment)	Canopy (N-S) (% increment)	Canopy (E-W) (% increment)	Tree volume		
					At planting (m^3)	After one year (m^3)	Annual increment (%)
T_1= BARI Aam-1	61.41	123.32	68.72	68.15	0.16	0.72	350
T_2= BARI Aam-2	53.13	84.25	90.76	77.03	0.12	0.63	425
T_3= BARI Aam-3	42.86	135.60	80.49	88.51	0.25	1.11	152
T_4= BARI Aam-4	78.27	122.22	113.09	127.68	0.13	1.14	776.92
T_5= BARI Aam-8	32.98	90.28	75.23	76.23	0.095	0.30	215.79
T_6= BARI Aam-10	48.16	83.33	91.6	88.23	0.11	0.21	90.91
T_7= BARI Aam-11	32.62	82.76	140.23	156.38	0.13	1.05	707.69
T_8= Katimon Aam	48.06	65.93	85.15	74.62	0.24	1.15	379.17
T_9=Gouramoti Aam	33.99	88.42	124.8	113.22	0.16	0.79	393.75
T_{10}= Banana Aam	49.65	85.19	44.29	64.43	0.18	0.61	238.89
T_{11}= Himsagar Aam	45.10	63.81	39.98	49.99	0.44	1.35	206.82
T_{12}=Gobindavog Aam	37.56	85.36	85.61	66.02	0.80	3.43	328.75

Conclusion

Vegetative data will be collected every year to analyze the growth pattern and flowering and yield data will be collected from the following year.

Tuber Crops

ADAPTIVE TRIAL WITH NEWLY RELEASED POTATO VARIETIES IN DIFFERENT LOCATIONS

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Abstract

A set of trials were conducted at farmers' fields in seventeen different locations (Chandpur, Faridpur, Gaibandha, Khulna, Kishorganj, Manikganj, Mymensingh, Norshingdi, Rangpur, Tangail, Kushtia, Sherpur, Sylhet, Rajshahi, Gopalganj, Noakhali and Bhola) under the supervision of the On-Farm Research Division (OFRD), BARI during the rabi season of 2021-22 to evaluate the performance of the 10 (Ten) high yielding potato varieties and to know farmers' preference about the varieties. Ten potato varieties viz. BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-47, BARI Alu-48, BARI Alu-50, BARI Alu-56, BARI Alu-57, and BARI Alu-62 were used across the locations of Bangladesh. In all trial sites, trials were laid following RCB design with four-five dispersed replications. The yield performance of most of the varieties appeared to be promising in the tested locations. Among the tested potato varieties BARI Alu-41 produced the highest average tuber yield (35.80 t ha^{-1}), followed by BARI Alu-40 (34.68 t ha^{-1}) and BARI Alu-62 (33.79 t ha^{-1}) whereas the lowest was in BARI Alu-37 (30.64 t ha^{-1}). Considering the location, the highest average tuber yield (40.96 t ha^{-1}) was recorded in Kishoregonj, followed by Rajshahi (39.51 t ha^{-1}) and Sylhet (38.10 t ha^{-1}) whereas the lowest in Noakhali (20.82 t ha^{-1}). No variety was found tolerant to Late Blight and the foliage infestation was wide ranging from 0-45% across the locations among the tested varieties. The average foliage infection by late blight was the highest in BARI Alu-37 (25.1%) and the lowest in BARI Alu-48 (14.04%). In the case of locations, the average highest late blight infestation was recorded in Gaibandha (29%) and the lowest in Mymensingh with a value of 6%. On the contrary, the average maximum virus infection was recorded in BARI Alu-36 (1.56%), similar to BARI Alu-50 (1.51%) andBARI Alu-41 (1.54%), and the lowest in BARI Alu-47 and BARI Alu-56 (0.84%). The average highest virus infection was recorded in Rangpur (2.29%) and the lowest in Rajshahi (0.06%). In the case of common scab disease, the average highest infestation recorded in Mymensingh (5.8%) and the lowest in Kishoreganj (0.84%). The average highest common scab was observed in BARI Alu-40 (4.9%) and the lowest in BARI Alu-47 (1.03%). Moreover, the average highest cutworm infestation was recorded in BARI Alu-56 (3.39%), followed by BARI Alu-40 and BARI Alu-57 with a value of 3.1% whereas the lowest in BARI Alu-47 (0.59%). Considering the locations, the average highest cutworm infestation was overserved in Faridpur (4.61%) and the lowest in Rajshahi (0.09%). The average highest gross return (Tk. 605940 ha^{-1}) and gross margin (Tk. 390690 ha^{-1}) were recorded in Mymensingh and the lowest (Tk. 312300 ha^{-1}) and gross margin (Tk. 147800 ha^{-1}) in Noakhali. Among the crop varieties, BARI Alu-41 produced the average highest gross return (452520 Tk. ha^{-1}) and gross margin (267787Tk. ha^{-1}) similar to BARI Alu-62 with a value of 451130 Tk. ha^{-1} (gross return) and 266355 Tk. ha^{-1} (gross margin), whereas the average lowest gross return (401508 Tk. ha^{-1}) and gross margin (216958 Tk. ha^{-1}) were founded in BARI Alu-36 and the variation founded mainly due to the variation of yield and the local market price of potato across the locations.

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food crops in Bangladesh and is being cultivated throughout the country. In potato production, Bangladesh ranks in 8th position in production in the world and 2nd in the country [FAOSTAT, 2018]. Currently, 9.74 million tons (Mt) of potatoes were produced from around 0.47 million hectares (Million ha) of land and the average yield was 20.41 t ha^{-1} (FAOSTAT 2018). Over the two decades, total potato production has reached from 1.55 Mt to 9.47 Mt, in an area of 0.47 million ha from 0.136 million ha. The demand for potato production in the country is increasing to feed the ever-increasing population and by

2030 the country needs to increase its yield from 20.43 t ha^{-1} to 41.50 t ha^{-1} of potatoes to attain food and nutrition security also. In Bangladesh, the crop is the third most important crop in Bangladesh next to rice and wheat. It is grown not only for food but also for animal feed, industrial uses, and seed tuber production. Potatoes are also a good source of minerals, at least 12 essential vitamins, and an extremely high content of vitamin C comparable to other food crops. The national average yield of potatoes is very low (20.41 t ha^{-1}) compared to its potential yield, due to lack of quality seed, cultivation of indigenous potatoes, and the high price of quality seed. Tuber Crop Research Centre (TCRC), BARI has developed a good number of potato varieties that are supposed to be higher yielders and less susceptible to insect pests and diseases. These new varieties need to be evaluated for their performance under different agro-ecological zones. Therefore, an adaptive trial with BARI-developed potato varieties/lines was conducted to evaluate their yield performance and know farmers' opinions about the newly released improved potato varieties in different locations of Bangladesh.

Materials and Methods

Adaptive trials with recently released high-yielding potato varieties were carried out in the farmers' fields of Chandpur, Faridpur, Gaibandha, Khulna, Kishorganj, Manikganj, Mymensingh, Norshingdi, Rangpur, Tangail, Kushtia, Sherpur, Sylhet, Rajshahi, Gopalganj, Noakhali and Bhola during the *rabi* season of 2021-22 to evaluate the performance of the different potato varieties and to popularize the potato varieties among the potato growers. In the trial, 10 (ten) recently released potato varieties were used. The unit plot size was varied in the trial locations. Crop management practices across the location are presented in Table 1. Seed tubers were planted at a spacing of 60 cm × 25 cm. A standard fertilizer dose was used in the trials in all locations. Half of the area and all other fertilizers and manure were applied at the time of final land preparation. The rest half of the urea was top-dressed at 33-37 DAP. The crop was irrigated two to three times at 24-29, 36-39, and 57-60 DAP. Weeding and earthing up were done once at 30-35 DAP. The crop was sprayed one time with Dursban (33-35 DAP) for cutworm control and sprayed 3 times with Indofil (18-19, 33-35, and 46-48 DAP) and secure (63-64 DAP) for controlling Late blight infection. Halum pulling was done at 85-86 DAP in all locations. The tubers were harvested after 8-10 days after haulm pulling. Data on yield was taken and analyzed statistically in all locations.

Table 1. Crop management practices are used for Potato in different locations during the Rabi season of 2021-22.

Location	Variety	Planting time	Harvesting time	Unit Plot size
Chandpur	BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-47, BARI Alu-48, BARI Alu-50, BARI Alu-56, BARI Alu-57 and BARI Alu-62	29 Nov. -27 Dec.21	6-14 Mar. 22	82.5 m^2
Faridpur		30 Nov-20 Dec.21	08-14 Mar. 22	60 m^2
Manikganj		1-18 Dec.21	22 Feb.-9 Mar. 22	80 m^2
Gaibandha		20-30 Nov. 21	21 Feb.-2 Mar. 22	20 m^2
Kushtia		30 Nov.-14 Dec. 21	1-20 Mar. 22	1000 m^2
Sylhet		20-20 Nov. 21	20-28 Feb. 22	20 m^2
Rangpur		30 Nov. -8 Dec. 21	2- 7 Mar. 22	200 m^2
Rajshahi		24 Nov-7 Dec. 21	22-Feb.-19 Mar. 22	80 m^2
Khulna		27 Nov-19 Dec.21	22 Feb.-20 Mar. 22	80 m^2
Sherpur		25-28 Nov.21	10-16 Feb. 22	40 m^2
Tangail		25 Nov.-06 Dec.21	16 Feb.-07 Mar. 22	30 m^2
Mymensingh		21-30 Nov. 21	12Feb-07 Mar. 22	55 m^2
Norsingdi		24-28 Nov. 21	01-05 Mar.22	110 m^2
Kishoreganj		10 Dec. 21	5-7 Mar. 22	100 m^2
Gopalganj		20-21 Dec. 21	20-25 Mar. 22	30 m^2
Bhola		23-30 Dec. 21	24-30 Mar. 22	100 m^2
Noakhali		24 No. - 10 Dec. 21	16-24 Mar. 22	160 m^2

Results and Discussions

Yield of potato (t ha^{-1}): Tuber yield among the varieties across the locations ranged from 18.30 to 46.52 t ha^{-1} (Table 2) The highest tuber yielded by BARI Alu-50 in Rajshahi (46.52 t ha^{-1}), followed by BARI Alu-40 (46.30 t ha^{-1}), BARI Alu-41 (45.00 t ha^{-1}) in Sylhet, and BARI Alu-62 (44.30 t ha^{-1}) in Kishoregonj. The reasons for the yield variation in different locations are mainly due to the difference in agro-climatic conditions. Similarly, the lowest tuber yield was recorded in BARI Alu-36 in Noakhali (18.30 t ha^{-1}). Considering the variety, the average highest tuber (35.80 t ha^{-1}) produced by BARI Alu-41 followed by BARI Alu-40 (34.68 t ha^{-1}) whereas the lowest tuber (30.64 t ha^{-1}) recorded in BARI Alu-37. In terms of location, the average highest tuber yield was recorded in Kishoreganj (40.96 t ha^{-1}), followed by Rajshahi (39.51t ha^{-1}), Sylhet (38.10 t ha^{-1}) and the lowest tuber yielded in Noakhali (20.82 t ha^{-1}).

Pest and disease incidence: There had some disease infestation (late blight, common scab, and virus) recorded in Gaibandha, Rangpur, Mymensingh, Tangail, Kishoreganj, Rajshahi, and Faridpur areas. The late blight infestation was ranged from 0-45% (Table 3) where the highest late blight infestation (45%) recorded in BARI Alu-37 in Gaibandha and the lowest (0%) recorded in BARI Alu-56 in Tangail. The average late blight infestation in all the potato varieties was much higher (29%) in Gaibandha whereas it was the lowest in Mymensingh (6%). Among the varieties, the highest late blight infestation (25.1%) was recorded in BARI Alu-37 and the lowest in BARI Alu-48 (14.04). In the case of virus infestation, the range was low by only 0.02-2.29% in all the varieties across the locations (Table 3). In the case of common scab, the highest value (10.9%) was recorded in BARI Alu-40 in Faridpur while it was minimum in Rajshahi (0.25-0.93%) with an average of 0.57% (Table 4). Among the varieties, the average highest common scab infestation (4.90%) was recorded in BARI Alu-40 and the lowest in BARI Alu-47 (1.03%). The average cutworm infestation was the highest in Faridpur (4.61%) while it was minimum in Rajshahi (0.09%). Among the varieties, the highest cutworm infestation was recorded in BARI Alu-56 (3.39%) and the lowest in BARI Alu-47 (0.59%) (Table 4).

Cost and return analysis: The average highest gross return (Tk. 605940 ha^{-1}) and gross margin (Tk. 390690 ha^{-1}) were recorded in Mymensingh and the lowest (Tk. 312300 ha^{-1}) and gross margin (Tk. 147800 ha^{-1}) in Noakhali (Table 5). Considering the potato varieties, BARI Alu-41 showed the average highest gross return (452520 Tk. ha^{-1}) and gross margin (267787Tk. ha^{-1}) similar to BARI Alu-62 (gross return, 451130 Tk. ha^{-1}) and (gross margin, 266355 Tk. ha^{-1}). On the contrary, the average lowest gross return (401508 Tk. ha^{-1}) and gross margin (216958 Tk. ha^{-1}) were founded in BARI Alu-36 and this variation is established due to variation in potato yields and local market prices across different locations.

Farmers' opinion: Framer's choices regarding variety selection differed on tuber shape and size, the skin color of the tuber, vigorous plant growth and high yielding potentialities of the potato variety, and higher gross return/market price and varied from location to location. They also consider disease and pest reactions to the variety during the crop growth period. In Chandpur, farmers preferred new varieties because of less disease infection and less pest infestation with higher tuber yield (BARI Alu-40, BARI Alu-48, BARI Alu-50, and BARI Alu-62). Farmers in the Faridpur, Gaibandha, Manikganj, Kushtia, Sylhet, Rangpur districts preferred red skin potato varieties like BARI Alu-36, BARI Alu-41, BARI Alu-56. But the farmers in Bhola, Gopalganj, and Kishoreganj gave more preference to yield regarding variety selection and choose BARI Alu-40, BARI Alu-41, and BARI Alu-62. Farmers in the Noakhali, preferred BARI Alu-56, BARI Alu-36 and BARI Alu-40. In southern parts of the country (In Khulna) potato growers choose a variety of after-cooking qualities like mashed potatoes. The market price was similar for both red and white skin potatoes, but red-colored potatoes are preferable as they looked attractive. Again, BARI Alu-41. BARI Alu-62 was preferred by the potato growers in Rajshahi, Mymensingh, and Kishoreganj.

Table 2. Yield (t ha^{-1}) of different Potato varieties in different locations during 2021-22.

Varieties	Tuber yield (t ha^{-1})																	Mean
	Chandpur	Faridpur	Manikganj	Gaibandha	Kushtia	Sylhet	Rangpur	Rajshahi	Khulna	Sherpur	Tangail	Mymensingh	Norsingdi	Bhola	Gopalganj	Kishoreganj	Noakhali	
BARI Alu-36	34.30	34.33	30.25	32.76	37.68	35.00	29.87	29.22	28.05	33.90	33.83	27.57	31.20	25.73	31.58	39.24	18.30	**31.34**
BARI Alu-37	33.47	27.33	26.78	29.04	36.59	32.00	30.45	32.69	29.26	34.25	32.42	30.55	28.63	28.43	32.03	35.14	21.90	**30.64**
BARI Alu-40	35.77	28.37	33.60	31.09	35.94	40.00	32.78	46.30	28.00	38.00	35.86	30.95	41.47	28.84	36.83	42.40	23.40	**34.68**
BARI Alu-41	34.40	37.20	34.53	35.55	42.62	45.00	36.41	40.09	30.36	39.60	35.68	33.70	35.90	30.68	34.75	42.34	19.80	**35.80**
BARI Alu-47	30.53	28.13	29.76	29.32	35.98	43.00	35.66	38.50	27.07	39.38	30.29	30.28	32.73	29.06	40.08	41.58	20.10	**33.03**
BARI Alu-48	34.64	27.70	27.20	35.95	40.01	38.00	33.02	39.33	25.61	39.80	33.77	27.72	33.29	34.89	32.73	37.72	19.00	**32.96**
BARI Alu-50	34.43	25.83	26.00	31.49	42.13	44.00	30.90	46.52	27.22	35.80	35.61	28.70	34.60	28.19	34.48	41.76	19.80	**33.38**
BARI Alu-56	29.94	23.63	28.30	30.52	32.56	33.00	32.84	40.40	25.22	36.81	34.36	29.53	29.01	26.72	32.42	42.32	27.40	**31.47**
BARI Alu-57	29.90	29.23	24.78	30.27	34.07	34.00	31.16	40.46	28.75	35.81	31.52	29.35	32.37	29.24	35.32	42.76	18.80	**31.63**
BARI Alu-62	34.95	26.20	32.35	32.04	35.21	37.00	31.03	41.62	31.22	40.93	34.11	34.62	34.90	27.98	36.20	44.30	19.70	**33.79**
Mean	**33.23**	**28.80**	**29.36**	**31.80**	**37.28**	**38.10**	**32.41**	**39.51**	**28.08**	**37.43**	**33.75**	**30.30**	**33.41**	**28.98**	**34.64**	**40.96**	**20.82**	
LSD	**2.01**	**2.35**	**0.87**	**5.25**	**-**	**3.13**	**-**	**9.93**	**3.72**	**-**	**9.88**	**6.97**	**3.01**	-	4.31	**-**		**-**
CV (%)	**4.19**	**10.84**	**5.72**	**6.79**	**9.53**	**6.71**	**-**	**10.51**	**7.73**	**-**	**12.95**	**11.98**	**11.8**	-	7.27	**-**		**-**

Table 3. Late Blight (%) and Virus infection (%) in different potato varieties in different locations during 2021-22.

Varieties	Late Blight (%)					Mean	Virus (%)			**Mean**
	Gaibandha	Rangpur	Mymensingh	Tangail	Kishoreganj		Kishoreganj	Rangpur	Rajshahi	
BARI Alu-36	35.0	16.25	-	11.42	16.25	**19.73**	2.29	2.29	0.09	**1.56**
BARI Alu-37	45.0	21.25	-	12.90	21.25	**25.10**	1.54	1.54	0.05	**1.04**
BARI Alu-40	30.0	18.75	7.00	29.23	18.75	**20.75**	2.31	1.875	0.04	**1.41**
BARI Alu-41	25.0	16.25	-	1.02	16.25	**14.63**	2.29	2.29	0.05	**1.54**
BARI Alu-47	25.0	13.75	-	7.50	13.75	**15.00**	1.225	1.22	0.06	**0.84**
BARI Alu-48	20.0	18.75	5.00	7.69	18.75	**14.04**	1.88	1.875	0.09	**1.28**
BARI Alu-50	25.0	16.25	-	2.73	16.25	**15.06**	2.22	2.29	0.02	**1.51**
BARI Alu-56	35.0	13.75	-	0.00	13.75	**15.63**	1.23	1.22	0.07	**0.84**
BARI Alu-57	25.0	13.75	-	16.10	18.75	**18.40**	1.88	1.22	0.05	**1.05**
BARI Alu-62	25.0	18.75	-	31.32	12.75	**21.96**	1.13	1.875	0.03	**1.01**
Mean	**29.0**	**16.75**	**6.00**	**11.99**	**16.65**	**18.03**	**1.80**	**2.29**	**0.06**	**1.21**

Table 4. Common scab infection (%) and cutworm infestation in tuber in different locations during 2021-22.

Varieties	Common scab (%)						Mean	Cutworm infestation (%)			Mean
	Gaibandha	Rangpur	Rajshahi	Kishoreganj	Mymensingh	Faridpur		Rajshahi	Sherpur	Faridpur	
BARI Alu-36	5.67	0.62	0.75	0.63	2.00	0	**1.93**	0.12	1.71	7.1	**2.98**
BARI Alu-37	3.33	1.62	0.44	1.43	13.00	4.30	**4.02**	0.08	0.00	7.9	**2.66**
BARI Alu-40	2.21	1.45	0.55	1.29	13.00	10.90	**4.90**	0.07	2.03	7.2	**3.10**
BARI Alu-41	3.46	0.62	0.73	0.24	7.00	0	**2.41**	0.09	3.17	4.8	**2.69**
BARI Alu-47	1.22	0.25	0.44	0.25	3.00	0	**1.03**	0.07	0.00	1.7	**0.59**
BARI Alu-48	2.33	1.45	0.25	1.42	4.00	0	**1.89**	0.13	1.16	2.9	**1.40**
BARI Alu-50	4.12	0.62	0.54	0.63	3.00	0	**1.78**	0.08	4.94	1.8	**2.27**
BARI Alu-56	3.45	0.25	0.55	0.50	3.00	0	**1.55**	0.11	3.95	6.1	**3.39**
BARI Alu-57	3.33	0.25	0.93	1.37	5.00	0	**2.18**	0.07	5.64	3.6	**3.10**
BARI Alu-62	2.11	1.45	0.56	0.68	5.00	3.80	**2.27**	0.06	2.95	3.0	**2.00**
Mean	**3.12**	**0.86**	**0.57**	**0.84**	**5.80**	**1.90**	**2.40**	**0.09**	**2.56**	**4.61**	**2.42**

Table 5. Average yield and partial economic analysis of different potato varieties at the farmer's field of different districts of Bangladesh during 2021-22.

Location	Variety/ Genotype	Potato price (Tk. kg^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Chandpur	BARI Alu-36	12.50	428750	183000	245750
	BARI Alu-37		418375	183000	235375
	BARI Alu-40		447125	183000	264125
	BARI Alu-41		430000	183000	247000
	BARI Alu-47		381625	183000	198625
	BARI Alu-48		432875	183000	249875
	BARI Alu-50		417875	183000	234875
	BARI Alu-56		374250	183000	191250
	BARI Alu-57		373750	183000	190750
	BARI Alu-62		436875	183000	253875
	Mean		**414150**	**183000**	**231150**
Gaibandha	BARI Alu-36	10.00	327600	136700	190900
	BARI Alu-37		290400	136700	153700
	BARI Alu-40		310900	136700	174200
	BARI Alu-41		355500	136700	218800
	BARI Alu-47		293200	136700	156500
	BARI Alu-48		359500	136700	222800
	BARI Alu-50		314900	136700	178200
	BARI Alu-56		305200	136700	168500
	BARI Alu-57		302700	136700	166000
	BARI Alu-62		320400	136700	183700
	Mean		**318030**	**136700**	**181330**
Manikganj	BARI Alu-36	15.00	453750	216355	237395
	BARI Alu-37		401700	216355	185345
	BARI Alu-40		504000	216355	287645
	BARI Alu-41		517950	216355	301595
	BARI Alu-47		446400	216355	230045
	BARI Alu-48		408000	216355	191645
	BARI Alu-50		390000	216355	173645
	BARI Alu-56		424500	216355	208145
	BARI Alu-57		371700	216355	155345
	BARI Alu-62		485250	216355	268895
	Mean		**440325**	**216355**	**223970**
Kushtia	BARI Alu-36	12.00	452130	207581	244549
	BARI Alu-37		439050	207581	231469
	BARI Alu-40		431310	207581	223729
	BARI Alu-41		511440	207581	303859
	BARI Alu-47		431790	207581	224209
	BARI Alu-48		480150	207581	272569
	BARI Alu-50		505500	207581	297919
	BARI Alu-56		390750	207581	183169
	BARI Alu-57		408810	207581	201229
	BARI Alu-62		422550	207581	214969
	Mean		**447348**	**207581**	**239767**
Rajshahi	BARI Alu-36	12.00	350640	231075	119565
	BARI Alu-37		392280	231075	161205
	BARI Alu-40		555600	231075	324525
	BARI Alu-41		481080	231075	250005
	BARI Alu-47		462000	231075	230925
	BARI Alu-48		471960	231075	240885
	BARI Alu-50		558240	231075	327165

Location	Variety/ Genotype	Potato price (Tk. kg-1)	Gross return (Tk. ha-1)	Total variable cost (Tk. ha-1)	Gross margin (Tk. ha-1)
	BARI Alu-56		484800	231075	253725
	BARI Alu-57		485520	231075	254445
	BARI Alu-62		499440	231075	268365
	Mean		**474156**	**231075**	**243081**
Khulna	BARI Alu-36	15.00	420750	177824	242926
	BARI Alu-37		438900	177842	261058
	BARI Alu-40		420000	177842	242158
	BARI Alu-41		455400	177842	277558
	BARI Alu-47		406050	177842	228208
	BARI Alu-48		384150	177842	206308
	BARI Alu-50		408300	177842	230458
	BARI Alu-56		378300	177842	200458
	BARI Alu-57		431250	177842	253408
	BARI Alu-62		468300	177842	290458
	Mean		**421140**	**177840**	**243300**
Sherpur	BARI Alu-36	15.00	406800	175860	230940
	BARI Alu-37		411000	175860	235140
	BARI Alu-40		456000	175860	280140
	BARI Alu-41		475200	175860	299340
	BARI Alu-47		472560	175860	296700
	BARI Alu-48		477600	175860	301740
	BARI Alu-50		429600	175860	253740
	BARI Alu-56		441720	175860	265860
	BARI Alu-57		429720	175860	253860
	BARI Alu-62		491160	175860	315300
	Mean		**449136**	**175860**	**273276**
Tangail	BARI Alu-36	10.00	338250	163705	174545
	BARI Alu-37		324200	163705	160495
	BARI Alu-40		358600	163705	194895
	BARI Alu-41		356750	163705	193045
	BARI Alu-47		302900	163705	139195
	BARI Alu-48		337700	163705	173995
	BARI Alu-50		356100	163705	192395
	BARI Alu-56		343550	163705	179845
	BARI Alu-57		315200	163705	151495
	BARI Alu-62		341100	163705	177395
	Mean		**337435**	**163705**	**173730**
Mymensingh	BARI Alu-36	20.00	551400	215250	336150
	BARI Alu-37		611000	215250	395750
	BARI Alu-40		619000	215250	403750
	BARI Alu-41		674000	215250	458750
	BARI Alu-47		605600	215250	390350
	BARI Alu-48		554400	215250	339150
	BARI Alu-50		574000	215250	358750
	BARI Alu-56		590600	215250	375350
	BARI Alu-57		587000	215250	371750
	BARI Alu-62		692400	215250	477150
	Mean		**605940**	**215250**	**390690**
Kishoreganj	BARI Alu-36	BARI ALu-41 and 56:10 Tk/kg, BARI alu-50:11Tk/kg, BARI ALu-36, BARI ALu-40 and 48:10.50 Tk/kg	412020	158200	253820
	BARI Alu-37		404110	160800	243310
	BARI Alu-40		445200	161500	283700
	BARI Alu-41		423400	160200	263200
	BARI Alu-47		478170	162500	315670
	BARI Alu-48		396060	161800	234260

Location	Variety/ Genotype	Potato price (Tk. kg^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
	BARI Alu-50	and BARI ALu-37, 47, 57 and 62:11.50 Tk/kg.	459360	160500	298860
	BARI Alu-56		423200	159800	263400
	BARI Alu-57		491740	165750	325990
	BARI Alu-62		509450	160650	348800
	Mean		**444271**	**161170**	**283101**
Noakhali	BARI Alu-36	15.00	274500	164500	110000
	BARI Alu-37		328500	164500	164000
	BARI Alu-40		351000	164500	186500
	BARI Alu-41		297000	164500	132500
	BARI Alu-47		301500	164500	137000
	BARI Alu-48		285000	164500	120500
	BARI Alu-50		297000	164500	132500
	BARI Alu-56		411000	164500	246500
	BARI Alu-57		282000	164500	117500
	BARI Alu-62		295500	164500	131000
	Mean		**312300**	**164500**	**147800**

Conclusion

Based on the yield performance of the potato varieties, it may be concluded that potato var. BARI Alu-41 suited best in all tested locations followed by BARI Alu-40, BARI Alu-57, BARI Alu-50, and BARI Alu-47. Farmer's choices varied from location to location depending on yield, color, taste, and market price. To disseminate and popularization of the selected varieties for the desired location community-based pilot production program should be initiated.

PROMOTION AND DISSEMINATION OF LATE BLIGHT-RESISTANT POTATO VARIETIES IN DIFFERENT LOCATIONS

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Abstract

The trial was conducted at farmers' field of MLT site of OFRD, Gaibandha, Lalmonirhat, Kurigram, Rangpur, and Rajshahi during the Rabi season of 2021-22 to evaluate the field performance of BARI released three late blight resistant Potato varieties (BARI Alu-46, BARI Alu-53, and BARI Alu-77) and to know farmers' judgement about the varieties. Among the tested potato varieties BARI Alu-46, BARI Alu-53 and BARI Alu-77 performed better in all the locations and gave 46, 42, and 34% higher tuber yield than the check variety (BARI Alu-25). These two-variety showed less than 0-5% late blight infection in the foliage. Regarding Common Scab susceptibility, its severity was very low (<3%). Farmers' judgment about potato varieties varied with locations mostly for yield performance and skin color. According to farmers' judgment the popular var. BARI Alu-46, BARI Alu-53, and BARI Alu-77 were highly resistant to the late blight of potato disease and reduced the cost of production without hampering tuber yield. Considering yield, the skin color of the tuber, market demand, and cost-benefit analysis farmers in all locations choose BARI Alu-53.

Introduction

Late blight is the most devastating disease of Potato in Bangladesh. It causes around 30-50% annual yield loss. It may cause total loss of the crop if attacks at an early stage of the crop. Late blight can become epidemic within a few days under favorable environmental conditions. Tuber Crops Research Center of BARI has released three late blight resistant varieties viz. BARI Alu-46 and BARI Alu-53 are higher yielders and resistant to late blight disease. Genetic disease resistance is an effective tool for sustainable management of late blight, caused by *Phytophthora infestans,* which is economically the most important disease of Potato. Breeding at the beginning of the twentieth century concentrated on major dominant late blight resistance (*R*) genes from the Mexican wild species *Solanum demissum* and eleven of these *R* genes were introgressed in potatoes (Muller and Black, 1951; Bradshaw et al. 2006). However, the rapid breakdown of resistance in Potato varieties containing *S. demissum R1, R2, R3,* and *R10* (Wastie, 1991) has sparked an increased focus on the introgression of multiple broad-spectrum *R* genes to impart durability to commercial varieties. It has turned out in various crops and pathosystems that the stacking of multiple *R* genes is necessary to provide satisfactory resistance in the field (Que et al. 2010). Although the used *R* genes provide resistance to broad spectra of late blight strains, the predominant agricultural deployment of only one *R* gene can drive the evolution of new virulent strains. In the absence of chemical controls, this might even be destroying an entire harvest (Strange and Scott, 2005F). Therefore, the use of combinations of *R* genes with different spectra must be pursued to increase the durability of resistance and thereby provide food security under no or little fungicide application. These new varieties need to be evaluated for their performance in different late blight-prone areas. The present study was conducted to evaluate and popularize the varieties under farmer's field conditions in Gaibandha, Lalmonirhat, Kurigram, and Rangpur districts.

Materials and Methods

Disease-free seed tubers of potato var. BARI Alu-46, BARI Alu-53, and BARI Alu-77 were distributed among 25 farmers of MLT sites of OFRD, Gaibandha, Lalmonirhat, Kurigram, Rangpur, and Rajshahi. Each farmer received 50 Kg of quality seed tubers of each potato varieties BARI Alu-25 (Asterix) was used as a check variety. Orientation was given to the farmers during the cropping season subject to newly released late blight resistant Potato varieties; BARI Alu-46, BARI Alu-53, and BARI Alu-77 production techniques as well as irrigation, disease management practices, etc. Seed plantations were started on 21 November and continued up to 5 December 2021 (Table 1). The haulms were pulled after 80 days of planting. The crop was harvested on 20 February to 17 March 2022 (Table 1). Farmers were also suggested to follow a routine spray schedule to control late blight infection in the control plot. But, in the case of BARI Alu-46, BARI Alu-53, and BARI Alu-77 no spray was required. Farmers were suggested not to spray fungicide before appearing Late Blight symptoms in the foliage. If disease symptoms appear, apply 1-2 sprays in the potato field. Finally, the yield data and disease observation data were taken from the trial and farmers' fields and finally compared.

Table-1. Details of the trials at different locations during the Rabi season, of 2021-22.

Location	Varieties	Number of farmers	Date of planting	Date of Harvesting	Plot size (Decimals)
Gaibandha	BARI Alu-25 (Check Variety) BARI Alu-46 BARI Alu-53 BARI Alu-77	5	21-29 Nov. 21	20-27 Feb. 22	4
Rajshahi		5	24 Nov.-1 Dec. 21	10-17 Mar. 22	4
Kurigram		5	1-5 Dec. 21	4-8 Mar. 22	10
Lalmonirhat		5	1-5 Dec. 21	4-8 Mar. 22	10
Rangpur		5	1-5 Dec. 21	4-8 Mar. 22	10

Results and Discussion

Tuber yield among the varieties across the locations ranged from 22.44 to 41.38 t ha^{-1} (Table 2) where the highest yield was obtained from BARI Alu-46 (41.38 t ha^{-1}) in Gaibandha and the lowest from check var. BARI Alu-25 (22.44 t ha^{-1}) in Lalmonirhat location. Among the potato varieties, BARI Alu-46 produced the maximum average tuber yield (34.14 t ha^{-1}) followed by BARI Alu-53 (33.19 t ha^{-1}) and BARI Alu-77 (31.32 t ha^{-1}) whereas BARI Alu-25 produced the average lowest tuber yield (23.40 t ha^{-1}). Considering the varieties across locations, all three late blight-resistant varieties along with the check variety (BARI Alu-25) produced the highest tuber yield in Gaibandha where BARI Alu-46 yielded 41.38 t ha^{-1}, BARI Alu-53 yielded 36.05 t ha^{-1}, BARI Alu-77 yielded 34.55 t ha^{-1} and the check variety yielded 24.87 t ha^{-1}. Considering the location, the average highest tuber yield was produced in Gainbandha (34.22 t ha^{-1}) whereas the lowest was in Lalmonirhat (28.09 t ha^{-1}).

Disease incidence: Regarding Late Blight infection, BARI released three late blight resistant varieties that showed excellent resistance against Late Blight disease where the average foliar infection ranged from 1.50 to 4.78% (Table-3) whereas the check var. BARI Alu-25 (Asterix) was badly infected by LB and the foliage damage ranged from 37.00 to 47.50% which caused the yield reduction greatly.

Concerning Common scab incidence in the tuber, it ranged from 0.86 to 2.20% where the lowest was found in BARI Alu-77 in Rajshahi and the highest was found in BARI Alu-53 in Kurigram. Among the varieties, the average highest common scab infection was found in BARI Alu-53 (1.58%) and the lowest was found in BARI Alu-77 (0.93%) (Table-4).

The virus infection ranged from 0.43 to 3.5% across the location (Table 5). The highest virus infection was recorded in BARI Alu-46 (3.5%) in Rangpur and the lowest was in BARI Alu-77 (0.43%) in Rajshahi.

Farmers' opinion

- Farmers were incredibly happy to observe the performance of the var. BARI Alu-46, BARI Alu-53, and BARI Alu-77 against Late Blight disease as well as higher yield.
- Both the three Late Blight Resistant potato varieties can resist Late Blight greatly and cut the spray cost which lowers the production cost. They also opined that scab infection was also less in the newly released Potato varieties BARI Alu-46, BARI Alu- 53, and BARI Alu-77.
- Farmers preferred Late Blight resistant Potato variety BARI Alu-53 for its red skin color, market demand, and higher economic return.

Table 2. Tuber yield (t ha^{-1}) of newly released late blight resistant potato variety at farmer's field during the Rabi season, 2021-22.

Location	Tuber yield (t ha^{-1})					Mean tuber yield (t ha^{-1})	% yield increase over the check (t ha^{-1})
	Gaibandha	Rajshahi	Lalmonirhat	Kurigram	Rangpur		
BARI Alu-46	41.38	38.21	30.37	30.39	30.36	34.14±2.36	46
BARI Alu-53	36.05	32.31	31.45	32.86	33.28	33.19±0.78	42
BARI Alu-77	34.56	28.07	-	-	-	31.32±2.05	34
BARI Alu-25 (Check)	24.87	-	22.44	22.93	23.35	23.40±0.47	-
Mean	34.22	32.87	28.09	28.73	29.00	-	
LSD (0.05)	2.29	5.864	-	-	-	-	
CV (%)	14.21	12.895	-	-	-	-	

Table 3. Late Blight infection (%) of newly released late blight resistant Potato variety at farmer's field during the Rabi season, 2021-22.

Location	Late Blight Infection (%)					Mean
	Gaibandha	Rajshahi	Lalmonirhat	Kurigram	Rangpur	
BARI Alu-46	1.50	-	3.4	2.6	4.0	2.88
BARI Alu-53	4.78	-	3.9	3.1	4.2	4.00
BARI Alu-77	1.75	-	-		-	1.75
BARI Alu-25 (Check)	47.50	-	44	41	37	42.38

Table 4. Common scab incidence (%) of newly released late blight resistant Potato variety at farmer's field during the year 2021-22.

Location	Common scab infection (%)					Mean
	Gaibandha	Rajshahi	Lalmonirhat	Kurigram	Rangpur	
BARI Alu-46	1.21	1.10	1.49	1.06	1.2	1.21
BARI Alu-53	1.25	1.02	1.82	2.2	1.6	1.58
BARI Alu-77	1.00	0.86		-	-	0.93
BARI Alu-25 (Check)	1.13	-	1.7	1.2	1.9	1.48

Table 5. Virus infection (%) of newly released late blight resistant Potato variety at farmer's field during the year 2021-22.

Location	Virus infection (%)					Mean
	Gaibandha	Rajshahi	Lalmonirhat	Kurigram	Rangpur	
BARI Alu-46	1.67	0.53	2.5	2.46	3.5	2.13
BARI Alu-53	1.83	0.48	1.9	2.03	3.4	1.93
BARI Alu-77	1.50	0.43	-	-	-	0.97
BARI Alu-25 (Check)	1.71	-	2.1	2.2	2.72	2.18

Conclusion

This program should be continuing to disseminate the Late Blight Resistant potato cultivation in different areas of Bangladesh.

PROMOTION AND DISSEMINATION OF NEWLY RELEASED CLIMATE-SMART POTATO VARIETIES

M. M. CHOWDHURY, M.H. RASHID, K. ISLAM, M.K. SHAHADAT, M. RAHMAN, G.N. HASAN AND R. HASAN

Abstract

BARI released three climate-smart varieties viz. BARI Alu-72, BARI Alu-73, and BARI Alu-78 were evaluated at the farmer's fields in the Khulna, Bhola and Noakhali to observe their yield performance in the southern districts of Bangladesh. Soil Salinity was recorded for the locations of Khulna location and Bhola was non-Saline. The average soil salinity levels ranged from 1.85 to 8.11 dSm^{-1} in all locations. Among the varieties, BARI Alu-78 (28.57 t ha^{-1}) was the average highest yielder and BARI Alu-72 was the 2nd highest yielder (26.07 t ha^{-1}) and BARI Alu-73 was the lowest yielder (23.71 t ha^{-1}). In all locations, BARI Alu-78 performed better due to its higher adaptability to heat and saline conditions. Higher average gross return and gross margin were accounted from BARI Alu-78 for its higher yield.

Introduction

In Bangladesh, 1.36 lakh hectares of land are under Potato cultivation which produces 15.58 lakh tons of potatoes. The coastal area includes 32% of the cultivable land in Bangladesh (Haque, 2006). About 1.06 Mha of the 2.86 MhaOut of 2.86 Mha of coastal and off-shore cultivable lands in Bangladesh, approximately 1.06 Mha are affected by varying degrees (>2 to 16 dS m-1) of salinity (SRDI , 2010) After harvesting T. Aman, a vast area of land remains fallow in this region. Again, during the *rabi* season, the soil salinity levels increase through capillary movement. It is a major production constraint in the saline coastal region. In the Khulna region, the area under Potato cultivation is only 1,584 ha which is negligible (0.79%) in the context of the total Potato cultivated area of the country. Lack of high-yielding salt-tolerant variety, soil salinity, and lack of irrigation facilities are the major challenges for potato cultivation in this area. BARI has developed three climate-smart potato varieties (BARI Alu-72, BARI Alu-73, and BARI Alu-78) having different characteristics such as tolerance to heat and salinity stress, etc. Potato has the capacity of producing more calories and proteins per unit of land area with minimum time than most other major food crops (Azimuddin et al., 2009;). Although many modern varieties of Potatoes have been released by the country's research centers for different agro-ecologies, the yield potential is seeming unsatisfactory because the traditional varieties still occupy about 35% of the total Potato cultivation area. The Tuber Crop Research Centre (TCRC) of BARI has released so far 91 high-yielding potato varieties having good yield potential and tolerant to biotic and abiotic stresses during the last decade and recommended 20 varieties after screening for cultivation under Bangladesh conditions. The performance of these varieties needs to be evaluated for cultivation in this saline area. Keeping this view in mind, the experiment was undertaken to find out the performance of BARI Alu-72, BARI Alu-73 and BARI Alu-78 for cultivation in the coastal area of Bangladesh.

Materials and Methods

The trial was conducted at the farmer's fields at Khulna, Bhola and Noakhali during 2021-22 to observe the performance of BARI Released climate-smart potato varieties (BARI Alu-72, BARI Alu-73 and BARI Alu-78) in the southern areas of Bangladesh. The unit plot size differed from location to location (Table 1). The whole potato tuber was planted from 24 November and continued up to 15 December 2021. Plant spacing was maintained 60 cm x 25 cm. Two irrigations and one weeding were done when required. The crop started harvesting on 10 March and continued up to 20 March 2022. Soil salinity data were taken at the emergence stage, vegetative stage (25 days), tuberization stage (50 days), and maturity stage (75 days). The average soil salinity level ranged from 1.5 to 8.11 dSm^{-1} in the Khulna region and 2.0 to 7.52 dSm^{-1} in the Noakhali region (Fig. 1). The trial location of Bhola was non-saline. Soil salinity gradually increased up to the maturity stage of the crop.

Table 1. Details of the trials at different locations during the Rabi season, 2021-22.

Location	Variety	N-P-K-S-Zn-B (kg ha^{-1})	Date of Planting	Date of Harvesting	Plot size (m^2)
Khulna	BARI Alu-72,	115-30-125-22-2-2	15 Dec. 21	20 Mar. 22	400
Bhola	BARI Alu-73 and	161-44-132-15-5-2	2 Dec. 21	10 Mar. 22	200
Noakhali	BARI Alu-78	115-30-125-22-2-2	24 Nov. 21	16 Mar. 22	240

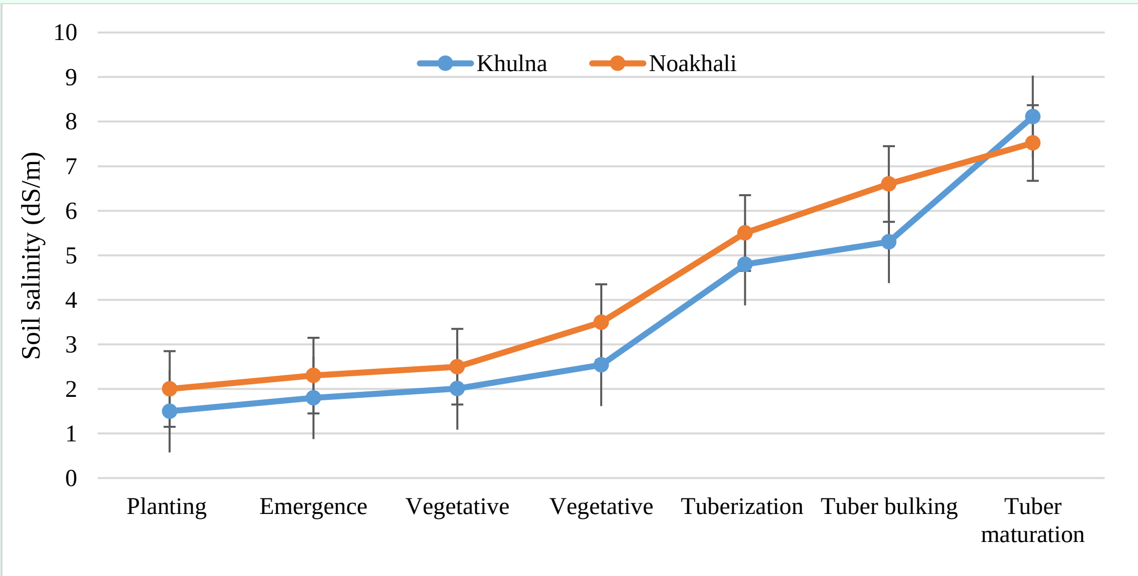

Fig. 1. The average soil Salinity level in the trial site in Khulna and Noakhali region, 2021-22

Results and Discussion

The results of the experiment are shown in table 2. The mean yield of the three potato varieties across locations ranged from 20.50 to 34.31 t. ha^{-1}. BARI Alu-78 was the highest yielder in both locations (28.51 t ha^{-1} in Khulna and 34.31 t ha^{-1} in Bhola) with some exception in Noakhali. Among the varieties, the mean highest yield was found in BARI Alu-78 (28.57 t ha^{-1}) followed by BARI Alu-72 (26.07 t ha^{-1}), and the lowest in BARI Alu-73 (23.71 t ha^{-1}). Among the locations, the mean lowest yield was observed in Noakhali (22.73 t ha^{-1}). Cutworm infestation (%) in potato varieties ranged from 1.72 to 2.21. Common scab was observed in all varieties ranging from 1.83 to 2.37 (Table 3) and both cutworm infestation and common scab infection were found high in BARI Alu-72 and the lowest was in BARI Alu-78.

Economic analysis

From the economic analysis, the average gross return and gross margin for BARI Alu-78 accounted for 428600 Tk. ha^{-1}, and 252872 Tk. ha^{-1} followed by BARI Alu-72 (gross return and gross margins were 391050 Tk. ha^{-1} and 215322 Tk. ha^{-1}). The average lowest return and gross margin were accounted from BARI Alu-73 (355650 Tk. ha^{-1} and 179922 Tk. ha^{-1}) (Table-4). The reason of higher gross return as well as gross margin was mainly due to the more tuber yield and market price.

Farmers' opinion

Farmers of each location reported that BARI Alu-78 was high yielding and suitable for cultivation on their land and they also preferred BARI Alu-72 because of its attractive color and yield, but few farmers showed their interest in BARI Alu-73 for its white skin color. So, promotional works should be taken to disseminate these three varieties in coastal regions.

Table 2. Yield performance of 3 climate-smart potato varieties in Khulna, Bhola and Noakhali during the year 2020-21

Variety	Khulna	Bhola	Noakhali	Mean
BARI Alu-72	26.63	26.78	24.80	26.07
BARI Alu-73	21.84	28.79	20.50	23.71
BARI Alu-78	28.51	34.31	22.90	28.57
Mean	25.66	29.96	22.73	
LSD (0.05)	4.76	4.62	2.32	
CV (%)	8.50	5.46	8.90	

Table 3. Insect and disease infestation % of different potato varieties during 2021-22

Variety	Infestation of insect pests and diseases (%)	
	Cutworm (tuber)	Common scab
BARI Alu-72	2.21	2.37
BARI Alu-73	1.90	2.09
BARI Alu-78	1.72	1.83
Range	1.72-2.21	1.83-2.37

Table 4: Economic analysis of BARI Alu-72, BARI Alu-73 and BARI Alu-78 during 2021-22

Location	Variety	Price (Tk kg^{-1})	Gross Return (Tk. ha^{-1})	Total Variable Cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
Khulna	BARI Alu-72	15	399450	177842	221608
	BARI Alu-73		327600	177842	149758
	BARI Alu-78		427650	177842	249808
Bhola	BARI Alu-72	15	401700	187842	213858
	BARI Alu-73		431850	187842	244008
	BARI Alu-78		514650	187842	326808
Noakhali	BARI Alu-72	15	372000	161500	210500

Location	Variety	Price (Tk kg^{-1})	Gross Return (Tk. ha^{-1})	Total Variable Cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
	BARI Alu-73		307500	161500	146000
	BARI Alu-78		343500	161500	182000
Mean	BARI Alu-72		391050	175728	215322
	BARI Alu-73		355650	175728	179922
	BARI Alu-78		428600	175728	252872

Conclusion

Potato var. BARI Alu-78 produced satisfactory yield in all locations might be due to its salt and heat tolerance character.

ADAPTIVE TRIALS WITH MUKHIKACHU VARIETIES IN DIFFERENT LOCATIONS

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Abstract

The experiment was conducted at six locations, Narsingdi, Kushtia, Jashore, Mymensingh, Sherpur, and Kishoreganj under OFRD during the Kharif season of 2020-21 to evaluate the performance of three Mukhikachu varieties namely, BARI Mukhikachu-1, BARI Mukhikachu-2 and local (Check) under farmers' field and to popularize among the farmers. The average maximum corm yield (25.95 t ha^{-1}) was produced by BARI Mukhikachu-2 followed by BARI Mukhikachu-1 (24.31 t ha^{-1}) whereas the minimum corm yield (23.61 t ha^{-1}) in local variety. In terms of location, the average highest corm yield was recorded in Kustia (40.59 t ha^{-1}), followed by Mymensingh (29.70 t ha^{-1}), Sherpur (28.31 t ha^{-1}) and the minimum corm yield in Jashore (10.43 t ha^{-1}). The highest gross return (Tk. 814500 ha^{-1}) and gross margin (Tk. 627180 ha^{-1}) were found from the local variety in Kushtia. The lowest gross return (Tk. 206520 ha^{-1}) and gross margin (Tk. 93840 ha^{-1}) were from the local cultivar in Kishoreganj (Table 3).

Introduction

Mukhikachu *(Calocassia esculenta* var. *antiquorum*) is one of the important tuber crops of Bangladesh grown during the Kharif season. It is a carbohydrate, protein and iron, and vitamin 'A' rich vegetable that is generally grown from February/March to September/October. It is considered an important vegetable, particularly in the month of August-October when the supply of other vegetables is limited in the market. The demand for Mukhikachu in Bangladesh is increasing day by day but its yield per unit area is very low. Farmers usually grow a local variety of which yield potentiality is low and susceptible to pests and diseases. Tuber Crops Research Centre (TCRC) of BARI has developed two Mukhikachu varieties, which has high yield potential and are less susceptible to pest and diseases. Only BARI Mukhikachu-1 (Bilashi) has become popular with the farmers. Some local varieties are being also cultivated by the farmers. The newly released variety is not well known to them. Therefore, the trials were conducted to evaluate the performance of this variety and popularize as well as disseminate it in the country.

Materials and Methods

The experiment was conducted at six locations namely, Narsingdi, Kushtia, Jashore, Mymensingh, Sherpur, and Kishoreganj districts during the Kharif season of 2020-21 to evaluate the performance of the two mukhiikachu varieties, BARI Mukhikachu-1 and BARI Mukhikachu-2 along with the local cultivar and to popularize among the farmers. No check variety was used in Sherpur. Thirty days old seedlings were transplanted. The crop was fertilized with a dose of 350-180-250 kg ha^{-1} of Urea-TSP-MoP, respectively with 10 t ha^{-1} of cowdung. The full amount of cowdung, TSP, and half of MOP were applied at the final land preparation. The rest half of MOP and 1/6th of urea was applied at 45-60 Days after planting (DAP). The remaining 1/5th urea was applied at 15 days intervals. The crop was slightly infested with leaf spot disease, and it was controlled by spraying several times with Ridomil Gold- 72 @ 2 ml L^{-1} water. No other significant diseases and pest infestation was observed in the plots. Data on maturity, plant height, yield, and yield contributing characters were collected and analyzed statistically following MSTAT-C. Means were separated by using LSD at 5% level and DMRT

Results and Discussion

The maximum average plant height was obtained from BARI Mukhikachu-1 (88.10 cm) followed by BARI Mukhikachu-2 (80.94 cm). The minimum plant height was obtained from the local cultivar (69.94 cm). The maximum number of corms per plant and weight of corms were obtained from BARI Mukhikachu-2 followed by BARI Mukhikachu-1and the lowest from the local variety. The maturity days among the varieties ranged from 194 to 242 days where the local variety took minimum days (194), and the BARI Mukhikachu-1 took the maximum average days to maturity (Table 1).

The corm yield among the varieties across the locations ranged from 9.20 to 54.30 t ha^{-1} (Table 2). The maximum corm yield was obtained from the local cultivar in Kushtia (54.30 t ha^{-1}), followed by BARI Mukhikachu-2 (35.20 t ha^{-1})and BARI Mukhikachu-2 (33.10 t ha^{-1}) in Mymensingh, BARI Mukhikachu-1 (32.28 t ha^{-1}) in Kustia and BARI Mukhikachu-1 in Mymensingh (31.30 t ha^{-1}). The lowest corm yield was obtained from the local variety in the Jashore (9.20 t ha^{-1}). The reasons for the yield variation in different locations are mainly due to the difference in agro-climatic conditions and cultural management. Similarly, Considering the variety, the average maximum corm yield (25.95 t ha^{-1}) was produced by BARI Mukhikachu-2 followed by BARI Mukhikachu-1 (24.31 t ha^{-1}) whereas the minimum corm yield (23.61 t ha^{-1}) recorded in local variety. In terms of location, the average maximum corm yield was recorded in Kustia (40.59 t ha^{-1}), followed by Mymensingh (29.70t ha^{-1}), Sherpur (28.31 t ha^{-1}), and the minimum corm yield in Jashore (10.43 t ha^{-1}).

Cost and return analysis: The highest gross return (Tk. 814500 ha^{-1}) and gross margin (Tk. 627180 ha^{-1}) were found from the local variety in Kushtia. The lowest gross return (Tk. 206520 ha^{-1}) and gross margin (Tk. 93840 ha^{-1}) were from the local cultivar in Kishoreganj (Table 3).

Farmers' reaction: Farmers expressed their satisfaction with the high yield of BARI Mukhikachu-1 and BARI Mukhikachu-2. In Kustia farmers preferred the local variety for its higher yield. They are interested to grow this variety in the future.

Table 1. Average plant and yield attributes of Mukhikachu varieties at different locations during 2020-21.

Treatment	Plant height (cm)	No. of corm $plant^{-1}$	Wt. of corm $plant^{-1}$ (g)	Days to maturity
BARI Mukhikachu-1	88.10	19.8	633	242
BARI Mukhikachu-2	80.94	20.4	672	213
Local	69.94	16.7	529	194

Table 2. Yield (t ha^{-1}) of Mukhikachu varieties in different locations during the year 2020-21

Variety	Corm yield (t ha^{-1})						Mean corm yield (t ha^{-1})
	Narsingdi	Kushtia	Jashore	Mymensingh	Sherpur	Kishoreganj	
BARI Mukhikachu-1	25.93	32.28	11.60	31.30	27.75	17.01	24.31
BARI Mukhikachu-2	29.67	35.20	10.50	33.10	28.86	18.34	25.95
Local	16.60	54.30	9.20	24.70	-	13.23	23.61
Mean	24.07	40.59	10.43	29.70	28.31	16.19	
CV (%)	6.70	7.34	-	2.88	-	-	-
LSD	12.94	-	-	1.13	-	-	-

Table 3. Cost and analysis of mukhikachu varieties at different locations during 2020-21

Location	Variety/ Genotype	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})
Narsingdi	BARI Mukhikachu-1	388950	165250	223700
	BARI Mukhikachu-2	445050	165250	279800
	Local (Bhuakur)	249000	165250	83750
	Mean	361000	165250	195750
Kushtia	BARI Mukhikachu-1	387360	187320	200080
	BARI Mukhikachu-2	422400	187320	234670
	Local	814500	187320	627180
	Mean	541420	187320	353976
Jashore	BARI Mukhikachu-1	348000	181700	166300
	BARI Mukhikachu-2	315000	181700	133300
	Local	276000	175000	101000
	Mean	313000	179466	133533
Mymensingh	BARI Mukhikachu-1	626163	166500	459663
	BARI Mukhikachu-2	662596	166500	496096
	Local	493605	166500	327105
	Mean	594121	166500	427621
Sherpur	BARI Mukhikachu-1	689700	190500	499200
	BARI Mukhikachu-2	736920	190500	546420
	Local	-	-	-
	Mean	713310	190500	522810
Kishoreganj	BARI Mukhikachu-1	223600	125000	98600
	BARI Mukhikachu-2	261500	129560	131940
	Local	206520	112680	93840
	Mean	230540	122413	108127
Mean	BARI Mukhikachu-1	458899	168575	290303
	BARI Mukhikachu-2	455620	169933	285691
	Local	475673	170919	304686

Conclusion

From the results, it may be concluded that Mukhikachu var. BARI Mukhikachu-1 and BARI Mukhikachu-2 were found best for corm production in all locations except Kushtia.

ADAPTIVE TRIALS WITH NEWLY RELEASED PANIKACHU VARIETIES IN DIFFERENT LOCATIONS

K.U. AHAMMAD AND M. MOHIUDDIN

Abstract

The experiment was conducted at three locations such as the MLT site of Magura, and Kishoregonj under OFRD during the Kharif season of 2020-21 to evaluate the performance of eight panikachu varieties/genotypes (BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6, PK 179 and PK 183) along with local varieties at farm level and to popularize among the farmers. The stolon yield of the Panikachu varieties ranged from 4.80 to 23.20 t ha^{-1}, where the highest in BARI Panikachu-1 (23.20 t ha^{-1}) and the lowest was observed in BARI Paniikachu-6 (4.80 t ha^{-1}) in Magura. Considering rhizome yield, the highest in BARI Panikachu-4 (40.80 t ha^{-1}) in Magura and the lowest was observed in BARI Paniikachu-1 (16.89 t ha^{-1}) in Kishoreganj. In Magura, the highest gross return (1076000 Tk.ha^{-1}), gross margin (847700 Tk.ha^{-1}. Similarly, in

Kishoreganj, The highest gross return (954850.00 Tk.ha^{-1}) and gross margin (735350.00 Tk. ha^{-1}) were obtained from the BARI Panikachu-1 variety and the lowest gross return (329300.00 Tk. ha^{-1}), and gross margin (109800.00 Tk. ha^{-1}) were obtained from BARI Panikachu-5.

Introduction

Aroid (Panikachu) is one of the important tuber crops in Bangladesh during the summer season. The demand for aroids in Bangladesh is increasing day by day, but its yield per unit area is very low. Nutritionally, this crop is highly rich, particularly the stolon, leaf blade, and leaf stalk. The yield of aroids is markedly influenced by planting materials. Farmers in this region grow local variety which is low yield potentiality and susceptible to pests and diseases. BARI has developed some Panikachu varieties, which are high yielders and less susceptible to pests and diseases. BARI has released six improved varieties of Panikachu, and these are BARI Panikachu-1, BARI Panikachu-2, Panikachu-3, Panikachu-4, Panikachu-5, and Panikachu-6. Only BARI Panikachu-1 (Latiraj) has become popular with the farmers. Some local varieties are being also cultivated by the farmers. The newly released variety is not well known to them. So, trial was conducted to evaluate the performance of these varieties and popularize as well as disseminate them in different locations of the country.

Materials and Methods

The experiment was conducted at three locations such as MLT site of Magura and Kishoregonj, , respectively during the Kharif season of 2020-21 to evaluate the performance of panikachu genotypes/varieties (BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6, PK-179, PK-183 and local variety under farmers' field and to popularize among the farmers. Thirty days old seedlings were transplanted. Crop management across the locations presented in Table 1. The recommended fertilizer doses were applied as N_{152} P_{34} K_{180} S_{20} $Zn_{4.3}$ $B_{1.7}$ kg^{-1} respectively. The full amount of cow dung, TSP and half of MOP was applied at the final land preparation. Rest half of MOP and 1/6th of urea was applied at 45-60 Days after planting (DAP). The remaining 1/5th urea was applied at 15 days intervals. The crop was slightly infested with leaf spot disease, and it was controlled by spraying several times with Ridomil Gold- 72 @ 2 ml L^{-1} water. No other significant diseases and pest infestation was observed in the plots.

Results and Discussion

Considering the stolon yield of the Panikachu varieties ranged from 4.80 to 23.20 t ha^{-1}, where the highest in BARI Panikachu-1 (23.20 t ha^{-1}) and the lowest was observed in BARI Paniikachu-6 (4.80 t ha^{-1}) in Magura (Table 2). Regarding rhizome yield, it ranged from 16.89 to 40.80 t ha^{-1}, where the highest was observed in BARI Panikachu-4 (40.80 t ha^{-1}) in Magura and the lowest in BARI Paniikachu-1 (16.89 t ha^{-1}) in Kishoreganj (Table 3).

Cost and return analysis

In Magura, the highest gross return (1076000 Tk.ha^{-1}), gross margin (847700 Tk.ha^{-1}), and MBCR (61.2) were obtained from BARI Panikachu-1. Similarly, in Kishoreganj, The highest gross return (954850.00 Tk.ha^{-1}) and gross margin (735350.00 Tk. ha^{-1}) were obtained from the BARI Panikachu-1 variety and the lowest gross return (329300.00 Tk. ha^{-1}), and gross margin (109800.00 Tk. ha^{-1}) were obtained from BARI Panikachu-5 (Table -4).

Farmers' reaction

Farmers in Magura expressed their satisfaction with the higher yield of BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, and BARI Panikachu-4. They are interested to grow this variety in the future. In Kishoreganj, they showed their interest in BARI Panikachu-4, 5, and 6 for rhizome production and the highest gross return. On the other hand, farmers opined that BARI Panikachu-

1 gave the highest stolon yield in Magura and Kishoreganj and are still satisfied with BARI Panikachu-1 for its higher stolon yield.

Table 1. Crop management practices used for Panikachu in different locations during the year, 2020-2021

Location	Variety	Planting time	Harvesting time	Plot size
Magura	BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6, PK-179, PK-183 and local	4 Feb. 2021	9 April - 10 July, 2021	9m x 4.5m
Kishoreganj	BARI Panikachu-1, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6	22 Dec 2020	20 March to 05 September, 21	9m x 4.5m

Table 2. Stolon yield performance of different panikachu varieties in different locations during the year of 2020-21.

Variety	Mean stolon yield (t ha^{-1})		
	Magura	Kishoreganj	Average
BARI Panikachu-1	23.20	22.27	22.74
BARI Panikachu-2	21.00	-	21.00
BARI Panikachu-3	18.00	-	18.00
BARI Panikachu-4	8.30	6.15	7.23
BARI Panikachu-5	5.80	6.72	6.26
BARI Panikachu-6	4.80	6.83	5.82
PK-179	9.60	-	9.60
PK-183	9.80	-	9.80
Local	9.50	-	9.50
Mean	12.22	10.49	12.22

Table 3. Rhizome yield performance of different Panikachu variety's different locations during the year 2020-21

Variety	Rhizome yield (t ha^{-1})		Mean yield (t ha^{-1})
	Magura	Kishoreganj	Average
BARI Panikachu-1	29.60	16.89	23.25
BARI Panikachu-2	34.80	-	34.80
BARI Panikachu-3	31.00	-	31.00
BARI Panikachu-4	40.80	30.59	35.70
BARI Panikachu-5	37.60	29.23	33.42
BARI Panikachu-6	35.50	31.20	33.35
PK-179	34.60	-	34.60
PK-183	36.00	-	36.00
Local	37.60	-	37.60
Mean	35.28	26.98	

Table 4. Cost and return analysis of different Panikachu varieties in Magura, and Kishoreganj locations during the year of 2020-21

Location	Treatment	Price (Tk. kg^{-1})	Gross return (Tkha^{-1})	Total variable cost (Tkha^{-1})	Gross margin (Tk. ha^{-1})
Shimakhali, Magura	BARI Panikachu-1	Stolon = 40 Rhizome = 5	1076000	228300	847700
	BARI Panikachu-2		1014000	228300	785700
	BARI Panikachu-3		875000	228300	646700
	BARI Panikachu-4		536000	228300	307700
	BARI Panikachu-5		420000	228300	191700

Location	Treatment	Price (Tk. kg^{-1})	Gross return (Tkha^{-1})	Total variable cost (Tkha^{-1})	Gross margin (Tk. ha^{-1})
	BARI Panikachu-6		369500	228300	141200
	PK-179		557000	228300	328700
	PK-183		572000	228300	343700
	Local		568000	220000	348000
Mean			665278	227378	437900
Kishoreganj	BARI Panikachu-1	Stolon = 8 Rhizome = 13	424630	226500	198130
	BARI Panikachu-4		342670	226500	116170
	BARI Panikachu-5		321200	226500	94700
	BARI Panikachu-6		338390	226500	111890
Mean			356723	226500	130223

Conclusion

Considering the yield potentiality, panikachu var. BARI Panikachu-1 gave the highest yield of stolon and BARI Panikachu-4 highest production of the rhizome. BARI Panikachu-1 for stolon and BARI Panikachu-4 for rhizome were found superior. The genotypes PK-179 and PK 183 were also found good for rhizome production.

ON-FARM TRIAL WITH BARI RELEASED VARIETIES OF PANIKACHU

M.M. ZAMAN, N. SULTANA, A. ISLAM, S. AKTAR, S. SULTANA, N. AKTAR

Abstract

The trial was conducted at MLT site of Tishal under Mymensingh during the Kharif season of 2021 to evaluate the performance of seven Panikachu varieties i.e., BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6 and local . The average stolon yield was the highest (24.3 t ha^{-1}) in BARI Paniikachu-1 and lowest (7.2 t ha^{-1}) for BARI Paniikachu-5. The rhizome yield was the highest (62.5 t ha^{-1}) in BARI Panikachu-6 and the lowest (20.6 t ha^{-1}) in BARI Paniikachu-1. The highest gross return (954850.00 Tk. ha^{-1}) and gross margin (735350.00 Tk. ha^{-1}) were also obtained from the BARI Panikachu-1 variety and the lowest gross return (329300.00 Tk. ha^{-1}), and gross margin (109800.00 Tk. ha^{-1}) were obtained from BARI Panikachu-5.

Introduction

Aroid (Panikachu) is one of the important tuber crops in Bangladesh during the summer season. Total lowland taro (panikachu) production is 38, 502 ton and the area are 17,008 (BBS,2018). The demand for aroids in Bangladesh is increasing day by day, but its yield per unit area is very low. Nutritionally, this crop is highly rich, particularly the stolon, leaf blade, and leaf stalk. The yield of aroids is markedly influenced by planting materials. Farmers in this region grow local variety which is low yield potentiality and susceptible to pests and diseases. BARI has developed some panikachu varieties, which are high yielders and less susceptible to pests and diseases. BARI has released six improved varieties of panikachu, and these are BARI Panikachu-1, BARI Panikachu-2, Panikachu-3, Panikachu-4, Panikachu-5, and Panikachu-6. Only BARI Panikachu-1 (Latiraj) has become popular with the farmers. Some local varieties are being also cultivated by the farmers. The newly released variety is not well known to them. So, trial was conducted to evaluate the performance of these varieties and popularize as well as disseminate them among the farmers.

Materials and Methods

The trial was conducted at MLT site of Tishal under Mymensingh during the Kharif season of 2021 to evaluate the performance of seven Panikachu varieties i.e., BARI Panikachu-1, BARI Panikachu-2, BARI Panikachu-3, BARI Panikachu-4, BARI Panikachu-5, BARI Panikachu-6 and local to popularize among the farmers. The seedlings were planted on December 29, 2020, with a unit size, was 9 m $\times$ 4.5 maintaining line to line distance 60 cm and plant distance 45 cm. The crop was fertilized with a dose of 350-175-300-125-14-10 kg ha^{-1} of Urea-TSP-MOP- Gypsum- Zinc sulphate- Boric acid, respectively and 15 t ha^{-1} of cowdung. Half of the MOP and the full dose of TSP, Gypsum, Zinc sulphate, Boric acid and cowdung was applied to the plot during the final land preparation. One-fifth of Urea was top dressed started from 20-25 days after planting (DAP) and the other 4 installments were applied at an interval of 25-30 days after that 1st top dressed. The rest of MoP was top dressed at 50-60 DAPS with the second top dressed of Urea. Other intercultural operations like weeding, earthing up, irrigation etc. were done ad per schedule. There were no notable significant diseases and pest infestation was observed in the plots. The stolon was harvested from 15 April 2021 to 23 August 2021 and the rhizome was harvested from August 31, 2021 to 06 September. Data were collected on yield and yield contributing characters and were calculated by statistical software STAR.

Results and Discussion

Results obtained from the study are presented in Tables 1 and 2. The maximum plant height (131.1 cm) was in BARI Panikachu-6 followed by local cultivar (119.2 cm), BARI Panikachu-5, BARI Panikachu-2, BARI Panikachu-3, and the lowest in BARI Panikachu-4 (91.8 cm). The highest stolon yield per hectare (24.3 tons) was obtained from BARI Panikachu-1 due to the maximum number of stolons per plant, stolon length, stolon weight per plant, and followed by BARI Panikachu-2 and local cultivar. The lowest stolon (7.2 t ha^{-1}) was obtained from BARI Paniikachu-5. Rhizome yield was highest (62.5 t ha^{-1}) from BARI Panikachu-6 and the lowest (20.6 t ha^{-1}) from BARI Paniikachu-1. The highest gross return (954850.00 Tk.ha^{-1}) and gross margin (735350.00 Tk. ha^{-1}) were obtained from the BARI Panikachu-1 variety and the lowest gross return (329300.00 Tk. ha^{-1}), and gross margin (109800.00 Tk. ha^{-1}) was obtained from BARI Panikachu-5.

Farmers expressed their satisfaction with the higher stolon yield of BARI Paniikachu-1 and BARI Paniikachu-2. They are interested to grow these two varieties in the future.

Table 1. Stolon yield and yield contributing characters of Panikachu varieties at Trishal, Mymensingh during- 2021

Varieties	Plant height (cm)	No. of stolon plant^{-1}	Stolon length (cm)	Stolon diameter (cm)	Stolon yield plant^{-1} (g)	Stolon yield (t ha^{-1})
BARI PK-1	94.8	26.6	62.8	3.33	619	24.3
BARI PK-2	105.6	19.5	50.8	4.53	605	22.1
BARI PK-3	105.5	17.5	49.6	2.77	326	12.0
BARI PK-4	91.8	16.9	41.7	2.53	218	8.6
BARI PK-5	106.5	11.3	23.7	3.00	176	7.2
BARI PK-6	131.1	13.6	55.3	3.13	183	7.6
Local check	119.2	18.7	52.5	4.57	590	21.8
LSD $_{(0.05)}$	5.77	2.75	4.41	0.59	48.07	1.53
CV (%)	1.88	5.43	3.22	6.07	4.33	3.62

Table 1. cont'd

Varieties	Rhizome length (cm)	Rhizome (cm)	Rhizome yield (t ha^{-1})
BARI PK-1	24.3	22.4	20.6
BARI PK-2	22.5	29.3	23.4
BARI PK-3	22.4	28.2	30.4
BARI PK-4	32.6	23.8	32.5
BARI PK-5	31.4	25.5	37.2
BARI PK-6	41.0	29.4	62.5
Local check	23.5	28.3	24.3
LSD $_{(0.05)}$	2.58	2.33	1.74
CV (%)	3.21	3.06	1.85

Table 2. Cost and return analysis of Panikachu varieties at Trishal, Mymensingh during- 2020-21

Varieties	Gross return (Tk. ha^{-1})			Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
	Stolon	Rhizome	Total		
BARI PK-1	851667.00	103183.00	954850.00	219500.00	735350.00
BARI PK-2	773383.00	117050.00	890433.00	219500.00	670933.00
BARI PK-3	359200.00	152233.00	511433.00	219500.00	291933.00
BARI PK-4	172267.00	162467.00	334733.00	219500.00	115233.00
BARI PK-5	143067.00	186233.00	329300.00	219500.00	109800.00
BARI PK-6	151867.00	312583.00	464450.00	219500.00	244950.00
Local check	763000.00	121333.00	884333.00	219500.00	664833.00

Conclusion

Considering the yield potentiality, Panikachu var. BARI Panikachu-1 and BARI Panikachu-2 gave the highest yield of stolon. BARI Panikachu-6 was given the highest production of the rhizome.

ADAPTIVE TRIAL OF PROMISING SWEET POTATO VARIETIES IN DIFFERENT LOCATIONS

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Abstract

Field trials were conducted in Jamalpur and Kishoreganj during 2021-22 to evaluate the comparative performance of sweet potato varieties and to know the farmer's views about these cultivars in the respective locations. In Jamalpur four sweet potato varieties viz. BARI Mistialu-12, BARI Mistialu-15, BARI Mistilu-16, and BARI Mistialu-17 whereas in Kishoreganj three sweet potato varieties viz. BARI Mistialu-12, BARI Mistialu-14 and BARI Mistilu-17 were used. The root yield of sweet potato varieties ranged from 21.15 to 31.60 t ha^{-1}, where BARI Mistialu-12 produced the highest average root yield (31.60 t ha^{-1}) in Jamalpur, and the lowest average root yield recorded from BARI Mistialu-17 in Kishoregonj (21.15 t ha^{-1}). Among the BARI released sweet potato varieties, BARI Mistialu-12 produced the highest average tuberous root yield (30.05 t ha^{-1}) and the lowest average root yield (23.10 t ha^{-1}) in BARI Mistialu-16. Considering the location, the root yield was around 2.0 t ha^{-1} more in Kishoregonj compared to Jamalpur. The highest gross return (Tk. 437000 ha^{-1}) and gross margin (Tk. 286430 ha^{-1}) were calculated from BARI Mistialu-15 in Jamalpur.

Introduction

Sweet potato (*Ipomoea batatas*) is the fourth most important food crop in Bangladesh after rice, wheat, and Potato (Delowar and Hakim, 2014). It is mainly cultivated by marginal or subsistence farmers sporadically in different river belts, char lands, deltas, and seasonally inundated flood plains (Ahmed *et al*., 1998). It gives satisfactory yield under adverse climatic and soil conditions as well as under low or non-use of external inputs (Ndolo *et al.,* 2001). The average yield is very low as compared to many tropical to subtropical countries due to the cultivation of local and poor-quality indigenous sweet potato varieties. (Vimala and Rajendra, 1998). The prevalence of malnutrition in Bangladesh is still alarming and it is even higher than in countries like Nepal, Cambodia, Ethiopia, and Uganda. Bangladesh, 48% of children under the age of five across the country are chronically malnourished, 13.5% are acutely malnourished and 3.4% or 600 000 of the under-five population suffers from severe acute malnutrition (Anonymous, 2016).

To combat malnutrition and vitamin A deficiency of the people living in char lands, orange-fleshed sweet potato (OFSP) may be one of the options. Sweet potato has numerous agronomic advantages such as adaptability to diverse (including marginal) growing conditions (Islam et al., 2003 and Islam, 2006). The climatic condition of northern Bangladesh is suitable for sweet potato production. In Bangladesh, Sweet potato is generally harvested during March-May when the supply of cereal like rice is low. During this lean period, the sweet potato could play a vital role to fulfill the demand for the cereal of poor people of Bangladesh (Rafique et. al., 2015). The char land farmers of Gaibandha cultivated white-fleshed local sweet potato varieties despite lower yield and very low nutritional benefits.

Since 1985, TCRC, BARI has released 13 high-yielding sweet potato varieties in Bangladesh. But adaptation rate of those varieties among the farmers in different agro-ecological zones is very poor due to the lack of very few promotional activities had been undertaken by BARI, DAE, and other organizations. Considering this point of view, adaptive trials with BARI-released sweet potato varieties have been undertaken at farmers' fields to find out a suitable variety for char lands and to know the farmer's opinion about the varieties regarding yield, and economic return, and overall acceptance in different locations of Bangladesh.

Materials and Methods

Trials were conducted at farmer's field of MLT site at Melandah, Jamalpur, and MLT site of Kishoreganj during the Rabi season of 2021-22. Vines of the sweet potato varieties Trials were set up in a randomized complete block design with three dispersed replications. Planting of Sweet potato vines was started on 02 November 2021 and continued up to 30 November 2021. The unit plot size varied from location to location. The vine was planted at the spacing of 60 cm × 30 cm. Manures and fertilizers were applied at the rate of 10 t ha^{-1}cowdung and 105-45-105-15-2-1Kg of N-P-K-S-Zn-B ha-1, respectively in the form of urea, TSP, MoP, gypsum, zinc sulfate, and boric acid. Fifty percent of N, K, and a full dose of other fertilizers were applied during final land preparation. The rest amount of the N and K fertilizers were applied at 35 DAPs. Intercultural operations and plant protection measures were made as and when necessary. Harvesting of the trials was started on 1 March 2022 and continued up to 30 April 2022 in different locations. The details have been presented in table 1. Total gross return under a treatment was calculated by multiplying the total gross amount of crop produced by the farm-gate price. The total gross margin was calculated by subtracting the cost of production from the total gross return.

Table 1. Crop management practices of adaptive trials on sweet potato at different locations during the Rabi season, 2021-22.

Location	Variety	Date of planting	Date of harvesting	Unit Plot size
Jamalpur	BARI Mistialu-12 BARI Mistialu-15 BARI Mistialu-16 BARI Mistialu-17	30 Nov. 2021	30 April, 2022	6m x3m
Kishoreganj	BARI Mistialu -12 BARI Mistialu-14 BARI Mistialu-17	02 Nov. 2021	01 March, 2022	14

Results and Discussion

In Jamalpur, the highest root yield (29.20 t ha^{-1}) was obtained from BARI Mistialu-15 and the lowest tuberous root yield (21.15 t ha^{-1}) from BARI Mistialu-17 (Table 2).

In Kishoreganj, the root yield ranged from 23.51 to 31.60 t ha^{-1} (Table 2) where BARI Mistialu-12 produced the highest root yield (31.60 t ha^{-1}) followed by BARI Mistialu-17 (26.65 t ha^{-1}) and the lowest root yield was obtained from BARI MistiAlu-14 (23.51 t ha^{-1}).

Benefit-Cost analysis:

In Jamalpur, the maximum gross return (Tk. 437000 ha^{-1}), and gross margin (Tk. 286430 ha^{-1}) were found from BARI Mistialu-15 whereas, the minimum gross return (Tk. 316833 ha^{-1}) and gross margin (Tk. 166263 ha^{-1}) from BARI Mistialu-17 (Table 3).

In Kishoreganj, the maximum gross return (Tk. 252800 ha^{-1}), and gross margin (Tk.126240 ha^{-1}) were found from BARI Mistialu-12 whereas, the minimum gross return (Tk. 188080 ha^{-1}) and gross margin (Tk. 61520 ha^{-1}) were found from BARI Mistialu-14 (Table 3).

Farmer's opinion: Farmers in Jamalpur showed interest to cultivate BARI var. BARI Mistialu-12 and BARI Mistialu-12 and BARI Mistialu-17 in Kishoreganj due to its higher root yield and higher market demand.

Table 2. Root yield (t ha^{-1}) of sweet potato varieties in two locations during the Rabi season of 2021-22

Variety	Root yield (t ha^{-1})		Mean root yield
	Jamalpur	Kishoreganj	Average
BARI Mistialu-12	28.50	31.60	30.05
BARI Mistialu-14	-	23.51	23.51
BARI Mistialu-15	29.20	-	29.20
BARI Mistialu-16	23.10	-	23.10
BARI Mistialu-17	21.15	26.65	23.90
Average	**25.49**	**27.25**	
$LSD_{0.05}$		2.14	
CV(%)	9.37		

Table 3. Cost and return analysis of sweet potato varieties in different locations during the year 2021-22

Location	Variety	Price (Tk. kg^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Jamalpur	BARI Mistialu-12	15.00	427500	150570	276930
	BARI Mistialu-15		437000	150570	286430
	BARI Mistialu-16		347500	150570	196930
	BARI Mistialu-17		316833	150570	166263
Mean			**1528833**	**602280**	**926553**
Kishoreganj	BARI Mistialu -12	8.00	252800	126560	126240
	BARI Mistialu-14		188080	126560	61520
	BARI Mistialu-17		213200	126560	86640
Mean			**218027**	**126560**	**91467**

Conclusion

Among the tested sweet potato varieties, BARI Mistialu-12 performed better in Jamalpur locations whereas BARI Mistialu-12 and BARI Mishtialu-17 were preferred in Kishoregonj by the growers due to their higher yield and gross return. But further study is needed for promoting newly developed color flesh carotene-rich varieties of sweet potato in the respected areas.

ON-FARM TRIAL OF BARI RELEASED SWEET POTATO VARIETIES

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Abstract

On-Farm trials of sweet potato varieties were conducted at farmers' fields of Kushtia, Tangail, Mymensingh, and Bhola during 2021-22. The objective of the trial was to popularize BARI-released sweet potato varieties. The tested varieties were BARI Mistialu- 4, 8, 10, 11, 12, 14, 15, 16, and 17 along with the local cultivar. The varieties had different skin and flesh colors, which attracted farmers. Most of the farmers chose BARI to release high-yielding sweet potato varieties across the locations.

Introduction

Sweet potato (*Ipomoea batatas*) is a very important tuber crop in terms of the nutritional value as it contains vitamin A and minerals. It is the fourth food crop in Bangladesh after rice, wheat, and potato (Delowar and Hakim, 2014). In Bangladesh, sweet potatoes are generally harvested during March-May when the supply of cereals like rice is low. During this lean period, the sweet potato could play a vital role to fulfill the demand for cereals from poor people of Bangladesh (Rafique *et. al.,* 2015). The average yield of sweet potatoes in the country is quite low compared to the world context. The farmers of the char areas grow a local variety of sweet potatoes which is low yielder. The Tuber Crop Research Centre of BARI already developed some improved sweet potato varieties that have significant yield and nutrient content advantages over the local cultivar. The introduction of BARI released sweet potato varieties in the Netrakona and Mymensingh area will bring improvement in the farmer's livelihood. Considering the above facts, the experiment was undertaken to the BARI released improved sweet potato varieties among the farmers by increasing their income as well as getting their opinion.

Materials and Methods

Trials were conducted at farmer's field of MLTs site of Kushtia, Tangail, Mymensingh and Bhola during the Rabi season of 2021-22. The tested varieties were BARI Misti Alu-4, 8, 10, 11, 12, 14, 15, 16 and 17. Sweet potato vines were sown from 06 November 2021 at 60 cm X 30 cm spacing. Manures and fertilizers were applied at the rate of 10 t ha^{-1}cowdung and 105-45-105-15-2-1Kg of N-P-K-S-Zn-B ha-1, respectively in the form of urea, TSP, MoP, gypsum, zinc sulfate, and boric acid. Fifty percent of N, K, and a full dose of other fertilizers were applied during final land preparation. The rest amount of the N and K fertilizers were applied at 35 DAPs. Intercultural operations and plant protection measures were made as and when necessary. Farmers harvested sweet potatoes from 24 March-20 May 2022. The details have been presented in Table 1.

Table 1. Crop management practices of adaptive trials on sweet potato at different locations during the Rabi season, 2021-22.

Location	Variety	Date of planting	Date of harvesting	Unit Plot size
Kushtia	BARI Mistialu-4, BARI Mistialu-12, BARI Mistialu-17, Local	25 November 2021	5-8 April 2022	6 m X 6 m
Tangail	BARI Mistialu-8, BARI Mistialu-15, BARI Mistialu-16, Local	6 November 2021	24 March 2022	8 m X 5 m
Mymensingh	BARI Mistialu-11, BARI Mistialu-12, BARI Mistialu-14, BARI Mistialu-16, BARI Mistialu-17, Local	17 November 2021	7-13 April 2022	6 m X 3 m
Bhola	BARI Mistialu-8, BARI Mistialu-10, BARI Mistialu-14, BARI Mistialu-16, Local	7-15 January 2022	15-20 May 2022	8 m X 5 m

Result and Discussion

In Kushtia, the highest tuber yield was obtained from BARI SP-4 (25.79 t ha^{-1}). The yield of BARI SP-12, BARI SP-17 and Local were 11.91, 6.26 and 17.01 t ha^{-1}, respectively (Table 2).

In Tangail, BARI Mistialu-15 produced the higher tuber yield (37.00 t ha^{-1}) due to its highest individual tuber weight and weight of tuber $plant^{-1}$. The lowest yield was recorded from BARI Mistialu-16 (24.00 t ha^{-1}) due to its lowest tuber weight $plant^{-1}$ and individual tuber weight (Table 2).

In Mymensingh, the root yield ranged from 25.6 to 33.7 t ha^{-1}. BARI Mistialu-17 produced the maximum root yield (33.7 t ha^{-1}) followed by BARI Mistialu-12 (31.3 t ha^{-1}) and BARI Mistialu-14 (30.5 t ha^{-1}). On the other hand, the minimum root yield was found from the local cultivar (25.6 t ha^{-1}) (Table 2).

In Bhola, among the tested sweet potato varieties, BARI Mishtialu-8 produced maximum root yield (32.34 t ha^{-1}) followed by BARI Mishtialu-10 (29.16 t ha^{-1}). On the other hand, the local variety gave the lowest root yield (22.67 t ha^{-1}) due to the lower number of roots $plant^{-1}$ and lowest root yield per unit area (Table 2).

Benefit-Cost analysis:

In Kushtia, the maximum gross return (Tk. 386850 ha^{-1}) and gross margin (Tk. 299300 ha^{-1}) were estimated from var. BARI Mistialu-4 and the lowest gross return (Tk. 93900 ha^{-1}) and gross margin (Tk. 6350 ha^{-1}) from BARI Mistialu-17 (Table 3).

In Tangail, cost and return analysis showed that the highest gross return (Tk. 600000 t ha^{-1}), and gross margin (Tk. 478820 t ha^{-1}) from local variety due to higher market prices compare to BARI high-yielding varieties (Table 3).

In Mymensingh, the highest gross return (Tk.417500.00 ha^{-1}) and gross margin (Tk.309300.00 ha^{-1}) was recorded from BARI Mistialu-17 might be due to its higher yield. BARI Mistialu-12 and BARI Mistialu-14 also gave gross return (Tk.381500.00 ha^{-1} and Tk. 369500.00 ha^{-1}, respectively) and gross margin (Tk. 273300.00 ha^{-1} and Tk. 261300.00 ha^{-1}, respectively). Local Check variety gave the lowest gross return (Tk.296000.00 ha^{-1}) and gross margin (Tk. 187800.00 ha^{-1}) (Table 3).

In Bhola, the highest gross return (Tk. 646800 ha^{-1}) and gross margin (Tk. 478600 ha^{-1}) were calculated from BARI Mishtialu-8 followed by BARI Mishtialu-10 (gross return Tk. 583200 ha^{-1} and gross margin Tk. 41500 ha^{-1}). On the contrary local variety gave the lowest (gross return Tk. 474300 ha^{-1} and gross margin Tk. 305200 ha^{-1}) economic return due to lower yield (Table 3).

Farmers' opinion

Farmers were pleased to see the performance regarding the higher yield of BARI Mistialu -4 in Kushtia; BARI Mistialu-8 and BARI Mistialu-15 in Tangail; BARI Mistialu-12, BARI Mistialu-14, and BARI Mistialu-17 in Mymensingh; and BARI Mishtialu-8 and BARI Mishtialu-10 in Bhola due to its higher root yield, market demand, attractive color, good market price.

Table 2. Root yield (t ha^{-1}) of sweet potato varieties in different locations during the Rabi season of 2021-22.

Variety	Root yield (t ha^{-1})				Mean root yield Average
	Kushtia	Tangail	Mymensingh	Bhola	
BARI Mistialu-4	25.79	-	-	-	25.79
BARI Mistialu-8	-	30.00	-	32.34	31.17
BARI Mistialu-10	-	-	-	29.16	29.16
BARI Mistialu-11	-	-	27.0	-	27.00
BARI Mistialu-12	11.91	-	31.3	-	21.61
BARI Mistialu-14	-	-	30.5	26.93	28.72
BARI Mistialu-15	-	37.00	-	-	37.00
BARI Mistialu-16	-	24.00	26.1	25.21	25.10
BARI Mistialu-17	6.26	-	33.7	-	19.98
Local	17.01	30.00	25.6	22.67	23.82
Average	**15.24**	**30.25**	**29.03**	**27.26**	
$LSD_{0.05}$		6.01	7.43	1.62	
CV(%)	7.61	10.00	14.15	2.88	

Table 3. Cost and return analysis of sweet potato varieties in different locations during the year 2021-22

Location	Variety	Price (Tk. kg^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Kushtia	BARI Mistialu-4	15.00	386850	87550	299300
	BARI Mistialu-12		178650	87550	91100
	BARI Mistialu-17		93900	87550	6350
	Local		255150	87550	167600
Mean			**228638**	**87550**	**141088**
Tangail	BARI Mistialu -8	BARI variety-Tk. 10.00 and Local variety-Tk. 20.00	300000	121180	178820
	BARI Mistialu-15		370000	121180	248820
	BARI Mistialu-16		240000	121180	118820
	Local		600000	121180	478820
Mean			**377500**	**121180**	**256320**
Mymensingh	BARI Mistialu-11	15.00	317000	108200	208800
	BARI Mistialu-12		381500	108200	273300
	BARI Mistialu-14		369500	108200	261300
	BARI Mistialu-16		303500	108200	195300
	BARI Mistialu-17		417500	108200	309300
	Local		296000	108200	187800
Mean			**347500**	**108200**	**239300**
Bhola	BARI Mistialu-8	20.00	646800	168200	478600
	BARI Mistialu-10		583200	168200	415000
	BARI Mistialu-14		538600	168200	388400
	BARI Mistialu-16		504200	168200	354000
	Local		474300	168200	305200
Mean			**549420**	**168200**	**388240**

Conclusion

Based on findings, it may be concluded that sweetpotato var. BARI Mistialu -4 is preferred by the farmers in Kushtia, BARI Mistialu-8 and BARI Mistialu-15 in Tangail; BARI Mistialu-12, BARI Mistialu-14 and BARI Mistialu-17 in Mymensingh and BARI Mishtialu-8 and BARI Mishtialu-10 in Bhola for its higher yield, attractive color, good market price as well as the demand and also delicious to eat.

Spices Crop

ON FARM TRIAL OF ONION VARIETIES

S. ALAM, M. HAWLADER, R.A. MOLLA, M.T. HASAN AND M.A. ISLAM

Abstract

A field trial was conducted at Bogura and Gopalganj during the *Rabi,* 2021-2022, to evaluate the performance of modern onion variety under farmers' field conditions. Onion var. BARI Piaz-6 gave the maximum bulb yield (**16.10** t ha^{-1}) followed by BARI Piaz-4 (14.67 t ha^{-1}) and BARI Piaz-1(13.96 t ha^{-1}) in Charland area of Sonatola, Bogura. Higher gross margin (Tk. 477250 ha^{-1}) was also obtained from BARI Piaz-6 followed by BARI Piaz-4 & BARI Piaz-1. But in Gopalganj the highest bulb yield (17.9 t ha^{-1}) was found from BARI Piaz-4 followed by from local variety Red-King (16.8 t ha^{-1}) whereas the lowest bulb yield (12.2 t ha^{-1}) by BARI Piaz-1. The highest gross return (Tk. 447500 ha^{-1}), gross margin (Tk. 2286210 ha^{-1}) was also found from BARI Piaz-4 in Gopalganj.

Introduction

Onion (*Allium cepa* L.) is one of Bangladesh's most important spice crops Onion has great economic importance due to its medicinal and dietetic values. It is widely used as a condiment, salad, and food dressing. The average onion consumption in Bangladesh is 30 g/head/day. It is grown in almost all the districts of Bangladesh; its commercial cultivation is concentrated in Faridpur, Dhaka, Rajshahi, Comilla, Mymensingh, Jessore, Rangpur, and Pabna. The national average yield of onion in Bangladesh is low. This low yield may be due to the cultivation of the low-yielding local varieties and lack of technical know-how etc. BARI has developed some high-yielding onion varieties with high-quality parameters. These varieties can help generate farmers' income in a very short period. The present study was undertaken to evaluate the performance of these varieties under farmer's field conditions and popularize them among the farmers to promote their adoption in the char land of Bogura.

Materials and Methods

The experiment was conducted at farmer’s field at Gopalganj and Bogura district during the winter season of 2021-22 to evaluate the comparative performance of different onion varieties (BARI Piaz-1, BARI Piaz-4 and local-Red king). The experiment was conducted with RCBD design with four dispersed replications. The unit plot size was 5m × 8m. The seedling was transplanted at different locations from 30 December 2021 with 15 cm x 10 cm spacing. The land was fertilized with 10-ton ha^{-1} cowdung and 110-44-75-S kg ha^{-1} of N-P-K-S, respectively. The half amount of urea and full dose of cowdung, MoP, TSP and Gypsum were applied as basal during final land preparation. The rest amounts of urea were top dressed in two equal installments at 25 and 50 days after planting. Irrigation and weeding were done as and when necessary. The harvesting date of crop was 30 March 2022 to 02 April 2022 at different locations. The collected data was statistically analyzed by using MSTAT-C software and the treatment means were evaluated by LSD test at 5% level of significance.

Results and Discussion

The bulb yield and yield contributing performance of onion are presented in Table 1. Significant variation was found among the treatments of all characters except the number of leaves plant^{-1}. The maximum plant height (57.27 cm) was obtained from BARI Piaz-4 followed by BARI Piaz-6 (55.23 cm) . The lowest plant height was 54.06 cm in BARI Piaz-1. The highest individual bulb weight (35.33 g) in BARI Piaz-6 and the lowest from BARI Piaz-1(24.70 g). The highest bulb yield was 16.10 tha^{-1} in BARI Piaz-6 while the lowest bulb yield (13.96 tha^{-1}) in BARI Piaz-1. The economic performance is presented in Table 2. The highest gross return (Tk. 563500 ha^{-1}) and gross margin (Tk. 477250 ha^{-1}) were calculated from BARI Piaz-6 and the lowest from BARI Piaz-1.

In Gopalganj, the maximum plant height (59.4 cm) at maturity stage was observed in BARI Piaz-4 followed by local variety (Red-King) (56.5 cm) and minimum plant height in BARI Piaz-1 (54.0 cm). In case of leaves plant^{-1} and plants m^{-2} there were no significant difference found among the varieties. The single bulb weight found maximum (34.5g) in BARI Piaz-4 which was statistically similar to local variety Red-King with value 32.6g and the lowest bulb wt. 25.2g from BARI Piaz-1. Finally, the highest bulb yield (17.9 t ha^{-1}) was found from BARI Piaz-4followed by local variety Red-King (16.8 t ha^{-1}) whereas the lowest bulb yield (12.2 t ha^{-1}) by BARI Piaz-1 (Table-1). The highest gross return (Tk. 447500 ha^{-1}), gross margin (Tk. 2286210 ha^{-1}) was found from BARI Piaz-4 and the lowest gross return (Tk. 305000 ha^{-1}), gross margin (Tk. 143710 ha^{-1}) in BARI Piaz-1. The local variety (red king) gave gross return, gross margin and BCR Tk.420000 ha^{-1}, Tk. 258710 ha^{-1} and 2.60, respectively (Table-2).

Farmers' opinion

Farmers are very happy to see the new variety and interested in growing VAR. BARI Piaz-1, BARI Piaz-4 and BARI Piaz-6 for higher yield and economic return.

Table 1. Crop management practices used in different location

Location	Sowing Time	Harvesting time	Fertilizer dose (kg ha^{-1})
Bogura	20-30 Dec 2021	22 March 2022 to 05 April 2022	110-44-75-S kg ha^{-1} of N-P-K-S
Gopalganj	25-30 Dec 2021	30 March 2022 to 02 April 2022	110-44-75-S kg ha^{-1} of N-P-K-S

Table 2. Yield and yield contributing characters of onion at different location during the *Rabi*, 2021-2022

Location	Variety	Plant height (cm)	No of leaves plant^{-1}	Individual bulb weight (g)	Bulb Yield (t ha^{-1})
Bogura	BARI Piaz-1	54.06	9.60	24.70	13.96
	BARI Piaz-4	57.27	8.46	31.43	14.67
	BARI Piaz-6	55.23	8.33	35.33	**16.10**
	CV (%)	4.24	NS	5.13	4.81
Gopalganj	BARI Piaz-1	54.0	12.0	25.2	12.2
	BARI Piaz-4	59.4	12.4	34.5	**17.9**
	Local (Red King)	56.5	12.2	32.6	16.8
	CV (%)	8.53	9.00	17.50	11.92
	Lsd (0.05)	5.12		7.04	3.40

Table 3. Cost and return analysis of onion during the *Rabi* season of 2021-2022

Location	Variety	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
Bogura	BARI Piaz-1	488600	86250	402350	5.66
	BARI Piaz-4	513450	86250	427200	5.95
	BARI Piaz-6	563500	86250	477250	6.53
Gopalganj	BARI Piaz-1	305000	161290	143710	1.89
	BARI Piaz-4	447500	161290	286210	2.77
	Local (Red King)	420000	161290	258710	2.60

The market price of onion @Tk.35 kg^{-1}

Conclusion

Onion var. BARI Piaz-1, BARI Piaz-4 and BARI Piaz-6 gave the reasonable bulb yield and economic return in the Char land of Khabolia, Sonatola, Bogura at as well as Gopalganj District.

ADAPTIVE TRIAL OF SUMMER CHILLI VARIETIES IN FARIDPUR

S. AHMED AND R. QUDDUS

Abstract

A trial was conducted at the farming System Research and Development (FSRD) site under On-Farm Research Division (OFRD), Faridpur under AEZ-12 during the kharif I season of 2020 and 2021 to find out the suitable chill i(*Capsicum annuum*.L) varieties and to increase the chilli production and productivity. It was laid out in RCB design in seven dispersed replications. BARI released chilli vari. BARI Morich-2 was evaluated in the trial with two local cv. Sholakundu and khalkhula. The average maximum green fruit yield was calculated from BARI Morich-2 (6.94 t ha^{-1}) followed by local Khalkhula variety (6.42 t ha^{-1}) and the lowest from local Sholakundu (6.35 t ha^{-1}). The yield of BARI Morich-2 was 8% higher than Khalkhula. The highest gross margin ((Tk. 443743 ha^{-1})) and BCR (3.16) was also obtained from BARI Morich-2 due to the highest yield.

Introduction

Chilli(*Capsicum annuum*.L) is one of the major spices crop grown in Bangladesh. Chilli is cultivated in 1.5 lac ha land (both winter and summer) and produced 176000 ton annually. Farmers of Faridpur usually grow local chilli variety which has no uniformity of fruit shape and yield. Yield potentiality of local/traditional variety is also poor and it's susceptible to different diseases and pests. Spices Research Centre of BARI has developed some improved summer variety of chilli, which are supposed to be higher yielder and less susceptible to pest and diseases. With this point of view, the study was undertaken to evaluate the performances of' chilli varieties at farmers field for higher yield and economic return.

Materials and Methods

The trial was conducted at farming System Research and Development (FSRD) site under On-Farm Research Division (OFRD), Faridpur under AEZ-12 during the kharif I season of 2020 and 2021 to find out the suitable chilli varieties and to increase the chilli production and productivity. It was laid out in randomized completed block design (RCBD) in seven dispersed replications. BARI released summer chilli var. BARI Morich-2 was evaluated against local cv. Sholakundu and khalkhula.Unit plot size was 4 m × 3 m. Thirty-five days old seedlings were transplantedin a spacing of 50 cm × 50 cm. Date of transplanting was 17-25 April, 2020 and 10 April,2021. Both the year, crop was fertilized with 130-50-50-15-1.5-1.5 kg ha^{-1} N-P-K-S-Zn-B in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. Additional 3 t ha^{-1} organic fertilizer was used in the first year only. All of organic fertilizer, P, K, S, Zn and B and half of N was applied as basal during final land preparation. Remaining N was applied as top dress at 25,52 and 72 DAT under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Weeding was done two times at 12 and 25 days after transplanting. Two irrigation was applied one at 6 DAT and last one was 29 DAT and earthing up was done immediately after *zoe*condition. Fungicide named Amister top was sprayed three times at 13-17, 55-65 and 85-89 DAT. Two times miticide named vertimek was sprayed at 75-80 & 90-95 DAT and two times insecticide named Carbofuran (45-50 DAT) and Pegasas (85-90 DAT). Chilli was harvested 8 times from 25 June to 28 September 2020 (70-164 DAT) in the first year but in second year only 5 times, it was during 20 June to 26 August, 2021 (71 to 138 DAT). The weather data was showed in appendix. Data on all operations and agronomic parameters were recorded properly and was analyzed statistically with open

Results and Discussion

All the yield and yield contributing characters except final plant population m^{-2}, fruit length and fruit breadth showed significant difference among the tested varieties (Table 1 and 2). The average two years result was shown in Table 3. Average number of final plant population m^{-2} ranged in between 3.60 to 3.62. The maximum plant height was calculated from BARI Morich-2

(88.17 cm) which was statistically similar with local Sholakundu (84.31 cm). The lowest plant height was observed from local Khalkhula (80.83 cm). The average maximum number of fresh fruits per plant was found from local Sholakundu (118.42) followed by BARI Morich-2 (113.12). The lowest number of fresh fruits per plant was found from local Khalkhulah-2 (112.8). The average highest (1.58 g) and lowest (1.42 g) single fruit weight was calculated from local Khalkhula and local Sholakundu, respectively.

The average fruit length and fruit breadth ranged between 5.38 cm to 5.71 cm and 0.82 cm to 0.84 cm, respectively. The average highest number of seeds fruit^{-1} was found from local Sholakundu (44.54) and lowest from BARI Morich-2 (38.79). The average green fruit yield per plant was recorded from 169 - 198 kg (Table 3). The average maximum green fruit yield was calculated from BARI Morich-2 (6.94 t ha^{-1}) followed by local Sholakundu (6.35 t ha^{-1}) and lowest fruit yield from local Khalkhula (6.42 t ha^{-1}). The average yield was low due to prevail unfavorable weather during the harvesting period. From July to August (Appendix 2) maximum temperature (33^{o}C) and total rainfall (358mm-463 mm) was higher that effected fruit setting and plant became died. As a result, harvesting period was less two times than first year (7 times). Chili peppers grow best and are likely to reach the maximum yield at temperature ranging from 21 °C to 33 °C.The fruit set and fruit growth of chilli are correlative with the high temperature condition (Tran LocThuy and Murakami Kenji,2015).The average highest gross return was obtained from BARI Morich-2 (Tk. 639510 ha^{-1}) due to the highest yield. The lowest gross margin (Tk. 408970 ha^{-1}) was calculated from local khalkhula due to the lowest yield (Table 6). The highest BCR was also calculated from BARI Morich-2 (3.16). Picking cost of green chilli (Tk 9.5 kg^{-1}) influenced on the cost of production.

Pest and disease incidence

Few cut worm infestations were observed in the seedling stage, and it was controlled by hand picking. Mite and thrips complex was observed at some plants. Insecticides (Vertimek and pegasas) were sprayed. No other disease or pest infestation was observed during the cropping period.

Farmers' opinion

Farmers were very happy to cultivate chilli var. BARI Morich-2 for its higher yield. Fruit shape of BARI variety were also uniform . They demanded BARI developed chilli variety

seeds available in the local markets.

Conclusion

Chilli var. BARI Morich-2 was the best in terms of yield and gross margin. Seeds of BARI developed chili variety should be available in the local markets.

Table 1. Yield (green fruit)) and yield attributes of chilli varieties in Faridpur, kharif I, 2020.

Variety	Final plants m^{-2} (No.)	Plant height (cm)	Fresh fruits plant^{-1} (nos.)	Single fruit wt. (g)	Fruit length (cm)	Fruit breadth (cm)	Seed fruit^{-1} (nos.)	Fruit yield plant^{-1} (g)	Green fruit yield (t ha^{-1})
BARI Morich-2	3.46	86.63 a	113.43	1.56	5.43	0.83	37.03	215.00	7.36
Local (Sholakundu)	3.51	83.11	133.43	1.48	5.25	0.83	45.63	209.71	7.29
Local (Khalkhula)	3.47	78.66 b	121.00	1.72 a	5.42	0.82	40.97	184.00	7.05
CV (%)	4.75	4.87	8.749	6.51	8.83	4.07	10.50	13.31	7.92

Table 2. Yield (green fruit) and yield attributes of chilli varieties at Faridpur, kharifI, 2021.

Variety	Plants m^{-2} (nos.)	Plant height (cm)	Fresh fruits $plant^{-1}$ (nos.)	Single fruit wt. (g)	Fruit length (cm)	Fruit breadth (cm)	Seed $fruit^{-1}$ (nos.)	Fruit yield $plant^{-1}$ (g)	Green fruit yield (t ha^{-1})
BARI Morich-2	3.75	89.7	112.8	1.58	5.98	0.85	40.54	180.4	6.52
Local (Sholakundu)	3.72	85.5	103.4	1.35	5.50	0.81	43.44	140.4	5.41
Local (Khalkhula)	3.75	83.0	104.6	1.44	5.7	0.84	41.96	154.4	5.78
CV (%)	1.66	2.47	7.54	6.62	4.27	4.59	5.97	8.20	10.36

Table 3. Yield and yield attributes of chilli varieties in Faridpur (av. of 2 yrs.)

Variety	Plantsn m^{-2} (nos.)	Plant height (cm)	Fresh fruits $plant^{-1}$ (nos.)	Single fruit wt. (g)	Fruit length (cm)	Fruit breadth (cm)	Seed $fruit^{-1}$ (No.)	Fruit yield $plant^{-1}$ (g)	Green fruit yield (t ha^{-1})
BARI Morich-2	3.60	88.17	113.12	1.57	5.71	0.84	38.79	197.70	6.94
Local (Sholakundu)	3.62	84.31	118.42	1.42	5.38	0.82	44.54	175.06	6.35
Local (Khalkhula)	3.61	80.83	112.8	1.58	5.56	0.83	41.47	169.20	6.42

Table 4. Cost and return of chilli varieties in Faridpur (av. of 2 yrs.).

Variety	Green Chilli yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
BARI Morich-2	6.94	639510	192767	443743	3.16
Local (Sholakundu)	6.35	605043	189659	415383	3.02
Local (Khalkhula)	6.42	598415	189445	408970	3.00

ON-FARM TRIAL OF BARI DEVELOPED GARLIC VARIETY

M.R. AMIN, M. HAWLADER, S. AHMED AND AFM RUHUL QUDDUS

Abstract

The experiment was conducted at Jashore, Manikganj, Gopalganj and Madaripur during the *Rabi* season of 2021-2022 to evaluate the performance of garlic var. BARI Rosun-1, BARI Rosun-2, BARI Rosun-3 and BARI Rosun-4 in the farmers' field. The maximum clover yield was observed in BARI Rosun-2 followed by BARI Rosun-1, BARI Rosun-3 and BARI Rosun-4 in Jashore. Although BARI Rashun-3 gave the maximum clove yield (7.89 t ha^{-1}), but it was statistically similar with BARI Rashun-4 (7.07 t ha^{-1}) and Local variety (6.80 t ha^{-1}) in Manikganj. In Gopalganj, BARI Rashun-3 also give the highest yield (9.25 t ha^{-1}) might be due to its highest number of cloves and maximum wt. of single bulb than others. At the same time lowest bulb yield (7.10 t ha^{-1}) was found in BARI Rashun-1. The maximum bulb yield (14.46 t ha^{-1}) was recorded from local followed by BARI Rashun-5 (11.50 t ha^{-1}) while the lowest yield (8.52 t ha^{-1}) from BARI Rashun-1 in Madaripur.

Introduction

Garlic is one of the most important spices crop. It is used in each household almost every day for preparing a wide variety of dishes. Normally, the farmers of Jashore cultivate local garlic variety. BARI has developed some garlic varieties, but the farmers of this region do not know how to cultivate these varieties. Therefore, the experiment was undertaken to find out the performance of BARI garlic varieties in the farmer's field.

Materials and Methods

The trial was conducted at Jashore Manikganj, Gopalganj and Madaripur during the *Rabi* season of 2021-2022 to evaluate the performance of BARI Rosun-1, BARI Rosun-2, BARI Rosun-3, BARI

Rosun-4 with local ones in farmers' field to popularize among the farmers. The trial was laid out in a RCB design with three replications. The unit plot size was 4m × 2.0 m with 20cm × 10cm plant spacing. Cloves of garlic were sown on 12 to 20 December, 2021. Fertilizers were applied at the rate of 120-120-100-20-2.5 kg ha^{-1} N-P-K in the form of urea, TSP and MoP, Gypsum, Zinc, respectively and CD 2 tha^{-1} were used. The full amount of cow dung, TSP, gypsum, $ZnSO_4$ and one third of MoP and urea was applied as basal at final land preparation. The rest amount of MoP and urea was applied in three equal splits at 15, 40 and 65 days after emergence (DAE).The field was irrigated three times at the same day of top dressing. Two weeding was done at 40 and 56 DAE. The crops were harvested on 31 March 2022 at to 28 March 2022. Data on yield and yield contributing character were recorded and analyzed statistically.

Results and Discussion

Jhikargacha, Jashore: Individual bulb weight (18.7g) of BARI Rosun-2 was the maximum followed by BARI Rosun-1, local, BARI Rosun-4 while the lowest in BARI Rosun-3 (10.4g). The maximum clove yield was observed in BARI Rosun-2 (5.0 t ha^{-1}) followed by BARI Rosun-1 (4.6 t ha^{-1}), BARI Rosun-4 (4.6 tha^{-1}) while the lowest (3.4 t ha^{-1}) from BARI Rosun-3 (Table 1).

Kaligonj: Individual bulb weight (28.7g) of BARI Rosun-2 was the maximum followed by BARI Rosun-1while the lowest in local (16.3g). The maximum yield was observed in BARI Rosun-2 (6.2 t ha^{-1}) followed by BARI Rosun-1 (5.8 t ha^{-1}) while the lowest (3.9 t ha^{-1}) from BARI Rosun-3 (Table 2).

Ghior, Manikganj: Plants m^{-2} ranged from 85 to 93 but did not differ statistically. Plant height of local variety (65.28 cm) was at par with BARI Rashun-4 (58.84cm) but lowest in BARI Rashun-3 (53.89 cm). The number of leaves $plant^{-1}$ from did not vary statistically among the varieties. The weight of single bulb was maximum (10.09 g) in BARI Rashun-3 but identical with BARI Rashun-4 (8.57g) and local variety (8.52g). Although BARI Rashun-3 gave the maximum clove yield (7.89 t ha^{-1}), but it was statistically similar with BARI Rashun-4 (7.07 t ha^{-1}) and Local variety (6.80 t ha^{-1}). The yield of garlic was low compared to traditional one due to ploughing system which might be due to rapid drying of clay type soil which became very hard for the normal growth of garlic producing smaller bulb size (Table 3).

Gopalganj: The highest plant height (69.12 cm) was found in BARI Rashun-3 and lowest (58.78cm) was found from BARI Rashun-2. In respect of no. of cloves $bulb^{-1}$, the maximum number of cloves $bulb^{-1}$ (20.0) was recorded from BARI Rashun-3 and lowest number (17.8) from BARI Rashun-4 which was statistically similar to BARI Rashun-2 (18.3). The maximum wt. of single bulb (20.01g) was found in BARI Rashun-3 and minimum wt. (16.00g) was recorded by BARI Rashun-1. Finally, BARI Rashun-3 gave the highest yield (9.25 t ha^{-1}) might be due to its highest number of cloves and maximum wt. of single bulb than others. At the same time lowest bulb yield (7.10 t ha^{-1}) was found in BARI Rashun-1 (Table 4).

Madaripur: The plants m^{-2} was ranged between 47.50 to 48.00. Plant height was maximum in local (83.35 cm) followed by BARI Rashun-5 (73.45 cm). The lowest plant height was obtained from BARI Rashun-1 (70.50 cm). The number of leaves $plant^{-1}$ ranged from11.80 (local) to 7.60 (BARI Rashun-1). In case of bulb length, it was observed that, maximum (3.11 cm) and minimum (2.42 cm) value was observed from local and BARI Rashun-1, respectively. Bulb diameter was found the maximum from local (4.49 cm) followed by BARI Rashun-5 (3.76 cm) and the lowest from BARI Rashun-1(3.35 cm). The highest number of cloves $plant^{-1}$ was found from local (30.3) and lowest from BARI Rashun-1 (22.0). The highest individual bulb weight (37.80 g) was obtained from local and the lowest individual bulb weight (22.20 g) from BARI Rashun-1. The maximum bulb yield (14.46t ha^{-1}) was recorded from local followed by BARI Rashun-5 (11.50 t ha^{-1}) while the lowest yield (8.52t ha^{-1}) from BARI Rashun-1 (Table 5). The highest gross return (Tk. 723000 ha^{-1}) and gross margin (Tk. 482350 ha^{-1}) was found in local cultivar due to the highest bulb yield. The lowest bulb yield was in BARI Rashun-1 variety (Tk. 207393 ha^{-1}).

Cost-return analysis:

Jashore: The highest gross return (149400 Tk. ha^{-1}), gross margin (74400 Tk.ha^{-1}) and MBCR (4.5) was obtained from BARI Rashun-2 variety while lowest from BARI Rosun-3 compared to local one (Table 6).

Manikganj: Cost and return of BARI garlic varieties is shown in Table 6. The maximum gross return (Tk. 197250 ha^{-1}) was found in BARI Rashun-3 followed BARI Rashun-4 (Tk. 176750 ha^{-1}) and the lowest in local variety (Tk. 170000 ha^{-1}). The variable cost was minimum in local variety (Tk. 128935 ha^{-1}) because of lower cost of seed/clove (Tk. 60 kg^{-1}) compared to BARI Rashun-3 and Rashun-4 (Tk. 70 kg^{-1}). The gross margin was maximum (Tk. 53315 ha^{-1}) in BARI Rashun-3 with higher BCR (1.37) followed by local variety with gross margin (Tk. 41065 ha^{-1}) and BCR (1.31). The minimum gross margin (Tk. 32815 ha^{-1}) was obtained from BARI Rashun-4.

Gopalganj: The highest gross return (Tk. 370000 ha^{-1}), gross margin (Tk. 235150 ha^{-1}) and BCR 2.74 were found in BARI Rashun-3 and the lowest gross return (Tk. 284000 ha^{-1}), gross margin (Tk. 149150 ha^{-1}) and BCR (2.10) were recorded from BARI Rashun-1. At the same time BARI Rashun-2 gave gross return, gross margin and BCR of Tk. 352000 ha^{-1}, Tk. 217150 ha^{-1} and 2.61, respectively (Table 6).

Madaripur: The highest gross return per hectare (Tk. 575000) and gross margin (Tk. 344300) were found in BARI Rashun-5. The lowest gross return per hectare (Tk. 426000), gross margin (Tk. 207393) was recorded from BARI Rashun-1 (Table 6).

Farmers' reaction

Farmers expressed their satisfaction with the higher yield of BARI Rashsun-2,BARI Rashsun-3, and BARI Rashun-5 and they are interested to grow this variety in future.

Table 1. Bulb yield and yield contributing characters of garlic at MLT site, Jhikorgacha during 2021-2022

Treatment	Plant height (cm)	Plants/m^2	Bulb diameter (cm)	Individual bulb weight (g)	Bulb Yield (tha^{-1})
BARI Roshun-1	70.2	29.3	3.1	18.5	4.6
BARI Roshun-2	63.0	29.7	3.2	18.7	5.0
BARI Roshun-3	41.1	31.3	2.9	10.4	3.4
BARI Roshun-4	52.9	30.3	3.3	14.8	4.6
Local	59.4	31.0	3.1	16.3	4.2
CV (%)	5.55	4.17	5.87	13.58	4.38
LSD ($_{0.05}$)	5.99		0.35	4.03	0.36

Table 2. Bulb yield and yield contributing characters of garlic at MLT site, Kaligonj during 2021-2022.

Treatment	Plant height (cm)	Plant population/m^2	Bulb diameter (cm)	Individual bulb weight (g)	Bulb yield (tha^{-1})
BARI Roshun-1	68.8	31.3	3.6	24.3	5.8
BARI Roshun-2	63.5	29.7	3.6	28.7	6.2
BARI Roshun-3	41.7	34.4	3.1	17.6	4.2
BARI Roshun-4	52.2	31.1	3.1	19.4	3.9
Local	59.4	31.0	3.1	16.3	4.2
CV (%)	4.76	2.0	4.94	9.95	3.99
LSD ($_{0.05}$)	5.37	1.26	0.33	4.47	0.39

Table 3. **Bulb** yield and yield characters of BARI garlic varieties grown under zero tillage condition at Ghior, Manikganj during Rabi season of 2021-22.

Variety	Plants (m^{-2})	Plant height (cm)	No. of leaf plant^{-1}	Single bulb wt. (gm)	Bulb yield (t ha^{-1})
BARI Rashun-3	93	53.89	6.50	10.09	7.89
BARI Rashun-4	85	58.84	6.32	8.57	7.07
Local variety	90	65.28	6.83	8.52	6.80
$LSD_{0.05}$	8.60	9.89	1.96	3.21	3.12
CV (%)	8.24	7.35	13.25	10.62	8.99

Table 4. Bulb yield and yield attributes of different garlic varieties at Gopalganj district during 2021-`22

Treatments (Varieties)	Plant height (cm)	Plant m^{-2} (no.)	No. of leaves plant^{-1}	No. of cloves bulb^{-1}	Wt. of single bulb (g)	Bulb yield (t ha^{-1})
BARI Rashun-1	61.79	51.48	8.3	19.4	16.00	7.10
BARI Rashun-2	58.78	54.08	9.0	18.3	17.81	8.80
BARI Rashun-3	69.12	53.68	9.5	20.0	20.01	9.25
BARI Rashun-4	60.88	52.08	8.5	17.8	17.71	7.64
CV (%)	10.50	5.6	7.80	8.00	10.65	11.03
Lsd (0.05)	6.95	-	-	1.59	1.70	1.13

Table 5. Agronomic and yield contributing parameters of garlic varieties at Shibchar, Madaripur during 2021-22

Variety	Plant population (m-2)	Plant height (cm)	Leaves plant^{-1} (nos.)	Bulb length (cm)	Bulb diameter (cm)	Cloves plant^{-1} (no.)	Single bulb wt. (g)	Bulb yield (t ha^{-1})
BARI Rashun-1	48.00	70.50	7.60	2.42	3.35	22.0	22.20	8.52
BARI Rashun-3	47.50	71.25	8.90	2.49	3.61	24.1	26.20	9.97
BARI Rashun-5	47.50	73.45	9.55	2.86	3.76	24.3	30.25	11.50
Local (Paraga Ufshi)	47.75	83.35	11.80	3.11	4.49	30.3	37.80	14.46
CV (%)	2.27	2.50	2.45	4.43	7.13	2.64	5.30	6.87

Table 6: Cost and return analysis of garlic variety during the year of 2021-2022

Location	Treatment	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Jashore	BARI Roshun-1	5.20	155600	75000	80600
	BARI Roshun-2	5.60	167700	75000	92700
	BARI Roshun-3	3.80	113800	75000	38800
	BARI Roshun-4	4.20	126850	75000	51850
	Local	5.20	155600	75000	80600
Manikganj	BARI Rashun-3	7.89	197250	143935	53315
	BARI Rashun-4	7.07	176750	143935	32815
	Local variety	6.80	170000	128935	41065
Gopalganj	BARI Rashun-1	7.10	284000	134850	149150
	BARI Rashun-2	8.80	352000	134850	217150
	BARI Rashun-3	9.25	370000	134850	235150
	BARI Rashun-4	7.64	305600	134850	170750
Madaripur	BARI Rashun-1	8.52	426000	218607	207393
	BARI Rashun-3	9.97	498500	225450	273050
	BARI Rashun-5	11.50	575000	230700	344300

Price (Tk./kg): Garlic =30, Urea=16, TSP=22, MoP=15, Gypsum=25 and $ZnSO_4$=240, and at Manikganj Market price of BARI Rashun-3, 4 and local variety @Tk. 25.00 kg^{-1}. Price of bulb as seed: BARI Rashun-3 and 4: Tk. 70.00 kg^{-1} Local variety: Tk. 60.00 kg^{-1}

ON-FARM TRIAL OF BARI TURMERIC VARIETIES IN NARSINGDI

M. ASADUZZAMAN AND Q. NAHER

Abstract

On farm trial of turmeric varieties were conducted at the farmers' field of Shibpur, Narsingdi district during the *Rabi* season 2021 to examine a suitable turmeric variety for this area. Two BARI developed varieties such as BARI Halud-4, BARI Halud-5 and local variety were tested. The highest finger yield was found from BARI Halud-4 (28.7 t ha^{-1}) and the lowest from localone (Rangila) (14.5 t ha^{-1}). From financial analysis, BARI Halud-4 gave the highest gross return (Tk. 430500 ha^{-1}) and gross margin (Tk. 296750 ha^{-1}).

Introduction

In Bangladesh total spices production is about 4.5 lakh tons and 11.5 lakh tons are imported to fulfill the national demand. Turmeric (*Curcuma longa*) is one of the most important spice crops in Bangladesh as well as in south Asia. Local variety covers the greater portion of turmeric growing areas in Narsingdi. Farmers traditionally practice this low yielding local variety for its production and thus get poor yield. If farmers practice and cultivate the BARI developed high yielding turmeric variety, they have the possibility to obtain good yield. Therefore, the study was undertaken to find out the appropriate variety for turmeric in Narsingdi.

Material and Methods

The experiment was conducted at Shibpur, Narsingdi district during 2021 to examine the suitable variety of turmeric for that area. The experiment was laid out in a randomized complete block design with three dispersed replications. Turmeric varieties viz. BARI Halud-4; BARI Halud-5 and local (Rangila) variety. The unit plot sizes were 10 m x 6 m. The mother rhizomes were planted on 20-25 April, 2021 followed by 60 cm x 25 cm spacing. The recommended fertilize doses were applied 105-30-120-15-3-1.4 (N-P-K-S-Zn-B) respectively. Half of urea and MoP and all other fertilizers were used at final land preparation. The remaining part of urea and MoP fertilizer was applied in two equal splits at 80-90 DAS and 110-120 DAS respectively. Two weeding and earthing-up was done after 80-90 DAS & 110-120 DAS respectively. This year did not appear any major disease of turmeric. Nevertheless, mancozeb and otostine were applied to control leaf blotch and rhizome rot of turmeric. BARI Halud-4 and BARI Halud-5 were harvested at 1-10 March 2022. Data on yield and yield contributing characters were recorded and analyzed statistically.

Results and Discussion

Yield and yield contributing characters have shown table 1. The highest plant height was found BARI Halud-5 (123.33 cm) and the lowest from local (Rangila) variety (80.67 cm). The highest number of fingers $plants^{-1}$ was shown by BARI Halud-5 (18.66) and the lowest in local (Rangila) variety (5.33). The highest weight of fingers/ plant was found from BARI Halud-4 (147.66 g) and the lowest weight of fingers $plant^{-1}$ from local (Rangila) variety (98.33 g). The highest weight of rhizome $plant^{-1}$ was found from BARI Halud-4 (482.67 g) and the lowest weight of rhizomes/plant from local (Rangila) variety (180.00 gm). Finally, the highest rhizome yield was found from BARI Halud-4 (28.33 t ha^{-1}) and the lowest from local (Rangila) variety (11.34 t ha^{-1}). The highest gross return BARI Halud-4 (Tk. 424950 ha^{-1}) and Gross margin (Tk. 289670 ha^{-1}) and the lowest gross return (Tk. 204120 ha^{-1}) and gross margin (Tk. 68840 ha^{-1}).

Farmer's opinion

Among three varieties, farmers have chosen the BARI Halud-4 for its high yielding potentiality and excellent colour.

Table 1. Rhizome yield and yield contributing characters of turmeric at Shibpur in Narsingdi during the year 2021

Treatments	Plant height (cm)	No.of fingers/plant	Weight of fingers/plant (g)	Weight of rhizome/plant (g)	Rhizome Yield (t ha^{-1})
BARI Halud-4	112.67	18.66	147.66	482.67	28.33
BARI Halud-5	123.33	15.33	110.00	280.33	17.33
Local (Rangila)	80.67	5.33	98.33	189.00	11.34
LSD (0.05)	5.12	8.82	55.52	3.01	3.01
CV (%)	17.24	3.28	7.71	6.99	6.99

Table 2. Economic performance of turmeric during the year 2019-2020

Treatments	Gross return (Tk. ha^{-1})	TVC (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
BARI Halud-4	424950	135280	289670
BARI Halud-5	259950	135280	124670
Local (Rangila)	204120	135280	68840

Price: BARI Halud-4 and BARI Halud- 5Tk. 15 /kg and local variety Tk.18/kg.

Conclusion

The result showed that turmeric var BARIHalud-4 gave higher yield and profit but for concrete decision trial may be repeated in the next year.

Minor Cereal Crops

ADAPTIVE TRIAL OF BARI BARLEY VARIETIES

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Abstract

The trial was conducted at Tangail, Kurigram, Rangpur, Bogura, Chandpur, Cumilla, Manikganj and Faridpur districts during Rabi 2021-22 to find out the performance and popularize BARI barley varieties among the farmers. Two varieties of barley viz., BARI Barley-7 and BARI Barley-9 in the Char areas of Tangail, Kurigram, Rangpur and Bogura where Four varieties viz. BARI Barley-6, BARI Barley-7, BARI Barley-8 and BARI Barley-9 were evaluated in the farmer's field of Cumilla and Manikganj. In Faridpur, the trial consists of three barley varieties viz., BARI Barley-7, BARI Barley-9 and local. Among the tested varieties, the highest mean grain yield of 1.86 and 1.90 t ha^{-1} was observed in BARI Barley-7 in Bhuapur and Atia, respectively in Tangail with gross return (Tk. 31530 and 27815 ha^{-1}) and gross margin (Tk. 83700 and 76000 ha^{-1}). In Rangpur, the highest grain yield 4940 Kg ha^{-1} from BARI barley-9 and lowest grain yield was recorded from BARI barley-7 (4135kg ha^{-1}). In Bagura, BARI barley-9 gave a satisfactory yield (2.45 tha^{-1}) over BARI barley-7 (2.32 tha^{-1}) with gross margin (Tk. 79720 ha^{-1}) from BARI barley-9. In Cumilla, the maximum grain yield (3.3 t ha^{-1}) was observed in BARI Barley-8 followed by BARI Barley-9 (3.2 t ha^{-1}). In Manikganj, the highest grain yield (2.60 t ha^{-1}) was obtained from of BARI Barley-6 with higher gross margin (Tk. 85170. ha^{-1}) than in BARI Barley-9 (1.99 t ha^{-1}) with gross margin (Tk. 61220. ha^{-1}). In Faridpur, the highest grain yield (2.66 tha^{-1}) was obtained from BARI Barley-9 and lowest from the local variety (1.90 tha^{-1}).

Introduction

Barley (*Hordeum vulgare*) is the most adaptive cereal crop in a different environment which is recognized as Char land than other cereals. It belongs to the family grasses and is used in various forms such as grain for human consumption and fodder for cattle, green manure, cover crop and short-lived forage. Barley is a fast-growing, short-season, drought tolerant, low input crop. It can be grown in less fertile soil with minimum inputs whereas it is a minor crop in Bangladesh. The vast char area of Bangladesh remains fallow where crop intensification is the major challenge. Cultivation of heat-tolerant crop cultivars of wheat, barley, and pulses with careful management practices can bring substantial change in the agricultural practice towards increased cropping intensity in the coastal area . In Bangladesh, the total area under barley cultivation is about 300 hectare of land and the production is about 800 metric tons (BBS, 2018). It has potentiality to grow under water stress condition. BARI has released some high yielding varieties of barley which could be fitted in drought prone areas in their cropping pattern. Therefore, the trial was undertaken to evaluate the performances of these varieties in char areas of Tangail, Kurigram, Rangpur Bogura, Chandpur, Cumilla, Manikganj and Faridpur for dissemination and popularizing among the farmers.

Materials and Method

The trial was conducted at Bhuapur and Atia at Delduar of Tangail under AEZ-8, Chilmari of Kurigram under OFRD Rangpur, Burichang and Titas of Cumilla and Hajigonj of Chandpur, Ramnagar village under Shibaloya upazila of Manikganj and FSRD site of Faridpur during Rabi season 2021-22 to observe the performance of BARI barley varieties in dry and char areas and to popularize and disseminate among the farmers. The experiment was laid out in randomized complete block design with two/three/five dispersed replications. Two varieties of barley viz., BARI Barley-7, and BARI Barley-9 were tested in the Char areas of Tangail, Kurigram, Rangpur and BoguraCrop variety, plot size and management practicesin different locations are presented in table 1. The seed rate was 120 kg ha^{-1}. All fertilizers were incorporated with soil during final land preparation. Plant protection measures were taken as required. All the fertilizers were incorporated with soil during final land preparation. Intercultural operations viz., weeding, irrigation, thinning and spraying were done when necessary. The data on different yield and yield components were recorded and analyzed statistically.

Table 1. Crop variety, plot size and management practices used in different locations

Location	Variety	Plot size	Sowing date	Harvesting date	Fertilizer dose (NPK kg ha^{-1})
Tangail	BARI Barley-7, BARI Barley-9	4 m x 5m	8 to 18 December, 2021	30 March to 3 April, 2022	100-60-40
Rangpur	BARI Barley-7, BARI Barley-9	200 m^2	7-10 December, 2021	24-28 March, 2022.	100-60-40
Bogura	BARI Barley-7, BARI Barley-9	1320 m^2	10 December 2021	28 March 2022	78-25-37.5
Cumilla	BARI Barley-6, BARI Barley-7, BARI Barley-8, BARI Barley-9	-	29 November to 23 December, 2021	11-30 March 2022	100-60-40
Manikgonj	*BARI Barley-6, BARI Barley-7, BARI Barley-8, BARI Barley-9*	20m x 20m	25 December, 2021	25-28 March 2022	100-32-55-22-5.5-1.5-5000 kg ha^{-1} of N-P-K-S-Zn-B and cowdung
Faridpur	BARI Barley-7, BARI Barley-9, local.	5 m x 3 m	20 December, 2021	29 March 2022	80-30-50-10-3-1 kg N-P-K-S-Zn-B kg ha^{-1}

Results and Discussion

Tangail

Bhuapur: Yield and yield attributes of barley varieties are presented in Table 2. The shorter days to maturity were observed in BARI Barley-9 (102 days) compared to BARI Barley-7 (107 days).

The tallest plant was found in the BARI Barley-9 (99.40 cm) whereas the shortest plant in BARI Barley-7 (92.63 cm). The maximum grains per spike (49.20) was recorded from the var. BARI Barely-7 which was statistically identical to BARI Barley-9. The maximum 1000- grain weight (33.50 g) was recorded from the var. BARI Barley-7 which was identical to BARI Barley-9 (32.10 g). The maximum grain yield was observed in BARI Barley-7 (1.86 t ha^{-1}) which was at par with BARI Barley-9 (1.74 t ha^{-1}). The cost and return analysis were observed that the highest gross margin (Tk. 31530 ha^{-1}) was calculated from BARI Barely-7 (Table 2) and the lowest gross margin (Tk. 26130 t ha^{-1}) from BARI Barely-9 (Table 3).

Atia, Delduar: Yield and yield attributes of barley varieties are presented in Table 4. The shorter days to maturity were observed in BARI Barley-9 (103 days) compared to BARI Barley-7 (109 days). The tallest plant was found in the BARI Barley-9 (72.27 cm) whereas the shortest plant in BARI Barley-7 (66.47 cm). The maximum number of grains per spike (44.33) was recorded from the var. BARI Barely-7 which was statistically identical to BARI Barley-9. The highest 1000-grain weight (31.80 g) was recorded from the var. BARI Barley-7 which was statistically identical to BARI Barley-9 (31.73 g). The maximum grain yield was observed in BARI Barley-7 (1.90 t ha^{-1}) which was at par with BARI Barley-9 (1.81 t ha^{-1}). The cost and return analysis were observed that the highest gross margin (Tk. 27815 ha^{-1}) was calculated from BARI Barely-7 and the lowest gross margin (Tk. 24215 ha^{-1}) from BARI Barely-9 (Table 5).

Rangpur

The results have been presented on table 6. The highest grain yield was 4940 Kg ha^{-1} from BARI Barley-9 and lowest from BARI Barley-7 (4135 kg ha^{-1}). Days to 50% flowering was 73-76 days and maturity 114-118 days. Plant height (88 cm), effectives tillers /plant (10.5), 1000- grains wt. (44g.), plant population (88 no./m^2) of BARI barley-9 were given highest than BARI barley-7. Gross margin (62225 Tk. ha^{-1}) and BCR (2.70) of BARI barley-9 was recorded highest where BARI barley-7 was lowest (Table 6).

Bogura

The yield and yield contributing performance of barley are presented in Table 7. The highest plant height (90.41 cm) was obtained from BARI barley-9 whereas BARI barley (781.30 cm) . The highest panicle length was 11.14 cm in BARI barley-9 and the lowest (9.72 cm) from BARI barley-7. The highest number of grain $panicle^{-1}$was (40.29) in BARI barley-9 but grain $panicle^{-1}$ was 35.25 in BARI barley-7. The highest 1000- grain weight was 35.24 g at BARI barley-9 and the lowest at 33.10 g at BARI barley-7. The highest grain yield was 2.45 $tha^{-1,}$ and straw yield was 3.61 tha^{-1} in BARI barley-9 wheareas the lowest grain yield (2.32 tha^{-1}) and straw yield (3.39 tha^{-1}) were found in BARI barley-7. The highest gross return (Tk. 129720 ha^{-1}) and gross margin (Tk. 79720 ha^{-1}) were calculated from BARI barley-9 and the lowest from BARI barley-7 (Table 8)

Cumilla

There were no significant differences in all the characters of except tiller $plant^{-1}$ and days to maturity. The maximum tiller $plant^{-1}$ (8.5) was found from BARI barley-9, which was at par with BARI Barley-6 and BARI Barley-8. BARI Barley-7 was produced the lowest (6.6) tiller $plant^{-1}$. The lowest (100) days to maturity was observed in BARI Barley-6, followed by BARI Barley-8 and BARI Barley-7. The highest (103.7) days to maturity was observed in BARI Barley-9. Numerically higher grain yield (3.3t ha^{-1}) was observed from BARI Barley-8 whereas BARI Barley-9 gave 25.8% higher yield over the BARI Barley-8 in last year trial (Table 9). From the economic analysis, gross return (264000Tk. ha^{-1}) and gross margin (222500 Tk. ha^{-1}) were also higher in BARI Barley-8 followed by BARI Barley-9 (256000 and 214500 Tk. ha^{-1}, respectively) (Table 10).

Manikganj

Yield and yield characters of BARI Barley varieties is shown in Table 11. The plant height of barley varieties ranged from 66.20 to 98.20 cm. The tallest plant was found from BARI Barley-9 (98.20

cm) than in Barley-7 (66.20 cm). The maximum panicle m^{-2} was obtained from BARI Barley-6 (58) and minimum in var. BARI Barley-7 (40). Seed weight was the maximum in BARI Barley-7 and BARI Barley-9 (38 g) followed by BARI Barley-8 (37g) and BARI Barley-6 (36 g). The highest grain yield (2.60 t ha^{-1}) was obtained from of BARI Barley-6 and lowest from var. BARI Barley-9 (1.99 t ha^{-1}). Cost and return are shown in Table 12. The maximum gross return (Tk. 107450 ha^{-1}) and gross margin (Tk. 85170 ha^{-1}) was found in BARI barely-6, but gross margin obtained from other varieties were almost similar (Tk. 61220 to 66220 ha^{-1}).

Faridpur

The performance of yield and yield parameters of barley were presented in Table 13. The higher plant height was obtained from local variety (95.17 cm). The maximum number of spike per m^2 was calculated from local variety (266) and the lower in BARI Barley-7 (229). There was no significant difference among the barley varieties in related to number of grains per spike but numerically higher was found in BARI Barley-9 (48). Thousand seed weight was the highest (30.9 g) in BARI Barley-9 and the lowest in local variety (22.3 g). The maximum grain yield was observed in BARI Barley-9 (2.66 t ha^{-1}) due to higher grains per spike and thousand seed weight which identical in BARI Barley-7 (2.60 t ha^{-1}).

Farmers' opinion

Tangail: Farmers showed their keen interest in the BARI Barley-7 and BARI Barlely-9 due to their higher yield potentialities, awn less and less disease and pest infestation. They are interested to have an available seed supply during the growing season.

Bogura: Previously farmers of the area were not cultivated barley. They are pleased to see the new variety and interested in growing bare barley-9 and BARI barley-7 for their higher yield and economic return.

Cumilla: Farmers of Cumilla region are not habituated with barley cultivation. As a new crop they showed their keen interest to the BARI Barley varieties due to the higher yield potentialities and less disease and pest infestation. . Processing machine should be given to the farmers to expand the crop in the farmer's level.

Manikganj: Farmers opined that barley is a new crop in the area and locally it is called *Payra*. They knew that grain meal in the local market is costly (Tk.120.00 kg^{-1}), and it is consumed by the diabetic patients. Farmer commented that grain yield reduced due to the infestation of rats. However, the selected farmer was interested to grow this crop in the next year.

Faridpur: Overall performance of barley varieties was good in respect of yield. Farmers preferred both the varieties. One problem was bird attack during grain filling stage.

Table 2. Grain yield and yield contributing characters of BARI Barley varieties at Charland under MLT site, Bhuapur, Tangail during the Rabi, 2021-22

Variety	Days to maturity	Plant height (cm)	Grain $spike^{-1}$ (no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})
BARI Barly-7	107	92.63	49.20	33.50	1.86
BARI Barly-9	102	99.40	39.37	32.10	1.74
t test	*	*	ns	ns	ns

*= Significant at 5% level, NS= Nonsignificant

Table 3. Cost - return analysis of BARI Barley varieties at Charland areas of Bhuapur, Tangail during the Rabi 2021-22

Variety		Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Barly-7		83700	52170	31530
BARI Barly-9		78300	52170	26130

Farm gate price of grain (Tk. Kg^{-1}): 45

Table 4. Grain yield and yield contributing characters of BARI Barley varieties at Charland areas under FSRD site, Atia, Tangail during the Rabi, 2021-22

Variety	Days to maturity	Plant height (cm)	Grain spike^{-1} (no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})
BARI Barly-7	109	66.47	44.33	31.80	1.90
BARI Barly-9	103	72.27	43.47	31.73	1.81
t test	*	*	ns	ns	ns

*= Significant at 5% level, NS= Nonsignificant

Table 5. Cost and return analysis of BARI Barley varieties at Charland areas under FSRD site, Atia, Tangail during the Rabi 2021-22

Variety		Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Barly-7		76000	48185	27815
BARI Barly-9		72400	48185	24215

Farm gate price of grain (Tk. Kg^{-1}): 40

Table 6. Grain yield and yield contributing characters of barley varieties at char Bongram, Ranigonj, Chilmari, Kurigram, OFRD, Rangpur during Rabi season 2021-22

Variety	Plants . (no./m^2)	Plant height (cm)	Effectives tillers/ plant	1000-grains wt. (g.)	Grain yield (kg ha^{-1})	GR (Tk./kg)	TVC (Tk./kg)	GM (Tk./kg)	BCR
BARI Barley-7	87	99.4	10.1	39	4135	82700	36575	46125	2.26
BARI Barley-9	88	102.2	10.5	44	4940	98800	36575	62225	2.70

Price: Barley=20 Tk./Kg

Table 7. Grain yield and yield contributing characters of barley at Khabuliar char, Sonatola, Bogura during *rabi*, 2021-2022

Variety	Plant height (cm)	Panicle length (cm)	Grains panicle-^{1} (no)	1000-grain wt. (g)	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})
BARI barley-7	81.30	9.72	35.25	33.10	2.32	3.39
BARI barley-9	90.41	11.14	40.29	35.24	2.45	3.61
t-value	9.64	1.78	4.21	2.47	3.32	4.33

Table 8. Cost and return analysis of barley at Khabuliar char, Sonatola, Bogura during *rabi*, 2021-2022

Variety	Yield		Gross return (Tk. ha^{-1})			Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
	Grain	Straw	Grain	Straw	Total			
BARI barley-7	2.32	3.39	116000	6780	122780	50000	72780	2.46
BARI barley-9	2.45	3.61	122500	7220	129720	50000	79720	2.60

The market price of barley @Tk.50 kg^{-1} and straw @ Tk .2.00 kg^{-1}

Table 9. Grain yield and yield contributing characters of Barley varieties at farmer's field of Burichang, andTitas of Cumilla and Hajigonj, Chandpur during the Rabi' 2021-22

Variety	Plant height (cm)	Tiller plant^{-1} (no.)	Spike length (cm)	Grains spike^{-1} (no.)	1000-grain wt. (gm)	Grain yield (t ha^{-1})	Plant pop^{n}	Days to maturity
BARI Barley-6	85.93	8.3 a	9.7	47.7	32.7	3.13	42.0	100.3 b
BARI Barley-7	85.77	6.6 b	9.0	43.6	33.3	3.13	39.3	102.0 ab
BARI Barley-8	82.07	7.9 ab	9.6	43.7	33.0	3.3	40.7	101.0 ab
BARI Barley-9	84.53	8.5 a	9.2	42.4	33.7	3.2	37.7	103.7 a
CV (%)	5.51	10.27	3.95	10.06	4.23	5.71	11.15	1.38
LSD (0.05)	ns	1.6024	ns	ns	ns	ns	ns	2.806

Table 10. Cost benefit analysis of BARI Barley varieties at farmer's field of Burichang, andTitas of Cumilla and Hajigonj, Chandpurduring the Rabi 2021-22

Pattern		Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Barley-6		250400	41500	208900
BARI Barley-7		250400	41500	208900
BARI Barley-8		264000	41500	222500
BARI Barley-9		256000	41500	214500

Price (Tk. kg^{-1}): Barley grain= hull less- 80.00

Table 11. Performance of Barley varieties in the farmers' field at Shibaloya, Manikganj during Rabi season of 2021-22.

Variety	Plant height (cm)	No. of panicle m^{-2}	1000-grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
BARI Barley-6	90.60 a	58.00 a	36.00 a	2.60 a	3.45 c
BARI Barley-7	66.20 c	40.00 c	38.00 a	2.00 a	3.50 c
BARI Barley-8	74.60 b	55.00 ab	37.00 a	2.10 a	4.50 a
BARI Barley-9	98.20 a	45.00 bc	38.00 a	1.99 a	3.90 b
LSD $_{(0.05)}$	8.66	11.29	NS	0.939	0.155
CV (%)	5.43	10.41	6.09	7.66	2.01

Table 12. Cost and return of Barley varieties at Shibaloya Manikganj during Rabi season of 2021-22.

Variety	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Barley-6	107450	22280	85170
BARI Barley-7	83500	22280	61220
BARI Barley-8	88500	22280	66220
BARI Barley-9	83500	22280	61220

Price of seed @ Tk. 40.00 kg^{-1}, Price of straw @ 1.00 kg^{-1}

Table 13. Grain yield and yield contributing characters of different barley varieties in Faridpur during Rabi 2021-22

Variety	Plant height cm)	Spike (m^{-2})	Grains spike^{-1} (nos.)	TSW (g)	Grain yield (t ha^{-1})
BARI Barley-7	89.87 b	229 b	47 a	29.23 b	2.60 a
BARI Barley-9	91.03 ab	244b	48 a	30.9 a	2.66 a
Local	95.17 a	266 a	44 a	22.27 c	1.90 b
CV (%)	2.14	2.96	2.57	0.79	2.93

Conclusion

In **Tangail and Bagura**, it may be concluded thatbarley var. BARI Barely-7 and BARI Barely-9 are promising varieties. In **Rangpur, t**he var. BARI Barley-9 was given better performance than BARI Barley-7. In **Cumilla,** Among the tested varieties, BARI Barley-8 produced numerically higher yield. In **Manikganj, a**mong the tested barley varieties, barley var. BARI Barley-6 produced higher seed yield than . In **Faridpur**, BARI Barley-7 (2.60 t ha^{-1}) and BARI Barley-9 (2.66 t ha^{-1}) produced the satisfactory yield.

PERFORMANCE OF SELECTED BARLEY VARIETIES AND ADVANCED LINES IN COASTAL AND BARIND AREA

M.H. RASHID, K. ISLAM, M.K. SHAHADAT, M. RAHMAN, S. RAHMAN, N.A. SIDDIKI AND Z. ISLAM

Abstract

The experiment was conducted at the farmer's field of Khulna and Rajshahi districts during Rabi season 2021-22 to study the performances of three BARI barley varieties viz., BARI Barley-7, BARI Barley-8 and BARI Barley-9, and two barley lines viz. BHL-25 and BHL-27. Among the varieties and lines, there was no significant yield variations but between the two sites yield and yield components were higher at Dacope. Numerically highest grain yield was recorded from BHL-27 (2.5 t ha^{-1}). In case of Rajshahi, BARI Barley-9 gave the highest grain yield (2.15 t ha^{-1}) followed by BHL-27 (1.98 t ha^{-1}) and the lowest grain yield by BHL-25 (1.68 t ha^{-1}). Considering the yield and yield contributing characters BARI Barley-9 is the suitable one for Barley production in High Barind Tract.

Introduction

Barley is one of the important cereals of the world. In Bangladesh barley is cultivated as a minor cereal. In many diverse environments, barley is the most adaptable cereal crop. Bangladesh has 4000 hectares of land under barley cultivation, with a production of about 3000 metric tons (BBS, 2004). In coastal area, a wide range of land remains fallow due to salinity in *rabi* season. BARI has recently developed some high yielding barley varieties. It has potentiality to grow under water stress condition. Several studies revealed that also it can be successfully grown after harvest of T. aman. As a result, a field trial was conducted to identify an early and high yielding barley variety for a salt tolerant and drought-resistant barley variety.

Materials and Methods

The trial was conducted at MLT site, Koyra and Dacope of Khulna and FSRD site, Basantopur, Rajshahi district during *Rabi* season 2021-`22. Three barley varieties viz. BARI Barley-7, BARI Barley-8, BARI Barley-9 and two advanced lines viz. BHL-25 and BHL-27 were tested. The experiment was laid out in a randomized complete block design (RCBD) with three dispersed replications. In Khulna, seeds were sown in lines of 29 cm apart and sown continuously along the line. Line to line spacing was 30 cm. In Rajshahi, the line-to-line distance was 25 cm with continuous sowing and seed rate was maintained 120 kg ha^{-1}. Crop variety, plot size and management practices used in different locations are given in table 1. All of urea, TSP and MoP were applied as basal. The crop was irrigated two times. All the intercultural operations were done as and when necessary. Data on yield and yield attributes were collected and analyzed statistically.

Table 1. Crop variety, plot size and management practices used in different locations

Location	Variety	Plot size	Sowing date	Harvesting date	Fertilizer dose (N-P-K-B-S-Zn-B kg ha^{-1})
Khulna	BARI Kaun-2 and BARI Kaun-4	5 m × 5 m	30 Nov. 2021 at Koyra and 21 Dec. 2021 Dacope	7 March 2022 in Koyra and 25 March 2022	100-60-40
Rajshahi	Three barley varieties: BARI Barley-7, BARI Barley-8, BARI Barley-9 and two advance lines viz. BHL-25 and BHL-27	10 m x 10 m	03 December 2021	16 March 2022.	100-60-40-1

Results and Discussion

Khulna

Effect of locations and variety on yield and yield components: Significant variation in growth, yield components and yield of barley were observed in location but there no significant difference among the varieties and lines were observed (Table 2). Growth, grain yield and yield components were found highest at Dacope. At Dacope, plant population per square meter (286), plant height (76.40 cm), spike length (17.93 cm), number of grains per spike (52.27), thousand grain weight (36.07 g) and grain yield (2.70 t ha^{-1}) etc. were found higher than Koyra. The yield advantage at Dacope over Koyra may be attributed to timely management and relatively high land of the experimental site, which was less affected by the heavy rainfall at early January 2022. There was no significant difference among the varieties and lines were observed. However, numerically both lines BHL-25 and BHL-27 produced highest plant height (80.8 and 83.9 cm, respectively), spike length (17.9 and 17.5 cm) and number of grains per spike (48.9 and 47.7, respectively). Numerically highest grain yield was recorded from BHL-27 (2.5 t ha-^{1}).

Rajshahi

Table 3 shows the production and yield indices of barley. Barley var. BARI Barley-9 produced the highest grain yield (2.15 t ha^{-1}) because of the larger number of grains spike^{-1} and thousand grain weight followed by BHL-27 (1.98 t ha^{-1}). BHL-25 showed that the lowest grain yield (1.68 t ha^{-1}). BHL-27 produced the maximum straw yield (4.08 t ha^{-1}) followed by BARI Barley-9 (3.94 t ha^{-1}). All genotypes / varieties took 56-64. days to flower and 95-105 days to mature under rainfed conditions.

Farmers' opinion

Khulna: Farmers and the neighbors were encouraged observing the yield performance of BHL-25 and BHL-2 and also hullless. Farmers were particularly interested to cultivate BHL-27 next year.

Rajshahi: The overall yield performance of barley varieties/lines was favorable where BARI Barley-9 was favoured by farmers because of its higher yield.

Table 2. Yield and yield attributing characters of barley varieties at Koyra and Dacope site during *rabi* season, 2021-22

Varieties	Plants m^{-2}	Plant height (cm)	Spike length (cm)	Grains spike^{-1} (no.)	TGW (g)	Grain yield (t ha^{-1})
Location						
Koyra	204.6	82.17	17.18	41.70	32.07	2.06
Dacope	286.0	76.40	17.93	52.27	36.07	2.70
p-value	2.93e-05	0.01	0.00	8.097e-10	0.00	2.191e-05
Variety and Lines						
BARIbarly-7	248.0	76.4	17.4	47.6	34.8	2.4
BARIbarly-8	249.5	78.0	17.5	45.1	32.7	2.4
BARIbarly-9	237.3	77.4	17.5	45.7	33.5	2.3
BHL-25	245.3	80.8	17.9	48.9	34.7	2.4
BHL-27	246.3	83.9	17.5	47.7	34.7	2.5
LSD $_{(0.05)}$	51.96	5.87	0.57	3.43	2.99	0.35
CV (%)	17.46	6.12	2.69	6.02	7.24	12.02

Table 3. Grain yield and yield contributing characters of different barley varieties/lines in HBT during Rabi 2021-2022.

Variety/Lines Name	Days to Flowering	Days to Maturity	Plant height (cm)	No. of spike/m^2	Spike length (cm)	No. of grains/spike	TGW (g)	Grain yield (t/ ha)	Straw yield (t ha^{-1})
BARI Barley-7	56d	95d	101.2a	210.3b	7.31	51.1c	40.0	1.76bc	3.76ab
BARI Barley-8	56cd	99c	96.03ab	274.3a	9.45	59.8b	43.3	1.86bc	3.60b
BARI Barley-9	57c	100c	100.3a	266.3a	8.55	74.4a	38.0	2.15a	3.94ab
BHL-25	62b	102.b	91.6ab	281.7a	8.60	52.8c	34.7	1.68c	3.77ab
BHL-27	64.3a	104.7a	86.9b	288.0a	9.10	59.8b	40.0	1.98ab	4.08a
CV (%)	0.93	0.59	7.43	5.25	11.21	3.82	11.93	6.72	6.30

Conclusion

In Khulna, yield variation was observed between the two sites, which is due to mainly management differences. Though there was no statistical yield difference among the varieties and lines, however, numerically highest yield (2.5 t ha^{-1}) was observed from the line BHL-27 In Rajshahi, under drought conditions, BARI Barley-9 provided the highest yield of all the varieties/lines evaluated.

REGIONAL YIELD TRIALS OF HULL-LESS BARLEY IN CHAR AREAS

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Abstract

A field trail was conducted at char Bongram, Ranigonj, Chilmari, Kurigram, OFRD, Rangpur during Rabi season 2021-22 to find out the better performing hull-less barley lines (s). The highest grain yield (1947 Kg ha^{-1}) was obtained from INBON-19-E-24 line and lowest grain yield (1650 kg ha^{-1}) from INBON-19-E-100 followed by BHL 16 (1675 kg/). However, among the barley lines / varieties, line INBON-19-E-24 gave the highest grain yield in char area. .

Introduction

Barley is a nutritious crop that can be grown in saline and drought prone areas. Barley production can be expanded throughout Bangladesh as it requires low impute to cultivate Evaluation of selective barley lines in regional yield trial could provide location specific and stable promising high yielding hull-less barley lines. With this view, this experiment was undertaken to select highly adaptive and high yielding barley genotypes.

Materials and Methods

The experiment was conducted at char Bongram, Ranigonj, Chilmari, Kurigram, OFRD, Rangpur during Rabi season 2021-22 to select better performing hull-less barley lines (s). The experiment site represents the agro-ecological zone (AEZ-3) recognized as “Tista Mender Flood Plain Soil”. The design was followed with RCB with three replications. The experiment was started 25 November 2021 and crop was harvested on 22-25 March, 2022. The nine varieties: BHL 26 (V_1), BHL 34 (V_2), INBON-19-E-100 (V_3), INBON-19-E-24 (V_4), BHL 30 (V_5), E-19 (V_6), L-53 (V_7), BB-7 (cheek) (V_8) and BB-7 (cheek) (V_9) were evaluated. Weeding, irrigation and spraying were done as required. Fertilizers were applied at the rate of 100-60-40 Kg ha^{-1} of N-P-K as respectively. One third of Urea, whole amount of TSP and MoP were applied as basal. One third urea was applied after seedling establishment and rest of one third was applied heading stage with mixed thoroughly with the soil for better utilization. Data were taken on different growth parameters like plant height, tuber/plant, tuber weight/plant, and tuber yield. The data were compiled and analyzed with MSTAT software.

Results and Discussions

The results have been presented on table 1. The highest grain yield (1947 Kg ha^{-1}) from INBON-19-E-24 line and lowest grain yield was recorded from INBON-19-E-100 (1650 kg ha^{-1}) followed by BHL 16 (1675 kg/) . New lines and cheek varieties were showed almost same grain yield performance. Days to 50% flowering was given 73-76 days and maturity 114-118 days. This grain yield was supported by all yield contributing characters.

Table 1. Grain yield and yield contributing characters of hull-less varieties at char Bongram, Ranigonj, Chilmari, Kurigram, OFRD, Rangpur during Rabi season 2021-22

Treatments	Plant height (cm)	Effectives tillers/plant	1000 grain- wt. (g.)	Grain yield (Kg ha^{-1})
L_1= BHL 26	93.2	9.4 a	30.0	1735b
L_2=BHL 34	89.8	9.2 a	30.0	1725b
L_3=INBON-19-E-100	83.2	7.8 b	30.0	1650c
L_4=INBON-19-E-24	79.4	5.2 d	30.0	1947a
L_5=BHL 30	80.0	7.2 bc	30.0	1675c
L_6=E-19	100.0	10.0 a	30.0	1725b
L_7=L-53	84.2	5.2 d	30.0	1725b
L_8=BB-7 (cheek)	86.8	9.0 a	30.0	1775b
L_9=BB-9 (cheek)	79.2	6.4 c	30.0	1725b
Put LSD Value			ns	
CV (%)	6.45	8.74	7.5	4.5

Conclusion

The line INBON-19-E-24 showed better performance in grain yield . This was one-year results; Farmers was not satisfied due lack of market facilities. However, it would be continuing next year for better variety.

ON-FARM TRIAL OF BARI DEVELOPED FOXTAIL MILLET VARIETY

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Abstract

Adaptive trials with BARI-developed millet varieties were conducted at Cumilla, B. Baria, Chandpur under OFRD, Cumilla, Rajendrapur of Netrakona and Vabokhali of Mymensingh under OFRD, Mymensingh, Saghata, Gaibandha and in the farmer's field of Basantopur, Godagari under OFRD, Rajshahi during Rabi season of 2021-22 to evaluate the performance of BARI developed high yielding foxtail millet varieties. Among the tested varieties BARI Kaon 4 produced maximum grain yield in all locations. Besides, gross return and gross margin was also higher in BARI Kaun-4.

Introduction

Foxtail millet (*Setaria italica)* is a small grain crop grown in drought-prone and less fertile soils with minimal maintenance and inputs. It can play a partial role in fulfilling the food crisis of our country. Each 100 g millet grain contains 351 calories, 11.2 g protein, 4 g fat, 63.2 g carbohydrate, and 6.7 g fiber, 2.8 mg iron, 3.2 mg niacin, 0.1 mg riboflavin, and 31 mg calcium (Islam *et al.*, 2017). Millets offer nutritional security and there is a need for promoting millets as they are highly nutritious. Its play an important role in global agriculture and have been grown from ancient time in traditional agricultural systems with low or without inputs with consequent low productivity. They can tolerate both drought and saline soil condition and possess wider adaptation to environmental fluctuation and as such they can escape drought or flood and give more or less yield. So, at present to challenge the climatic change due to global warming, millets should receive more attention for its varietal improvement as they can be grown in areas where irrigation water is limited, and other cereals cannot be grown successfully. The farmers of the char areas grow local variety of foxtail millet which is low yielder. The plant breeding division of BARI already developed four improved foxtail millet varieties that have significant yield and nutrient content advantage over local one. Introduction of BARI released foxtail millet varieties in that areas could bring the improvement of the farmer's livelihood. AS such , this experiment was undertaken to find out the most suitable, highly adaptive and high yielding variety in the farmer's field and popularize the BARI released Kaon varieties among the farmers by increasing their income.

Materials and Methods

The study was conducted in a farmer's field of Debidwer of Cumilla, Kasba of B. Baria and Saharasti of Chandpur under OFRD Cumilla, Rajendrapur, Netrakona and Vabokhali, Mymensingh under OFRD, Mymensingh, Saghata under OFRD, Gaibandha and Basantopur, Godagari under OFRD Rajshahi during rabi season of 2021-2022. The experiment was laid out in a randomized complete block design (RCBD) with three dispersed replications with spacing row to row distance 25 cm with continuous seeding. Crop variety, plot size and management practices used in different locations are given in table 1. Entire fertilizers and one third of urea were applied as basal during final land preparation. The rest urea was top dressed in two equal spilt at seeding establishment & before heading followed by irrigation. All intercultural operations viz. Irrigation, weeding and thinning etc. were done when needed. Plant protection measures were taken as and when necessary. At harvest, the yield data was recorded and analyzed statistically.

Table 1. Crop variety, plot size and management practices used in different locations

Location	Variety	Plot size	Sowing date	Harvesting date	Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})
Cumilla	BARI Kaun-2 and BARI Kaun-4	10 m × 8 m	30 Nov. to 22 Dec., 2021	4-15April, 2022	60-20-45-9-1.5
Mymensingh	BARI Kaon-1, BARI Kaon-2, BARI Kaon-3, BARI Kaon-4 and a local check.	8 m× 5 m	12 Dec. 2021 at Netrakona and 13 Dec., 2021 Mymensingh	April 10, 2022 at Netrakona and April 12, 2022 at Mymensingh.	45-30-20
Gaibandha	BARI Kaon-2, BARI Kaon-3 and BARI Kaon-4	600 m^2 area	10-15 January 2022	1-16 May 2022	40-30-20
Barind, Rajshahi	BARI Kaon-2, BARI Kaon-3 and BARI Kaon-4	8 m× 5 m	06 December, 2021.	19 April, 2022	46-14-18-1.5 (N-P-K-B kg ha^{-1})

Results and Discussion

Cumilla: Significant variations were observed only in plants /sq.m and grains panicle^{-1} of foxtail millet varieties (Table 1). Highest grains panicle $^{-1}$ (2476.8) and plant popl. (38.5), were observed in BARI Kaun-3. Numerically higher thousand seed weight (2.43g) and grain yield (2.45 t ha^{-1}) were observed from BARI Kaun-3. From the economic analysis it was documented that the gross return and gross margin were also higher in BARI Kaun-4 (196000 and 146000 Tk. ha^{-1}, respectively) (Table 3).

Mymensingh: The yield and yield contributing characters of tested BARI released Kaon varieties were differed significantly when local cultivar used as a check (Table 4). The tallest plant was found from BARI Kaon-2 (114 cm) and the shortest plant from BARI Kaon-3 (61 cm). The highest number of tillers per plant was produced by the BARI Kaon-3 (2.53) and the lowest in local cultivar (2.14). But the maximum panicle was obtained from BARI Kaon-2 (19.17 cm) that was statistically identical with BARI Kaon-4 (18.17 cm) and the shortest panicle (16.67 cm) from local cultivar. The maximum grain yield per hectare was obtained from BARI Kaon-4 (1.98 t ha^{-1}) which was statistically identical with BARI Kaon-2 (1.82 tha^{-1}) and the lowest from local cultivar (1.40 t ha^{-1}). The number of tillers per plant, panicle length and grain weight might be contributed for more yield. The gross return and gross margin were varied among the varieties (Table 5). The calculated highest gross return (Tk. 99000 ha^{-1}) and gross margin (Tk. 71310 ha^{-1}) was recorded from BARI Kaon-4 and local check variety gave the lowest gross return (Tk. 70000 ha^{-1}) and gross margin (Tk. 42310 ha^{-1}).

Gaibandha: The yield and yield attributes of kaon were presented in Table 6. The days to maturity in BARI Kaon-2 ranged from 121-123 d with an average of 122 d, plant height ranged from 116.3-123.5 cm with an average of 120.8 cm. In BARI Kaon-3 days to maturity ranged from 118-124 d with an average of 121 d and plant height ranged from 40.6-45.9 cm with an average of 43.3 cm. In BARI Kaon-4 days to maturity ranged from 105-108 d with an average of 107 d and plant height ranged from 99.8-107.2 cm with an average of 103.8 cm. On an average, field duration of BARI Kaon-4 (14-15 d) shorter than BARI Kaon-2 and BARI Kaon-3, respectively. The plant height in BARI Kaon-2 showed higher (120.8 cm) compared to BARI Kaon-4 (103.8 cm) whereas it was much shorter in BARI Koan-3 (40.6 to 45.9 cm). However, the average, maximum grain yield (3.14 t ha^{-1}) was recorded in BARI Kaon-4 followed by BARI Kaon-2 (2.88 t ha^{-1}) and BARI Kaon-3 (2.77 t ha^{-1}). No lodging, disease and insect incidence occurred in the BARI Kaon-2, BARI Kaon-3 and BARI Kaon-4.

Rajshahi: The yield and yield attributes of kaon were presented in Table 7. The highest days to flowering and days to maturity were found in BARI Kaon-2 (134 days) and the lowest in BARI Kaon-3 (126 days). Maximum plant height was found in BARI Kaon-4 (118.67 cm) and minimum in BARI Kaon-3 (59.67 cm). The maximum plants m^{-2} (334.3), highest length of tail (14.97 cm), maximum number of seeds/ panicle (2523.7), 1000- grain weight (1.94 g) and grain yield (1.94 t ha^{-1}) were found in variety BARI Kaon-4. The lowest yield was observed in in variety BARI Kaon-2. It was found that BARI Kaon-4 gave higher yield in the farmer's field.

Farmers' opinion

Mymensingh: Farmers are preferred the BARI developed Kaon varieties due to their higher yield potentiality as well as its low input requirements. They can be grown in areas where irrigation water is limited, and other cereals cannot be grown successfully. They showed their keen interest for growing BARI Kaon-3 for its darkness, and it has ability to protect them from rainstorm for lodging. On the other hand, BARI Kaon-4, BARI Kaon-2 and BARI Kaon-1 were more productive than local variety that's why farmers also showed their interest for cultivating mentioned varieties.

Ghaibandha: Farmers preferred BARI Kaon-2, BARI Kaon-3 and BARI Kaon-4 varieties due to their higher yield. Farmers demanded a timely supply of more quality seed to spread in char areas.

Barind Rajshahi: Farmers were happy get higher yield from BARI kaon-4 and they were interested to cultivate kaon in next Rabi season because the highest yield.

Table 2. Grain yield and yield attributes of foxtail millet varieties at different locations of Cumilla, B. Baria and Chandpur during Rabi season of 2021-22

Variety	Field duration (d)	Plant height (cm)	Panicle $plant^{-1}$ (no.)	Spike length (cm)	Grains $panicle^{-1}$ (No.)	Plant Pop^{n} m^{-2}	1000 seed weight (g)	Yield (t ha^{-1})
BARI Kaon-2	116.3	124.1	3.93	18.32	2008 a	34.5	2.34	2.30
BARI Kaon-4	114.3	117.4	3.65	16.88	2477 b	38.5	2.43	2.45
CV (%)	0.87	9.89	11.94	10.34	7.14	4.19	7.67	4.03
LSD (0.05)	ns	ns	ns	ns	360.19	3.4374	ns	ns

Table 3. Cost and Return analysis of foxtail millet varieties at different locations of Cumilla and Chandpur during Rabi season of 2021-22

Varieties	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Kaon-2	184000	50000	134000
BARI Kaon-4	196000	50000	146000

The price of foxtail millet is Tk. 80 kg^{-1}

Table 4. Grain yield and yield contributing characters of different Kaon varieties at farmer's field of Rajedrapur, Netrakona and Vabokhali, Mymensingh during rabi season of 2021-2022

Varieties	Plant height (cm)	Tiller $plant^{-1}$	Panicle length (cm)	1000- grain weight (g)	Grain yield (g m^{-2})	Yield (t ha^{-1})
BARI Kaon-1	108	2.38	16.83	2.33	164.8	1.65
BARI Kaon-2	114	2.42	19.17	2.47	180.5	1.82
BARI Kaon-3	61	2.53	17.00	2.27	178.5	1.78
BARI Kaon-4	109	2.48	18.17	2.63	198.0	1.98
Local cultivar	96	2.14	16.67	2.05	138.8	1.4
LSD $_{(0.05)}$	8.39	0.25	1.19	0.16	19.43	0.19
CV (%)	7.30	8.68	5.57	5.66	9.23	9.37

Table 5. Cost and return analysis of different Kaon varieties at farmers filed of Rajedrapur, Netrakona and Vabokhali, Mymensingh during rabi season of 2021-2022

Varieties	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
BARI Kaon-1	82500	29690	52810
BARI Kaon-2	91000	29690	61310
BARI Kaon-3	89000	29690	59310
BARI Kaon-4	99000	29690	69310
Local cultivar	70000	29690	40310

Price of input and output: Urea: 16.00 Tk. kg^{-1}, TSP: 22.00 Tk. kg^{-1} and MOP: 15.00 Tk. $kg^{-1,}$ Market price of kaon 50 Tk. kg^{-1}

Table 6. Grain yield and other parameters of BARI developed Foxtail millet varieties in farmer's field of char areas, Gaibandha during 2021-22

Variety	Days to maturity	Plant height (cm)	Grain Yield (t ha^{-1})	Lodging (%)	Disease (%)	Insect (%)
BARI Kaon-2	122	120.8	2.88	x	x	x
BARI Kaon-3	121	43.3	2.77	x	x	x
BARI Kaon-4	107	103.8	3.14	x	x	x

Table 7. Yield and yield attributes of Kaon under FSRD site, Godagari, Rajshahi during 2021-2022

Treatment	Days to Flowering	Days to maturity	Plant height (cm)	Plants m^{-2}	)	No. of seeds/tail	1000 grain wt. (g)	Grain yield (t ha^{-1})
BARI Kaon-2	92.3	133.7	115.6	307.0		1689	1.72	1.71
BARI Kaon-3	88.0	125.7	59.7	288.7		1962	1.84	1.84
BARI Kaon-4	92.3	131.0	118.7	334.3		2524	1.94	1.94
CV (%)	1.07	1.36	3.09	0.90		13.59	3.79	2.57
LSD (0.05)								

Conclusion

Kaon can be grown in areas where irrigation water is limited / absent and other cereals cannot be grown successfully. Considering yield potentiality and low incidence of pest and diseases, it was found that BARI released Kaon varieties were performed better in all locations. Among the tested varieties they showed more interest for growing BARI Kaon-4 in all locations. On the other hand, BARI Kaon-3, BARI Kaon-2 and BARI Kaon-1 were more productive than local variety.

ON-FARM TRIAL OF PROSO MILLET VARIETIES IN THE CHAR LAND AND HIGH BARIND TRACTS

M.S. ALAM, R.A. MOLLA, M.T. HASAN, M.A. ISLAM, J.C. BARMAN, S. HOSSAIN AND E. A. PRAMANIK

Abstract

A field trial was conducted at Khabuliar char Sonatola, Bogura and in the farmer's field at FSRD site, Basantopur, Godagari, Rajshahi during *rabi,* 2021-2022, to evaluate the performance of modern proso millet variety under farmers' field conditions. Cheena var. BARI Cheena-1 gave a satisfactory yield (2.42 tha^{-1}) over the local variety (1.73 tha^{-1}) in Boghura. The tested variety also showed higher gross margin (Tk. 83100 ha^{-1}) over local cultivar. In High Barind Tract, seven lines viz., BD-777, BD-791, BD-1399, BD-1402, BD-1411, BD-144,6 BD-1447 along with one BARI released variety BARI China-1 and local one (check) were tested in the trial. Proso millet is a short duration crop and matures in 61 to 68 days. The thousand grain weight was also small ranging from 4.13 to 4.65 g. Among the tested genotypes, BD-1446 produced the maximum grain yield (1.60 t ha^{-1}) followed by BD-1402 (1.54 t ha^{-1}) and BD-1411 (1.51 t ha^{-1}) and the lowest one was from BARI Cheena-1 (1.26 t ha^{-1}).

Introduction

Proso millet is one of the oldest cultivated cereal crops and one of the important minor cereal crops in Bangladesh. It can be grown on dry land even under adverse weather conditions where the major crops cannot be grown. Proso millet is a fast-growing, short-season, drought tolerant, low input crop (Gowda and Kaul 1982). It is a promising crop for Southeast Asia, and its ecological suitability is wide. The national average yield of Proso millet in Bangladesh is low. This low yield may be due to the cultivation of the low-yielding local varieties and lack of technical knowledge etc. With several high-quality parameters, BARI has developed some high-yielding Proso millet varieties such as BARI Cheena-1. This variety can help generate farmers' income in a very short period. The present study was undertaken to evaluate the variety's performance under farmer's field conditions and popularize them among the farmers to in the char land of Bogura and High Barind Tracts, Rajshahi.

Materials and Methods

The experiment was conducted in Khabuliar char Sonatola, Bogura and FSRD site, Basantopur, Godagari, Rajshahi during Kharif, 2022 cropping season. One proso millet var. BARI Cheena-1 and Local (check), were tested in OFRD, Bogura and seven lines viz., BD-777, BD-791, BD-1399, BD-1402, BD-1411, BD-144,6 BD-1447 along with one BARI released var. BARI Cheena-1 and local one (check) were tested in OFRD, Barind, Rajshahi. The experiment was conducted in a randomized complete block design with three dispersed replications. Weeds, stubble and crop residues were removed. Crop variety, plot size and management practices used in different locations are given in table 1. One third of the urea and all other inorganic fertilizers were applied mixed with soil at the time of final land preparation. The remaining urea was applied in two stages, after seedling establishment and before heading. When 80% of the spikes turned golden in colour, the crop was assessed to attain maturity. Yield attributes viz., Panicle length, Grains panicle^{-1}, 1000- grain weight and grain yield were recorded . Data on various yields and yield components were collected and statistically analyzed.

Table 1. Crop variety, plot size and management practices used in different locations

Location	Variety	Plot size	Sowing date	Harvesting date	Fertilizer dose (NPK kg ha^{-1})
Bogura	BARI Cheena-1 and Local (check),	1320 m^2	12 December 2021	27 March 2022.	N at the rate of 50 kg ha-^{1}.
Rajshahi	Seven lines viz., BD-777, BD-791, BD-1399, BD-1402, BD-1411, BD-144,6 BD-1447 along with one BARI released variety BARI China-1 and local one (check)	30 m^2	06 March 2022.	12 May 2022	45-30-20-10-1 kg N-P-K-S-B ha^{-1}

Results and Discussion

Bogura: The yield and yield contributing performance of proso millet are presented in Table 2. Significant variation was found among the treatments of all characters. The local variety was obtained the highest plant height (78.81 cm) from BARI Cheena-1 . The highest panicle length was 19.10 cm in BARI Cheena-1 and the lowest (16.17 cm) from the local variety. The highest number of grain panicle^{-1}was (285.08) in BARI Cheena-1 but grains panicle^{-1} (177.07) in the local cultivar. The highest 1000- grain weight was 4.62 g at BARI Cheena-1 and the lowest (4.23 g) at the local variety. The highest grain yield (2.42 tha^{-1}) and straw yield (3.15 tha^{-1}) was obtained in BARI Cheena-1. The local variety was found the lowest grain yield (1.73 tha-1) and straw yield (2.68 tha-1). The economic performance is presented in Table 3. The highest gross return (Tk. 103100 ha^{-1}) and gross margin (Tk. 83100 ha^{-1}) were calculated from BARI Cheena-1and the lowest from the local variety.

Rajshahi: The yield and yield attributes of proso millet were presented in Table 4. The crop took 5 to 7 days for its emergence where BD-777 received the lowest time (5 days) and local one received the highest time (7 days). The crop reached flowering stage in 29 to 35 days, whereas BD-791 obtained minimum days (28 days) and maximum days (36 days) from BD-1447 and BARI Cheena-1. The maximum days to maturity were found in BD-777 (68 days) line which was identical to BD-1402 (66 days); and minimum and similar days were required for BD-1446 (61 days), BD-791 (62 days) and BD-1411 (63 days). Plant height was ranging from 90-103 cm where BARI Cheena-1 (103.3 cm), BD-1402 (102 cm), BD-1446 (101.3 cm) and BD-791 (100 cm). Plant population was almost similar among all the genotypes wvhich ranged from 409 to 508 while the maximum number was from BD-1399 (508) and the minimum from local cultivar (409.3). Tiller production was similar among all the genotypes except BARI Cheena-1. Thousand grain weight was varied from 4.13-4.65 g while BD-1411 gave the maximum and the minimum from

BD-1411. The maximum grain spike^{-1} (206.7) and grain yield (1.60 t ha^{-1}) were found in BD-1446 line. The minimum values of aforesaid parameters were from BARI Cheena-1 and BD-777. The maximum grain yield was obtained from genotypes (1.60 t ha^{-1}) followed by BD-1402 (1.54 t ha^{-1}) and BD-1411 (1.51 t ha^{-1}). The maximum grain yield was found in BD 1446 mainly due to higher number of plant population, more tiller production per plant and the maximum grains spike^{-1}.

Farmers' opinion

Bogura: They are happy to see the new variety and interested in growing BARI Cheena-1 for its higher yield and economic return.

Rajshahi: Farmers are positive about cultivating proso millets in Kharif-1 in the High Barind area.

Table 2. Grain yield and yield contributing characters of proso millet at Khabuliar char, Sonatola, Bogura during rabi, 2021-2022

Variety	Plant height (cm)	Panicle length (cm)	Grain panicle-^{1} (no)	1000-grain wt. (g)	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})
BARI Cheena-1	78.81	19.10	285.08	4.62	2.42	3.15
Local variety	65.95	16.17	177.07	4.23	1.73	2.68
t-value	15.64	4.12	5.33	2.56	2.18	4.39
Level of significance	**	*	**	*	**	*

**= Significance at 1% level *= Significance at 5% level NS= Not significant

Table 3. Cost and return analysis of proso millet at Khabuliar char, Sonatola, Bogura during *rabi*, 2021-2022

Variety	Yield		Gross return (Tk. ha^{-1})			Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
	Grain	Straw	Grain	Straw	Total			
BARI Cheena-1	2.42	3.15	96800	6300	103100	20000	83100	5.16
Local variety	1.73	2.68	69200	5360	74560	20000	54560	3.73

The market price of Proso millet @Tk.40 kg^{-1} and straw @ Tk .2.00 kg^{-1}

Table 4. Grain yield and yield attributes of Proso millet at Basantopur, Rajshahi during Kharif, 2022

Treat	DE	DF	DM	PH (cm)	PP (m^{-2})	Tiller plant^{-1}	Spike length (cm)	Grains Spike^{-1}	TGW (g)	GY (t ha^{-1})	SY (t ha^{-1})
BD-777	5	29	68	92	445	4.33	21.1	141	4.28	1.35	3.27
BD-791	6	28	62.	100	442	5.66	20.0	171	4.13	1.39	3.49
BD-1399	6	30	64.	96	508	5.66	21.1	175	4.61	1.45	3.07
BD-1402	6	29	66.	102	481	6.00	20.3	196	4.33	1.54	3.75
BD-1411	6	30	63.	94.7	438	5.66	23.1	187	4.65	1.51	3.47
BD-1446	6	32	61.	101	478	5.00	23.8	207	4.47	1.60	3.67
BD-1447	6	36	65.	90	467	6.33	21.3	180	4.41	1.40	3.98
BARI Cheena-1	6	36	65	103	439	3.66	19.9	158	4.27	1.26	3.12
Local	7	30	65	90	409	5.33	18.4	159	4.36	1.39	3.24
LSD(0.05)	0.78	0.83	2.05	5.25	70.38	2.15	1.95	23.78	0.41	0.11	0.45
CV (%)	7.48	1.55	1.84	3.13	8.90	23.51	5.36	7.85	5.45	4.29	7.44

NB. DE=days to emergence; DE=days to flowering; DM=days to maturity; PH=plant height; PP=plant population; TGW=thousand grain weight; GY=grain yield and SY=straw yield

Conclusion

In Bogura, Cheena var. BARI Cheena-1 gave higher yield and economic return in the Char land of Khabolia, Sonatola, Bogura. In Rajshahi, the performance of the BD-1446 line was better than other proso millet genotypes tested at Basantopur, Godagari, Rajshahi during the study period.

ADAPTIVE TRIALS WITH BARI BARLEY AND OAT VARIETIES IN CHAR AREAS

A.A. MAHMUD AND J. ALAM

Abstract

An adaptive trial was conducted under the Charland situation at the MLT sites Saghata, Gaibandha to observe the performance of Barley and Oat varieties in the Char areas during the 2021-22 crop season. Two barley varieties viz., BARI Barley-7 and BARI Barley-9, and one oat var. BARI Oat-1 were tested . BARI Barley-9 produced the maximum grain yield (2.38 t ha^{-1}) followed by BARI Barley-7 (2.13 t ha^{-1}). BARI Oat-1 grain yield ranged from 0.9 to 1.0 t ha^{-1} with an average of 0.95 t ha^{-1}.

Introduction

Barley (*Hordeum vulgare*) is the most adapted food grain in different environments which is recognized as char land more than other food grains. It contains about 11.5% protein which is almost double that of rice (Saldivar, 2003). Barley contains minerals like niacin (vitamin B3), thiamine (vitamin B1), selenium, iron, manganese, zinc, phosphorus, copper, etc. It helps in the normal growth of the human body and helps in the prevention of diseases. t has been observed that 6 (six) month old baby milk, as well as barley, regularly plays barley helps in normal growth and formation of the body.Barley can be grown in less fertile char areas with minimal input. Extensive char areas of Bangladesh remain fallow where crop intensification is a major challenge. Cultivation of heat-tolerant crops of wheat, barley, and pulses can bring significant changes in agricultural practices towards increasing the intensity of crops in the country through careful management practices. (Rahman et al., 2009). To increase crop intensity, barley can be cultivated profitably in char areas where water-stressed prevents most crops from growing in the dry season.

Oats (*Avena sativa* L.) are another important minor cereal crop grown both in irrigated and rain-fed areas. Its adaptation to the changing environment and soil type makes it a better choice than other food crops (Ahmad et al., 2014). It contains more protein than other cereals. Oat contains 17.1% protein, 6.4% fat, 11.3% crude fiber, 3.2% ash, 52.8% starch, 12.5% total dietary fiber and 1.2 mg 100g^{-1} total phenol (Saldivar, 2003). Oats are a gluten-free whole grain and a great source of important vitamins, minerals, fiber, and antioxidants. Studies reported that oats and oatmeal have many health benefits such as weight loss, lowering blood sugar levels, and reducing the risk of heart disease. BARI has developed some high-yielding barley and Oat varieties that have the potential to grow in harsh environments with satisfactory yields. Therefore, the trial was undertaken to evaluate the performances of BARI barley and Oat varieties in char areas of Gaibandha for dissemination and popularizing among the farmers.

Materials and Method

The trial was conducted char land situation at the MLT site Saghata, Gaibandha during 2021-22. Two barley varieties viz., BARI Barley-7 and BARI Barley-9 along with oat var. BARI Oat-1 were tested. The trial was laid out in RCB design in four dispersed replications. The unit plot size was 10 m x 10 m. Seeds were sown on 7 December 2021 @ 120 kg ha^{-1} seed, maintaining 25 cm row spacing and continuous seeding. 100, 60, and 40 kg of N, P, and K were applied in the form of urea, TSP, and MoP. All the fertilizers were incorporated with soil during final land preparation. Intercultural operations viz., weeding, and thinning were done when necessary. The crop was harvested from 20 - 30 March 2022. Data on yield and yield attributes were taken and analyzed statistically using STAR software at a 5% level of significance ($p<0.05$).

Results and Discussion

The field duration of BARI Barley-9 was about one week earlier compared to the BARI Barley-7. BARI Barley-9 produced the maximum grain yield (2.38 t ha^{-1}) followed by BARI Barley-7 (2.13 t ha^{-1}) (Table 1). On the other hand, the infield crop duration of BARI Oat-1 was 120-126 days with an average of 123 days. The field duration of BARI Oat-1 was approximately two weeks shorter than the recommended crop duration of 138–140 days, mainly due to late sowing and an increase in temperature at the maturity stage. BARI Oat-1 produced 0.9-1.0 t ha^{-1} grain with an average of 0.95 t ha^{-1} at char areas of Gaibandha.

Farmers' opinion

Farmers in the char area showed keen interest in minor grain especially, BARI Barley-7, BARI Barley-9, and BARI Oat-1 cultivation. They demanded a timely supply of the seeds to cultivate the barley and oat in the char area.

Table 1.Grain yield and yield contributing characters of BARI Barley and Oat varieties at Charland in Gaibandha during 2021-22

Variety	Farmers (no)	Days to maturity	Plant height (cm)	Grain yield (t ha^{-1})
BARI Barley-7	E1	99	65.5	2.00
	E2	102	75.0	2.25
	Mean	101	70.3	2.13
BARI Barley-9	E1	90	95.4	2.25
	E2	94	100.2	2.50
	Mean	92	97.8	2.38
BARI Oat-1	E1	120	107.5	0.90
	E2	126	111.3	1.00
	Mean	123	109.4	0.95

Conclusion

The yield performance of BARI Barely-7, BARI Barely-9, and BARI Oat-1 is promising. Therefore, BARI Barely-7, BARI Barely-9, and BARI Oat-1 may be cultivated in char areas of Gaibandha.

Project IV:

Integrated Farming

- Plainland Ecosystem
- Drought Ecosystem
- Coastal Ecosystem
- Charland Ecosystem

INTEGRATED FARMING RESEARCH AND DEVELOPMENT FOR LIVELIHOOD IMPROVEMENT IN THE PLAINLAND ECOSYSTEM

M.S.H. MOLLA, M.R. ALAM, M.A.H. TALUKDER, M.S. RAHMAN, S. AHMED, M.A.H. KHAN AND Q. NAHER

Abstract

Livelihood improvement is a very complex system and an individual's livelihood involves the capacity to acquire necessities in order to satisfy the basic needs. The program was undertaken during 2018-19 to 2020-21 to develop integrated farming technologies, fine tune the technologies generated by NARS institutes, integrate component technologies with efficient use of farm resources and thereby improve family income and livelihoods. It was conducted at 5 Farming Systems Research and Development (FSRD) Sites viz., Ajoddhapur (Rangpur), Ganggarampur (Pabna), Sholakundu (Faridpur), Atia, Delduar (Tangail) and Tarakandi (Sherpur). The activities persistently continued during the year of November 2018 to October 2021. Farmers were selected from marginal, small and medium farmers group considering homestead vegetables and fruits, field crops, poultry and livestock, fisheries and off-farm component of farming systems. All components were brought under improved technological intervention. The average homestead size was 0.05, 0.14, 0.09, 0.13 and 0.07 ha at FSRD site Rangpur, Pabna, Faridpur, Tangail and Sherpur, respectively. Over the location, the average vegetables produced per homestead 629 kg after intervention (AI), which was only 167 kg before intervention (BI). The average vegetables consumption during AI was 254 g head^{-1}day^{-1}, which was 279% higher than BI. The average fruits produced per homestead 502 kg, which was only 279 kg during BI. The average consumption of fruits was also increased (Avg. 84%) during AI. The daily nutritional requirements of a family members were supplemented considerably especially carotene and Vit-C through more consumption of vegetables and fruits from the homestead gardening. Animal product from fish, chicken, pigeon, Turkey and livestock also could help to minimize the protein deficiency. Fruit tree management was created a good impact on farm households and a total of 611 fruit trees were brought under pest management and a total of 3811 saplings of different fruits were distributed in different FSRD sites. Women participation (25-80%) in different agricultural activities increased to a great extent that showed some positive effect on gender equity within the family. The average crop land size was 0.43, 0.84, 0.64, 0.61 and 0.54 ha^{-1} in Rangpur, Pabna, Faridpur, Tangail and Sherpur area, respectively. Two or three crops-based CP could be successfully replaced by three to four crops-based CP. Among them Potato included 4 crop-based CP T. Aus-T. Aman rice-Potato/Sweet gourd and T. Aus-T. Aman-Potato-Mungbean produced higher REY 51.39 and 29.99 t ha^{-1}, respectively. In livestock component, after deworming and vaccination, the frequency of major diseases of cattle were reduced to below 7% and addition of vitamin ADE injection increased the lactation period and yield remarkably. Cattle fattening and calf rearing programs were created interest among the farmers. Goat rearing was found promising as low cost required for rearing. In poultry system, Sonali breed, Naked-neck (Garchila) chicken, Khaki Campbell duck, Turkey bird and pigeon rearing in the homestead area created a good impact among the farm families as a good source of income and child nutrition. Mortality of poultry reduced (70-99%) after vaccination. Moreover, production of farmyard manure (3050 kg homestead^{-1}) and vermicompost (320 kg homestead^{-1}) and their utilization, and also green fodder production (53 t ha^{-1}) were created a good impact among the farm families. The average pond size was 0.04-0.06 ha over the locations. Seasonal fish culture with carp polyculture in seasonal pond was found promising than monoculture of Tengra, Pabda and Shing. Carp polyculture gave a satisfactory fish yield (avg. 171 kg per 13 decimal size pond) and gross margin (avg. Tk. 12513 per 13 decimal size pond). From different types of off-farm activities, farmers also earned some extra money (avg. gross margin Tk. 5173 household^{-1}). Among the different production components, field crop sector gave maximum gross margin (Tk. 103647-250910 farm^{-1}) but gross margin increased maximum at homestead vegetable production sector (64-753%), where total gross margin increased 63-277% per farm. The activities (seed and seedling collection, production and distribution/sell) of Local Service Provider (LSP) were found promising for home gardening, vaccination and other activities at FSRD site, Ajoddhapur, Rangpur where about twenty three thousands seedlings of different crops could be produced and supplied or sell among the neighbor farmers by LSP. Partial integration among the farm components was found as a cost saving technology.

Introduction

Integrated farming is a combination of different agricultural activities and a whole farm management system which aims to deliver more sustainable agriculture. It is a dynamic approach which can be applied to any farming system around the world. The subsistence farms of Bangladesh are highly diversified with complex relationships among the various sub-system and the enterprises within a subsystem. While there are different production alternatives, farmers have a limited set of resources. These resources may be utilized in such a manner that maximize farm productivity, farmers benefit and resource use efficiency in an environmentally sound and sustainable way. Particular emphasis is placed on a holistic management approach looking at the whole farm as cross-linked unit, on the fundamental role and function of agro-ecosystems, on nutrient cycles which are balanced and adapted to the demand of the crops, and on health and welfare of all livestock on the farm. Preserving and enhancing soil fertility, maintaining and improving a diverse environment and the adherence to ethical and social criteria are indispensable basic elements (Boller *et al.*, 2004). As per EISA (European Initiative for Sustainable Development in Agriculture) Integrated Farming Framework includes Organization and Planning, Human and Social Capital, Energy Efficiency, Water Use and Protection, Climate Change and Air Quality, Soil Management, Crop Nutrition, Crop Health and Protection, Animal Husbandry, Health and Welfare, Landscape and Nature Conservation and Waste Management Pollution Control (EISA, 2012). An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high and sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment. Farming system is a resource management strategy to achieve economic and sustained production to meet diverse requirement to farm household while presenting resources base and maintaining a high level environmental quality (Lal and Millar, 1990). In other words, farming system is a decision making unit comprising the farm household, cropping and livestock system that transform land, capital and labour into useful products that can be consumed or sold (Fresco and Westphal, 1988). The system specially refers to a group combination of enterprises in which the products and or the by products of one enterprise serve as the inputs for production of other enterprise. However, land topography, soil composition and availability of different inputs along with the environmental factors influence the farmers in choosing different enterprises (Uddin and Takeya, 2005).

A holistic approach to technology generation and packaging is essential to achieve this result through maximizing the complementary interactions among the different farming enterprises/ production system and the biophysical and socio-economic environment. Bangladesh Agricultural Research Institute (BARI) is conducting research on different discipline through a number of programs and divisions. Those programs and divisions are generating a good number of technologies including new cultivars/different management techniques/machines etc. for the farmers of Bangladesh. However, before transferring those to extension agencies/ NGOs and farmers they need on-farm verification/test of fine-tuning to fit into the farmers existing socio-agro-economic environments. Moreover, to modify technology or to develop new technology through on-farm trial, valuable farmers' feedback was obtained. BARI has given this noble responsibility to OFRD to test those developed on–station technologies directly to the farmer's field. Higher production and income generation can ensure by proper utilization of these resources with improved technologies. BARI has developed a number of technologies which can be used for increasing production and income of the farmer. BARI and BRRI have already developed improved cropping pattern with management practices involving 3 or 4 crops. Besides, BFRI and BLRI also developed improved technologies on calf rearing, poultry rearing and high value fish culture. Increasing profitability by minimizing resource loss through reuse of wastage of one component as an input of other components and making integration is getting priority in the program. Thrusts are given on Local Service Provider (LSP) development at the site level for more sustainability of farming systems activities. Verification of new technologies, integration of different farming components for livelihood improvement and dissemination of proven technologies developed by NARS institutes on crops, cropping pattern, climate resilient options, resource conservation technologies, plantation crops, homestead production systems, fish, livestock and poultry production as well as other income generating activities were included in this program. Therefore, the program was conducted under plainland ecosystem focusing the improvement of livelihood of rural households through generation and adoption of Farming System Technologies.

Objectives

i) To develop integrated farming technologies to maximize farm productivity with efficient use of farm resources.

ii) To modify fine tune on station technologies generated by NARS institutes and at different FSRD sites of plainland ecosystems.

iii) To integrate component technologies (crops, livestock, fisheries, agro-forestry, homestead gardening and off farm activities, etc.) for improving farm productivity.

iv) To establish linkage with different stakeholders.

Methodology

Implementing locations: The implementing locations were selected based on climatic, edaphic, social, vegetation and economic conditions of the regions. Two villages were selected for each FSRD site i.e., Ajoddhapur, Rangpur; Gangarampur, Pabna; Sholakundu, Faridpur; Atia, Delduar, Tangail and Tarakandi, Sherpur.

FSRD site Ajoddhapur, Rangpur:

Two villages named South Ajoddhapur and Jhautary village under Rangpur Sadar upazila of Rangpur district were considered for FSRD activities. Ajoddhapur has a distance of sixteen km from the upazila head quarter and is located at the west side (25°40′ N latitude and 89°10′ E longitude; AEZ-3).

FSRD site Gangarampur, Pabna:

In Pabna, Gangarampur has a distance of eighteen km from the upazila head quarter and is located at the east side (24°03′ N latitude and 89°38′ E longitude; AEZ-11).

FSRD site Sholakundu, Faridpur:

The Integrated Farming Research and Development for Livelihood Improvement in the Plainland Ecosystem project site named Sholakundu, Kanaipur, Faridpur is located at 23°43' north latitude and 89°28' east longitude (AEZ-11 and 12). The site is situated about 10 km south of district head quarter. It spreads over a part of Kanaipur union under Faridpur Sadar upazila.

FSRD site Atia, Tangail:

The FSRD site Atia is situated at the two villages namely Hinganagar and Mahmudpur of Atia union under Delduar Upazila of Tangail district. It is twelve km far away from the district headquarter and is also located at the east side 24°17' N latitude and 89°90' E longitude. Delduar Upazila with an area of 184 sq.km is bounded by Tangail Sadar and Basail upazilas on the north, Nagorpur upazila on the south, Basail and Mirzapur upazilas on the east and Nagorpur and Tangail Sadar on the west. Dholeshori river flow at the west side of this Upazila. Communication of the village with upazila headquarter is well and mode of transportation is bus, autorickshaw, motorcycle, bicycle, rickshaw, 3-wheelers etc.

FSRD site Tarakandi, Sherpur:

The Tarakandi, Sherpur FSRD site is located at N 24°58'59.33" to E 90°06'21.62". The area is under Old Bhramaputra Floodplain (AEZ-8 and AEZ-9). Sherpur is bounded by Jamalpur district on the south and west, Mymensingh district on the east, Indian province of Meghalaya on the north. Main rivers are Brahmaputra and Vogad.

Specific Methodology

The following methods were considered for the successful implementation of the proposed integrated farming systems research and development program -

The integrated farming research and development activities were executed at Plainland ecosystem (FSRD site Gangarampur, Pabna; Ajoddhapur, Rangpur; Sholakundu, Faridpur; Atia, Tangail and Tarakandi, Sherpur) during the years of November 2018 to October 2021 to improve livelihood of rural households through generation and adoption of Farming System Technologies especially integrated farming technologies and the technologies generated by NARS institutes. The program was executed in a participatory approach, where critical inputs and technological suggestions were provided by BARI personnel and other commodities were used from farmer's own sources. Based on farmer's traditional practices, their needs and choices, several alternatives of technologies of crops, livestock, fisheries, off-farm activities and other components were incorporated with active participation of the farmers. According to the aim of the program resource poor farmers-marginal, small and medium having major components of farming and sizeable homestead under single ownership were targeted and twelve farm households from two villages were selected at each site (Table 1).

Table 1. Category-wise selected farmers information of different FSRD sites.

FSRD site	Categories	No. of Farmer	Av. family size (no.)	Av. crop land size (ha)	Av. homestead area (ha)	Av. pond area (ha)
Ajoddhapur, Rangpur	Marginal	4	4.5	0.18	0.057	0.032
	Small	4	4.25	0.44	0.058	0.034
	Medium	4	5.25	0.97	0.048	0.054
Gangarampur, Pabna	Marginal	4	5.0	0.435	0.084	0.03
	Small	4	5.75	0.891	0.126	0.04
	Medium	4	5.5	1.188	0.195	0.04
Sholakundu, Faridpur	Marginal	4	4.50	0.17	0.047	0.028
	Small	4	5.00	0.64	0.103	0.037
	Medium	4	4.25	1.12	0.11	0.06
Atia, Delduar Tangail	Marginal	4	6.5	0.19	0.11	-
	Small	4	4.66	0.58	0.13	0.05
	Medium	4	5.0	1.05	0.16	0.05
Tarakandi, Sherpur	Marginal	1	4.00	0.06	0.06	-
	Small	8	4.38	0.45	0.064	0.048
	Medium	3	5.33	1.12	0.08	0.08

Farmers capacity building and awareness develment activities regarding nutrition and crop production were conducted through training program. An individual household survey (Benchmark survey) was carried out before starting the project activities. The detail information regarding livelihoods pattern were documented. Total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year was accounted by detail households' case study with intensive visit and cross examinations for authentication of the data before intervention. Based on the potentials suitable technological options were addressed to the farmers and accordingly farmers selected suitable technologies adjusting with their need for livelihood improvement. Year-round vegetable production followed by respective location-wise model in each homestead, fruit tree management and new plantation, crops and cropping system improvement through improve cropping pattern development and promising variety piloting, vaccination of poultry and livestock, rearing of Turkey, poultry, pigeon and calf, green fodder production, fish culture and some off-farm activities were identified as their major potential area.

Site working group meeting, PRA, base line survey, field visit was done, and field staffs were organized during the implementation period of program. On-Farm Research Division (OFRD) team facilitated the cooperators for technological intervention to maximize the productivity of the components. However, season-wise data on production, farm level utilization with disposal pattern, possible integration among the components, economic return focusing income and expenditure and other socio-economic information were collected and presented in the report in tabular form.

A. HOMESTEAD PRODUCTION SYSTEM

A benchmark survey was carried out before going to implement the program to know the existing agricultural situation for technology intervention of the pilot areas. Twelve different categories farmers were selected on the basis of available resources and potentials for homestead farming and averaged shown here. Each farm families consist of average 5 members. The selected farmers were provided training and suggestion by the FSRD team on year-round vegetables and quick growing fruits production following respective site wise production model. Thereafter, the trained farm families produced vegetables and fruits in their homestead area following respective site-wise homestead production model.

a) Vegetables

Depending on farmers' choice and agro-ecological suitability, the vegetables production models of different locations were determined and followed accordingly**.**

Table 2**.** Different models for vegetables production in homestead area in different farming system research and development **(**FSRD**)** sites under plainland ecosystem.

Table 2a. Goyeshpur model (Gangarampur, Pabna)

Niche/space				Cropping patterns		
				Rabi	Kharif–I	Kharif–II
1.	Open sunny space	Bed-1	:	Radish	Stem Amaranth	Indian spinach
		Bed-2	:	Cabbage	Brinjal	Red Amaranth
		Bed-3	:	Tomato	Spinach	Okra
2.	Fence		:	Bitter gourd	Yard long bean	Bitter gourd
3.	Trellis		:	Bottle gourd	Sweet gourd	Sweet gourd
4.	Roof		:	Bottle gourd	Wax gourd	Wax gourd
5.	Tree support		:	Bitter gourd	Ridge gourd	Sponge gourd
			:	Potato yam	Snake gourd Potato yam	Potato yam
			:	Country bean	Yard long bean	Yard long bean/Country bean
6.	Partial shady area		:	Elephant foot yam		
			:	Leaf aroid (moulavi kachu)		
			:	Turmeric		
			:	Perennial chilli		
7.	Marshy land		:	Pani kachu (Latiraj)		
8.	Homestead boundary		:	Papaya (3-5 plant)		
			:	Guava (1-2 plant)		
			:	Lemon (1-2 plant)		
9.	Back yard /waste land		:	Laizna (1-2 tree)		
			:	Banana		

Table 2b. Syedpur model (Modified) (Ajoddhapur, Rangpur)

Niche/space		Year–round homestead vegetables and fruits pattern		
		Rabi (October- March)	Kharif–I (April-June)	Kharif–II (July-September)
1. Open sunny space	Bed 1	Radish	Red amaranth	Kangkong
	Bed 2	Cabbage	Stem amaranth	Merah shak
	Bed 3	Brinjal + **Spinach**	Red amaranth	Indian spinach
	Bed 4	Tomato + Napashak	Okra	Red amaranth
	Bed 5	Garlic+Leafy coriander	Leafy Jute	Okra

Niche/space	Year–round homestead vegetables and fruits pattern		
	Rabi (October- March)	Kharif–I (April-June)	Kharif–II (July-September)
2. Roof	Bottle gourd	Ash gourd	Ash gourd
3. Trellis	Country bean	Sweet gourd/snake gourd	Sweet gourd
4. Fence	Bitter gourd/country bean	Yard long bean/Ribbed gourd	Bitter gourd
5. Tree support	Country bean	Potato yam/Sponge gourd	Potato yam/
6. Marshy land	Water tarro (Kalakachu), Aroid (Latiraj)		
7. Backyard	Papaya, Banana, Guava, Mango, Lemon, Sugarcane, Palm, Moringa		
8 . Partially shady place	Ginger, Turmeric, Moulovi kachu		
9. House boundary	Papaya, Lemon, Multa etc.		
10. Pond bank	Creeper vegetables, Papaya, Lemon, Napier grass etc.		

Table 2c. Ishan Gopalpur model (Sholakundu, Faridpur)

Sl.no	Location		Cropping Pattern
1	Open space	a	Radish-Red Amaranth-Indian spinach
		b	Spinach-Tomato-Stem Amaranth
		c	Cabbage-Okra-Okra
		d	Cauliflower -Gimakolmi- Gimakolmi
		e	Broccoli-Red Amaranth- Stem Amaranth
		f	Potato-Indian Spinach-Indian Spinach
2	Roof top		Bottle gourd-Ash gourd
3	Trellis		Bottle gourd-Sponge gourd Bottle gourd- Sweet gourd
4	Tree support		Potato yam
5	Partial shady area		Moulavi kachu
6	Marshy Land		Tarro
7	Fence		Country bean-Ribbed gourd/ Country bean- Bitter gourd
8	Homestead boundary		Papaya, Guava and Lemon
9	Back Yard/ Waste land		Banana
10	Pond bank		Sweet gourd-Ash gourd/ Country bean- Ribbed gourd

Table 2d. Palima model (Atia, Tangail)

Niche/space			Cropping patterns		
			Rabi	Kharif–I	Kharif–II
1.	Open sunny space	Bed 1	Tomato/Radish	Okra	Indian spinach
		Bed 2	Brinjal + Lalshak	Indian spinach	Okra + Lalshak
		Bed 3	Spinach	Gimakalmi	Gimakalmi
		Bed 4	Bush bean	Amaranthus	Indian spinach
2.	Trellis		BARI Lau-1/Local	Ash gourd	Sponge gourd
			BARI Lau-2/Local	Bitter gourd	Snake gourd
			Lau	Sweet gourd	Ash gourd
3.	Roof		BARI Lau-1/Local	Ash gourd	Ash gourd
			Sweet gourd	Ash gourd	Ash gourd
4.	Tree support		Mete Alu	Mete Alu	Mete Alu
			Mete Alu	Mete Alu	Mete Alu
			-	Sponge gourd	Sponge gourd
5.	Partial shady area		Ginger	Ginger	Ginger
			Ginger	Ginger	Ginger
6.	Pond bank		Napier	Napier	Napier
			Lau	Blackgram	Blackgram
			Arum	Arum	Arum
7.	Slightly marshy land		Latiraj	Latiraj	Latiraj

Table 2e. Narekeli model (Tarakandi, Sherpur)

Niche/space		Cropping pattern		
		Rabi	Kharif–I	Kharif–II
1. Open sunny space	Bed 1	Tomato	Indian spinach	Danta
	Bed 2	Lalshak + Cabbage	Kangkong	
	Bed 3	Coriander + Onion	Okra	
	Bed 4	Spinach + Garlic	Chilli	
	Bed 5	Carrot + Bitter gourd	Latiraj kachu	
2. Roof top		Country bean	White gourd	-
3. Trellis		Country bean, bottle gourd	Yard long bean	-
4. Fence		Bitter gourd	-	-
5. Marshy land		Latiraj kachu		
6. Shady place		Turmeric, Ginger		
7. Boundary		Papaya, Drumstick		
8. Unused tree		Potato yam		

b) Fruits

Based on farmers' choice, agro-ecological suitability and human nutrition requirement, the fruits saplings were supplied and plantation were done in the homestead area and nearby homestead area. In Rangpur, a sole Dragon fruit orchard and a mixed fruit garden with Mango, Guava and Litchi were established. Mixed fruit garden was also established at Pabna. Irrigation, fertilization, pest control and other management of new and existing fruit trees were undertaken in this program.

B. CROPS AND CROPPING SYSTEM

a) Improvement or development of cropping pattern

Among the existing cropping patterns of different locations, more prominent cropping pattern were considered for the improvment or replace by alternate profitable cropping pattern. To increase crop productivity, two to three cropping patterns were considerd for development at each FSRD site under plainland ecosystem.

Table 3. Activities for improvement or development of cropping pattern under plainland ecosystem.

FSRD sites	Existing cropping pattern	Date of sowing/ transplanting	Date of harvesting	Alternative/improved cropping pattern	Date of sowing / transplanting	Date of harvesting
Gangarampur, Pabna	T. Aman (BRRI dhan39)- Mustard (Tori-7)-Boro(Toba)	22-28 Jul 26-30 Nov 25-28 Feb	02.03 Oct 20-25 Feb 3-7 Jun	T .Aman (Binadhan-17)- Mustard (BARI Sarisha-17)-Boro (BRRI dhan28)	24 July 15 Nov 20 Feb	05 Nov. On going 16 May
	T. Aman (BRRI dhan39)- Lentil (BARI Masur-6)- Sesame (Local)	25-30 July 15-20 Nov 15 Mar	02.03 Oct 15 Mar 25 Jun	T. Aman (Binadhan-17)- Lentil (BARI Masur-8)- Sesame (BARI Til-4)	30 Jul 10 Nov 9 Mar	8 Nov On going 20 June, 19
Ajoddhapur, Rangpur	T. Aman (Swarna)- Fallow- Boro (BRRI dhan28)	20-25 July - 25-28 Feb	27-30 Nov - 20-23 Jun	T .Aman (Binadhan-17)- Mustard (BARI Sarisha-14)- Boro (BRRI dhan28)	5-18 Aug 27 Nov-7 Dec 25 Feb-7 Mar	11-19 Nov 22-27Feb 28Jun-11 Jul
	T. Aman (Swarna)- Potato (BARI Alu-8)-Boro (BRRI dhan28)	5-10 Aug 1-5 Dec 1-7 Mar	23-30 Nov 24-27 Feb 15-22Jun	T .Aus (BRRI dhan48)- T. Aman (Binadhan-17)- Potato (BARI Alu-25)- Sweet gourd (BARI Hybrid Mistikumra-1)	10-17 May 12-17 Aug 25-30 Nov 7-12 Dec. (relay)	5-10 Aug 20-23 Nov 5-9 Feb 7-14 April
Sholakundu, Faridpur	Lentil (Local)- Jute (JRO 524)-	28 Nov to 4 Dec 26 Mar to 5 Apr 30 Jul to 15 Aug	15-20 Mar- 20-30 Jul- 12-30 Nov	Lentil (BARI Masur-8)-	16-30 Nov 28 Mar 7 Apr 10-15 Aug	8-24 Mar 1-8 Aug 17-20 Nov

	T. Aman (BRRI dhan39)			Jute (Rabi-1)- T. Aman (Binadhan-17 /BRRI dhan75)		
	Mustard (Tori-7)- Jute (JRO 524)- T. Aman (BRRI dhan39)	9-20 Nov/ 25-30 Nov.- 26 Mar to 5 Apr 20-30 Mar	27 Jan to 6 Feb /10-15 Feb- 20 Jul to 3 Aug /18-25 Jul. 5-15 Nov./ 25-30 Nov	Mustard (BARI Sarisha-17/18)- Jute (Rabi-1)- T. Aman (Binadhan-17/ BRRI dhan75)	9-20 Nov./ 25-30 Nov.-26 Mar to 5 Apr./ 20-30 Mar.- 12-18 Aug./ 5-10 Aug	10-18 Feb/ 5-8 Mar- 28 Jul to 6 Aug/20-27 July- 15-20 Nov.
Atia, Delduar Tangail	Boro (BRRI dhan29)- T. Aman (BR11)- Mustard (Tori-7)	6-15 Feb.- 8-14 Jul- 10-15 Nov.	13-22 Jun- 24-31 Oct- 25-30 Jan	Boro (BRRI dhan29)- T. Aman (BRRI dhan72)- Mustard (BARI Sarisha-14)	10-18 Feb.- 25-31 Jul- 12-16 Nov.	15-24 Jun.- 25-30 Oct.- 5-10 Feb.
	Brinjal (Singhnath)- T. Aman (BR11)- Cabbage (Autumn queen)	20-25 Jan.- 14-25 Jul- 15-19 Nov.	10 Mar to 28 Jun- 24-29 Oct 10-20 Feb.	Okra (BARI Dherosh-2)- T. Aman (BRRI dhan72)- Cabbage (Autumn queen)	9-12 Mar. 20-25 Jul.- 10-16 Nov.	20 Apr to 25 Jun 14-20 Oct.- 7-17 Feb.
Tarakandi, Sherpur	T. Aman (Hori) -Fallow- Boro (BRRI dhan29)	27 to 29 Jul- Fallow- 25 to 26 Jan	20 to 25 Nov-Fallow- 20 to 30 May	T. Aman (BRRI dhan49)- Potato (BARI Alu-25)- Mungbean (BARI Mung-6)- T. Aus (BRRI dhan48)	18 to 29 Aug- 18 to 28 Nov- 4 to 9 Mar- 28 May to 02 Jun	10 to 15 Nov- 17 to 20 Feb- 10 to 20 May- 15 to 20 Aug
	T. Aman (Hori) -Fallow- Boro (BRRI dhan29)	27 to 30 Jul- Fallow- 25 to 27 Jan	24 to 26 Nov-Fallow- 25 to 29 May	T. Aus (BRRI dhan48- T. Aman (BRRI dhan49)- Motorshuti (BARI Motorshuti-3)- Boro (Hybrid shakka)	25 to 30 May- 20 to 28 Aug- 21 to 24 Nov- 4 to 17 Feb	13 to 15 Aug- 10 to 15 Nov- 28 to 30 Jan- 14 to 20 May

b) On-farm verification/production program

Bangladesh Agricultural Research Institute and other NARS Institutes have developed many modern varieties of different crops, which are high yielder as well as short in duration. To identify the suitable crops and varieties, on-farm verification trial was conducted during years of 2018-19 and 2019-20 with different types of crops e.g., Mustard, Potato, Tomato, Wheat, Mungbean, Sesame, Lentil, Barley, Okra, Radish, etc. The identified suitable varieties were brought under production program at each location in the following years. The details of crop management are given in result part.

Table 4. Different operations conducted for production program at different FSRD sites under plainland ecosystem during the years of 2018 to 2021.

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Ajoddhapur, Rangpur	Mustard	BARI Sarisha-14	6	1	21-28 Nov.	27-28 Feb.
		BARI Sarisha-18	2	1	20-30 Nov.	7-8 March
	Tomato	BARI Tomato-15	3	0.5	16-18 Nov.	15 Feb-09 March
	Potato	BARI Alu-25	7	1.4	28-30 Nov.	27Feb.-05 March
		BARI Alu-53	5	1	30 Nov-10 Dec	04-10March
Gangarampur, Pabna	Mustard	BARI Sarisha-17	4	0.5	2-5 Dec.	13-15 March
	Lentil	BARI Masur-8	4	0.5	1-5 Dec.	15-20 March
	Pea	BARI Motor-3	9	1.0	25-28 Nov.	5-10 March
Sholakundu, Faridpur	Mustard	BARI Sarisha-14	3	0.24	8-15 Nov 18	6-12 Feb

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
		BARI Sarisha-18	3	0.3	30 Nov. -3 Dec.	9-11 Mar
	Wheat	BARI Gom-28	4	0.4	30 Nov. -2 Dec.	24-25 Mar
		BARI Gom-33	3	0.4	30 Nov. -8 Dec.	19-27 Mar
	Mungbean	BARI Mung-6	2	0.16	5 Mar	12-27 May (2 picking)
		BARI Mung-8	3	0.24	1-2 March	9-10 May (1 picking)
	Sesame	BARI Til-4	3	0.24	8-12 Mar	1-3 Jun
		BARI Til-4	4	0.25	19-25 March	15-22 Jun.
	Lentil	BARI Masur-8	3	0.3	28 Nov.-3 Dec.	20-22 Mar
		BARI Masur-8	4	0.25	19 Nov-3 Dec	--
	Onion	BARI Piaj-1	3	0.3	4-14 Jan	24-31 Mar
		BARI Piaj-4	3	0.3	1-10 Jan	24-31 Mar
		BARI Piaj-1	4	0.5	30 Dec 20-10 Jan	--
		BARI Piaj-4	4	0.5	30 Dec 20-10 Jan	--
	Bottle gourd	Hybrid	1	0.06	25 Jul	25 Sep-20 Nov
	Summer Tomato	BARI Hybrid Tomato-11	1	0.012	16 Aug	7-31 Oct
	Black gram	BARI Mash-3	2	0.2	17 Sep	3 Dec
	Intercropping of Radish + Onion bulb + Red amaranth with Sugarcane	Radish (BARI Mula-1), Onion (BARI Piaz-1), Red amaranth (BARI Lalshak-1), Sugarcane (Gendari local)	1	0.06	Sugarcane: 28 Oct Radish+Onion+red amaranth: 1 Nov	Sugarcane: 5-18 Oct Radish: 1-5 Jan Onion: 5-10 Jan Red amaranth: 4-5 Dec
Atia, Delduar, Tangail	Mustard	BARI Sarisha-14	29	5.53	14-24 Nov.	03-11 Feb.
		BARI Sarisha-17	25	3.90	16-24 Nov.	5-12 Feb.
	Barley	BARI Barley-6	8	1.15	20-26 Nov.	15 Feb-09 March
		BARI Barley-7	7	1.11		
	Potato	BARI Alu-41	21	2.92	25Nov.- 04 Dec	20-27 Feb.
Tarakandi, Sherpur	Mustard	BARI Sarisha-14	1	124 dec	03-06 Nov.	21-22 Jan.
	Okra	Shakti (Hybrid)	1	15 dec	15-18 March	1-25 May
	Potato	BARI Alu-35 BARI Alu-36 BARI Alu-37 BARI Alu-40 BARI Alu-41	1	124 dec	28-30 Nov.	19-20 Feb.

C. LIVESTOCK COMPONENT

Farm animal health is the triggering criteria for productivity and profitability of livestock and maintaining of livestock health is an integral part of integrated farming. Cattle health may be improved through deworming which may make the farmer economically benefitted. More than 10 faeces sample of cattle were selected from different location by the symptomatic parasitic infection and then investigated the parasites through faeces sample analysis for the confirmation. After confirmation of parasitic infestation, the test animal was de-wormed by broad spectrum anthelmintics i.e., Trilev-vet (Livamisole and Triclabendazole) for round worm and liver fluke as per recommendation for the body weight. After deworming, Vitamin A, D and E containing injections were also being injected in cattle. Proper vaccination against four major diseases may reduce the mortality rate of cattle. For this purpose a short FGD was conducted to identify the disease severity and mortality after vaccination. In the vaccinated group Anthrax vaccine, Foot and mouth disease (FMD) vaccine, Blood quarter (BQ) vaccine and Hemorrhagic septicemia (HS) vaccine were injected as per recommended schedule. Cattle fattening and Calf rearing programs were also continued at some areas.

Besides of cattle product, cowdung is very important by-product for integrated farming and farmers were motivated to use it for preparation of farm yard manure (FYM) including other homestead westage instead of using the cowdung as fuel.

Napier grass was identified as a suitable and profitable green fodder to produce in the homestead and its surrounding areas especially on pond bank. Farmers were advised to apply FYM after every cut of grass. It was introduced among the farmers under the program to produce for feeding their cattle. Some farmers were also selling their produced Napier grass in the market besides of feeding their cattle.

In rural Bangladesh, poultry rearing is a common practice. Poultry disease is the main problem faced by the farmers for poultry rearing. Only proper vaccination can reduce the mortality rate of poultry. To reduce mortality rate and investigating effectiveness of poultry vaccine at farmers' level this program was conducted at the farmer's field. A good number of poultry birds were vaccinated during the project period. In the vaccinated group BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague vaccine were used as per recommended schedule. Regular contact was done by the facilitator team for providing necessary suggestions to solve their specific problems. In some locations, Chick rearing, Pigeon rearing, Duck rearing and Turkey rearing programs were also carried out.

D. FISHERIES COMPONENT

In case of fish culture in pond under homestead area, improper management is the major hindrance against profitability. The carp poly culture and monoculture of Tilapia, Pabda, Shing, Tengra etc. programs in perennial and seasonal ponds were undertaken at the FSRD sites with the objectives of increasing farmer's income and removing protein deficiency of rural people. For fish cultivation, weeds and wild fishes were removed from the pond and Lime was given at the rate of 1 kg per decimal as well as prepared for stocking with organic manure (cowdung) at the rate of 3 kg per decimal. Fingerlings stocking density is mostly depending on fingerlings size, species, pond depth, feed availability etc. However, in poly culture system, Silver carp, Catla, Rui, Mrigal, Common and Mirror carp may form 20–30%, 10–15%, 15–20%, 10–15% and 15–20% respectively maintaining 20-30 fingerlings decimal^{-1} Fish feed partially collected and supplied by the co-operative farmers whereas Lime and fingerlings were supported from the program. The office personnel of the respective FSRD site were checked periodically and provided suggestion for fish culture.

E. OFF-FARM ACTIVITIES

Off-farm (non-farm) income refers to the portion of farm household income obtained off the farm, including nonfarm wages and salaries, pensions, and interest income earned by farm families. Since the last three decades or so, there has been increasing evidence showing that small-holder farm households in developing countries rarely rely on agriculture alone, but often maintain a portfolio of income activities in which off-farm activities are an important component (Barrett *et al.*, 2001).

Some farm families' especially the women were engaged with off-farm activities. Some farmers had small grocery shop and opened at his off-time and also had practice of weaving *Katha* and cloth sewing with machine. Commercially cooking is also practiced in some cases by the men. The women were also engaged in making *Kumra bora, Pilo cover,* making handicrafts with rope, plastic ball etc. during their leisure periods and men were engaged with basket making and van/rickshaw pulling.

F. LOCAL SERVICE PROVIDER (LSP)

For the better execution of farming activities and to make them more sustainable, one male and one female Local Service Provider (LSP) was selected form the co-operator farmers. The LSP was selected based on their knowledge level, eagerness, technology understanding and dissemination capability, local and social acceptance, etc.

G. INTEGRATION AMONG DIFFERENT COMPONENTS

Several enterprises like home gardening with vegetables and fruits, crops and cropping system, dairying, poultry, fishery, etc. are the part of integrated farming and these enterprises are interrelated. The final product and wastage of one enterprise may use as input in another enterprise. Moreover, judicious use of farm resources may reduce production cost and can help to keep clean the environment. The contribution of one component on other component ('s) is important consideration for sustainable farming.

Results and Discussion

A. HOMESTEAD PRODUCTION SYSTEM

Activity 1. Year-round vegetables and fruits production in homestead area

FSRD Site, Gangarampur, Pabna

Vegetables production: Available and utilizable production niches of the homestead areas were brought under cultivation with the suggested vegetables following Goyeshpur model. The fallow and under-utilized homestead areas were utilized scientifically considering time and space. In the production system, nine niches were utilized in Goyeshpur model. After intervention of the proven and improved technologies in the homestead, vegetables production has increased remarkably. It was observed that the average vegetables production was 459 kg homestead^{-1}) in *Rabi* season followed by *Kharif-1* (278 kg homestead^{-1}) and *Kharif-2* (271 kg homestead^{-1}) season (Table 6a).

Maximum vegetables were produced during *Rabi* season followed by *Kharif-1* season. *Kharif-2* season was comparatively a dull season for vegetables production when vegetables were mostly affected by seasonal drought and sometimes excessive rainfall. After intervention of the improved technologies, vegetables production was increased 134% compared to before intervention of the program (Table 6b). The remarkable increment of vegetables production in homestead area might be enhanced by using improved technologies and optimum management practices.

Utilization of vegetables: The disposal pattern of different vegetables produced in the homestead area was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetables varied with amount of total vegetables production (Table 6c). The average vegetables intake per year per farm family was 466 kg after program intervention which was 122% higher as compared to the before intervention (210 kg per family per year). Vegetable intake by a member of 5 member's farm family was increased remarkably and it was on an average 255 g head^{-1} day^{-1}. After program intervention, the average distribution of vegetables per farm per year was recorded 72 kg and sell of vegetables per year was 392kg. Increased production of vegetables encouraged the farm families to distribute relatively more vegetables to their relatives and neighbor, which might be helpful to increase their relationship and it also, helped them to earn more money from more selling of vegetables. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Fruits production: Quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Jack fruit, Coconut, Wood apple, pummelo etc.) were managed through pruning, pest control, fertilization and irrigation. After intervention of the proven and improved technologies in the homestead, fruits production has increased remarkably. Higher quantity of average fruits production per year per farm was found in *Kharif-2* (537 kg homestead^{-1}) followed by *Kharif-1* (410 kg homestead^{-1}) and *Rabi* (283 kg homestead^{-1}) season, which was more or less the reverse scenario of vegetables production (Table 6a). Maximum fruits were produced during *Kharif-2* season and minimum fruits were produced during *Rabi* season and it is actually due to less availability of *Rabi* (winter) fruits species and variety. In this regard, scientists should give more emphasis to develop more winter fruits varieties. After implementation of the program, the fruits productions were increased 47% compared to before intervention of the program (Table 6b). Using of improved technologies including judicious fertilizer management in fruits production has increased the yield tremendously.

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely. The average fruits intake per year per farm family was 599 kg after program intervention which was 103% higher as compared to before intervention (295 Kg per family per year) mainly due to incremental production (Table 6c). After program intervention, the distribution of fruits per year per family was recorded 175 kg and selling of fruits per year per family was 456 kg. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, and the farmers were also sold their fruits for getting satisfactory cash money.

Income: After program intervention, gross return and gross margin was recorded Tk. 13955 and Tk. 10699 per year per farm from year-round vegetables whereas gross return and gross margin was Tk. 4566 and Tk. 3818 per year per farm was noted before intervention. From the fruits sector, after program intervention, average gross return and gross margin was recorded as Tk. 31158 and Tk. 24391 per farm whereas gross return and gross margin was Tk. 16700 and Tk. 13775 per year per farm was noted before intervention (Table 6c).

Table 6a. Round the year vegetable and fruits production from different niches of homestead during the years of November 2018 to October 2021 at FSRD site, Gangarampur, Pabna.

Space		Rabi			Kharif-1			Kharif-2			Total (kg)		
		2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
open sunny space	Bed-1	30	43	60	22	27	31	20	21	25	72	91	116
	Bed-2	45	47	65	25	19	27	10	16	14	80	82	106
	Bed-3	30	41	57	26	22	23	12	12	14	68	75	94
Roof top		40	31	42	35	-	1	15	-	19	90	31	77
Trellis		60	56	69	17	21	25	30	20	30	107	97	124
Shady place		45	21	35	60	23	26	50	32	30	155	76	91
Marshy land		-	-	-	40	24	22	25	34	25	65	59	47
Unproductive tree		21	13	24	-	9	12	10	10	10	31	32	46
Fence		16	16	18	10	14	12	10	8	6	36	38	36
Backyard		18	25	40	35	33	41	45	54	32	98	112	113
House boundary		38	48	49	45	40	52	50	65	60	133	153	161
Total vegetables		343	341	459	315	232	286	277	272	264	935	845	1011
Fruits		275	245	329	430	395	406	545	505	561	1250	1145	1296
Total (veg.+ fruits)		618	586	788	745	627	692	822	777	825	2185	1990	2307

Table 6b. Round the year vegetables and fruits production from different niches of homestead during the years of November 2018 to October 2021 at FSRD site, Gangarampur, Pabna.

Niches	Before intervention		After intervention									
			2018-19		2019-20		2020-21		Av. 2018 to 2021		Av. increment over before intervention	
	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)	Production (Kg)	Income (Tk)
Open sunny place	-	-	220	3530	248	3852	316	4740	261	4040	261	4040
Roof top	25	288	90	2035	31	357	77	1155	66	1182	41	894
Trellis	75	862	107	1230	97	1116	124	1860	109	1402	34	540
Shady place	90	1035	155	1783	76	874	91	1365	107	1340	17	305
Marshy place	50	575	65	748	59	678	47	705	57	710	7	135
Unproductive tree	12	138	31	356	32	368	46	690	36	471	24	333
Fence	-	-	36	414	38	437	36	540	37	464	37	464
Backyard	60	690	98	1127	112	1288	113	1695	108	1370	48	680
House boundary	85	978	133	1530	153	1760	161	2415	149	1901	64	923
Total	397	4566	935	10753	845	9717	1011	15165	930	11880	533	7314
Fruit (Other places)	835	16700	1250	25000	1145	22900	1296	32400	1230	26766	395	10066
Total (veg. + fruit)	1232	21266	2185	35753	1990	32617	2307	47565	2160	38646	928	17380

Table 6c. Round the year vegetables and fruits production and utilization pattern before and after intervention during the years of November 2018 to October 2021 at FSRD site, Gangarampur, Pabna.

Description	Before intervention		After intervention					
	Vegetables (kg)	Fruits (kg)	Vegetables (kg)			Fruits (kg)		
			2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
Consumption	210	295	472	450	475	607	550	641
Distribution	37	118	56	70	91	135	175	215
Selling	150	422	407	325	445	508	420	440
Total production	397	835	935	845	1011	1250	1145	1296
Gross return (Tk.)	4566	16700	14025	12675	15165	31875	29198	32400
Variable cost (Tk.)	748	2925	3273	2958	3539	6875	6298	7128
Net return (Tk.)	3818	13775	10753	9717	11626	25000	22900	25272

FSRD Site, Ajoddhapur, Rangpur

Vegetables production: The vegetables cultivation program at homestead area was carried out for three consecutive years at the Farming Systems Research and Development (FSRD) site, Ajoddhapur, Rangpur following the "Syedpur Model" (Table 5a) from February 2018 to January 2021. From the results it was found that Open sunny place contributed more for vegetables production followed by Back yard and trellis in all the years and the average vegetables production from open sunny place was 248 kg homestead^{-1}year^{-1} (Table 5b and 5c). From the Table 5a it was observed that the vegetables production was maximum in *Rabi* season (275, 239 and 305 kg homestead^{-1} in 2018-19, 2019-20 and 2020-21, respectively). The second highest vegetables were obtained in *Kharif*-2 season except 2020-21 and in 2020-21, the less vegetables are due to damage by severe flood (Table 5a). The total vegetables production was in increasing trend in 2019-20 compared to 2018-19 but in 2020-21, it was decreased due to almost fully damage of *Kharif*-2 vegetables by severe flood (Table 5b and 5c). Round the year total vegetable produced 516, 595 and 574 kg homestead^{-1} in 2018-19, 2019-20 and 2020-21, respectively and it was partially contributed by the total number of available production niches. After intervention of the improved technologies, the average vegetable production was increased 290% compared to before intervention of the program. Using of improved technologies and judicious time management for vegetables production might be enhanced the remarkable increment of vegetable production in homestead area.

Utilization of vegetable: The disposal pattern of different vegetable produced in the homestead area was recorded regularly through the help of the co-operator farmers. The three years average results indicated that disposal pattern of vegetables varied after intervention (Table 5c). The average vegetable intake per year per 5 members farm family was 412 kg after program intervention and the increment was 308%, whereas intake was only 101 kg per farm family per year before program intervention. The average vegetables intake by a 5 member's farm family was increased remarkably and it was 226 g head^{-1}day^{-1}. After program intervention, the average distribution of vegetable per year was recorded as 46 kg and average sell of vegetable per year was 104 kg. Increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their relationship and it also helped them to earn more money from more selling of vegetable. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Fruits production: Different types of quick growing fruit trees (Dragon fruit, Papaya, Lemon, Banana etc.) along with other existing fruit trees (Mango, Jackfruit, Coconut, Wood apple etc.) were managed through pruning, pest control, fertilization and irrigation. After intervention of the proven and improved technologies, fruits production was increased significantly. Table 5a showed that higher quantity of fruits production was obtained from *Kharif-1* (699, 572, 570 kg homestead^{-1} in 2018-19, 2019-20 and 2020-21, respectively) season followed by *Kharif-2* (55, 167, and 63 kg homestead^{-1} in 2018-19, 2019-20 and 2020-21, respectively). The *Rabi* season was lean period, which was more or less the reverse scenario of vegetable production (Table 5a). Minimum fruits were produced during *Rabi* season and it is actually due to less availability of *Rabi* (winter) fruits species and variety, where scientists should give more emphasis to develop more winter fruits varieties. After implementation of the program, the average fruits production was increased 110% (Table 5b). The tremendous production of fruits might be due to use of improved technologies including judicious fertilizer management and pest control.

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely in three consecutive years. The three years average fruits intake per year per farm family was 359 kg after program intervention, whereas it was only 264 kg before intervention and the 36% increment was mainly due to increment of total production and motivation (Table 5c). After program intervention, the average distribution of fruits per year was recorded as 113 kg and sell of fruits per year was 291 kg. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested to sell for getting some cash money.

Income: In case of vegetables, after intervention of homestead production system, the income was Tk. 6910, 14140 and 13269 in 2018-19, 2019-20 and 2020-21, respectively. The average increment of income was 511% at after intervention compared to before intervention (Table 5b).

In case of fruits sector, after program intervention, income per homestead was recorded as Tk. 11933, 19850 and 17450 in 2018-19, 2019-20 and 2020-21, respectively. The income was increased in 2nd year than 1st year but decreased in 3rd year due to damage of fruit trees especially Papaya by flood. The average increment of gross margin was 216% at after intervention compared to before intervention (Table 5c).

Table 5a. Round the year vegetables and fruits production per homestead from different niches of homestead during the years of 2018-19 to 2020-21 at FSRD site, Ajoddhapur Rangpur

Space		Rabi October- March			Kharif-1 April-June			Kharif-2 July-September			Total (kg)		
		2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
Open sunny space	Bed-1	45.4	26	28	4	13	15	12	21	5	61.4	60	48
	Bed-2	48.5	29	35	7	26	19	2	4	0	57.5	59	54
	Bed-3	21	20	24	6	23	20	7	24	3	34	67	47
	Bed-4	23.5	32	28	5	20	22	12	13	0	40.5	65	50
	Bed-5	0	8	21	7	17	18	8	23	0	15	48	39
Roof		21	23	35	14	0	10	20	16	10	55	39	55
Trellis		50	33	41	15	23	26	18	14	5	83	70	72
Fence		11.2	2	7	4	6	8	5	0	0	20.2	8	15
Tree support		11.5	0	8	5	0	5	4	7	2	20.5	7	15
Marshy land		14.5	0	3	0	3	8	11	9	13	25.5	12	24
Backyard		15.5	27	23	12	31	28	22	30	10	49.5	88	61
Partially shady place		0	19	18	11	3	7	12	4	2	23	26	27
House boundary		1	3	11	2	4	6	4	6	10	7	13	27
Pond bank		12	17	23	5	9	15	7	8	2	24	34	40
Total (vegetable)		***275***	***239***	305	***97***	***178***	207	***144***	***179***	62	***516***	***595***	574
Fruits		***42***	***55***	65	***699***	***572***	570	***55***	***167***	63	***796***	***794***	698
Total (vegetables +fruit)		317	294	370	796	750	777	199	346	125	1312	1389	1272

Table 5b. Round the year vegetables and fruits production and income per homestead from different niches of homestead during the years of 2018-19 to 2020-21 (Comparative data) at FSRD site, Ajoddhapur Rangpur

Niches	Before intervention		After intervention									
			2018-19		2019-20		2020-21		Av. Nov. 2018 to Oct. 2021		Av. increment over before intervention	
	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (%)
Open sunny place	0	0	208	2084	299	4580	238	3570	248	3411	248	-
Roof	0	0	55	830	39	780	55	1100	50	903	50	-
Trellis	86	1295	83	1335	70	1480	72	1440	75	1418	0	-
Fence	0	0	20	808	8	235	15	450	14	498	14	-
Tree support	0	0	21	308	7	137	15	300	14	248	14	-
Marshy land	0	0	26	510	12	230	24	480	21	407	21	-
Backyard	36	356	50	495	88	5208	61	3050	66	2918	30	-
Partially shady place	22	220	23	230	26	1020	27	1080	25	777	3	-
House boundary	0	0	7	70	13	130	27	729	16	310	16	
Pond bank	0	0	24	240	34	340	40	1070	33	550	33	
Total (vegetable)	144	1871	516	6910	595	14140	574	13269	562	11440	418	511
Fruits	363	5438	796	11933	794	19850	698	17450	763	16411	400	202
Total (vegetables +fruit)	507	7309	1312	18842	1389	33990	1272	30719	1324	27850	817	281

Table 5c. Round the year vegetables and fruits production and utilization pattern before and after Intervention during the years of 2018-19 to 2020-21 at FSRD site, Ajoddhapur Rangpur

Description	Before Intervention		After Intervention							
	Vegetables (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			2018-19	2019-20	2020-21	Av. Nov. 2018 to Oct. 2021	2018-19	2019-20	2020-21	Av. Nov. 2018 to Oct. 2021
Consumption	101	264	396	465	375	412	439	305	332	359
Distribution	28	54	38	35	65	46	145	95	99	113
Selling	15	45	82	95	134	104	212	394	267	291
Total production	144	363	516	595	574	562	796	794	698	763
Gross return (Tk.)	1871	5438	6910	14140	13269	11440	11933	19850	17450	16411
Variable cost (Tk.)	650	1250	2720	2739	2480	2646	3175	3240	3150	3188
Gross margin (Tk.)	1221	4188	4190	11401	10789	8793	8758	16610	14300	13223

FSRD Site, Sholakundu, Faridpur

Vegetables and fruit production : The vegetables cultivation program at homestead area was carried out at the Farming Systems Research and Development (FSRD) site following Ishan Gopalpur vegetable production model using the available and utilizable production niches of the homestead areas. With the consideration of time and space, the fallow and under–utilized homestead areas were utilized scientifically. In the production system at Sholakundu, Faridpur, nine niches were utilized for 2018 to 2021 (Table 7a). After intervention of improved technologies, vegetables production has increased significantly and the most remarkable change was observed in case of open space vegetables produced at open sunny place (Table 7a). The first two years, vegetable production was increasing but in the third year (Feb 2020 to Jan 2021), vegetable production was slightly decreased due to not including of completely rabi 2020-21 vegetables. The total vegetable production was 566 kg, 831 kg, 820 kg per homestead during Feb 18-Jan 19, Feb 19-Jan 20 and Feb 20-Jan 21, respectively (Table 7a). Average increment of vegetables production and income over before intervention was 532 kg and 479%, respectively (Table 7b). Vegetables production in homestead area was enhanced remarkably might be due to effectively use of different production niches, improved technologies and judicious management. Improved management through pruning, pest control, fertilization and irrigation in quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Jackfruit, Coconut, hog Plum etc.) were provide after program intervention and as a result, fruits production has increased significantly. The total fruit production was 167 kg, 200 kg, 390 kg per homestead during Feb 18-Jan 19, Feb 19-Jan 20 and Feb 20-Jan 21, respectively . Average increment of fruit production and income over before intervention was 128 kg and 78%, respectively. Using of improved technologies including judicious fertilizer, pest management in fruits production has increased the yield tremendously. Minimum fruits were produced during Rabi season and it is actually due to less availability of Rabi (winter) fruits species and variety, which needs to introduce more winter fruiting fruit trees like Ber, Guava, Multa etc. In every homestead, a total of 693 kg of fruit and vegetables were produced and 211% income increment over before intervention was shown in Table 7b.

Utilization of vegetables and fruits: Utilization of homestead produced vegetables in the means of consumption, distribution and sold was recorded regularly with the help of the co-operator farmers. From the results it was found that disposal pattern of vegetables varied (Table 7c). During before intervention, vegetables consumption, distribution and selling was 101 kg, 14 kg and 59 kg, respectively whereas after intervention, utilization pattern was increased remarkably (3 to 5 times higher). The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent consumption, distribution and sold . Surplus vegetables produced in homestead area helped the farmers' to earn more cash money from more selling of vegetables . Increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their inter-relationship. After program intervention, the fruits consumption per year per farm family was 71 kg, 155 kg and 225 kg, respectively for Feb 18-Jan 19, Feb 19-Jan 20 and Feb 20-Jan 21. Thus, it is concluded that, consumption ratio was increasing year wise. Average gross margin of after intervention for vegetables and fruits were Tk. 9868 and Tk. 6617, respectively.

Table 7a. Round the year vegetables and fruits production from different niches of homestead during the years of November 2018 to October 2021 at the FSRD site, Sholakundu, Faridpur.

Space		Rabi			Kharif-1			Kharif-2			Total (kg)		
		October- March			April-June			July-September					
		2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
Open sunny space	Bed-1	35	60	54	12	22	22	16	27	24	64	109	100
	Bed-2	21	51	50	21	18	18	17	23	25	60	92	93
	Bed-3	31	39	51	11	21	19	9	15	24	51	75	94
	Bed-4	24	37	50	13	15	21	11	19	20	48	71	91
	Bed-5	18	36	41	12	18	14	14	18	19	43	72	74
	Bed-6	21	31	45	15	22	17	12	19	21	47	72	83
Roof top		18	17	16	13	8	5	10	21	7	42	46	28
Trellis		27	47	49	21	23	18	16	36	27	64	106	94
Tree support		1	12	10	2	5	4	1	9	8	4	26	22
Shady Place		8	5	09	8	7	7	8	16	8	24	28	24
Marshy Land		3	4	05	3	6	5	5	14	7	11	24	17
Backyard		11	13	10	14	11	3	18	20	3	43	44	16
Homestead Boundary		16	17	24	16	11	12	13	21	17	45	49	53
Pond bank		8	*9*	14	6	*4*	*8*	6	*4*	*9*	20	*17*	31
Total (vegetable)		243	378	428	167	191	173	156	262	219	566	831	820
Fruits		22	38	71	107	91	205	38	71	114	167	200	390
Total (veg. +fruit)		**432**	**416**	**499**	**274**	**282**	**378**	**194**	**333**	**333**	**733**	**1031**	**1210**

Table 7b. Round the year vegetables and fruits production from different niches of homestead during the years of November 2018 to October 2021 (comparative data) at FSRD site, Sholakundu, Faridpur.

Niches	Before intervention		After intervention									
			2018-19		2019-20		2020-21		Av. Nov.. 2018 to Oct. 2021		Av. increment over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (%)
Open sunny place	0	0	313	4457	491	6870	535	9630	446	6986	446	--
Roof top	12	144	42	598	46	828	28	504	39	643	27	347
Trellis	61	732	64	911	106	1908	94	1692	88	1504	27	105
Tree support	0	0	4	57	26	390	22	396	17	281	17	
Shady Place	11	110	24	342	28	336	24	432	25	370	14	236
Marshy Land	10	100	11	157	24	288	17	306	17	250	7	150
Backyard	18	180	43	612	44	660	16	288	34	520	16	189
Homestead Boundary	47	494	45	641	49	931	53	954	49	842	2	70
Pond bank	15	168	20	285	17	255	31	558	23	366	8	118
Total	174	1928	566	8060	831	12466	820	14760	739	11762	565	510
Fruit (other places)	124	4340	167	5833	200	7000	390	10335	252	7723	128	78
Total	298	6268	733	13893	1031	19466	1210	25095	991	19485	693	211

Table 7c. Round the year vegetables and fruits production and utilization pattern before and after Intervention during the years of November 2018 to October 2021 at FSRD site, Sholakundu, Faridpur.

Description	Before Intervention		After Intervention							
	Vegetables (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			2018-2019	2019-2020	2020-2021	Av. Nov.. 2018 to Oct. 2021	2018-2019	2019-2020	2020-2021	Av. Nov.. 2018 to Oct. 2021
Consumption	101	65	324	633	580	512	71	155	225	150
Distribution	14	25	44	51	50	48	34	22	68	41
Selling	59	34	198	147	190	178	62	23	97	61
Total production	174	124	566	831	820	739	167	200	390	252
Gross return (Tk.)	1928	4340	8060	12466	14760	11762	5833	7000	10335	7723
Total Variable cost (Tk.)	276	280	2350	1513	1820	1894	1130	860	1328	1106
Net return (Tk.)	**1652**	**4060**	**5710**	**10953**	**12940**	9868	**4703**	**6140**	**9007**	**6617**

Cropping pattern I: Tomato-Chilli/Sweet gourd

Improved cropping pattern: Tomato (BARI Tomato-18) + Lettuce (BARI Lettuce-1)-Chilli (BARI Morich-2)/Sweet gourd (BARI Mistikumra-2) in Dragon fruit orchard

Existing cropping pattern: Tomato (Hybrid)-Chilli (Local)/Sweet gourd (Hybrid) in Dragon fruit orchard

Farmers cultivate sole Tomato but intercropping of Lettuce with BARI developed Tomato might be a good practice. During kharif II season, Sweet gourd was cultivated as a relay crop with chilli. BARI varieties were used in after intervention package. Before intervention, farmers normally used local or imported hybrid varieties (Table 7d) and their date of sowing was earlier than that of after intervention sowing date. BARI developed varieties were used in after intervention.

Farmers Tomato variety performed better (32.00 t ha^{-1}) due to use of hybrid variety. In the improved cropping pattern, additional 6.40 t ha^{-1} Lettuce was produced along with 26.20 t ha^{-1} Tomato (BARI Tomato-8). The yield of chilli was 6.15 t ha^{-1} and 6.36 t ha^{-1} for before and after intervention, respectively. BARI Mistikumra-2 produced 11% higher yield than imported hybrid due to lower fertile flower in before intervention. Whole patter net return was Tk 964430 ha^{-1} during after intervention and it was 7% higher than that of before intervention (Table 7e.).

Farmers were interested to cultivate Tomato with Lettuce as intercropping technology and other crops with BARI released varieties in the next year.

Table 7d. Crop managements of vegetables production near by the homestead as cropping pattern during November 2018 to October 2021 at FSRD site, Sholakundu, Faridpur.

Observation	Before Intervention (kg)			After Intervention (kg)		
Season	Rabi	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2
Crop	Tomato	Chilli	Sweet gourd	Tomato+Lettuce	Chilli	Sweet gourd
Variety	Hybrid	Local	Hybrid	BARI Tomato-18+BARI Lettuce-1	BARI Morich-2	BARI Mistikumra-2
Date of sowing/ Transplanting	26 Nov 19	4 Apr 20	10 Sep 20	30 Dec 19	20 Apr 20	18 Sep 20
Seed rate ((kg ha^{-1})	0.25	0.90	6	0.25+0.20	0.80	6
Spacing	50 cm x 50 cm	60 cm x 50 cm	2.40 m x 2.25 m	60 cm x 40 cm	60 cm x 50 cm	2.4 m x 2 m
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	115-55-75-25-3-2	170-60-60-22-1.8-1.7	100-50-60-0--0	104-45-64-24-2.7-1.3	130-60-50-15-1.5-1.5	100-50-60-0--0
Date of harvesting (range)	Feb-Mar 20	15 June-15 Nov 20	15-30 Nov 20	20 Feb-15 Apr 20 (Tomato) 10-15 Feb 20 (Lettuce)	20 Jun-10 Nov 20	7-30 Nov 20
Field duration(days)	127	241	82	108	205	74
Turned around time (days)	3	Relay	--	10	Relay	--

Table 7e. Yield and economics of vegetables production near by the homestead before and after Intervention during November 2018 to October 2021 at FSRD site, Sholakundu, Faridpur.

Vegetables	Before Intervention (kg)			After Intervention (kg)			
	Rabi	Kharif-1	Kharif-2	Rabi		Kharif-1	Kharif-2
Crop	Tomato	Chilli	Sweet gourd	Tomato+Lettuce		Chilli	Sweet gourd
Variety	Hybrid	Local	Hybrid	BARI Tomato-18	BARI Lettuce-1	BARI Morich-2	BARI Mistikumra-2
Total production (t ha^{-1})	32.00	6.15	10.50	26.20	6.40	6.36	11.62
Gross return (Tk. ha^{-1})	384000	738000	210000	314400	128000	763200	232400
TVC (Tk. ha^{-1})	213300	159640	60895	237630		173520	62420
Net return (Tk. ha^{-1})	170700	578360	149105	204770		589680	169980
Whole pattern net return (Tk ha^{-1})	898165			964430			

Output price (Tk. kg^{-1}): Tomato: 12, Lettuce: 20, Chilli: 120, Sweet gourd: 20

Cropping pattern II: Tomato-Bitter gourd

Improved cropping pattern: Tomato (BARI Tomato-19)-Bitter gourd (BARI Korola-2)
Existing cropping pattern: Tomato (Hybrid)-Bitter gourd (Hybrid)

Before intervention, farmers normally used imported hybrid varieties for Tomato and Bitter gourd cultivation (Table 7f) but BARI developed varieties named BARI Tomato-19 and BARI Korola-2 were used in after intervention. Bitter gourd was harvested up to Kharif II season.

Farmers Tomato variety performed better (62.83.00 t ha^{-1}) due to use of hybrid variety. In the improved cropping pattern, BARI Tomato-19 produced 57.87 t ha^{-1} yield. The yield of Bitter gourd was 12.28 t ha^{-1} and 17.84 t ha^{-1} for before and after intervention, respectively. In hybrid Bitter gourd, plant leaf was infected with diseases. Whole patter net return was Tk 927051 ha^{-1} during after intervention and it was 39% higher than that of before intervention (Table 7g).

Farmers were interested to cultivate vegetable crops with BARI released higher yielding varieties in the next year.

Table 7f. Crop managements of vegetables production near by the homestead as cropping pattern during November 2018 to October 2021 at FSRD site, Sholakundu, Faridpur.

Observation	Before Intervention (kg)			After Intervention (kg)		
Season	Rabi	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2
Crop	Tomato	Bitter gourd	Bitter gourd continued	Tomato	Bitter gourd	Bitter gourd continued
Variety	Hybrid	Hybrid	Hybrid	BARI Tomato-19	BARI Korola-2	BARI Korola-2
Date of sowing/ Transplanting	28 Nov 19	13 May 20	--	3 Dec 19	19 May 20	--
Seed rate ((kg ha^{-1})	0.25	8	--	0.25	8	--
Spacing	50 cm x 50 cm	2 m x 1.25 m	--	60 cm x 40 cm	2 m x 1.25 m	--
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	115-55-75-25-3-2	115-50-50-45-3.5-2	--	104-45-64-24-2.7-1.3	100-40-30-15-1-1	--
Date of harvesting (range)	3 Mar-10 Apr 20	14 Jul-17 Sep 20		9 Mar -15 Apr 20	23 Jul-8 Aug20	
Field duration(days)	127	128		135	143	
Turned around time (days)	32	--		33		

Table 7g. Yield and economics of vegetables production near by the homestead before and after Intervention during November 2018 to October 2021 at FSRD site, Sholakundu, Faridpur.

Vegetables	Before Intervention (kg)			After Intervention (kg)		
	Rabi	Kharif-1	Kharif-2	Rabi	Kharif-1	Kharif-2
Crop	Tomato	Bitter gourd	Bitter gourd continued	Tomato	Bitter gourd	Bitter gourd continued
Variety	Hybrid	Hybrid	--	Tomato (BARI Tomato-19)	Bitter gourd (BARI Korola-2)	Bitter gourd continued
Total production (t ha^{-1})	62.83	12.28		57.87	17.84	
Gross return (Tk. ha^{-1})	628300	552600		636680	802800	
Total variable cost (Tk. ha^{-1})	324395	187428		322995	189434	
Net return (Tk. ha^{-1})	303905	365172		313685	613366	
Whole pattern net return (Tk. ha^{-1})	669077			927051		

Output price (Tk. kg^{-1}): Tomato: 10, Bitter gourd: 45

FSRD Site, Atia, Tangail

Vegetables production: Available and utilizable production niches of the homestead areas were brought under cultivation with the suggested vegetables following Palima model. The fallow and under-utilized homestead areas were utilized scientifically considering time and space. In the production system, seven niches were utilized in Palima model. After intervention of the proven and improved technologies in the homestead, vegetables production has increased significantly. It was observed that the average vegetables production was 664 kg $homestead^{-1}$) in *Rabi* season followed by *Kharif-2* (546 kg $homestead^{-1}$) and *Kharif-1* (437 kg $homestead^{-1}$) season (Table 8a).

Maximum vegetables were produced during *Rabi* season followed by *Kharif-2* season. *Kharif-1* season was comparatively a dull season for vegetables production when vegetables were mostly affected by seasonal drought. After intervention of the improved technologies, vegetables production was increased 880% compared to before intervention of the program (Table 8b). The remarkable increment of vegetables production in homestead area might be enhanced by using improved technologies and judicious time management.

Utilization of vegetables: The disposal pattern of different vegetables produced in the homestead area was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetables varied with amount of total vegetables production (Table 8b). The average vegetables intake per year per farm family was 283 kg after program intervention and the increment was 529%, whereas intake was only 45 kg per farm family per year before program intervention. Vegetable intake by a member of 5 member's farm family was increased remarkably and it was on an average 155 g $head^{-1}day^{-1}$. After program intervention, the distribution of vegetables per year was recorded 32 kg and sell of vegetables per year was 233kg. Increased production of vegetables encouraged the farm families to distribute relatively more vegetables to their relatives and neighbor, which might be helpful to increase their relationship and it also, helped them to earn more money from more selling of vegetables. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Fruits production: Quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Jack fruit, Coconut, Wood apple pummelo etc.) were managed through pruning, pest control, fertilization and irrigation. After intervention of the proven and improved technologies in the homestead, fruits production has increased significantly. Higher quantity of average fruits production was found in *Kharif-1* (112 kg $homestead^{-1}$) season followed by *Kharif-2* (87 kg $homestead^{-1}$) and *Rabi* (86 kg $homestead^{-1}$) season, which was more or less the reverse scenario of vegetables production (Table 8a). Maximum fruits were produced during *Kharif-1* season and minimum fruits were produced during *Rabi* season and it is actually due to less availability of *Rabi* (winter) fruits species and variety, where scientists should give more emphasis to develop more winter fruits varieties. After implementation of the program, the fruits production was increased 48% compared to before intervention of the program (Table 8b). Using of improved technologies including judicious fertilizer management in fruits production has increased the yield tremendously.

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely. The average fruits intake per year per farm family was 62 kg after program intervention, whereas it was only 40 kg before intervention and the 55% increment was mainly due to increment of total production (Table 8c). Average fruits intake by a member of 5 member's farm family was 34g $head^{-1}day^{-1}$. After program intervention, the distribution of fruits per year was recorded 11kg and sell of fruits per year was 32 kg. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested in sell for getting some cash money.

Income: After program intervention, from the vegetables production average gross return per farm was recorded as Tk. 5828 with the average gross margin of Tk. 4141 which was only Tk. 536 before intervention. From the fruits sector, after program intervention, average gross return per farm was recorded as Tk. 1940 with the average gross margin of Tk. 1505 which was only Tk. 917 before intervention (Table 8c).

Table 8a. Round the year vegetables and fruits production from different niches of homestead during the years of November 2018 to October 2021 at FSRD site, Atia, Tangail.

Space		Rabi October- March			Kharif-1 April-June			Kharif-2 July-September			Total (kg)		
		2018-2019	2019-2020	2020-2021	2018-2019	2019-2020	2020-2021	2018-2019	2019-2020	2020-2021	2018-2019	2019-2020	2020-2021
Open sunny space	Bed-1	38	43	23	11	14	11	23	33	15	72	90	49
	Bed-2	38	19	16	19	29	18	27	18	14	84	66	48
	Bed-3	32	27	27	13	31	10	19	31	17	64	89	54
	Bed-4	30	29	30	15	25	9	24	27	21	69	81	60
Roof top		0	14	19	17	13	6	15	18	13	32	45	38
Trellis		23	48	34	28	58	15	25	47	15	76	153	64
Shady Place		11	14	10	10	13	6	16	18	13	37	45	29
Marshy Land		15	7	15	17	9	3	9	11	0	41	27	18
Unproductive Tree		12	10	21	0	0	4	15	12	0	27	22	25
Fence		-	-	-	-	-	-	-	-	-	-	-	-
Backyard		16	19	24	13	14	6	17	19	14	46	52	44
House Boundary		-	-	-	-	-	-	-	-	-	-	-	-
Total (veg.)		215	230	219	143	206	88	190	234	122	548	670	429
Fruits		22	36	28	20	36	56	35	29	23	77	101	107
Total (veg. + fruit)		237	266	247	163	242	144	225	263	145	625	771	536

Table 8b. Round the year vegetables and fruits production from different niches of homestead during November 2018 to October 2021 (Comparative data) at FSRD site, Atia, Tangail.

Niches	Before intervention		After intervention									
			2018-2019		2019-2020		2020- 2021		Av. Nov. 2018 to Oct. 2021		Av. increment over before intervention	
	Production (kg)	Income (Tk.)	Production (gg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)
Open sunny place	24	298	289	2312	326	2608	211	2532	275	2484	251	640
Roof top	21	204	32	320	45	540	38	456	38	439	17	115
Trellis	11	244	76	760	153	1224	64	960	98	981	87	202
Fence	-	-	-	-	-	-	-	-	-	-	-	-
Tree support	0	0	27	270	22	264	25	375	25	303	25	100
Marshy place	0	0	41	328	27	324	18	144	29	265	29	100
Backyard	0	0	46	360	52	624	44	352	47	445	47	100
Partial shady place	0	0	37	740	45	540	29	1450	37	910	37	100
Total	56	746	548	5090	670	6124	429	6269	549	5828	493	608
Fruit (other places)	64	1280	77	1540	101	2020	107	2260	95	1940	31	46
Total (veg.+ fruit)	120	2026	625	6014	771	7639	536	8529	644	7768	524	226

Table 8c. Round the year vegetables and fruits production and utilization pattern before and after Intervention at FSRD site, Atia, Tangail during November 2018 to October 2021.

Description	Before Intervention		After Intervention							
	Vegetables (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			2018-2019	2019- 2020	2020-2021	Av. Nov. 2018 to Oct. 2021	2018-2019	2019-2020	2020-2021	Av. Nov. 2018 to Oct. 2021
Consumption	45	40	220	360	270	283	47	70	70	62
Distribution	02	5	20	46	31	32	9	7	11	9
Selling	09	19	308	264	128	233	21	24	32	26
Total production	56	64	548	670	429	549	77	101	107	95
Gross return (Tk.)	746	1280	5090	6124	6269	5828	1540	2020	2260	1940
Variable cost (Tk.)	210	363	1390	1980	1690	1687	410	440	456	435
Gross margin (Tk.)	536	917	3700	4144	4279	4141	1130	1580	1804	1505

FSRD Site, Tarakandi, Sherpur

Vegetables production: Available and utilizable production niches of the homestead areas were brought under cultivation with the suggested vegetables following Narekeli Model. The fallow and under-utilized homestead areas were utilized scientifically considering time and space. In the production system, seven niches were utilized in Narikeli Model. After intervention of the proven and alternate technologies in the homestead, vegetables production has increased significantly. It was observed that the average vegetables production was 264 kg homestead^{-1}) in *Rabi* season followed by *Kharif-1* (105 kg homestead^{-1}) and *Kharif-2* (45 kg homestead^{-1}) season (Table 9a).

Maximum vegetables were produced during *Rabi* season followed by *Kharif-1* season. *Kharif-2* season was comparatively a dull season for vegetables production when vegetables were mostly affected by seasonal rainfall. After intervention of the alternate technologies, vegetables production was increased 962% compared to before intervention of the program (Table 9b). The remarkable increment of vegetables production in homestead area might be enhanced by using alternate technologies and judicious time management.

Utilization of vegetables: The disposal pattern of different vegetables produced in the homestead area was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetables varied with amount of total vegetables production (Table 9c). The average vegetables intake per year per farm family was 129 kg after program intervention and the increment was 616%, whereas intake was only 18 kg per farm family per year before program intervention. Vegetable intake by a member of 5 member's farm family was increased remarkably and it was on an average 70 g head^{-1}day^{-1}. After program intervention, the distribution of vegetables per year was recorded 35 kg and sell of vegetables per year was 196 kg. Increased production of vegetables encouraged the farm families to distribute relatively more vegetables to their relatives and neighbor, which might be helpful to increase their relationship and it also, helped them to earn more money from more selling of vegetables. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Fruits production: Quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana, Coconut, Alubukhara Multa etc.) along with other existing fruit trees (Mango, Jack fruit, pummelo, etc.) were managed through pruning, pest control, fertilization and irrigation. After intervention of the proven and alternate technologies in the homestead, fruits production has increased significantly. Higher quantity of average fruits production was found in *Kharif-2* (107 kg homestead^{-1}) season followed by *Kharif-1* (93 kg homestead^{-1}) and *Rabi* (35 kg homestead^{-1}) season, which was more or less the reverse scenario of vegetables production (Table 9a). Maximum fruits were produced during *Kharif-2* season and minimum fruits were produced during *Rabi* season and it is actually due to less availability of *Rabi* (winter) fruits species and variety, where scientists should give more emphasis to develop more winter fruits varieties. After implementation of the program, the fruits production was increased 1583% compared to before intervention of the program (Table

9b). Using of alternate technologies including judicious fertilizer management in fruits production has increased the yield tremendously.

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely. The average fruits intake per year per farm family was 65 kg after program intervention, whereas it was only 6 kg before intervention and the 983% increment was mainly due to increase total production (Table 9c). After program intervention, the distribution of fruits per year was recorded 13kg and sell of fruits per year was 91 kg. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested to sell for getting some cash money.

Income: After program intervention, from the vegetables production average gross return per farm was recorded as Tk. 6531 with the average gross margin of Tk. 5576 which was only Tk. 560 before intervention. From the fruits sector, after program intervention, average gross return per farm was recorded as Tk. 2525 with the average gross margin of Tk. 2283 which was only Tk. 114 before intervention (Table 9c).

Table 9a. Round the year vegetables and fruits production from different niches of homestead during November 2018 to October 2021at FSRD site, Tarakandi, Sherpur.

Space		Rabi			Kharif-1			Kharif-2			Total (kg)		
		October- March			April-June			July-September					
		2018-2019	2019-2020	2020-2021	2018-2019	2019-2020	2020-2021	2018-2019	2019-2020	2020-2021	2018-2019	2019-2020	2020-2021
Open sunny space	Bed-1	5.8	40.98	29.99	0	12.1	11.39	0	4.46	8.87	5.8	57.54	50.25
	Bed-2	43.0	78.13	72.20	0	21.38	20.21	0	7.67	11.85	43.0	107.18	104.26
	Bed-3	9.47	10.47	6.40	0	18.49	13.34	0	4.26	9.03	9.47	33.22	28.77
	Bed-4	6.10	11.11	9.54	0	3.32	3.28	0	4.59	3.80	6.10	19.02	16.62
	Bed-5	25.50	13.57	17.8	0	10.9	12.08	0	8.33	14.39	25.50	32.8	44.27
Roof		81.00	85	33	0	0	50	0	0	0	81.00	85.00	83
Trellis		30.00	31	40	0	0	15	0	0	0	30.00	31.00	55
Fence		8.00	7	9	0	0	0	0	0	0	8.00	7.00	9
Unused tree		0	3.5	0	0	0	0	0	0	12	0	3.5	12
Marshy land		0	0	0	0	0	8	0	0	0	0	0	8
Backyard		0	4.5	12	0	0	0	0	0	0	0	4.5	12
Shady place		10.00	13	16	0	0	0	0		0	10.00	13	16
House boundary		5.00	15	15	0	0	10	0	0	0	5.00	15.00	25
Total (vegetable)		218.87	313.26	260.93	0	66.19	143.3	***0***	***29.31***	59.94	218.87	408.8	464.17
Fruits		25.00	25	55	0	46	140	***0***	***34***	180	25.00	105	375
Total (veg. +fruit)		348.87	338.26	315.93	0	112.19	283.3	0	63.31	239.94	348.87	513.76	839.17

Table 9b. Round the year vegetables and fruits production from different niches of homestead during November 2018 to October 2021 at FSRD site, Tarakandi, Sherpur.

Niches	Before intervention		After intervention									
			2018-2019		2019-2020		2020-2021		Av. Nov. 2018 to Oct. 2021		Av. increment over before intervention	
	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (Tk.)	Production (Kg)	Income (%)
Open sunny place	22	215.00	89.87	879.70	249.76	4960.25	244.17	6104.25	194.60	3981.17	172.6	-
Roof	15	150.00	81.00	810.00	85.00	1020.00	83.00	1245.00	83.00	1025.00	68.00	-
Trellis	25	250.00	30.00	300.00	31.00	310.00	55.00	550.00	38.67	386.67	13.67	-
Fence	0	0	8.00	240.00	7.00	210.00	9.00	270.00	8.00	240.00	8.00	-
Unused tree	0	0	0	0	3.50	105.00	12.00	360.00	5.17	155.00	5.17	-
Marshy land	0	0	0	0	0	0	8.00	160.00	2.67	53.33	2.67	-
Backyard	0	0	0	0	4.50	90.00	12.00	240.00	5.50	110.00	5.50	-
Shady place	0	0	10.00	200.00	13.00	260.00	16.00	480.00	13.00	313.33	13.00	-
House boundary	0	0	0	0	15.00	300.00	25.00	500.00	13.33	266.67	13.33	-
Total (vegetable)	62	615.00	218.87	2429.70	408.76	7255.25	464.17	9909.25	363.94	6531.17	301.94	962
Fruits	10	150.00	25.00	375.00	105.00	1575.00	375.00	5625.00	168.33	2525.00	158.33	1583
Total (veg. +fruit)	72	765.00	243.87	2804.70	513.76	8830.25	839.17	15534.25	532.27	9056.17	460.27	1083

Table 9c. Round the year vegetables and fruits production and utilization pattern before and after Intervention during the years of November 2018 to October 2021 at FSRD site, Tarakandi, Sherpur.

Description	Before Intervention		After Intervention							
	Vegetables (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			2018- 2019	2019- 2020	2020- 2021	Av. Nov. 2018 to Oct. 2021	2018- 2019	2019- 2020	2020- 2021	Av. Nov. 2018 to Oct. 2021
Consumption	18	6	76.00	126.00	186.17	129.39	5	39	150	64.67
Distribution	6	0	21.00	55.00	38.00	38.00	4	10	25	13
Selling	38	4	121.87	227.76	240.00	196.54	16	56	200	90.67
Total production	62	10	218.87	408.76	464.17	363.93	25	105	375	168.33
Gross return (Tk.)	615	150	2429.70	7255.25	9909.25	6531.40	375.00	1575.00	5625.00	2525.00
Variable cost (Tk.)	55.00	36.00	5011.00	1103.00	1250.00	954.66	86.00	156.00	485.00	242.33
Gross margin (Tk.)	560.00	114.00	1918.70	6152.25	8659.25	5576.73	289.00	1419.00	5140.00	2282.67

Activity-2: Family labor utilization pattern in homestead production system at different FSRD sites during the years of November 2018 to October 2021.

Homestead gardening is a sector where all family member can work in a group. Homestead production system gave an opportunity for women employment and empowerment. From the Table 10, it was revealed that women had a good involvement in seed/seedling preparation and planting, intercultural operation, harvesting and marketing of vegetable and fruits. It is revealed that women are coming forward and participating more in income generation system. Hard working i.e., land preparation mostly was done by the men workers. Children were also help the men and women adult workers in the production systems especially in non-hard-working areas. So, it was found that homestead gardening has created a good opportunity to utilize unused labor of women and children properly, which can help to produce more crop and to earn more money by a resource poor farm family.

Table 10. Family labor utilization pattern for homestead vegetables and fruits production at different FSRD sites.

Working area	Men (%)					Women **(%)**					Children **(%)**				
	Pab	Ran	Far	Tan	Sher	Pab	Ran	Far	Tan	Sher	Pab	Ran	Far	Tan	Sher
Land preparation	40	70	50	63	65	50	25	30	33	25	10	5	20	4	10
Seed/seedling production	25	55	40	66	30	60	40	50	34	50	15	5	10	0	20
Sowing/planting	40	35	40	54	25	55	65	40	39	55	5	0	20	7	20
Intercultural operation	10	25	30	42	45	60	65	50	54	45	30	10	20	4	10
Harvesting	10	25	20	56	20	70	60	50	42	55	20	15	30	2	25
Marketing	30	45	20	76	75	65	55	80	21	20	5	0	00	3	5
Cooking	0	0	00	0	0	100	90	100	99	85	0	10	00	1	15

Pab. = Pabna, Ran.= Rangpur, Far.= Faridpur, Tan. = Tangail, Sher. = Sherpur

Plantation and management of fruit tree:

Activity-3: Establishment of homestead and nearby homestead fruit garden during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Sapling/seedling distribution: To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings were supplied to homestead and for mother garden e.g., Mango, Litchi, Dragon fruit, etc. The supplied total number of saplings of different fruits plants are shown in Table 11.

Table 11. Distributed of fruit saplings at FSRD site during the years of November 2018 to October 2021.

Sl. No	Types of fruits sapling	Variety	Number				Mortality (%)
			2018-2019	2019-2020	2020 -2021	Total	
1	Mango	BARI Aam-,3, 4	12	30	10	52	10-25
2	Litchi	BARI Litchi-3	12	5	2	19	15-20
3	Guava	BARI Peyara-2	12	-	2	14	0
4	Multa	BARI Multa-1	12	-	-	12	8
5	Lime	BARI Lebu-1	12	-	-	12	0
6	Papaya	Local	36	-	108	144	8-90
7	Dragon fruit	BARI Dragon Fol-1	4	60	36	100	0
8	Moringa	Year round	24	-	-	24	4
9	Sugarcane	BSRI Akh-42	12	-	-	12	33
10	Palm	Local	100	-	-	100	40

FSRD Site, Gangarampur, Pabna

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings of BARI developed varieties and locally popular varieties were supplied to homestead e.g., Mango, Litchi Guava, Lemon, Papaya, Sugarcane and Bay leaf. Total number of supplied saplings of different fruit plants was 818. The saplings are in good condition and survival rate ranges from 5-10% (Table 12). We also provide technical support to the farmer for better management of fruit trees such as fertilization, irrigation and insect and disease control.

Table 12. Distributed of fruit saplings at FSRD site, Gangarampur, Pabna during the years of November 2018 to October 2021.

Sl. No	Types of fruits sapling	Variety	Number				Mortality (%)
			2018-2019	2019-2020	2020 -2021	Total	
01.	Mango	BARI Aam-4	12	12	0	24	0
		Langra	0	13	16	29	2
		Gopalvogue	0	24	20	44	2
		Khirsha	0	12	20	32	2
02.	Litchi	BARI Litchi-3	12	10	7	29	0
03.	Guava	BARI Peyara-2	20	30	24	74	
04.	Sweet orange	BARI Multa-1	12	0	0	12	0
05.	Lemon	Kagij	12	0	0	12	0
06.	Papaya	Local improved	160	170	150	480	5
07.	Black paper	BSRI Golmorich-1	12	24	10	46	0
0.8.	Bay leaf	BARI Tejpata-1	12	10	14	36	10
Total			252	305	261	818	21

FSRD Site, Sholakundu, Faridpur

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings were supplied to homestead e.g., Dragon, Multa, Guava, Mango, Papaya, Chuijhal and Sugarcane. Total number of supplied saplings of different fruit plant were 867. The saplings are in good condition and survival rate ranges from 25-100% (Table 13). We also provide technical support to the farmer for better management of fruit trees such as fertilization, irrigation and insect and disease control.

Table 13. Distributed of fruit saplings/spices/Sugarcane at FSRD site during the years of November 2018 to October 2021.

Sl.no.	Types of fruits sapling	Variety	Number				Mortality (%)
			2018-2019	2019-2020	2020 -2021	Total	
1	Dragon fruit	BARI Dragon fruit-1	--	60	--	60	0
2	Multa	BARI Multa-1	--	20	--	20	0
3	Guava	BARI Peara-2	10	20	15	45	0
4	Mango	BARI Aam-4	06	--	15	21	0
		BARI Aam-11	--	--	01	01	
5	Lemon	BARI Lebu-4	--	--	15	15	0
6	Papaya	Red lady	20	20	300	340	10
7	Ber	Kashmiri kul	--	--	15	15	10-12
8	Cuijahl (Piper chaba)	Local	--	50	--	50	75-80
9	Sugarcane	BSRI 41 and 42	50	150	100	300	65-70
	Total		86	320	461	867	--

FSRD Site, Atia, Tangail

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings were supplied to homestead e.g., Mango, Litchi, Guava, Sweet orange, Lemon, Papaya, Dragon fruit, Moringa, Sugarcane, Plum, Burmese grape, Aonla, Hogplum, Pomegranate, Coconut and Bay leaf. Total number of supplied saplings of different fruit plant were 632. The saplings are in good condition and survival rate ranges from 75-100% (Table 14). We also provide technical support to the farmer for better management of fruit trees such as fertilization, irrigation and insect and disease control.

Table 14. Distributed of fruit saplings at FSRD site, Atia, Tangail during the years of November 2018 to October 2021.

Sl. No	Types of fruits sapling	Variety	Number				Mortality (%)
			2018-2019	2019-2020	2020 -2021	Total	
01.	Mango	BARI Aam-4	12	0	06	18	16
		BARI Aam-11	0	12	04	16	0
		BARI Aam-3	0	24	10	34	0
02.	Litchi	BARI Litchi-3	12	24	06	42	17
03.	Guava	BARI Peyara-2	12	12	10	34	10
04.	Sweet orange	BARI Multa-1	12	18	12	42	5
05.	Lemon	BARI Lebu-1	12	10	12	34	0
06.	Papaya	Red Lady	36	120	50	206	20
07.	Dragon fruit	BARI Dragon Fol-1	4	10	12	26	0
08.	Moringa	Year Round	24	10	0	34	0
09.	Sugarcane	BSRI Akh-42	12	0	0	12	0
10.	Plum	BARI Alubokhara-1	10	12	05	27	25
11.	Burmese grape	BARI Lotkon-1	0	12	12	24	0
12.	Aonla	BARI Amloki-1	0	12	05	17	9
13.	Hog Plum	BARI Amra-1	0	12	10	22	17
14.	Pomegranate	BARI Dhalim-2	0	10	0	10	10
15.	Coconut	Vietnami Coconut	0	12	0	12	10
16.	Bay leaf	BARI Tejpata-1	0	12	10	22	25
Total			146	322	164	632	-

FSRD Site, Tarakandi, Sherpur

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. From this view, a number of different quality fruits saplings were supplied to homestead e.g., Mango, Guava, Papaya, Litchi, Lime, Multa, Banana, Alubokhara, Coconut, Sugarcane etc. Spices seedlings also given for increase of spices production at homestead level. The supplied total number of saplings of different fruits and spices plants are shown in Table 15.

Table 15. Distributed of fruit saplings at FSRD site, Tarakandi, Sherpur during the years of November 2018 to October 2021.

Sl. No	Types of fruits sapling	Variety	Number				Mortality (%)
			2018-2019	2019-2020	2020-2021	Total	
1	Mango	BARI Aam-,3, 4	24	100	112	236	0
2	Litchi	BARI Litchi-3	12	50	50	112	5
3	Guava	BARI Peyara-2	0	0	24	24	0
4	Multa	BARI Multa-1	12	100	112	224	0
5	Lime	BARI Lebu-4	0	250	250	500	5
6	Papaya	Local	24	-	0	24	10
7	Alubokhara	BARI Alubokhara-1	0	0	24	24	0
8	Coconut	Dwarf variety	0	8	8	16	0
9	Sugarcane	BSRI Akh-42	12	-	-	12	50
10	Banana	BARI Kola-1	0	12	12	24	0

Activity-4: Pest management activities for increasing fruits production in homestead area during the years of 2018 to 2020.

Pest management of fruit tree: Availability of fruit trees in the homestead area is the best source of human nutrition. Although in most cases, it was found that pest is the major hindrance for sufficient edible fruits production, which sometimes discourages the farmers to plantation of fruit trees in homestead area. But very simple technology, two times spray of both insectiside and fungicide, once at just before flower blooming and once at pea size fruit stage, can help for successful fruits production in homestead area. From these views, pesticide spraying activities in safe way were conducted at each FSRD site (Table 16). A total of 611 fruit trees were sprayed with insectide and pesticide, where maximum fruit trees were Mango (246).

Table 16. Number of fruit trees sprayed for hopper and other pest control at different FSRD sites during the year of November 2018 to October 2021

FSRD site	Mango	Guava	Jackfruit	Litchi	Multa	Coconut	Others*
Gangarampur, Pabna	51	15	20	15	12	7	11
Ajoddhapur, Rangpur	62	9	9	12	12	4	19
Atia, Tangail	40	12	10	12	12	8	14
Tarakandi, Sherpur	45	10	25	11	12	13	15
Sholakundu, Faridpur	48	12	7	12	12	6	17
Total	*246*	*58*	*71*	*62*	*60*	*38*	*76*

c) Apparent nutrient intake and supplementation: Vegetables and fruits produced in homestead areas are the important sources of human nutrition. Apparent nutrient intake especially protein, iron, carotene, vitamin B and vitamin C by a 5 member's family from year-round vegetables and fruits consumption was estimated (Table 17a). The apparent nutrient supplementation was also calculated on the basis of per head requirement and considering apparent nutrient intake from vegetables and fruits sources (Table 17b). Nutrient intake was varied with different locations. Intake of nutrient was positively correlated with vegetable and fruits consumption and also with production. Among the nutrient's protein intake was increased more than other nutrients but it still needs to supplement from animal source. Iron supplementation was more in Gangarampur, Pabna (68.96%), which is very crucial nutrient for women. Other nutrients intake and supplementation also increased remarkably especially carotene and vitamin C, which was more or less sufficiently supplemented from homestead vegetables and fruits source after program intervention and it might be due to more production and relatively more intake through motivational activities.

Table 17a. Apparent nutrient Consumption in a year by a family from homestead vegetables and fruits (before and after intervention) during the year of November 2018 to October 2021.

FSRD site	Intervention	Protein (g)	Iron (mg)	Carotene (µg)	Vit-B (mg)	Vit-C (mg)
Gangarampur, Pabna	Before	9108	18687	15227000	611	160516
	After	18036	35240	30152478	1209	317855
Ajoddhapur, Rangpur	Before	1315	2697	2197826	88	23168
	After	15493	30272	25901409	1038	273042
Sholakundu, Faridpur	Before	3174	6513	5306836	213	55942
	After	15730	30737	26299406	1055	277238
Atia, Tangail	Before	1533	3145	2562960	103	27018
	After	13346	26078	22312834	895	235213
Tarakandi, Sherpur	Before	649	1332	1085489	44	11443
	After	5555	10854	9286963	372	97899

Table 17b. Apparent nutrient supplementation from a homestead produced vegetables and fruits on the basis of per head per day requirement (Av. of five member's family: male 3 and female 2) during the year of November 2018 to October 2021.

FSRD site	Category	Year	Protein (%)	Iron (%)	Vit-A (%)	Vit-B (%)	Vit-C (%)
Gangarampur, Pabna	Male	Before	9.07	36.56	139.06	27.90	219.88
		After	23.40	91.14	398.35	49.39	571.46
	Female	Before	9.99	36.56	139.06	33.46	219.88
		After	25.74	91.14	398.35	59.18	571.46
Ajoddhapur, Rangpur	Male	Before	5.62	22.66	86.19	17.29	136.28
		After	16.08	61.72	246.00	49.41	389.70
	Female	Before	6.19	22.66	86.19	20.74	136.28
		After	17.69	61.72	246.00	59.29	389.70
Sholakundu, Faridpur	Male	Before	3.16	12.74	48.46	9.72	76.63
		After	14.16	54.34	216.59	43.50	343.11
	Female	Before	3.48	12.74	48.46	11.66	76.63
		After	15.58	54.34	216.59	52.20	343.11
Atia, Tangail	Male	Before	1.53	6.15	23.41	4.70	37.01
		After	13.30	51.03	203.40	40.85	322.21
	Female	Before	1.68	6.15	23.41	5.63	37.01
		After	14.63	51.03	203.40	49.02	322.21
Tarakandi, Sherpur	Male	Before	0.65	2.61	9.91	1.99	15.67
		After	5.53	21.24	84.66	17.00	134.11
	Female	Before	0.71	2.61	9.91	2.39	15.67
		After	6.09	21.24	84.66	20.40	134.11

Note: Standard nutritional demand: Protein (g)- 55(Male), 50 (Fem)., Iron(mg)- 28 (MaleandFem.), Vit A (µg)- 600 (Male andFem)., Vit B (mg)- 1.2 (Male), 1.0(Fem) and Vit C (mg)- 40 (Male and Fem.), Source : AIS, 2017 (Krishi Diary, 2017)

B. CROPS AND CROPPING SYSTEM

I. Improvement of cropping pattern (CP)

FSRD site, Ajoddhapur, Rangpur

Activity 5. Improvement of existing T. Aman-Fallow-Boro cropping pattern at FSRD site, Ajoddhapur, Rangpur during the years of 2018 to 2021.

Existing cropping pattern: T. Aman (Swarna)-Fallow-Boro (BRRI dhan28)
Improved cropping pattern: T. Aman (Binadhan-17)-Mustard (BARI Sarisha-14)-Boro (BRRI dhan28)

The total field duration and turnaround time were 288-305 and 60-77 and 232-241 and 124-133 in improved and existing cropping pattern, respectively. Cost, return and yield performance of the tested pattern (T. Aman rice -Mustard-Boro rice) against existing pattern (T. Aman rice-Fallow- Boro rice) during Nov. 2018 to Oct. 2021 is presented in Table 18a, 18b, 18c and 18d. In the first year (2018-19), the T Aman rice could be grown only during the project period. In 2019-20, the rice equivalent yield (REY) was 18.53 and 10.81 t ha^{-1} with the whole pattern gross margin Tk. 98588 and 31540 ha^{-1} in improved and existing cropping pattern, respectively. In 2020, the rice equivalent yield (REY) was 11.30 and 6.12 t ha^{-1} with the whole pattern gross margin Tk. 158740 and 59760 ha^{-1} in improved and existing cropping pattern, respectively. The MBCR in improved cropping pattern was attained 3.14 and 4.23 in 2019-20 and 2020, respectively over existing cropping pattern. The higher REY was obtained from improved cropping pattern due to use of modern variety, inclusion of extra crop Mustard and improve crop management technologies.

Table 18a. Crop managements of improved and existing cropping pattern at FSRD site, Ajoddhapur Rangpur.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Varity	Binadhan-17	BARI Sarisha-14	BRRI dhan28	Swarna	_	BRRI dhan28
Date of sowing/ Transplanting	05-18 Aug.	29 Nov.-07 Dec.	25 Feb.-07 Mar.	20-25 Jul.	_	25-28 Feb.
Seed rate (kg ha^{-1})	30	1	30	35	-	35
Spacing	20 x 15 cm	Broadcast	20 x 15 cm	20 x 20 cm	_	20 x 20 cm
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	100-12-30-10-1.5	129-34-45-29-2-2	123-18-71-18-2	92-30-25-11	_	101-26-30-11-CD 3 t
Date of harvesting (range)	11-19 Nov.	22-27 Feb.	28 Jun.-11 Jul.	27-30 Nov.	_	20-24 Jun.
Field duration (days)	89-96	80-85	118-124	113-116	-	119-125
Turned around time (days)	18-24	7-10	26-34	70-85	-	28-31

Table 18b. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of November 2018 to October 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Seed /grain Yield (t ha^{-1})	4.41	-	-	3.31	-	-
Straw yield (t ha^{-1})	4.81	-	-	3.7	-	-
Rice equivalent yield (t ha^{-1})	4.73	-	-	3.56	-	-
Whole pattern Rice equivalent yield (t ha^{-1})	-			-		
Gross return (Tk. ha^{-1})	70960	-	-	53350	-	-
Total variable cost (Tk. ha^{-1})	46500	-	-	45100	-	-
Gross margin (Tk. ha^{-1})	24460	-	-	8250	-	-
Whole pattern gross margin (Tk. ha^{-1})	24460			8250		
MBCR	-			-		

Unit price (Tk. kg^{-1}): *Aman* rice=12.75, Boro rice=15, Rice straw =1, Mustard=41, Mustard stover=1.

Table 18c. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of November 2018 to October 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Seed /grain Yield (t ha^{-1})	4.61	1.89	5.63	3.31	-	4.67
Straw yield (t ha^{-1})	4.8	2.67	5.78	3.7	-	5.15
Rice equivalent yield (t ha^{-1})	5.13	6.32	7.08	4.18	-	6.63
Whole pattern REY (t ha^{-1})	18.53			10.81		
Gross return (Tk. ha^{-1})	65375	80633	90230	53350	-	84540
Total variable cost (Tk. ha^{-1})	45800	29350	62500	45100	-	61250
Gross margin (Tk. ha^{-1})	19575	51283	27730	8250	-	23290
Whole pattern gross margin (Tk. ha^{-1})	98588			31540		
MBCR	3.14					

Unit price (Tk. kg^{-1}): *Aman* rice=12.75, Boro rice=15, Rice straw =1, Mustard=41.25, Mustard stover=1.

Table 18d. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of November 2018 to October 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Seed /grain yield (t ha^{-1})	2.53	1.52	5.48	2.1	-	4.67
Straw yield (t ha^{-1})	3.09	2.1	4.4	1.87	-	5.15
Rice equivalent yield (t ha^{-1})	3.27	2.59	5.44	1.71	-	4.41
Whole pattern REY (t ha^{-1})	11.30			6.12		
Gross return (Tk. ha^{-1})	81790	64800	136000	42720	-	110290
Total variable cost (Tk. ha^{-1})	32000	29350	62500	32000	-	61250
Gross margin (Tk. ha^{-1})	49790	35450	73500	10720	-	49040
Whole pattern gross margin (Tk. ha^{-1})	158740			59760		
MBCR	4.23					

Unit price (Tk. kg^{-1}): *Aman* rice=25, Boro rice=20, Rice straw =6, Mustard=41.25, Mustard stover=1.

Activity 6. Development of alternative cropping pattern T. Aus-T. Aman-Potato/Sweet gourd at FSRD site, Ajoddhapur, Rangpur during the years of 2018 to 2021

Existing cropping pattern: T. Aman (Swarna)-Potato (BARI Alu-8)-Boro (BRRI dhan28)
Improved cropping pattern: T. Aus (BRRI dhan48)-T. Aman (Binadhan-17)-Potato (BARI Alu-8)/Sweet gourd (BARI Hybrid Mistikumra-1)

Crop management practices of different crops under cropping pattern-2 are given in Table 19a. The total field duration and turnaround time were 318-330 and 35-47 and 299-309 and 56-66 in improved and existing pattern, respectively. Crop yield and economical performances of the tested pattern (T. Aus-T. Aman-Potato/Sweet gourd) against existing pattern (T. Aman-Potato-Boro) during November 2018 to October 2021 is presented in Table 19a, 19b, 19c and 19d. In the first year (2018-19), the T. Aus and T Aman rice could be grown only. In 2019-20, the rice equivalent yield (REY) was 51.39 and 24.98 t ha^{-1} with the whole pattern gross margin Tk. 423064 ha^{-1} and Tk. 98770 ha^{-1} in improved and existing cropping pattern, respectively. In 2020, the REY was 24.96 and 14.00 t ha^{-1} with the whole pattern gross margin Tk. 391730 and 130180 ha^{-1} in improved and existing cropping pattern, respectively. The MBCR in improved pattern was attained 12.08 over existing pattern. Use of modern variety, inclusion of extra crop T. Aus and replacing Boro with Sweet gourd including improve crop management technologies were triggered the higher REY in improved cropping pattern.

Table 19a. Crop managements of improved and existing cropping pattern at FSRD site, Ajoddhapur Rangpur.

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Potato	Sweet gourd	T. Aman	Potato	Boro
Varity	BRRI dhan48	Binadhan-17	BARI Alu-25	BARI Hybrid Mistikumra-1	Swarna	BARI Alu-13	BRRI dhan28
Date of sowing/ Transplanting	10-17 May	12-17 Aug.	25-30 Nov.	7-12 Dec.	5-10 Aug.	2-5 Dec.	22-27 Feb.
Seed rate ((kg ha^{-1})	30	30	2000	5	35	2000	30
Spacing	20 x 15 cm2	20 x 15 cm2	60 x 20 cm2	1.8 x 1.8 cm2	20 x 20 cm2	45 x 15 cm2	20 x 20 cm2
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	97-20-40-13-3.5	100-12-30-10-1.5	135-25-140-17-3-1.5	0	92-30-25-11	140-30-150-20-3-2	101-26-30-11-CD 3 t
Date of harvesting (range)	5-10 Aug.	20-23 Nov.	05-09 Feb.	07-14 April	23-30 Nov.	14-17 Feb.	20-28 Jun
Field duration (days)	89-91	97-99	72-75	Potato+60-65	109-111	74-77	116-121
Turned around time (days)	7-8	5-7	-	30-33	7-9	8-10	40-46

Table 19b. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of November 2018 to October 2021

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Potato	Sweet gourd	T. Aman	Potato	Boro
Seed /grain yield (t ha^{-1})	5.16	4.16	-	-	3.74	-	-
Straw yield (t ha^{-1})	5.71	4.61	-	-	4.21	-	-
Rice equivalent yield (t ha^{-1})	-	-	-	-	-	-	-
Whole pattern REY (t ha^{-1})	-				-		
Gross return (Tk. ha^{-1})	83110	67010	-	-	56100	-	-
Total variable cost (Tk. ha^{-1})	40500	46250	-	-	42500	-	-
Gross margin (Tk. ha^{-1})	42610	20760	-	-	13600	-	-
Whole pattern gross margin (Tk. ha^{-1})	63370				13600		
MBCR	-				-		

Unit price (Tk. kg^{-1}): *R*ice=12.75, Rice straw =1,

Table 19c. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of November 2018 to October 2021

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Potato	Sweet gourd	T. Aman	Potato	Boro
Seed /grain yield (t ha^{-1})	4.89	4.58	28.75	35.82	3.74	25.29	5.02
Straw yield (t ha^{-1})	5.11	4.67	0	0	4.21	0	5.62
Rice equivalent yield (t ha^{-1})	6.15	5.09	18.04	22.11	4.40	13.88	6.69
Whole pattern REY (t ha^{-1})	51.39				24.98		
Gross return (Tk. ha^{-1})	78460	64851	230000	281903	56100	177030	85340
Total variable cost (Tk. ha^{-1})	40550	44600	125000	22000	42500	115950	61250
Gross margin (Tk. ha^{-1})	37910	20251	105000	259903	13600	61080	24090
Whole pattern gross margin (Tk. ha^{-1})	423064				98770		
MBCR	7.04						

Unit price (Tk. kg^{-1}): *Aman* rice=12.75, Boro rice=15, Rice straw =1, Potato=10.

Table 19d. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Ajoddhapur Rangpur during the year of November 2018 to October 2021

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Potato	Sweet gourd	T. Aman	Potato	Boro
Seed /grain Yield (t ha^{-1})	4.95	2.68	28.63	36.18	2.43	25.29	5.02
Straw yield (t ha^{-1})	5.23	2.76	0	0	2.89	0	5.62
Rice equivalent yield (t ha^{-1})	5.22	3.34	9.16	7.24	2.15	7.08	4.76
Whole pattern Rice equivalent yield (t ha^{-1})	24.96				14		
Gross return (Tk. ha^{-1})	130380	83560	229040	180900	53790	177030	119060
Total variable cost (Tk. ha^{-1})	40550	44600	125000	22000	42500	115950	61250
Gross margin (Tk. ha^{-1})	89830	38960	104040	158900	11290	61080	57810
Whole pattern gross margin (Tk. ha^{-1})	391730				130180		
MBCR	12.08						

Unit price (Tk. kg^{-1}): T. Aus=20, *Aman* rice=25, Boro rice=20, Rice straw =6, Potato=8.

FSRD Site, Gangarampur, Pabna

Activity-7: Improvement of existing T. Aman-Fallow-Boro rice cropping pattern at FSRD site, Gangarampur, Pabna during the year of 2018-2021.

Existing cropping pattern: T. Aman rice (BRRI dhan39)-Mustard (Tori-7)-Boro (Local Toba)
Improved cropping pattern: T. Aman rice (Binadhan-7)-Mustard (BARI Sarisha-17)- Boro (BRRI dhan28)

Different crop management practices are presented in Table 20a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern is presented in Table 20b and 20c. In the improved pattern though Tori-7 required at least 7 days less than BARI Sarisha-17 but BARI Sarisha-17 gave higher seed yield (2.25 and 2.0 t ha^{-1}) over Tori-7 (1.05 and 1.02 t ha^{-1}) at the FSRD site, Gangarampur, Pabna during both the year. The T. Aman variety BRRI dhan39 gave lower yield (4.5 and 4.4 t ha^{-1}) than the Binadhan-17 (5. 5 and 5.25 t ha^{-1}). Yield of Boro rice in improved pattern is also higher (5.2 and 5.3 t ha^{-1}) than the existing local Boro rice whose field duration is long too. Mustard yield in improved cropping pattern was increased by above 100%, Boro rice yield increased by 30% and T.Aman rice yield increased by 23%, respectively due to application of balance fertilizer, appropriate seedling rate and age, better management practices and also due to inclusion of modern variety. Rice equivalent yield of improved cropping pattern was 15.84 and 14.55 t ha^{-1} $yr.^{-1}$ which was about 45 and 33% higher against existing cropping pattern (10.90 and 10.94 t $ha^{-1}yr^{-1}$). Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was observed that improved cropping pattern produced higher gross margin Tk. 131580 and 195830 ha^{-1} which was 65% higher than existing cropping pattern in two consecutive years. The marginal benefit cost ratio (MBCR) was obtained 3.60 and 4.75 during two consecutive years which further indicated the superiority to improved cropping pattern over existing pattern.

Table 20a. Crop managements of improved and existing cropping pattern at FSRD site, Gangarampur, Pabna.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Mustard	Boro
Varity	Binadhan-7	BARI Sarisha-17	BRRI dhan28	BRRI dhan39	Tori-7	Local Toba
Date of sowing/ Transplanting	25-30 July	15-20 Nov.	20-25 Feb.	22-28 July	25-30 Nov.	25-28 Feb.
Seed rate ((kg ha^{-1})	35	7.5	35	45	10	45
Spacing	20 X 15cm	Broadcasting	20 X 15cm	Not properly maintained	Broadcasting	Not properly maintained
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	90-10-35-12-1-0	90-27-32-15-1-1	150-12-55-18-1.3-0	90-10-35-12-1-0	90-27-32-15-1-1	150-12-55-18-1.3-0
Date of harvesting (range)	5-10 Nov.	10-15 Feb.	25-31 May	10-20 Nov.	10-15 Feb.	10-15 June
Field duration(days)	95-100	85-90	95-100	105-110	75-80	105-110
Turned around time (days)	30-35	5-10	10-15	40-45	15-20	12-15

Table 20b. Yield and economic analysis of improved and existing cropping pattern at FSRD site, Gangarampur, Pabna during the year of November 2018 to October 2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Mustard	Boro
Seed /grain Yield (t ha^{-1})	5.50	2.25	5.20	4.50	1.05	4.00
Straw yield (t ha^{-1})	6.10	2.85	5.90	5.13	1.70	4.85
Rice equivalent yield (t ha^{-1})	5.50	5.14	5.20	4.50	2.4	4.00
Whole pattern Rice equivalent yield (t ha^{-1})	15.84			10.90		
Gross return (Tk. ha^{-1})	96250	90000	91000	78750	42000	70000
Total variable cost (Tk. ha^{-1})	74500	53500	78500	73500	40500	68500
Gross margin (Tk. ha^{-1})	21750	36500	12500	5250	1500	1500
Whole pattern gross margin (Tk. ha^{-1})	70750			8250		
MBCR	3.6					

Unit price (Tk. kg^{-1}): Boro rice=17.50, T. *Aman* rice =17.50, Rice straw = 4, Mustard seed =40 and stover=1.00

Table 20c. Yield and economic analysis of improved and existing cropping pattern at FSRD site, Gangarampur, Pabna during the year of November 2018 to October 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Mustard	Boro	T. Aman	Mustard	Boro
Seed /grain Yield (t ha^{-1})	5.25	2.00	5.30	4.40	1.02	4.50
Straw yield (t ha^{-1})	4.75	2.3	4.32	4	1	4.25
Rice equivalent yield (t ha^{-1})	5.25	4.00	5.30	4.40	2.04	4.50
Whole pattern Rice equivalent yield (t ha^{-1})	14.55			10.94		
Gross return (Tk. ha^{-1})	131250	100000	132500	110000	51000	112500
Total variable cost (Tk. ha^{-1})	74500	53500	78500	73500	40500	73500
Gross margin (Tk. ha^{-1})	56750	46500	54000	36500	10500	39000
Whole pattern gross margin (Tk. ha^{-1})	157250			86000		
MBCR	4.75					

Unit price (Tk. kg^{-1}): Boro rice=25.0 T. *Aman* rice=25.0, Rice straw = 4, Mustard seed = 50 and stover=1.00

Activity 8. Improvement of existing T. Aman-Lentil-Sesame cropping pattern at FSRD site, Gangarampur, Pabna during the years of 2018 to 2021.

Existing cropping pattern: T. Aman rice (BRRI dhan39)-Lentil (BARI Masur-6)- Sesame (Local)
Improved cropping pattern: T. Aman rice (Binadhan-17)- Lentil (BARI Masur-8)- Sesame (BARI Til-4)

Different crop management practices are presented in Table 21a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern is presented in Table 21b and 21c. In the improved pattern BARI Masur-8 gave higher seed yield (1.8 and 1.9 t ha^{-1}) over BARI Masur-6 (1.6 and 1.8 t ha^{-1}) at the FSRD site, Gangarampur, Pabna during both the year. The T. Aman variety BRRI dhan39 gave lower yield (4.65 and 4.45 t ha^{-1}) than the Binadhan-17 (5. 6 and 5. 5t ha^{-1}). Yield of BARI Til-4 in improved pattern is also higher (1.45 and 1.4 t ha^{-1}) than the existing local. Lentil yield in improved cropping pattern was increased by above 10%, T.Aman rice yield increased by 20% and Sesame yield was increased by 15% respectively due to application of balance fertilizer, appropriate seedling rate and age, better management practices and also due to inclusion of modern variety. Rice equivalent yield of improved cropping pattern was 15.57 and 14.00 t ha^{-1} yr.$^{-1}$ which was about 16 and 12% higher against existing cropping pattern (13.33 and 12.45 t ha^{-1}yr^{-1}). Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was observed that improved cropping pattern produced higher gross margin Tk. 159200 and 236990 ha^{-1} which was about 36% and 22% higher than existing cropping pattern in two consecutive years. The marginal benefit cost ratio (MBCR) was obtained 4.95 and 4.84 during two consecutive years which further indicated the superiority to improved cropping pattern over existing pattern.

Table 21a. Crop managements of improved and existing cropping pattern at FSRD site, Gangarampur, Pabna.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Lentil	Sesame	T. Aman	Lentil	Sesame
Varity	Binadhan-17	BARI Masur-8	BRRI Til-4	BRRI dhan39	BARI Masur-6	Local
Date of sowing/ Transplanting	22-30 July	20-25 Nov.	20-25 March	22-30 July	01-05 Dec.	15-20 March
Seed rate ((kg ha^{-1})	35	40	7.5	45	45	10
Spacing	20 X 15cm	Broadcasting	Broadcasting	Not properly maintained	Broadcasting	Broadcasting
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	90-10-35-12-1-0	18-30-25-18-1-1	78-18-27-20-1	90-10-35-12-1-0	18-30-25-18-1-1	78-18-27-20-1
Date of harvesting (range)	14-20 Nov.	10-15 March	25-30 June	13-20 Nov.	10-15 March	20-25 June
Field duration(days)	105-110	110-115	95-100	105-110	105-110	95-100
Turned around time (days)	25-35	5-10	10-15	22-30	15-20	5-10

Table 21b. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Gangarampur, Pabna during the year of November 2018 to October 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Lentil	Sesame	T. Aman	Lentil	Sesame
Seed /grain Yield (t ha^{-1})	5.60	1.80	1.45	4.65	1.60	1.20
Straw yield (t ha^{-1})	5.10	1.60	2.10	4.50	1.50	1.50
Rice equivalent yield (t ha^{-1})	5.60	6.66	3.31	4.65	5.94	2.74
Whole pattern Rice equivalent yield (t ha^{-1})	15.57			13.33		
Gross return (Tk. ha^{-1})	98000	117000	58000	81375	104000	48000
Total variable cost (Tk. ha^{-1})	71500	36500	34500	70500	32500	31500
Gross margin (Tk. ha^{-1})	26500	80500	23500	10875	71500	16500
Whole pattern gross margin (Tk. ha^{-1})	130500			98875		
MBCR	4.95					

Unit price (Tk. kg^{-1}): Boro rice=17.50, T. *Aman* rice=17.50, Rice straw =4.0, Lentil seed =65.0 and stover=2.00, Mustard seed=40.0 and stover=1.00

Table 21c. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Gangarampur, Pabna during the year of November 2018 to October 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Lentil	Sesame	T. Aman	Lentil	Sesame
Seed /grain Yield (t ha^{-1})	5.50	1.90	1.40	4.45	1.80	1.30
Straw yield (t ha^{-1})	5.25	1.72	2.05	4.41	1.64	1.53
Rice equivalent yield (t ha^{-1})	5.50	5.7	2.8	4.45	5.4	2.6
Whole pattern Rice equivalent yield (t ha^{-1})	14.00			12.45		
Gross return (Tk. ha^{-1})	137500	142500	70000	111250	135000	65000
Total variable cost (Tk. ha^{-1})	71500	38500	35500	70500	33500	33500
Gross margin (Tk. ha^{-1})	66000	104000	34500	40750	101500	31500
Whole pattern gross margin (Tk. ha^{-1})	204500			173750		
MBCR	4.84					

Unit price (Tk. kg^{-1}): Boro rice=25.0, T. *Aman* rice=25.0, Rice straw =4.0, Lentil seed =75.0 and stover=2.00, Mustard seed=50.0 and stover=1.00

FSRD Site, Sholakundu, Faridpur

Activity-9: Improvement of existing Lentil-Jute-T. Aman cropping pattern at FSRD site, Sholakundu, Faridpur during the years of 2018 to 2021.

Existing cropping pattern: Lentil (Local)- Jute (JRO524)- T. Aman rice (BRRI dhan39)
Improved cropping pattern: Lentil (BARI Masur-8)-Jute (Rabi-1)- T. Aman rice (Binadhan-17/BRRI dhan75)

For improved cropping pattern, BARI Masur-8, Rabi-1 and Binadhan-17 for 2019 and BRRI dhan75 for 2020 were used whereas, local Lentil, JRO-524 (Jute) and BRRI dhan39 were used in existing cropping pattern (Table 22a). Sowing date of Lentil, Jute and T. Aman (transplanting) for improved cropping pattern during both the year was 12 Nov to 30 Dec, 28 March to 7 Aprril and 10 to 15 August, respectively. For both years in improved cropping pattern, field duration was 116-124 days, 123-125 days and 97-99 day for Lentil, Jute and T. Aman, respectively.
The crop yield and return of the improved and existing patterns for both the years are presented in Table 22b and 22c. From those table, it was found that, NARS varieties were performed better than that of farmer's existing varieties. For second year, main *pat* (mature Jute) and *baschh pat (*immature Jute*)* yield were included resulting higher fibre and stick yield. The MBCR of first year and second year (2019-20) was 2.04 and 3.26, respectively. During 2nd year, yield of product and by product was higher than that of first year resulting higher rice equivalent yield (19.68), whole pattern gross margin (Tk. 531100 ha^{-1}) and MBCR.

The Table 22d showed the average yield and economy of improved and existing cropping pattern for 2018-19 and 2019-20. In the improved pattern, BARI Masur-8 gave higher seed yield (1.71 t ha^{-1}) over local (0.83 t ha^{-1}) at FSRD site, Sholakundu, Faridpur. The Lentil yield in improved pattern was increased by 106% due to application of balance fertilizer, better management practices and also due to inclusion of modern variety. Rabi-1 gave higher fibre yield (2.96 t ha^{-1}) over JRO-524 (2.64 t ha^{-1}). The T. Aman yield in improved cropping pattern was increased by above 12%. The Whole pattern Rice equivalent yield was 18.66 t ha^{-1} and 14.64 t ha^{-1}, respectively. Whole pattern gross margin was Tk. 170851 ha^{-1} and Tk. 107034 ha^{-1} for improved pattern and existing pattern, respectively. The average MBCR was 2.65.

Farmers were interested following improved cropping pattern with BARI Masur-8 for Lentil, Rabi-1 for Jute and BRRI dhan75 for rice production. Binadhan-17 was infected with false smut during pre-mature stage of grain resulting lower yield. They stored seed for next year cultivation.

Table 22a. Crop managements of improved and existing cropping pattern during the years of November 2018 to October 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Jute	T. Aman	Lentil	Jute	T. Aman
Variety	BARI Masur-8	Rabi-1	Binadhan-17/ BRRI dhan75	Local	JRO524	BRRI dhan39
Date of sowing/ Transplanting	16-30 Nov.	28 Mar.-7 Apr	10-15 Aug	28 Nov- 4 Dec.	26 Mar – 5 Apr	30 July 15 Aug
Seed rate ((kg ha^{-1})	35	6.5	50	40	7	50
Spacing	Broadcast	Broadcast	20 cm x 15 cm	Broadcast	Broadcast	20 cm x 15 cm
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	28-24-14-9-2-1	140-30-25-15-4-2	80-15-35-8-1-0	23-24-25-9-1.8-0.8	95-20-50-0-0-0	45-20-25-18-3-1
Date of harvesting (range)	8-24 Mar	1-8 Aug	17-20 Nov	15-20 Mar	20-30 Jul	12-30 Nov.
Field duration(days)	117-118 110-114	123-124 123-125	98-100 97-99	119-125 107-108	118-119 117	106-110 105-106
Turned around time (days)	10	13-20	--	4-16	11-16	-

Table 22b. Yield and Economic analysis of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu, Faridpur during the year of November 2018 to October 2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Jute	T. Aman	Lentil	Jute	T. Aman
Seed /grain/fibre yield (t ha^{-1})	1.63	2.67	4.11	0.8	2.48	4.00
Stover/straw/stick yield (t ha^{-1})	0.78	4.20	5.16	0.53	3.64	5.12
Rice equivalent yield (t ha^{-1})	5.26	7.39	4.99	2.61	7.00	4.66
Whole pattern REY (t ha^{-1})	17.64			14.26		
Gross return (Tk. ha^{-1})	91990	129412	87405	45590	122520	81520
Variable cost (Tk. ha^{-1})	45230	122680	66615	42500	107580	55460
Gross margin (Tk. ha^{-1})	46760	16732	20790	3090	14940	26060
Total Gross return (Tk. ha^{-1})	308807			249630		
Total variable cost (Tk. ha^{-1})	234525			205540		
Total gross margin (Tk. ha^{-1})	84882			44090		
MBCR	2.04					

Output price (Tk/kg). Lentil: 55.00, Stover: 3.00 rice: 17.50, rice straw: 3.00, Jute fiber: 43.75, Jute stick: 3.00

Table 22c. Yield and Economy of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu during the months of November 2018 to October 2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Jute (both main and *basch pat*)	T. Aman	Lentil	Jute (main pat)	T. Aman
Seed /grain/fibre yield (t ha^{-1})	1.79	3.26	5.05	0.87	2.81	4.20
Stover/straw/stick yield (t ha^{-1})	0.84	5.31	6.51	0.4	4.46	5.46
Rice equivalent yield (t ha^{-1})	4.80	8.14	6.74	2.38	7.00	5.65
Whole pattern REY (t ha^{-1})	19.68			15.03		
Gross return (Tk. ha^{-1})	129500	219680	181920	64275	188975	152600
Variable cost (Tk. ha^{-1})	45398	162062	66820	38093	139650	58130
Gross margin (Tk. ha^{-1})	84102	57618	115100	26182	49325	94470
Total Gross return (Tk. ha^{-1})	531100			405850		
Total variable cost (Tk. ha^{-1})	274280			235873		
Total gross margin (Tk. ha^{-1})	256820			169977		
MBCR	3.26					

Output price (Tk. kg^{-1}). Improved: Lentil: BARI Masur-8: 70.00, Stover: 5.00 rice: 27.00, rice straw: 7.00, Jute fiber: 62.50, Jute stick: 3.00, Existing: Lentil: 72.50, Stover: 3.00 rice: 27.00, rice straw: 7.00, Jute fiber: 62.50, Jute stick: 3.00

Table 22d. Average yield and Economy of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu during the years of November 2018 to October 2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Jute	T. Aman	Lentil	Jute	T. Aman
Seed/grain/fibre yield (t ha^{-1})	1.71	2.96	4.58	0.83	2.64	4.1
Stover/straw/stick yield (t ha^{-1})	0.81	4.75	5.83	0.46	4.05	5.29
Rice equivalent yield (t ha^{-1})	5.03	7.76	5.86	2.49	7	5.155
Whole pattern REY (t ha^{-1})	18.66			14.64		
Gross return (Tk. ha^{-1})	110745	174546	134662	54932	155747	117060
Variable cost (Tk..ha^{-1})	45314	142371	66717	40296	123615	56795
Gross margin (Tk. ha^{-1})	65431	37175	67945	14636	32132	60265
Total Gross return (Tk. ha^{-1})	419953			327740		
Total variable cost (Tk. ha^{-1})	254402			220706		
Total gross margin (Tk ha^{-1})	170851			107034		
MBCR	2.65					

Activity-10: Improvement of existing Mustard-Jute-T. Aman cropping pattern at FSRD site, Sholakundu, Faridpur during the years of 2018 to 2021.

Existing cropping pattern: Mustard (Tori-7)-Jute (JRO524)- T. Aman rice (BRRI dhan39)
Improved cropping pattern: Mustard (BARI Sarisha-17/18)- Jute (Rabi-1)-T. Aman rice (Binadhan-17/BRRI dhan75)

For improved cropping pattern, BARI Sarisha-17 for 2018-19 and BARI Sarisha-18 for 2019-20, Rabi-1 and Binadhan-17 for 2019 and BRRI dhan75 for 2020 were used whereas, local Mustard (Tori), JRO 524 (Jute) and BRRI dhan39 were used in existing cropping pattern (Table 23a). Sowing date of Mustard, Jute and T. Aman (transplanting) for improved cropping pattern during both the year was 9 to 30 Nov, 20 Mar to 5 Apr and 10 to 18 Aug, respectively. For both years in improved cropping pattern, field duration was 91-102 days, 120-125 days and 95-103 day for Lentil, Jute and T. Aman, respectively. Field duration of BARI Sarisha-18 was higher than BARI Sarisha-17.

The crop yield and monetary return of the improved and existing patterns for both the years are presented in Table 23b and 23c. From those table, it was found that, NARS varieties were performed better than that of farmer's existing varieties. For second year (2019-20), main *pat* (mature Jute) and *baschh pat (*immature Jute*)* yield were included for calculating gross return. The MBCR of first year (2018-19) and second year (2019-20) was 2.04 and 2.37, respectively. During 2nd year, yield of product and by product was higher than that of first year resulting higher rice equivalent yield (18.18), whole pattern gross margin (Tk. 214276 ha^{-1}) and MBCR.

The Table 23d showed the average yield and economy of improved and existing cropping pattern for 2018-19 and 2019-20. In the improved pattern, BARI released Mustard variety gave higher seed yield (1.71 t ha^{-1}) over local (0.91 t ha^{-1}) at FSRD site, Sholakundu, Faridpur. The Mustard yield in improved pattern was increased by 88% due to application of balance fertilizer, better management practices and also due to inclusion of modern variety. Rabi-1 gave higher fibre yield (3.02 t ha^{-1}) over JRO-524 (2.60 t ha^{-1}). The T. Aman yield in improved cropping pattern was increased by above 12%. The Whole pattern Rice equivalent yield was 17.34 t ha^{-1} and 13.95 t ha^{-1}, respectively. Whole pattern gross margin was Tk. 140331 ha^{-1} and Tk. 97055 ha^{-1} for improved pattern and existing pattern, respectively. The average MBCR was 2.25.

Farmers were interested following improved cropping pattern with BARI Sarisha-18 for Mustard, Rabi-1 for Jute and BRRI dhan75 for rice production. Binadhan-17 was infected with false smut during pre-mature stage of grain resulting lower yield. BARI Sarisha-18 produced higher yield than that of BARI Sarisha-17. Farmers who have more family members showed interest to harvest basch pat with main pat (Jute). They stored seed of Mustard and T. Aman for next year cultivation.

Table 23a. Crop managements of improved and existing cropping pattern during the years of November 2018 to October 2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Jute	T. Aman	Mustard	Jute	T. Aman
Variety	BARI Sarisha-17/ 18	Rabi-1	Binadhan-17/ BRRI dhan75	Torri	JRO524	BRRI dhan39
Date of sowing/ Transplanting	9-20 Nov /25-30 Nov	26 Mar to 5 Apr / 20-30 Mar	12-18 Aug / 5-10 Aug	10-19 Nov / 21-30 Nov	25 Mar-5 Apr / 20-30 Mar	25 Jul-10 Aug/ 12-21 Aug
Seed rate ((kg ha^{-1})	35	6.5	50	40	7	50
Spacing	Broadcast	Broadcast	20 cm x 15 cm	Broadcast	Broadcast	20 cm x 15 cm
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	120-36-40-15-2-1	140-30-25-15-4-2	80-15-35-8-1-0	92-30-50-9-2-1	95-20-50-0-0-0	45-20-25-18-3-1
Date of harvesting (range)	10-18 Feb/ 5-8 Mar	28 Jul to 6 Aug/ 20-27 Jul	16-20 Nov/ 15-20 Nov	27 Jan-6 Feb/ 10-15 Feb	20 Jul to 3 Aug/ 18-25 Jul	5-15 Nov/ 25-30 Nov
Field duration(days)	91-94/ 100-102	124-125	95-100	79-80	118-121	98-104
Turned around time (days)	43-45/ 14-21	11-14	--	56-57	4-6	--

Table 23b. Yield and Economic analysis of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu, Faridpur during the year of November 2018 to October 2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Jute	T. Aman	Mustard	Jute	T. Aman
Variety	BARI Sarisha-17	Rabi-1	Binadhan-17	Torri	JRO524	BRRI dhan39
Seed/grain/fibre yield (t ha^{-1})	1.65	2.73	3.94	0.90	2.36	3.85
Stover/straw/stick yield (t ha^{-1})	2.76	4.30	4.85	1.80	3.34	4.10
Rice equivalent yield (t ha^{-1})	4.17	7.56	4.77	2.42	6.64	4.55
Whole pattern Rice equivalent yield (t ha^{-1})	16.50			13.61		
Gross return (Tk. ha^{-1})	72900	132338	83500	42300	116220	79670
Variable cost (Tk. ha^{-1})	45860	113110	63383	36903	106180	54460
Gross margin (Tk. ha^{-1})	27040	19228	20117	5397	10040	25210
Total Gross return (Tk. ha^{-1})	288738			238190		
Total variable cost (Tk. ha^{-1})	222353			197543		
Total gross margin (Tk. ha^{-1})	66385			40647		
MBCR	2.04					

Output price (Tk. kg^{-1}). Mustard: 40.00, stover: 2.50, rice: 17.50, rice straw: 3.00 Jute fiber: 43.75, Jute stick: 3.00

Table 23c. Yield and Economy of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu, Faridpur during the year of November 2018 to October 2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Jute (both main and *basch pat*)	T. Aman	Mustard	Jute (Main pat)	T. Aman
Variety	BARI Sarisha-18	Rabi-1	BRRI dhan75	Tori-7	JRO 524	BRRI dhan39
Seed/grain/fibre yield (t ha^{-1})	1.77	3.32	4.97	0.91	2.84	4.12
Stover/straw/stick yield (t ha^{-1})	2.78	5.38	6.46	1.66	5.53	5.36
Rice equivalent yield (t ha^{-1})	3.26	8.28	6.64	1.70	7.08	5.51
Whole pattern REY (t ha^{-1})	18.18			14.29		
Gross return (Tk. ha^{-1})	87990	223640	179410	45930	191090	148760
Variable cost (Tk. ha^{-1})	48820	162562	65382	34210	141532	56575
Gross margin (Tk. ha^{-1})	39170	61078	114028	11720	49558	92185
Total Gross return (Tk. ha^{-1})	491040			385780		
Total variable cost (Tk. ha^{-1})	276764			232317		
Total gross margin (Tk. ha^{-1})	214276			153463		
MBCR	2.37					

Output price (Tk/kg). Improved and existing: Mustard: 45.00, Stover: 3.00 rice: 27.00, rice straw: 7.00, Jute fiber: 62.50, Jute stick: 3.00

Table 23d. Average yield and Economy of improved cropping pattern and existing cropping pattern at the FSRD site, Sholakundu, Faridpur during the year of November 2018 to October 2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Jute	T. Aman	Mustard	Jute	T. Aman
Seed/grain/fibre yield (t ha^{-1})	1.71	3.02	4.45	0.91	2.60	3.99
Stover/straw/stick yield (t ha^{-1})	2.77	4.84	5.65	1.73	4.44	4.73
Rice equivalent yield (t ha^{-1})	3.71	7.92	5.70	2.06	6.86	5.03
Whole pattern Rice equivalent yield (t ha^{-1})	17.34			13.95		
Gross return (Tk. ha^{-1})	80445	177989	131455	44115	153655	114215
Variable cost (Tk. ha^{-1})	47340	137836	64382	35556	123856	55517
Gross margin (Tk. ha^{-1})	33105	40153	67073	8559	29799	58698
Total Gross return (Tk. ha^{-1})	389889			311985		
Total variable cost (Tk. ha^{-1})	249558			214930		
Total gross margin (Tk. ha^{-1})	140331			97055		
MBCR	2.25					

FSRD Site, Atia, Tangail

Activity-11: Development of alternative cropping pattern at FSRD site, Atia, Tangail during the years of 2018 to 2020.

Existing cropping pattern: Boro (BRRI dhan29)-T. Aman rice (BR11)-Mustard (BARI Sarisha-14)

Improved cropping pattern: Boro (BRRI dhan29)-T. Aman rice (BRRI dhan72)-Mustard (BARI Sarisha-14)

Different crop management practices are presented in Table 24a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern are presented in Table 24b and 24c. In the improved cropping pattern, BARI Sarisha-14 gave seed yield 1.79 and 1.75 tha^{-1} which was 83 and 59 % higher over the farmers' existing variety Tori-7 (0.98 and 1.10 t ha^{-1}) due to introduce high yielding variety and improved management practices in two consecutive years. BRRI dhan29 produced grain yield 6.49 and 6.56 t ha^{-1} which gave 5 and 4 % higher yield compared to existing pattern (6.49 and 6.30 t ha^{-1}) might be due to better management practices and balance fertilization. BRRI dhan72 gave higher grain yield (5.42 and 5.36 t ha^{-1}) and farmers' existing variety BR11produced lower grain yield (4.59 and 4.56 t ha^{-1}) at the FSRD site, Atia, Tangail in two successive years. T. Aman rice variety BRRI dhan72 gave higher yield by 18 and 27 % over BR11 due to better management practices, use balance fertilizer, seedling age and also inclusion of new rice variety. Rice equivalent yield of improved cropping pattern was 16.84 and 16.75 t ha^{-1} $yr.^{-1}$ which was about 25 and 22% higher against existing cropping pattern (13.50 and 13.91t $ha^{-1}yr^{-1}$) due to introduction of high yielding T. Aman and Mustard variety and improved management practices. Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was observed that improved cropping pattern produced higher gross margin Tk. 105335 and 102810 ha^{-1} which was 62 and 57 % higher against existing cropping pattern in two consecutive years. The marginal benefit cost ratio (MBCR) was obtained 3.60 and 4.49 which further indicated the superiority to improved cropping pattern over existing pattern.

Table 24a. Crop managements of improved and existing cropping pattern at FSRD site, Atia, Tangail.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Boro	T. Aman	Mustard	Boro	T. Aman	Mustard
Varity	BRRI dhan29	BRRI dhan72	BARI Sarisha-14	BRRI dhan29	BR11	Tori-7
Date of sowing/ Transplanting	10-18 Feb.	25-31 Jul	12-16 Nov.	06-15 Feb.	8-14 Jul.	10-15 Nov.
Seed rate ((kg ha^{-1})	40	30	6	50	35	8
Spacing (cm)	25×15	25×15	Broadcast	25×15	25×15	Broadcast
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	140-15-45-10-2-0	70-10-40-10-2-0	100-32-40-24-1-1	115-24-50-20-0-0	90-20-40-20-0-0	70-15-17-0-0-0
Date of harvesting (range)	15-24 Jun	25-30 Oct	5-10 Feb.	13-22 Jun	24-31 Oct	25-30 Jan
Field duration(days)	125-126	92-93	85-86	127-128	108-110	76-77
Turned around time (days)	5-8	40-41	15-17	12-14	24-25	15-17

Table 24b. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Atia, Tangail during the year of November 2018 to October 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Boro	T. Aman	Mustard	Boro	T. Aman	Mustard
Seed/grain yield (t ha^{-1})	6.49	5.42	1.79	6.19	4.59	0.98
Straw yield (t ha^{-1})	5.85	5.30	2.41	6.12	4.87	1.58
Rice equivalent yield (t ha^{-1})	6.49	5.42	4.93	6.19	4.59	2.72
Whole pattern REY (t ha^{-1})	16.84			13.50		
Gross return (Tk. ha^{-1})	109050	97320	74010	105090	78590	40780
Total variable cost (Tk. ha^{-1})	77560	55805	41680	76128	51690	31700
Gross margin (Tk. ha^{-1})	31490	41515	32330	28962	26900	9080
Whole pattern gross margin (Tk. ha^{-1})	105335			64942		
MBCR	3.60					

Unit price (Tk. kg^{-1}): Boro rice=15, T. *Aman* rice=16.00, Rice straw =2, Mustard seed =40 and stover=1.00

Table 24c.Yield and Economic analysis of alternate and existing cropping pattern at the FSRD site during the year of November 2018 to October 2021.

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Boro	T. Aman	Mustard	Boro	T. Aman	Mustard
Seed/grain yield (t ha^{-1})	6.56	5.36	1.75	6.30	4.56	1.10
Straw yield (t ha^{-1})	5.90	5.30	2.50	5.70	4.85	1.80
Rice equivalent yield (t ha^{-1})	6.56	5.36	4.83	6.30	4.56	3.05
Whole pattern Rice equivalent yield (t ha^{-1})	16.75			13.91		
Gross return (Tk. ha^{-1})	110200	96360	72500	105900	82660	45800
Total variable cost (Tk. ha^{-1})	78650	56250	41350	77500	52500	36300
Gross margin (Tk. ha^{-1})	31550	40110	31150	28400	27600	9500
Whole pattern gross margin (Tk. ha^{-1})	102810			65500		
MBCR	4.49					

Unit price (Tk. kg^{-1}): Boro rice=15, T. *Aman* rice=16.00, Rice *straw =2, Mustard seed =40 and stover=1.00*

Activity-12: Development of alternative cropping pattern at FSRD site, Atia, Tangail during the years of 2018 to 2020.

Existing cropping pattern: Brinjal (Singhnath)-T. Aman rice (BR11)-Cabbage (Autumn queen)
Improved cropping pattern: Okra (BARI Derosh-2)-T. Aman rice (BRRI dhan72)- Cabbage (Autumn queen)

Different crop management practices are presented in Table 25a. Agronomic and economic performance of improved cropping pattern against existing cropping pattern are presented in Table 25b and 25c. In improved cropping pattern, Cabbage gave head yield 80.55 and 85.50 t ha^{-1} which was 2.74 and 3.76% higher over the farmers' practice (78.40 and 82.40 t ha^{-1}) due to improved management practices and balance fertilization in two successive years. BARI dherosh-2 produced fruit yield 16.15 and 16.56 t ha^{-1} and BRRI dhan72 gave higher grain yield (5.34 and 5.30 t ha^{-1}) and farmers' existing variety BR11produced lower grain yield (4.23 and 4.53 t ha^{-1}) at the FSRD site, Atia, Tangail. T. Aman rice variety BRRI dhan72 gave higher yield by 26 and 17 % over BR11 due to better management practices, use balance fertilizer, seedling age and also inclusion of new rice variety. Rice equivalent yield of improved cropping pattern was 40.62 and 42.21 t ha^{-1} yr.$^{-1}$ which was about 27.37 and 20.22% higher against existing cropping pattern (31.89 and 35.11 t ha^{-1}yr^{-1}) due to introduction of high yielding T. Aman rice variety and improved management practices. Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was also observed that the higher total gross margin Tk. 431160 and 465050 ha^{-1} was obtained from improved cropping pattern against existing cropping pattern which was 38 and 27% higher over existing pattern in two consecutive years. The marginal benefit cost ratio (MBCR) was obtained 6.34 and 6.98 which further indicated the superiority to improved cropping pattern over existing pattern.

Table 25a**.** Crop management of improved and existing cropping pattern, FSRD site, Atia, Tangail.

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Okra	T. Aman	Cabbage	Brinjal	T. Aman	Cabbage
Varity	BARI Derosh-2	BRRI dhan72	Autumn queen	Singhnath	BR11	Autumn queen
Date of sowing/ Transplanting	09-12 March	20-25 July	10-16 Nov	20-25 Jan	14-25July	15-19 Nov
Seed rate (kg ha^{-1})	5	40	0.4	0.4	50	0.4
Spacing (cm)	45 cm x 30cm	25cm x15cm	60 cm x 45cm	100 cm x 75cm	25cm x15cm	60 cm x 45cm
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	70-20-75-0-0-0	70-10-40-10-2	138-40-125-20-0-1	138-50-100-16-0-2	90-20-40-20	118-40-75-0-0-0
Date of harvesting	20 Apr.-25Jun	14-20 Oct.	7-17 Feb	10Mar-28Jun	24-29 Oct	10-20 Feb
Field duration(days)	106-110	84-88	88-92	157-161	102-104	85-89
Turned around time (days)	28-32	24-26	24-28	-	14-18	15-19

Table 25b. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Atia, Delduar, Tangail during the year of November 2018 to October 2021.

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Okra	T. Aman	Cabbage	Brinjal	T. Aman	Cabbage
Card/fruit/grain yield (t ha^{-1})	16.15	5.34	80.55	12.90	4.23	78.40
Straw yield (t ha^{-1})	-	5.30	-	-	4.20	-
Rice equivalent yield (t ha^{-1})	15.14	5.34	20.14	8.06	4.23	19.60
Whole pattern rice equivalent yield (t ha^{-1})	40.62			31.89		
Gross return (Tk. ha^{-1})	242250	85440	322200	129000	67680	313600
Total variable cost (Tk. ha^{-1})	83840	56570	78320	72760	49830	74120
Gross margin (Tk. ha^{-1})	158410	28870	243880	56240	17850	239480
Whole pattern gross margin (Tk. ha^{-1})	431160			297570		
MBCR	6.34					

Unit Price: Card price =Tk.4.00 kg^{-1}, Brinjal=10.00, Okra= Tk.15 kg^{-1}, T. Aman rice= Tk.16.00 kg^{-1}, Straw= Tk.2.00 kg^{-1} and stover=1.00

Table 25c. Yield and Economic analysis of improved and existing cropping pattern at FSRD site, Atia, Delduar, Tangail during the year of November 2018 to October 2021.

Observations	Improved cropping pattern			Existing cropping pattern		
Crop	Okra	T. Aman	Cabbage	Brinjal	T. Aman	Cabbage
Card/fruit/grain yield (t ha^{-1})	16.56	5.30	85.50	13.30	4.53	82.40
Straw yield (t ha^{-1})	-	5.40	-	-	4.80	-
Rice equivalent yield (t ha^{-1})	15.53	5.30	21.38	9.98	4.53	20.60
Whole pattern rice equivalent yield (t ha^{-1})	42.21			35.11		
Gross return (Tk. ha^{-1})	248400	95600	342000	159600	82080	329600
Total variable cost (Tk. ha^{-1})	84650	56750	79550	79500	51570	73450
Gross margin (Tk. ha^{-1})	163750	38850	262450	80100	30510	256150
Whole pattern gross margin (Tk. ha^{-1})	465050			366760		
MBCR	6.98					

Unit Price: Card price =Tk.4.00 kg^{-1}, Brinjal=12.00, Okra= Tk.15 kg^{-1}, T. Aman rice= Tk.16.00 kg^{-1}, Straw= Tk.2.00 kg^{-1} and stover=1.00

FSRD Site, Tarakandi, Sherpur

Activity-13: Development of alternative cropping pattern at FSRD site, Tarakandi, Sherpur during the years of 2018 to 2021.

Existing cropping pattern: T. Aman (Hori)-Fallow-Boro (BRRI dhan29)
Alternate cropping pattern: T. Aman (BRRI dhan49)-Potato (BARI Alu-25)-Mungbean (BARI Mung-6)-T. Aus (BRRI dhan48)

Different crop management practices are presented in Table 26a. Yield and economic performance of alternate cropping pattern against existing pattern are presented in Table 26b, 26c and 26d. In the alternate pattern, BARI Alu-25 gave tuber yield (38.7and 27.67 t ha^{-1} at 2018-19 and 2019-20) whereas in existing cropping pattern the land remained fallow at the FSRD site, Tarakandi, Sherpur during 2018-21. Inclusion of Mungbean in the pattern increased total production as well as improve soil health as leguminous crop. The variety Hori dhan gave higher yield than the BRRI dhan49 during two consecutive years. Boro rice variety BRRI dhan29 gave yield 5.5 t ha $^{-1}$ in existing pattern. Alternate cropping pattern gave higher REY (26.8 t ha^{-1}yr^{-1}) than existing pattern (9.21 t ha^{-1}yr^{-1}) in two consecutive years. From two years average, it was observed that the higher total gross margin Tk. 245188 ha^{-1} was obtained from alternate cropping pattern T. Aus (BRRI dhan48)-T. Aman (BRRI dhan49)-Potato (BARI Alu-25)-Mungbean (BARI Mung-6) against existing cropping pattern T. Aman (Hori dhan)-Fallow-Boro (BRRI dhan29) with Tk.75075 ha^{-1}. The marginal benefit cost ratio (MBCR) was obtained 1.93 and 1.84 which indicated the superiority to alternate cropping pattern over existing pattern.

Table 26a. Crop managements of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur.

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aman	Potato	Mungbean	T. Aus	T. Aman	Fallow	Boro
Varity	BRRI dhan49	BARI Alu-25	BARI Mung-6	BRRI dhan48	Hori dhan	_	BRRI dhan29
Date of sowing/ Transplanting	18-29 Aug.	18-28 Nov.	4-9 Mar.	28 May-2 June	27-29 Jul.	_	25-26 Jan.
Seed rate (kg ha^{-1})	40	2000	30	40	50	-	40
Spacing (cm)	(20 x 15)	(60 x 25)	Broadcast	(20 x 15) cm	(20 x 15)	-	(20 x 15)
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	82-24-35-11-4-0	150-40-113-18-2.7-1	20-15-38-0-0-0	69-15-38-10-0-0	90-20-25-0-0-0	_	130-30-81-15-0-0-0
Date of harvesting (range)	10-15 Nov.	17-20 Feb.	10-20 May	15-20 Aug.	20-25 Nov.	_	20-30 May
Field duration (days)	85-90	90-95	68-72	80-85	120-125	-	115-125
Turned around time (days)	8-13	17-19	12-18	3-9	53-66	-	33-37

Table 26b. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aman	Potato	Mungbean	T. Aus	T. Aman	Fallow	Boro
Seed/grain yield (t ha^{-1})	3.9	38.7	-	4.5	4.2	-	-
Straw yield (t ha^{-1})	4.4	-	-	5.06	5.2	-	-
Rice equivalent yield (t ha^{-1})	4.60	20.37	-	4.80	4.31	-	-
Whole pattern Rice equivalent yield (t ha^{-1})	-				-		
Gross return (Tk. ha^{-1})	82900	387000	-	91120	81800	-	-
Total variable cost (Tk. ha^{-1})	48020	162925	-	47045	50000	-	-
Gross margin (Tk. ha^{-1})	34880	224075	-	44075	31800	-	-
Whole pattern gross margin (Tk. ha^{-1})	-				-		
MBCR	-				-		

Unit price (Tk. kg^{-1}): *Aman* rice=19.00, T Aus=18.00, Boro rice=17.00, Hori Dhan= 17.00, Rice straw =2.00, Potato=10.00

Table 26c. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur

Observation	Alternate cropping pattern				Existing cropping pattern		
Crop	T. Aman	Potato	Mungbean	T. Aus	T. Aman	Fallow	Boro
Seed/grain yield (t ha^{-1})	3.9	27.67	1.08	4.7	4.3	-	5.5
Straw yield (t ha^{-1})	4.5	-	-	5.06	5.2	-	4.35
Rice equivalent yield (t ha^{-1})	4.16	18.97	3.08	3.78	4.47	-	5.12
Whole pattern Rice equivalent yield (t ha^{-1})	29.99				9.59		
Gross return (Tk. ha^{-1})	72750	332040	54000	66160	78300	-	89600
Total variable cost (Tk. ha^{-1})	49070	173142	31120	50000	50000	-	68350
Gross margin (Tk. ha^{-1})	23680	158898	22880	16160	28300	-	21250
Whole pattern gross margin (Tk. ha^{-1})	221618				49550		
MBCR	1.93						

Unit price (Tk. kg^{-1}): Aman rice=17.5, T. Aus rice=13.0, Boro Rice= 15.50, Hori dhan=17.0, Mungbean= 50.00, Rice straw =1.0, Potato=12.0

Table 26d. Yield and Economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur

Observation	Alternate cropping pattern				Existing cropping pattern		
Crop	T. Aman	Potato	Mungbean	T. Aus	T. Aman	Fallow	Boro
Seed/grain yield (t ha^{-1})	4.08	27.67	1.08	4.87	4.5	0	5.5
Straw yield (t ha^{-1})	4.85	-	-	5.07	5.1	0	4.35
Rice equivalent yield (t ha^{-1})	4.27	13.28	2.16	3.90	4.7	0	4.13
Whole pattern Rice equivalent yield (t ha^{-1})	23.61				8.83		
Gross return (Tk. ha^{-1})	106850	332040	54000	97600	117600	0	103350
Total variable cost (Tk. ha^{-1})	55450	173142	31120	62020	52000	0	68350
Gross margin (Tk. ha^{-1})	51400	158898	22880	35580	65600	0	35000
Whole pattern gross margin (Tk. ha^{-1})	268758				100600		
MBCR	1.84						

Unit price (Tk. kg^{-1}): *Aman* rice=25, Aus=19, Boro rice=18, Rice straw =1, Potato=12, Mungbean=50.

Activity-14: Development of alternative cropping pattern at FSRD site, Tarakandi, Sherpur

Existing cropping pattern: T. Aman (Hori dhan)-Fallow-Boro (BRRI dhan29)
Alternate cropping pattern: T. Aus (BRRI dhan48) – T. Aman (BRRI dhan49)-Motorshuti (BARI Motorshuti-3)-Boro (Hybrid shakka)

Different crop management practices are presented in Table 27a. Yield and economic performance of alternate cropping pattern against existing pattern are presented in Table 27b, 27c and 27d. In the alternate pattern, BARI Motorsuti-3 produced green pod yield (9.3 and 9.2 t ha^{-1} at 2018-19 and2019-20) whereas in existing cropping pattern the land remained fallow at the FSRD site, Tarakandi, Sherpur during 2018-21. The variety Hori dhan gave higher yield than the BRRI dhan 49 during two consecutive years. Boro rice variety Hybrid shakka gave higher average yield 6.13t ha $^{-1}$ in alternate cropping pattern. Alternate cropping pattern gave higher REY (29.4 t ha^{-1}yr^{-1}) than existing pattern (10.0 t ha^{-1}yr^{-1}) in two consecutive years. From two years average, it was observed that the higher total gross margin Tk. 265560 ha^{-1} was obtained from alternate cropping pattern T. Aus (BRRI dhan48)-T. Aman (BRRI dhan49)-Motorshuti (BARI Motorshuti-3)-Boro (Hybrid shakka) against existing cropping pattern T. Aman (Hori dhan)-Fallow-Boro (BRRI dhan29) with Tk. 56490 ha^{-1}. The marginal benefit cost ratio (MBCR) was obtained 1.80 and 2.39 which indicated the superiority to alternate cropping pattern over existing pattern.

Table 27a. Crop managements of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur.

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Motorshuti	Boro	T. Aman	Fallow	Boro
Varity	BRRI dhan48	BRRI dhan49	BARI Motorshuti-3	Hybrid shakka	Hori dhan	-	BRRI dhan29
Date of sowing/ Transplanting	25-30 May	20-28 Aug.	21-24 Nov.	4-17 Feb.	27-30 July	-	25-27 Jan.
Seed rate ((kg ha^{-1})	40	40	35	20	50	-	40
Spacing	20 x 15 cm2	20 x 15 cm2	25 x 10 cm2	20 x 15 cm2	20 x 15 cm2	-	20 x 15 cm2
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	69-15-38-10-0-0	82-24-35-11-4-0	46-30-50-0-0-0	100-30-40-10-3.6-0	90-20-25-0-0-0	–	130-30-81-15-0-0-0
Date of harvesting (range)	13-15 Aug.	10-15 Nov.	28-30 Jan.	14-20 May	24-26 Nov.	-	25-29 May
Field duration (days)	80-82	82-85	69-70	93-100	120	-	120-123
Turned around time (days)	10-11	7-13	9-11	7-17	63	-	63-64

Table 27b. Yield and economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur during the year of November 2018 to October 2021.

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Motorshuti	Boro	T. Aman	Fallow	Boro
Seed/grain yield (t ha^{-1})	4.0	3.41	9.3	5.9	4.2	-	5.5
Straw yield (t ha^{-1})	5.0	3.66	-	6.1	5.2	-	6.2
Rice equivalent yield (t ha^{-1})	4.54	3.81	15.08	6.08	4.65	-	5.72
Whole pattern Rice equivalent yield (t ha^{-1})	29.51				10.37		
Gross return (Tk. ha^{-1})	84000	70530	279000	112500	86000	-	105900
Total variable cost (Tk. ha^{-1})	50745	50070	81500	80500	50000	-	75600
Gross margin (Tk. ha^{-1})	33255	20460	197500	32000	36000	-	30300
Whole pattern gross margin (Tk. ha^{-1})	283215				66300		
MBCR	1.80				-		

Unit price (Tk. kg^{-1}): T Aus rice=18.50, T. Aman=18.50, Motorshuti= 30.00, Boro= 17.00, Hori dhan= 18.00, Rice straw =2.00.

Table 27c. Yield and economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur during the year of November 2018 to October 2021

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	T. Aus	T. Aman	Motorshuti	Boro	T. Aman	Fallow	Boro
Seed/grain Yield (t ha^{-1})	4.75	3.38	9.2	6.37	4.1	-	5.61
Straw yield (t ha^{-1})	5.65	3.81	0	7.18	5.1	-	4.4
Rice equivalent yield (t ha^{-1})	3.85	3.60	15.77	6.05	4.39	-	5.22
Whole pattern Rice equivalent yield (t ha^{-1})	29.27				9.61		
Gross return (Tk. ha^{-1})	67400	62960	276000	105915	74800	-	91355
Total variable cost (Tk. ha^{-1})	50745	50070	81500	82056	50000	-	69475
Gross margin (Tk. ha^{-1})	16655	12890	194500	23859	24800	-	21880
Whole pattern gross margin (Tk. ha^{-1})	247904				46680		
MBCR	2.39						

Unit price (Tk. kg^{-1}): T Aus rice=13, T. Aman=17.5, Motorshuti= 30.00, Boro= 15.50, Hori dhan= 17.00, Rice straw =1.00.

Table 27d. Yield and economic analysis of alternate and existing cropping pattern at FSRD site, Tarakandi, Sherpur during the months of November 2018 to October 2021

Observation	Improved cropping pattern				Existing cropping pattern		
Crop	Boro	T. Aus	T. Aman	Motorsuti	T. Aman	Fallow	Boro
Seed/grain yield (t ha^{-1})	6.37	4.6	4.05	9.4	4.4	-	5.60
Straw yield (t ha^{-1})	7.18	5.03	4.86	-	5.1	-	4.4
Rice equivalent yield (t ha^{-1})	4.87	3.70	4.24	11.28	4.60	-	4.21
Whole pattern Rice equivalent yield (t ha^{-1})	24.09				8.81		
Gross return (Tk. ha^{-1})	121840	62430	106110	282000	115100	-	105200
Total variable cost (Tk. ha^{-1})	82056	60500	54470	81000	52500	-	69475
Gross margin (Tk. ha^{-1})	39784	31930	51640	201000	62600	-	35725
Whole pattern gross margin (Tk. ha^{-1})	324354				98325		
MBCR	2.25						

Unit price (Tk. kg^{-1}): T Aus rice=19, T. Aman=25, Boro= 18, Hori dhan= 25, Rice straw =1.00 and Motorsuti=30.00

II. On-farm verification/Production program

On-farm verification trial

Activity-15: On-farm verification trials with modern verities of cereals, oilseed, pulses, vegetables, spices and tuber crops at different FSRD sites during the years of 2018-19.

FSRD site, Ajoddhapur, Rangpur

Different crop management, variety used, number of farmers involved in the on-farm verification trial are given in Table 28. The results revealed that in case of Mustard, BARI Sarisha-14 (yield 1.50-1.72 t ha^{-1}) and BARI Sarisha-18 (yield 1.51-1.70 t ha^{-1}) was performed better than other varieties and farmers also choose these varieties for next year cultivation. In case of Tomato, BARI Tomato-15 and BARI Tomato-18 both performed better than local variety and farmers were selected these varieties for next year cultivation. In case of Potato, all varieties gave satisfactory yield compared to BARI Alu-8, but farmers choose the BARI Alu-25 and BARI Alu-53 due to the red skin color.

Table 28 . Different operations conducted and yield of different crops under on-farm verification trial FSRD site Ajoddhapur, Rangpur during the year of November 2018 to October 2021

Crop	Variety	Planting date	Harvesting date	No. of farmers	Area (dec.)	Yield (t ha^{-1})
Mustard	BARI Sarisha-14	21-28 Nov.	27-28 Feb.	6	12	1.50-1.72
	BARI Sarisha-15	21-28 Nov.	27-28 Feb.	6	12	1.40-1.52
	BARI Sarisha-18	20-30 Nov.	7-8 March	6	12	1.51-1.70
	Tori-7	21-28 Nov.	23-25 Feb.	6	12	0.95-1.06
Tomato	BARI Tomato-15	16-18 Nov.	15Feb-09 March	3	9	76-88
	BARI Tomato-18	16-18 Nov.	15Feb-09 March	3	9	82-86
	Local	16-18 Nov.	15Feb-09 March	3	9	70-75
Potato	BARI Alu-8	28-30 Nov.	27Feb.-05 March	7	7	23.72
	BARI Alu-25	28-30 Nov.	27Feb.-05 March	7	7	29.12-30.96
	BARI Aul-46	28-30 Nov.	27Feb.-05 March	7	7	28.05-32.52
	BARI Aul-53	28-30 Nov.	27Feb.-05 March	7	7	29.53-31.25

FSRD site, Atia, Tangail

Different crop management, variety used, number of farmers involved in the on-farm verification trial are given in Table 29. iv. The results revealed that in case of Mustard, BARI Sarisha-14 (yield 1.61 t ha^{-1}) and BARI Sarisha-17 (yield 1.63 t ha^{-1}) was performed better than local varieties and farmers also choose these varieties for next year cultivation. In case of Barley, BARI Barley-6 and BARI Barley-7 both performed better than local variety and farmers were selected these varieties for next year cultivation. In case of Potato, BARI Alu-41 performed better than BARI Alu-7 and BARI Alu-8.

Table 29. Different operations conducted and yield of different crops under on-farm verification trial FSRD site Atia, Tangail during the year of November 2018 to October 2021

Crop	Variety	Planting date	Harvesting date	No. of farmers	Area (dec.)	Yield (t ha^{-1})
Mustard	BARI Sarisha-14	13-20 Nov.	4-11 Feb.	5	20	1.61
	BARI Sarisha-17	13-20 Nov.	3-12 Feb.	5	20	1.63
	Tori-7	13-20 Nov.	27-31 Jan.	5	20	0.99
Barley	BARI Barley-6	22-26 Nov	17-19 March	4	15	2.05
	BARI Barley-7	22-26 Nov	17-19 March	4	15	2.11
	Local	22-26 Nov	12-16 March	4	15	1.39
Potato	BARI Alu-7	24-28 Nov.	20-26 Feb	3	10	28.77
	BARI Alu-8	24-28 Nov.	20-26 Feb	3	10	28.96

Crop	Variety	Planting date	Harvesting date	No. of farmers	Area (dec.)	Yield (t ha^{-1})
	BARI Aul-41	24-28 Nov.	20-26 Feb	3	10	32.54
Wheat	BARI Gom-30	17-20 Nov.	12-15 March	3	60	3.65
	BARI Gom-31					3.80
	BARI Gom-32					3.78
	BARI Gom-33					3.97
Onion	BARI Piaj-1	04-11 Jan	06-15 April	3	60	17.77
	BARI Piaj-4					13.25
	Local					9.58

FSRD site, Tarakandi, Sherpur

Crop management, variety used, number of farmers involved in the on-farm verification trial are given in Table 30. The results revealed that incase of Potato, BARI Alu-41 performed better than other varieties.

Table 30**.** Different operations conducted and yield of Potato under on-farm verification trial FSRD site Tarakandi, Sherpur during the year of 2018-2019.

Crop	Variety	Planting date	Harvesting date	No. of farmers	Area (ha)	Yield (t ha^{-1})
Potato	BARI Alu-35 BARI Alu-36 BARI Alu-37 BARI Alu-40 BARI Alu-41	27.11.2019	19.02.2020-20.02.2020	01	0.5	40.62

Production program

Activity-16-35: Production a. iv. with modern verities of cereals, oilseed, pulses, vegetables, spices and tuber crops at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Different crop management, variety used, number of farmers involved in the production program of Mustard, Tomato and Potato is given in Table 31.

Table 31**.** Different operations conducted for production program at FSRD site Ajoddhapur, Rangpur.

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Mustard	BARI Sarisha-**14**	6	1	21-28 Nov.	27-28 Feb.
	BARI Sarisha-18	2	1	20-30 Nov.	7-8 March
Tomato	BARI Tomato-**15**	3	0.5	16-18 Nov.	15 Feb-09 March
Potato	BARI Alu-25	7	1.4	28-30 Nov.	27Feb.-05 March
	BARI Alu-**53**	5	1	30 Nov-10 Dec	04-10March

a. Production program of BARI released Mustard variety

The seed yield of Mustard variety BARI Sarisha-14 was 1.75 and 1.50 t ha^{-1} and the gross margin was calculated 44138 and Tk. 35695 ha^{-1} in 2018-19 and 2019-20, respectively (Table 32a). BARI Sarisha-18 produced 1.59 t ha^{-1} seed yield in 2019-20 with the gross margin Tk.40258 ha^{-1}. The average seed yield gross margin of Mustard was 1.61 t ha^{-1} and Tk. 40030 ha^{-1}, respectively.

Table 32a. Yield of Mustard variety at FSRD site, Ajoddhapur, Rangpur during the years of November 2018 to October 2021.

Year	Variety	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Gross return ($Tk.\ ha^{-1}$)			Cost of production ($Tk.\ ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
				Grain	Straw	Total		
2018-19	BARI Sarisha-14	1.75	1.9	72188	1900	74088	29950	44138
2019-20	BARI Sarisha-14	1.50	1.82	61875	1820	63695	28000	35695
2019-20	BARI Sarisha-18	1.59	2.67	65588	2670	68258	28000	40258
2020-21	BARI Sarisha-14	1.60	2.12	*66551*	*2130*	*68681*	28650	40031
Average	-	*1.61*	*2.13*	*66550*	*2130*	*68680*	*28650*	*40030*

Market price of output ($Tk.\ Kg^{-1}$): Seed=41.25 and Stover =1.00.

b. Production program of BARI released Tomato varieties

BARI Tomato-15 and BARI Tomato-18 seedlings were produced and supplied by the LSP to other farmers, who was bought it at reduced price. The fruit yield of BARI Tomato15 was 88.00 and 76.54 $t\ ha^{-1}$ and gross margin was calculated Tk. 662000 and 560400 ha^{-1} during the year of 2018-19 and 2019-20, respectively (Table 32b). BARI Tomato-18 produced 82.32 $t\ ha^{-1}$ fruit yield with gross margin Tk. 618200 ha^{-1} in 2019-20. The average fruit yield and gross margin were 82.29 t ha^{-1} and Tk. 613533 ha^{-1}, respectively.

Table 32b. Yield of Tomato variety at FSRD site, Ajoddhapur, Rangpur during the years of November 2018 to October 2021.

Year	Variety	Fruit yield ($t\ ha^{-1}$)	Gross return ($Tk.\ ha^{-1}$)			Cost of production ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
			Fruit	Straw	Total		
2018-19	BARI Tomato-15	88.00	880000	-	880000	218000	662000
2019-20	BARI Tomato-15	76.54	765400	-	765400	205000	560400
2019-20	BARI Tomato-18	82.32	823200	-	823200	205000	618200
2020	BARI Tomato-15	82.28	822868	-	822868	209335	613532
Average	-	82.29	822867	-	822867	209333	613533

Market price of output ($Tk.\ kg^{-1}$): Tomato=10.

c. Production program of BARI released Potato varieties

BARI Alu-53 and BARI Alu-25 were produced during 2018-19, 2019-20 and 2020. The tuber yield of BARI Alu-53 and BARI Alu-25 were 29.62 and 30.12 $t\ ha^{-1}$ and gross margin was calculated Tk. 170200 and 174200 ha^{-1} in 2018-19 and 2019-20, respectively (Table 32c). The average tuber yield and gross margin were 29.87 $t\ ha^{-1}$ and Tk.172200 ha^{-1}, respectively.

Table 32c. Yield of Potato variety at FSRD site, Ajoddhapur, Rangpur during the years of November 2018 to October 2021.

Year	Variety	Tuber yield ($t\ ha^{-1}$)	Gross return ($Tk.\ ha^{-1}$)			Cost of production ($Tk.\ ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
			Tuber	Straw	Total		
2018-19	BARI Alu-53	29.62	296200	-	296200	126000	170200
2019-20	BARI Alu-25	30.12	301200	-	301200	127000	174200
2020	BARI Alu-53	29.86	298699	-	298699	126500	172199
Average	-	*29.87*	*298700*	-	*298700*	*126500*	*172200*

Market price of output ($Tk.\ kg^{-1}$): Potato=10.

FSRD site, Gangarampur, Pabna

The production program on Wheat, Garlic, Onion, Mustard, Lentil, Sesame and Turmeric was conducted at FSRD site, Gangarampur, Pabna during the years of 2018 to 2021. The number of cooperator farmers, area coverage, date of sowing/planting and date of harvesting is presented in Table 33. The variety BARI Gom-28, BARI Rashun-2 and BARI Piaz-2, BARI Sarisha-17, BARI Masur-8 and BARI Halud-4 was used in the production program. The average yield of Wheat was

4.12 t ha^{-1} with gross margin of Tk. 24000 ha^{-1}. The average yield of Garlic was 8.75 t ha^{-1} with gross margin of Tk. 96250 ha^{-1}. The average yield of Onion was 12.50 t ha^{-1} with gross margin of Tk. 6500 ha^{-1}. (Table 34a). The production program of Mustard (var. BARI Sarisha-17), Lentil (var. BARI Masur-8) and Turmeric (var. BARI Halud-4) was conducted during 2019-20 and continuing at rabi season of 2020. The average seed yield of Mustard was 1.95 t ha^{-1} with gross margin of Tk. 42062 ha^{-1} (Table 34b). The average seed yield of Lentil was 1.58 t ha^{-1} with gross margin of Tk. 71500 ha^{-1} (Table 34c). The average rhizome yield of Turmeric was 14.50 t ha^{-1} with gross margin of Tk. 119750 ha^{-1} (Table 34d). The production program of Sesame (var. BARI Til-4) was conducted during 2019-20. The average seed yield of Sesame was 1.5 t ha^{-1} with gross margin of Tk. 38700 ha^{-1} (Table 34e).

Table 33**.** Different operations conducted for production program at FSRD site, Gangarampur, Pabna during the years of November 2018 to October 2021.

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ planting	Date of harvesting
Wheat	BARI Gom-28	2	0.5	20-26 Nov	26-28 Mar
Garlic	BARI Roshun-2	2	0.5	25-27 Nov	15-17 Mar
Onion	BARI Piaz-2	1	0.2	22-25 Dec	25-30 Mar
Mustard	BARI Sarisha-17	95	20	25-29 Nov	03-7 Mar
Lentil	BARI Masur-8	30	7	02-6 Dec	15-20 Mar
Sesame	BARI Til-4	12	2.5	15-20 March	01-5 June
Turmeric	BARI Halud-4	3	0.2	22-24 May	28-30 Dec

Table 34a. Performance of Wheat, Garlic and Onion at FSRD site, Gangarampur, Pabna during the year of 2018-2019.

Crop	Variety	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Gross return (t ha^{-1})	Cost of Production (t ha^{-1})	Gross margin (t ha^{-1})
Wheat	BARI Gom-28	4.12	4.45	82500	58500	24000
Garlic	BARI Roshun-2	8.75	-	218750	122500	96250
Onion	BARI Piaz-2	12.50	-	187500	122500	6500

Unit Price (Tk. Kg^{-1}): Wheat grain = 20, Garlic = 25, Onion = 15

Table 34b. Performance of Mustard at FSRD site, Gangarampur, Pabna during the year of November 2018 to October 2021.

Year	Variety	Seed yield (t ha^{-1})	Gross return (t ha^{-1})	Cost of Production (t ha^{-1})	Gross margin (t ha^{-1})
Feb. 2019 to Jan 2020	BARI Sarisha-17	1.95	95062	53000	42062
Feb.2020 to Jan. 2021	BARI Sarisha-17	1.94	95050	53050	42000

Unit Price: Mustard = 45

Table 34c. Performance of Lentil at FSRD site, Gangarampur, Pabna during the year of 2019-2021.

Year	Variety	Yield (t ha^{-1})	Gross return (t ha^{-1})	Cost of Production (t ha^{-1})	Gross margin (t ha^{-1})
Feb. 2019 to Jan 2020	BARI Masur-8	1.58	105000	33500	71500
Feb. 2020 to Jan. 2021	BARI Masur-8	1.59	105050	33500	71550

Unit Price: Lentil= 70

Table 34d. Performance of Turmeric at FSRD site, Gangarampur, Pabna during the year of 2019-2021.

Year	Variety	Yield (t ha-1)	Gross return (t ha-1)	Cost of Production (t ha-1)	Gross margin (t ha-1)
Feb. 2019 to Jan 2020	BARI Halud-4	14.50	290000	170250	119750
Feb.2020 to Jan.2021	BARI Halud-4	14.52	290200	170250	119950

Unit Price: Turmeric=20 Tk. kg-1.

Table 34e. Performance of Sesame at FSRD site, Gangarampur, Pabna during the year of November 2018 to October 2021.

Crop	Variety	Grain yield (t ha-1)	Gross return (t ha-1)	Total variable cost (Tk. ha-1)	Gross margin (t ha-1)
Sesame	BARI Til-4	1.5	77000	38300	38700

FSRD Site, Sholakundu, Faridpur

Different BARI released 15 crop varieties were used for conduction production program during the years of 2018 to 2021. A total of 51 farmer's field including 4.7 ha of land were used (Table 35).

Table 35. Production program conducted during the years of November 2018 to October 2021

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Mustard	BARI Sarisha-14	3	0.24	8-15 Nov 18	6-12 Feb 19
	BARI Sarisha-18	3	0.3	30 Nov. -3 Dec. 19	9-11 Mar. 2020
Wheat	BARI Gom-28	4	0.4	30 Nov. -2 Dec. 18	24-25 Mar 19
	BARI Gom-33	3	0.4	30 Nov. -8 Dec. 19	19-27 Mar 20
Mungbean	BARI Mung-6	2	0.16	5 Mar 19	12-27 May 19 (2 picking)
	BARI Mung-8	3	0.24	1-2 March 2020	9-10 May 2020 (1 picking)
Sesame	BARI Til-4	3	0.24	8-12 Mar 19	1-3 Jun 19
	BARI Til-4	4	0.25	19-25 March20	15-22 June,20
Lentil	BARI Masur-8	3	0.3	28 Nov.-3 Dec. 19	20-22 Mar 2020
	BARI Masur-8	4	0.25	19 Nov-3 Dec 20	--
Onion	BARI Piaj-1	3	0.3	4-14 Jan 2020	24-31 Mar 2020
	BARI Piaj-4	3	0.3	1-10 Jan 20	24-31 Mar 2020
	BARI Piaj-1	4	0.5	30 Dec 20-10 Jan 21	--
	BARI Piaj-4	4	0.5	30 Dec 20-10 Jan 21	--
Bottle gourd	Hybrid	1	0.06	25 Jul 20	25 Sep-20 Nov 20
Summer Tomato	BARI Hybrid Tomato-11	1	0.012	16 Aug 20	7-31 Oct 20
Black gram	BARI Mash-3	2	0.2	17 Sep 20	3 Dec 20
Intercropping of Radish+Onion bulb+Red amaranth with Sugarcane	Radish (BARI Mula-1), Onion (BARI Piaz-1), Red amaranth (BARI Lalshak-1), Sugarcane (Gendari local)	1	0.06	Sugarcane: 28 Oct 19 Radish+Onion+red amaranth: 1 Nov 2019	Sugarcane: 5-18 Oct 20 Radish: 1-5 Jan 2020 Onion: 5-10 Jan 2020 Red amaranth: 4-5 Dec 2019

Mustard: BARI Sarisha-14 and 18 were used during 2018-19 and 2019-20, respectively. The seed was sown on 8-15 Nov 2018 (BARI Sarisha-14) and 30 Nov -3 Dec 2019 (BARI Sarisha-18). A total of 0.54 ha of land with six farmers were selected. The fertilizers were applied @ 120-36-40-15-2-1 kg of N-P-K-S-Zn-B ha^{-1}. The crop was harvested on 6-12 Feb 2019 and 9-11 Mar 2020. The yield of BARI Sarisha-14 was 1.76 t ha^{-1} with gross margin Tk 27070 ha^{-1} (Table 36a). BARI Sarisha-18 produced 1.71 t ha^{-1} seed yield with 2.67 t ha^{-1} stover yield. Gross margin of BARI Sarisha-18 was 35% higher than that of BARI Sarisha-14. Average seed yield, gross return and gross margin was 1.74 t ha^{-1}, Tk 82080 ha^{-1} and Tk. 31843 ha^{-1}.

Farmers opined positive to the new variety BARI Sarisha-14 and 18 for its higher seed yield and negligible pest infestation. A good number of seed has been stored by the farmers for growing in the next year. Shattering tendency of seed in BARI Sarisha-18 was observed. Plant height was higher than that of BARI Sarisha-14 resulting lodging.

Wheat: BARI Gom-28 and BARI Gom-33 were used during 2018-19 and 2019-20, respectively. The seed was sown on 30 Nov-2 Dec 2018 (BARI Gom-28) and 30 Nov -8 Dec 2019 (BARI Gom-33). A total of 0.80 ha of land with seven farmers were selected. The fertilizers were applied @ 160-30-60-15-3-1 kg of N-P-K-S-Zn-B ha^{-1}. Two-third of N and full amount of P, K, S, Zn and B were applied as basal during final land preparation. The remaining one-third of N was applied at 20-25 DAS. The crop was irrigated twice (20-25 and 55-65 DAS). Nativo was sprayed at 55-60 DAS and 70-75 DAS. The crop was harvested during 24-25 March 2019 and 19 to 27 March 2020. The grain yield of BARI Gom-28 was 3.81 t ha^{-1}. Gross margin was calculated Tk. 26542 ha^{-1} (Table 36b). BARI Gom-33 produced 3.95 t ha^{-1} grain yield Gross margin of BARI Gom-33 was 7% higher than that of BARI Gom-28. Average grain yield, gross return and gross margin was 3.88 t ha^{-1}, Tk 88287 ha^{-1} and Tk. 27474 ha^{-1}.

Farmers' opined that grain color of BARI Gom-33 was attractive and shiny. Plants remain greenish even at the time of mature stage resulting lower lodging. Farmers are happy with that cultivar due to higher yield and blast resistant over their existing varieties.

Mungbean: BARI Mung-6 and BARI Mung-8 were used during the years of 2019 and 2020, respectively. The seed was sown on 5 March 2019 (BARI Mung-6) and 1-2 March 2020 (BARI Mung-8). A total of 0.40 ha of land with five farmers were selected. The fertilizers were applied @ 24-32-24-18-2-1 kg of N-P-K-S-Zn-B ha^{-1}. All fertilizer was applied as basal during final land preparation. One irrigation (29-30 DAS) and one hand weeding (26-28 DAS) were done. The crop was harvested during 12-27 May 2019 with 2 picking and 9 to 10 May 2020 (one picking). The seed yield of BARI Mung-6 was 0.76 t ha^{-1} with gross margin in Tk. 9988 ha^{-1} (Table 36c) . BARI Mung-8 produced 0.69 t ha^{-1} seed yield. Gross margin of BARI Mung-8 was 137% higher than that of BARI Mung-6. During 2nd year, seed price was higher @ Tk. 17.50 kg^{-1} than first year and one picking was happened. Average seed yield, gross return and gross margin was 0.73 t ha^{-1}, Tk 51350 ha^{-1} and Tk. 16838 ha^{-1}.

Farmers were happy for getting higher price from BARI Mung-8 because of yellow seed coat color over BARI Mung-6.

Sesame: A production program was conducted with BARI Til-4 at the FSRD site, Faridpur during Kharif I, 2019 and 2020. A total of 0.49 ha of land with seven farmers were selected. The seed was sown on 8-12 March 2019 and 19-25 March 2020. The fertilizers were applied @ 100-40-40-20-3-3 kg of N-P-K-S-Zn-B ha^{-1}. Half N and all amount of P, K, S, Zn and B was applied as basal during final land preparation. Rest N was applied as top dress at 25-27 DAS under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Irrigation and hand weeding were done when as necessary. The crop was harvested during 1-3 Jun 2019 and 15-22 Jun 2020. The seed yield obtained from BARI Til-4 was 1.83 t ha^{-1} and 1.34 t ha^{-1} during 2019 and 2020, respectively (Table 36d). Gross margin of BARI Til-4 during 2nd year was Tk 46093 ha^{-1} which was lower than that of 1st year gross margin (Tk 85255 ha^{-1}). This was due to lower seed yield during 2nd year for heavy rainfall at seed formation stage. Average seed yield, gross return and gross margin was 1.59 t ha^{-1}, Tk 105607 ha^{-1} and Tk. 65674 ha^{-1}.

Farmers were happy for getting higher yield from BARI Til-4 with higher price. They were disappointed for getting poor yield due to unexpected heavy rainfall was occurred during seed formation stage. Almost all plant was harvested before maturity of seed. Farmers demanded black colored seed variety of Sesame due to Tk.25 kg^{-1} more selling price of black seed than BARI variety (reddish colored seed)

Lentil: A production program with BARI Masur-8 was conducted during the *rabi* 2019-20 and 2020-21. A total of seven co-operator farmers were considered. A total of 0.55 ha of land was used. The seed was sown on 28 Nov to 3 Dec 2019 and 19 Nov to 3 Jan. 2021. The crop was fertilized with 28-24-14-9-2-1 kg of N-P-K-S-Zn-B ha^{-1} in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate, boric acid, respectively. All fertilizers were applied as basal. Provex and knowin (carbendazim) were applied at 22-25 DAS. Amistar top (1 ml $litre^{-1}$) was applied at 70-75 DAS as preventive measure against Stemphyllium blight disease. BARI Masur-8 was harvested during 20-22 March 2020. Second year Lentil is under vegetative condition. The seed yield obtained from BARI Masur-8 was 1.76 t ha^{-1} (Table 36e). The gross return and gross margin of BARI Masur-8 was Tk. 127600 ha^{-1} and Tk. 84370 ha^{-1}. Farmers stored different amount of seeds.

Farmers showed interest to BARI Masur-8 variety because of its higher yield potentiality and enriched iron and zinc. A good number of seed for BARI Masur-8 has been stored by the farmers for growing in the next year.

Onion: A production program of BARI Piaz-1 and BARI Piaz-4 was conducted at the FSRD site, Faridpur during the *rabi* 2019-20 and 2020-21. The program was conducted in about 0.6 ha of land. A total of six farmers were selected. Seedling was transplanted on 1-14 Jan 2020 and for second year, seedling will be transplanted on 30 Nov. 2020 both the varieties. The crop was fertilized with 140-60-60-30-3-1.5 kg of N-P-K-S-Zn and B ha^{-1} in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. All of P, S, Zn and B, and half of N and K will be applied as basal during final land preparation. Remaining N and K was applied in two equal splits at 25-30 DAT and 50-55 DAT under moist soil condition and mixed thoroughly with the soil. Pesticides named Rovral, Ridomil, Amister top, Confidor, karate were sprayed. Onion varieties were harvested during 24-31 March 2020 (Table 36f). The bulb yield of BARI Piaz-4 (16.22 t ha^{-1}) was 38% higher than that of BARI Piaz-1 (11.76 t ha^{-1}). Gross margin of BARI Piaz-1 and BARI Piaz-4 were Tk 260335 ha^{-1} and Tk 368925 ha^{-1}, respectively.

Farmers opined positively to the BARI Piaz-4 for its higher bulb yield. Next cropping season, they will cultivate BARI Piaz-4 variety covering large area.

Bottle gourd: A production program with imported hybrid was conducted during the *Kharif II* 2020. A total of 0.06 ha of land was used in one farmer's field. The seedling was transplanted on 25 July 2020. The crop was fertilized with 80-45-87-25-4-2-5000 kg of N-P-K-S-Zn -B and cowdung ha^{-1}. Full amount of cowdung, P, S, Zn, B and 1/3rd of K was applied during pit preparation at least 7 days before transplanting. N and the remaining K were applied in 4 equal installments at 20, 40, 60 and 80 days after transplanting. Irrigation, plant protection measures and other intercultural operations were done as and when necessary. The Bottle gourd was harvested during 25 Sep to 20 Nov 2020. Fruit yield of Hybrid Bottle gourd was 13.60 t ha^{-1}. The gross return and gross margin were Tk 231200 ha^{-1} and Tk 123200 ha^{-1}, respectively (Table 36g).

Farmers were satisfied with Hybrid variety due to its higher yield, market price and taste.

Summer Tomato: A production program with imported hybrid was conducted during the *kharif II* 2020. A total of 0.012 ha of land was used in one farmer's field. The seedling was transplanted on 16 August 2020. The fertilizer was applied @ 104, 45, 64, 24, 2.7 and 1.3 kg ha^{-1} as N, P, K, S, Zn and B, respectively. 2 t ha^{-1} vermicompost was also applied. Four times irrigation was applied at 1, 15, 44 and 74 DAP. Half of organic fertilizer and all of P, S, Zn and B was applied as basal during final land preparation. Remaining organic manure was applied in pits before planting of seedling. One third of N was applied at 15 DAP as ring method. Rest one third N and half of K Soil was applied at 44 and 74 DAP, respectively as ring method. No weeding was done because of providing polymulch. Two times fungicides with Autostin and Ridomilgold at 10 and 20 DAP, respectively. Bio control measures like sex pheromone trap and yellow skicky was applied at 37-39 DAP. Two times insecticides with Imitaf and Pegasus was applied at 28 and 38 DAP, respectively. The Tomato was harvested during 7-31 Oct 2020. Fruit yield of BARI Hybrid Tomato-11 was 5.50 t ha^{-1}. The gross return and gross margin were Tk 605000 ha^{-1} and Tk 159460 ha^{-1}, respectively (Table 36h).

Farmers' opined that it was first time cultivation with BARI Hybrid Tomato-11 to their life. Farmers became interested to cultivate BARI Hybrid Tomato-11 for its lucrative shape and higher market price.

Blackgram: A production program without ploughing (zero tillage) BARI Mash-3 was done at the FSRD site, Faridpur during the *kharif II* 2020. A total of 02 co-operator farmers were selected having a total of 0.2 ha of land. Seeds were sown during 17 September, 2020. All fertilizers were applied @ 20-18-20-10-1.8 N-P-K-S-B kg ha^{-1} before seed sowing. BARI Mash-3 was harvested during 3rd January 2021. The seed yield obtained from BARI Mash-3 was 1.12 t ha^{-1} (Table 36i). The gross return and gross margin of BARI Mash-3 was Tk. 67200 ha^{-1} and Tk. 43050 ha^{-1}.

Farmers showed interest to BARI Mash-3 for its lower cost of production and higher market value. A good amount of seed of BARI Mash-3 has been stored by the farmers for growing in the next year.

Table 36a. Yield and economics of BARI released Mustard variety during the years of November 2018 to October 2021.

Year	Variety	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2018-19	BARI Sarisha-14	1.76	2.10	79200	52130	27070
2019-20	BARI Sarisha-18	1.71	2.67	84960	48345	36615
Average	--	1.74	2.39	82080	50237	31843

Average market price of output (Tk.kg^{-1}): Seed: 43.75, Stover: 2.55

Table 36b. Grain yield, cost and return of Wheat at FSRD site during the years of 2018 to 2020.

Year	Variety	Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2018-19	BARI Gom-28	3.81	85725	59183	26542
2019-20	BARI Gom-33	3.95	90850	62444	28406
Average	--	3.88	88287	60813	27474

Average market price of output (Tk.kg^{-1}): Seed: 22.75

Table 36c. Seed yield, cost and return of Mungbean at FSRD site during the year of November 2018 to October 2021

Year	Variety	Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2019	BARI Mung-6	0.76	47500	37512	9988
2020	BARI Mung-8	0.69	55200	31512	23688
Average	--	0.73	51350	34512	16838

Average market price of output (Tk.kg^{-1}): Seed: 71.75

Table 36d. Seed yield, cost and return of Sesame at FSRD site during the year of November 2018 to October 2021

Year	Variety	Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2019	BARI Til-4	1.83	123630	38375	85255
2020	BARI Til-4	1.34	87585	41492	46093
Average	--	1.59	105607	39933	65674

Average market price of output (Tk.kg^{-1}): Seed: 66.00

Table 36e. Seed yield, cost and return of Lentil at FSRD site during the years of November 2018 to October 2021

Year	Variety	Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2019	BARI Masur-8	1.76	127600	43230	84370
2020	BARI Masur-8	1.76	127600	43230	84370
Average	--	1.76	127600	43230	84370

Average market price of output (Tk.kg^{-1}): Seed: 70.00

Table 36f. Bulb yield, cost and return of Onion at FSRD site during the years of November 2018 to October 2021.

Year		Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2019-20	BARI Piaz-1	11.76	411600	151265	260335
	BARI Piaz-4	16.22	527150	158225	368925
2020-21	BARI Piaz-1	11.76	411600	151265	260335
	BARI Piaz-4	16.22	527150	158225	368925
Average	BARI Piaz-1	11.76	411600	151265	260335
	BARI Piaz-4	16.22	527150	158225	368925

Market price of output (Tk.kg^{-1}): Bulb: 35.00 (BARI Piaz-1), 32.50 (BARI Piaz-7)

Table 36g. Fruit yield, cost and return of Bottle gourd at FSRD site during the year of November 2018 to October 2021.

Year	Variety	Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2020	Hybrid	13.60	231200	108000	123200

Market price of output (Tk.kg^{-1}): Fruit: 17.00

Table 36h. Fruit yield, cost and return of summer Tomato at FSRD site during the year of November 2018 to October 2021.

Year	Variety	Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2020	BARI Hybrid Tomato-11	5.50	605000	445540	159460

Market price of output (Tk.kg^{-1}): Fruit: 110.00

Table 36i. Seed yield, cost and return of black gram at FSRD site during the year of November 2018 to October 2021.

Year	Variety	Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2020	BARI Mash-3	1.12	67200	24150	43050

Market price of output (Tk.kg^{-1}): Seed: 60.00

Intercropping of Radish + Onion bulb + Red amaranth with chewing type Sugarcane:

A production program of intercropping of Radish + Onion bulb + Red amaranth with chewing type Sugarcane was conducted during 2019-20. A total of 0.06 ha of land was used in one farmer's field. The Sugarcane sett was planted on 28 Oct 2019. Radish, Onion bulb and Red amaranth were sown on 1 Nov 2019. The Sugarcane crop was fertilized with 230-100-750-45-4-2 kg ha^{-1} N-P-K-S-Zn-B. For Onion sett bulb and Radish production, 50% of recommended dose of Onion (140-60-60-30-3-1.5 kg ha^{-1} N-P-K-S-Zn-B) and Radish (180-60-80-18-3 kg ha^{-1} N-P-K-S-Zn) were used. 25% of 100-24-20-9 kg ha^{-1} N-P-K-S was used for Red amaranth production. Sugarcane was harvested on 5-18 Oct 2020. Radish, Onion and Red amaranth were harvested on 1-5 Jan 2020, 5-10 Jan 2020 and 4-5 Dec 2019, respectively. The yield of Sugarcane, Radish, Onion bulb and Red amaranth was 91.86 t ha^{-1} (57500 piece), 16.15 t ha^{-1}, 2.85 t ha^{-1} and 2.25 t ha^{-1}, respectively. The gross return of Sugarcane, Radish, Onion and Red amaranth was Tk. 862500 ha^{-1}, Tk. 80750 ha^{-1}, Tk. 256500 ha^{-1}, Tk 36000 ha^{-1}. The total gross return and gross margin was Tk. 1235750 ha^{-1} and Tk. 866012 ha^{-1} (Table 37).

Farmers showed interest to cultivate chewing type Sugarcane with different vegetables and spices. Intercropping of Onion with Sugarcane was found profitable.

Table 37. Yield, cost and return of different crops at FSRD site during the year of November 2018 to October 2021.

Year	Variety	Yield (t ha^{-1})	GR (Tk. ha^{-1})	TVC (Tk. ha^{-1})	GM (Tk. ha^{-1})
2019-20	Radish (BARI Mula-1), Onion (BARI Piaz-1), Red amaranth (BARI Lalshak-1), Sugarcane (Gendari local)	Sugarcane: 91.86 (57500 piece), Radish: 16.15 Onion bulb: 2.85 Red amaranth: 2.25	1235750 (Sugarcane: 862500, Radish: 80750, Onion: 256500, red amaranth: 36000)	369738	866012

Market price of output (Tk.kg^{-1}): Sugarcane: 15.00 per piece, Radish: 5.00, Onion: 90.00 and red amaranth: 16.00

FSRD Site, Atia, Tangail

Mustard: The Production program was conducted in the farmer's field of the FSRD site, Atia, Delduar, Tangail during rabi season of 2018-1920, 2019-20 and 2020-2021 for increasing area and production of Mustard. The variety viz. BARI Sarisha-14 and BARI Sarisha-17 were used in this production program. The number of cooperators farmers of BARI Sarisha-14 were 29 covered by 5.53 ha of land and BARI Sarisha-17 were 25 covered by 3.90 ha of land. The seeds of BARI Sarisha-14 were sown on 14-24 November and BARI Sarisha-17 was 16-24 November at the rate of 6 kg seed ha^{-1}. The crop was harvested during 3-11 February and 5-12 February, respectively (Table 38). The average yield of BARI Sarisha-14 was 1.57 t ha^{-1} and BARI Sarisha-17 was 1.65 with gross margin in Tk.34114 and Tk. 37531 ha^{-1}, respectively (Table 39a). Rovral 50WP was sprayed twice to control Alternaria leaf blight and white mould diseases. Farmers reacted positively and were satisfied with higher seed yield economic return than local variety. A good amount of seed has been stored by the farmers for growing Mustard in the next year.

Barley: The Production program was conducted in the farmer's field of the FSRD site, Atia, Delduar, Tangail during rabi season of 2018-19 and 2019-20 for increasing area and production of Mustard. The variety viz. BARI Barley-6 and BARI Barley-7 were used in this production program. The number of cooperators farmers were 15 covered by 2.26 ha of land. The seeds were sown on 20-26 November at the seed rate of 120 kg ha^{-1}. The crop was harvested during 7-14 March (Table 38). The average yield of BARI Barley-6 was 1.97 t ha^{-1} and BARI Barley-7 was 2.05 with gross margin in Tk.23408 and Tk. 25448 ha^{-1}, respectively (Table 39b). No remarkable pest and disease infestation was observed in the field during the crop period. Farmers showed their interest in new and promising BARI barley varieties due to awn less, higher yield, less disease infection and benefit than local variety. A good amount of seed has been stored by the farmers for growing Mustard in the next year.

Potato: BARI Alu-41was cultivated among five farmers covered by 1.40 ha of land to popularize Potato variety among the farmers and increase yield and economic return of the farmers. Seeds were sown on 21-25 November 2019 at the @ 1600 kg ha^{-1} of seeds and harvested during 17-19 February 2020 (Table 38). For controlling vector admire was sprayed twice and to prevent late of Potato, wilt and other fungal diseases Indofil-M 45 was sprayed 3 times in the field. BARI Alu-41produced tuber yield 31.57 t ha^{-1} with gross margin in Tk. 174037(Table 39c). Farmers showed their interest in new and promising Potato variety due to higher yield, less disease infection and higher benefit than local variety.

Table 38. Different operations conducted for production program at FSRD site, Atia, Tangail during the years of November 2018 to October 2021

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Mustard	BARI Sarisha-14	29	5.53	14-24 Nov.	03-11 February
	BARI Sarisha-17	25	3.90	16-24 Nov.	5-12 February
Barley	BARI Barley-6	8	1.15	20-26 Nov.	15 Feb-09 March
	BARI Barley-7	7	1.11		
Potato	BARI Alu-41	21	2.92	25Nov.- 04 Dec	20- 27Feb.

Table 39a. Yield of Mustard varieties at FSRD site Atia, Tangail during the year of November 2018 to October 2021.

Year	Variety	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Gross return (t ha^{-1})	Cost of Production (t ha^{-1})	Gross margin (t ha^{-1})
Feb. 2018 to Jan 2019	BARI Sarisha-14	1.55	2.32	72070	39402	32664
	BARI Sarisha-17	1.66	2.45	77150	39402	37748
Feb. 2019 to Jan 2020	BARI Sarisha-14	1.59	2.42	73970	38407	35563
	BARI Sarisha-17	1.63	2.37	75720	38407	37313
Feb. 2020 to Jan. 2021	BARI Sarisha-14	1.57	2.37	73020	38904	34114
	BARI Sarisha-17	1.65	2.41	76435	38904	37531
Average	BARI Sarisha-14	1.57	2.37	73020	38904	34114
	BARI Sarisha-17	1.65	2.41	76435	38904	37531

Unit Price: Mustard seed =45 and stover=1.00

Table 39b. Yield of Barley varieties at FSRD site Atia, Tangail during the years of November 2018 to October 2021

Year	Variety	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Feb. 2018 to Jan 2019	BARI Barley-6	1.95	191	50660	30875	19785
	BARI Barley-7	1.98	1.88	51380	30875	20505
Feb. 2019 to Jan 2020	BARI Barley-6	1.99	1.85	51600	24570	27030
	BARI Barley-7	2.12	1.96	54960	24570	30390
Average	BARI Barley-6	1.97	1.88	51130	27723	23408
	BARI Barley-7	2.05	1.92	53170	27723	25448

Barley grain price = Tk. 20.00 kg^{-1} and Straw price= Tk. 1.00 kg^{-1}

Table 39c. Yield of BARI Alu-41at FSRD site, Atia, Tangail during the years of November 2018 to October 2021

Year	Variety	Grain yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Feb. 2019 to Jan 202	BARI Alu-41	31.57	315700	141663	174037
Feb. 2020 to Jan. 2021	BARI Alu-41	31.48	314800	141663	173137

Tuber price= Tk. 10.00 kg^{-1}

FSRD Site, Tarakandi, Sherpur

Mustard: The Production program was conducted in the farmer's field of the FSRD site, Tarakandi, Sherpur during rabi season of 2018-19 for increasing area and production of Mustard. The variety viz. BARI Sarisha-14 was used in this production program. The number of cooperators farmers of BARI Sarisha-14 was 1 covered by 0.5 ha of land. The seeds of BARI Sarisha-14 were sown on 03-06 November. The crop was harvested during 21-22 January (Table 40). The average yield of BARI Sarisha-14 was 1.37 t ha^{-1} with gross margin in Tk.31510 (Table 41a). Rovral 50WP was sprayed twice to control Alternaria leaf blight and white mould diseases. Farmers opined positively and were satisfied with higher seed yield and economic return than local variety. A good amount of seed has been stored by the farmers for growing Mustard in the next year.

Okra: The Production program was conducted in the farmer's field of the FSRD site, Tarakandi, Sherpur during rabi season of 2019-20 for increasing area and production of Okra. The variety viz. Hybrid Shakti was used in this production program. The number of cooperators farmers of Hybrid Shakti was 1 covered by 0.1 ha of land. The seeds of Hybrid Shakti were sown on 15-18 March. Harvesting of Okra started from 1st May and it was continued up to 25th May (Table 40). The average yield of Hybrid Shakti was 28.82 t ha^{-1} with gross margin in Tk.144590 (Table 41b). Systemic insecticides were sprayed twice at pre fruit setting stage to control white fly and other sucking insects. Farmers were satisfied with higher fruit yield and economic return than local variety.

Potato: The Production program was conducted in the farmer's field of the FSRD site, Tarakandi, Sherpur during rabi season of 2019-2020 for increasing area and production of Potato. The variety viz. BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-40 and BARI Alu-41 were used in this production program. The number of cooperators farmers of Potato varieties was 1 and covered 0.5 ha of land. The tuber of Potato was sown on 28-30 November. The crop was harvested during 19-20 February (Table 40). The average tuber yield of Potato was 40.62 t ha^{-1} with gross margin in Tk .312298 (Table 41c). Dithane-M 45 and Ridomil gold was sprayed to control late blight disease. Farmers were satisfied with higher tube yield and economic return.

Table 40. Different operations conducted for production program at FSRD site, Tarakandi, Sherpur.

Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Mustard	BARI Sarisha-14	1	0.5	03-06 Nov.	21-22 Jan..
Okra	Hybrid variety shakti	1	0.1	15-18 March	1-25 May
Potato	BARI Alu-35	1	0.5	28-30 Nov.	19-20 Feb.
	BARI Alu-36				
	BARI Alu-37				
	BARI Alu-40				
	BARI Alu-41				

Table 41a. Yield of Mustard variety at FSRD site, Tarakandi, Sherpur during the year November 2018 to October 2021

Year	Variety	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Gross return (Tk. ha^{-1})			Cost of production (Tk. ha^{-1})	Gross margin (Tk.ha^{-1})
				Grain	Straw	Total		
2018-19	BARI Sarisha-14	1.37	1.81	57540	3620	61160	29650	31510

Market price of output (Tk. Kg^{-1}): Seed=42 and Stover=2.00.

Table 41b. Yield of Okra variety at FSRD site, Tarakandi, Sherpur during the year of November 2018 to October 2021.

Year	Variety	Fruit yield (t ha^{-1})	Stover yield (t ha^{-1})	Gross return (Tk. ha^{-1})			Cost of production (Tk. ha^{-1})	Gross margin (Tk.ha^{-1})
				Fruit	Straw	Total		
2019-20	Hybrid Shakti	28.82	-	345840	-	345840	201250	144590

Market price of output (Tk. Kg^{-1}): Okra=12.

Table 41c. Yield of Potato variety at FSRD site, Tarakandi, Sherpur during the year of November 2018 to October 2021.

Year	Variety	Tuber yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Gross return ($Tk.\ ha^{-1}$)			Cost of production ($Tk.\ ha^{-1}$)	Gross margin ($Tk.\ ha^{-1}$)
				Tuber	Stover	Total		
2019-20	BARI Alu-35	40.06	-	480720	-	480720	175190	35530
	BARI Alu-36	41.35	-	496200	-	496200	175190	321010
	BARI Alu-37	44.26	-	531120	-	531120	175190	355930
	BARI Alu-40	40.22	-	482640	-	482640	175190	307450
	BARI Alu-41	37.23	-	446760	-	446760	175190	271570
Average	-	*40.62*	-	*487488*	-	*487488*	*175190*	*312298*

Market price of output ($Tk.\ Kg^{-1}$): Potato=12.

C. LIVESTOCK SYSTEM

I. Vaccination program on Cattle

Activity-36: Effect of vaccination and deworming on cattle at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Number of livestock under vaccination program, name of the vaccine applied to the selected cattle, dates of vaccination are presented in Table 42. In an about 224 numbers of cattle including buffalo, cow, ox, calf and goat were vaccinated.

Frequency of diseases was listed among the cooperative farmers. It was found that, before vaccination frequency of different diseases was higher. After vaccination of cattle, all of the disease's frequency reduced (Table 42).

This technology was easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested and adopted this technology as per routine work.

Table 42. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site, Ajoddhapur, Rangpur during the years of February 2018 to January 2021.

Year of vaccination	Name of the vaccine	No. of livestock Vaccinated			Disease frequency (%)	
		Cattle	Goat	Sheep	Before intervention	After intervention
Feb 2018-Jan. 2019	Anthrax, PR, FMD	48	2	-	15-34	4-7
Feb 2019-Jan.2020	Anthrax, PR, BQ, FMD	110	12	-	15-34	3-4
Feb 2020- Jan. 2021	Anthrax, PR, BQ, FMD	62	10	-	15-34	2-4
Total	*Anthrax, PR, BQ, FMD*	*220*	*24*	-	*15-34*	*2-7*

FSRD site, Gangarampur, Pabna

Vaccination technology was found easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested and adopted this technology as per routine work. Table 43 shows the information on number of cattle under vaccination program, name of the vaccine applied to the selected cattle and dates of vaccination. Total number of livestock brought under vaccination program was 438 at FSRD site, Gangarampur, Pabna during the years of 2018 to 2020 . Percentage of mortality before and after vaccination was recorded among the cooperator farmers. It was found that before vaccination mortality rate of cattle was higher (5-10%). After vaccination of cattle, all of the diseases frequency reduced drastically and mortality rate was almost nil or around 2-3%.

Table 43. Mortality (%) of livestock before and after vaccination against major disease at FSRD site during the years of November 2018 to October 2021.

Year of vaccination	Name of Vaccine	No. of livestock vaccinated			Percentage of mortality (%)	
		Cattle	Goat	Sheep	Before intervention	After intervention
Feb 2018 to Jan 2019	Torka FMD	95 40	- -	- -	10 5	0 0
Feb 2019 to Jan 2020	Anthrax Paraclear FMD	77 25 77	- - -	- - -	5 6 10	3 3 2
Feb 2020 to Jan. 2021	Anthrax FMD	49 45	- -	- -	6 9	0 0
Total		438	-	-	-	-

FSRD Site, Sholakundu Faridpur

Number of livestock under deworming and vaccination program, name of the vaccine applied to the selected cattle and percentage of mortality are presented in Table 44. Total number of livestock brought under deworming and vaccination program were 300 in FSRD site, Sholakundu, Faridpur. Livestock diseases (Anthrax and FMD) occurred in the selected areas before and after vaccination was recorded cautiously. It was observed that, before de-worming and vaccination frequency of different diseases was higher and mortality rate was 13-15 % while after deworming and vaccination of cattle all of the diseases frequency reduced and most of the treated animals were free from Anthrax and FMD. Mortality rate also decreased (0%). Frequency of diseases was listed among the cooperative farmers. Local and cross breed livestock both were brought under vaccination program.

Table 44. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site Sholakundu, Faridpur during the years of November 2018 to October 2021.

Year of vaccination	Name of the vaccine	No. of livestock Vaccinated			Percentage of mortality (%)	
		Cattle	Goat	Sheep	Before intervention	After intervention
Feb 2018-Jan. 2019	Anthrax	100	--	--	15	0
Feb 2019-Jan.2020	Anthrax	100	--	--	13	0
Feb 2020-Dec.2020	FMD	100	--	--	14	0
Total	Anthrax, FMD	300			13-15	0

FSRD Site, Atia, Tangail

Number of livestock under deworming and vaccination program, name of the vaccine applied to the selected cattle and percentage of mortality are presented in Table 45. Total number of livestock brought under deworming and vaccination program were 477 in FSRD site, Atia, Tangail.

Livestock diseases (Abthrax and FMD) occurred in the selected areas before and after vaccination was recorded cautiously. It was observed that, before de-worming and vaccination frequency of different diseases was higher and mortality rate was 9-12 % while after deworming and vaccination of cattle all of the diseases frequency reduced and most of the treated animals were free from Anthrax and FMD. Mortality rate also decreased (1-4 %). Frequency of diseases was listed among the cooperative farmers. Local and cross breed livestock both were brought under vaccination program.

Table 45. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site, Atia, Tangail during the years of November 2018 to October 2021.

Year of vaccination	Name of the vaccine	No. of livestock Vaccinated			Percentage of mortality (%)	
		Cattle	Goat	Sheep	Before intervention	After intervention
Feb 2018-Jan. 2019	Anthrax and FMD	80	-	-	9-12	1-2
Feb 2019-Jan.2020	Anthrax and FMD	183	-	-	9-12	3-4
Feb 2020-Dec.2020	Anthrax and FMD	214	-	-	9-12	2-3
Total	Anthrax and FMD	477	-	-	9-12	1-4

FSRD Site, Tarakandi, Sherpur

Number of livestock under deworming and vaccination program, name of the vaccine applied to the selected cattle and percentage of mortality are presented in Table 46. Total number of livestock brought under deworming and vaccination program were 228 in FSRD site, Tarakandi, Sherpur during the years of 2018 to 2020 . It was observed that, before de-worming and vaccination frequency of different diseases was higher and mortality rate was 10-15 % while after deworming and vaccination of cattle all of the diseases frequency reduced and most of the treated animals were free from Anthrax and FMD. Frequency of diseases was listed among the cooperative farmers. Local and cross breed livestock both were brought under vaccination program.

Table 46. Mortality (%) of livestock before and after vaccination against major diseases at FSRD site, Tarakandi, Sherpur during the years of November 2018 to October 2021.

Year of vaccination	Name of the vaccine	No. of livestock Vaccinated			Percentage of mortality (%)	
		Cattle	Goat	Sheep	Before intervention	After intervention
Feb 2019-Jan.2020	Torka	100	50	5	10-15	0
Feb 2019- Jan.2020	*PPR*	65	5	3	5	0
Total	*Torka, PPR*	*165*	*55*	*8*	-	-

II. Vaccination program on poultry birds

Activity-37: Effect of vaccination on poultry production at different FSRD sites during the years of 2018 to 2021

FSRD site, Ajoddhapur, Rangpur

Poultry vaccination program was performed at FSRD site, Ajoddhapur, Rangpur during February 2018 to January 2021. Four different types of vaccines (BCRDV, RDV, Duck plague and Pigeon Pox) were provided to 1183 birds (Table 47). It is revealed that, mortality rate can be minimized significantly through vaccination. Mortality rate was reduced and went below 6% in maximum cases which can be considered as negligible comparing to the condition before the vaccination program. Application of RDV vaccine has reduced the mortality rate 47% and application of BCRDV vaccine has reduced the mortality rate 72%. Thus, mortality rate was turned down to tolerable level (Table 47).

Table 47. Mortality (%) of poultry **birds** before and after vaccination against major diseases at FSRD site during the years of November 2018 to October 2021.

Year of vaccination	Name of the vaccine	No. of poultry birds Vaccinated				Percentage of mortality (%)	
		Chicken	Duck	Pigeon	Turkey	Before intervention	After intervention
Feb 2018-Jan. 2019	BCRDV, RDV, Plague, Pigeon Pox	398	46	10	-	14-22	3-4
Feb 2019-Jan.2020	BCRDV, RDV, Plague, Pigeon Pox	274	47	24	60	14-22	2-6
Feb 2020-Dec.2020	BCRDV, RDV, Plague, Pigeon Pox	136	18	50	120	14-22	2-7
Total	BCRDV, RDV, Plague, Pigeon Pox	*808*	*111*	*84*	*180*	*14-22*	*2-7*

FSRD Site, Gangarampur, Pabna

Vaccination program of chicken was conducted at FSRD site, Gangarampur, Pabna during February 2018 to January 2021. Table 48 shows the information on number of poultry under vaccination program, name of the vaccine applied to the selected chicken and mortality percentage. The numbers of different types of vaccinated poultry were 450, 300, 100 and 150 in case of BCRDV, RDV, FOWL POX and FOWL COLERA respectively during 2018-19 while the number of chickens were 310 and 500 in case of BCRDV and RDV respectively during 2019-20. Mortality percentage of poultry birds against different diseases was recorded among the cooperative farmers. It was found that before vaccination mortality (%) of poultry birds due to different diseases was higher (15-30%). After vaccination of poultry, all of the diseases reduced drastically and mortality rate was recorded about 2-6% (Table 48).

Table 48. Mortality (%) of poultry birds before and after vaccination against major diseases at FSRD site, Gangarampur, Pabna during the years of November 2018 to October 2021.

Year of vaccination	Name of vaccine	No. of poultry birds vaccinated				Percentage of mortality	
		Chicken	Duck	Pigeon	Turkey	Before	After
Feb 2018 to Jan 2019	BCRDV	450	-	-	-	30	5
	RDV	300				20	4
	Fowl pox	100				20	5
	Fowl cholera	150				15	6
Feb 2019 to Jan 2020	BCRDV	310	-	-	-	20	3
	RDV	500	-	-	-	15	2
Total		1810				-	-

FSRD Site, Sholakundu, Faridpur

Vaccination program of chicken and plague was conducted at FSRD site, Sholakundu, Faridpur during February 2018 to January 2021. Name of the vaccines and number of the poultry are given in Table 49. Name of the vaccines used in the program was BCRDV, RDV and duck plague. Total 1390 poultry birds and 50 ducks were vaccinated against different diseases. It was observed that before vaccination mortality rate was higher (23-30 %) because of different diseases infestation. After vaccination all of the disease's frequency reduced (6-15 %) significantly.

Table 49. Mortality (%) of poultry birds before and after vaccination against major diseases at FSRD site during the years of November 2018 to October 2021.

Year of vaccination	Name of the vaccine	No. of poultry birds Vaccinated				Percentage of mortality (%)	
		Chicken	Duck	Pigeon	Turkey	Before intervention	After intervention
Feb 2018-Jan. 2019	BCRDV	150	--	--	--	30	10
	Duck pleg	--	50	--	--	25	0
Feb 2019-Jan.2020	BCRDV	315	--	--	-	30	8
	RDV	425	--	--	--	25	15
Feb 2020-Dec.2020	BCRDV	200	--	--	--	25	4
	RDV	300	--	--	--	23	6
Total	BCRDV	665	--	--	--	28	1-10
	RDV	725	--	--	--	24	6-15
	Duck pleg	--	**50**	--	--	23-30	0

FSRD Site, Atia, Tangail

Vaccination program of chicken and duck was conducted at FSRD site, Atia, Tangail during February 2018 to January 2021. Name of the vaccines and number of the poultry are given in Table 50. Name of the vaccines used in the program was BCRDV, RDV, Fowl Pox Fowl cholera and duck plague. Total 816 poultry birds and 439 ducks were vaccinated against different diseases. It was observed that before vaccination mortality rate was higher (20-24 %) because of different diseases infestation. After vaccination all of the disease's frequency reduced (2-5 %) significantly.

Table 50. Mortality (%) of poultry birds before and after vaccination against major diseases at FSRD site, Atia, Tangail during the years of November 2018 to October 2021.

Year of vaccination	Name of the vaccine	No. of poultry birds Vaccinated				Percentage of mortality (%)	
		Chicken	Duck	Pigeon	Turkey	Before intervention	After intervention
Feb 2018-Jan. 2019	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	211	85	-	-	20-24	2-5
Feb 2019-Jan.2020	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	319	168	-	-	20-24	2-4
Feb 2020-Jan. 2021	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	286	186	-	-	20-24	3-5
Total	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	816	439	-	-	-	2-5

FSRD Site, Tarakandi, Sherpur

Vaccination program of chicken and duck was conducted at FSRD site, Tarakandi, Sherpur during February 2018 to January 2021. Name of the vaccines and number of the poultry birds are given in Table 51. Name of the vaccines used in the program was BCRDV, RDV and PPR. Total 634 poultry birds were vaccinated against different diseases. It was observed that before vaccination mortality rate was higher (25-30 %) because of different diseases infestation. After vaccination all of the disease's frequency reduced (5-10 %) significantly.

Table 51. Mortality (%) of poultry **birds** before and after vaccination against major diseases at FSRD site during the years of November 2018 to October 2021.

Year of vaccination	Name of the vaccine	No. of poultry birds Vaccinated				Percentage of mortality (%)	
		Chicken	Duck	Pigeon	Turkey	Before intervention	After intervention
Feb 2018-Jan. 2019	BCRDV, Gamboro	150	30	10	-	30	8
Feb 2019-Jan. 2020	BCRDV	200	30	8	-	25	5
Feb 2019-Jan.2020	RDV, Plague	153	53	-	-	25-30	8-10
Total	BCRDV, RDV, Plague, Gamboro	*503*	*113*	*18*	-	-	-

III. Improvement of cattle health by deworming

Activity-38: Improvement of dairy cattle health by deworming and vitamin ADE injection at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Number of livestock under deworming program, and their performances are presented in Table 52. Fifty cattle were dewormed, forty cattle were dewormed with added vitamin ADE and twenty-eight cattle were control (no deworming). It was found that deworming as well as vitamin ADE supplementation have positive effect on body weight and lactation period increment. Lactation period was increased about 10% due to deworming.

Table 52. Average body weight gain, milk production and lactation period after deworming at FSRD site, Ajoddhapur, Rangpur during the years of November 2018 to October 2021.

Treatment	No. of animal	Av. body wt. gain day^{-1} $animal^{-1}$ (g)	Av. Lactation yield (litter day^{-1})	Av. Lactation period (day)
Controlled Cattle	28	30-40	1	178
Dewormed Cattle	50	70-90	1.75	195
Dewormed+ Vitamin ADE injection treated Cattle	40	70-100	1.8	196

FSRD Site, Gangarampur, Pabnaeworming and Vitamin ADE injection have positive effects on cattle health. That's why the co-operator farmers were interested and adopted this technology as per routine work. Table 53 shows the performance of body weight gain, milk production and lactation period after deworming and vitamin ADE injection. It indicates that maximum body weight gain (343-420 g $day^{-1}animal^{-1}$), milk production (1.5-1.75 L day^{-1}) and lactation period (210-214 day) was obtained from deworming and vitamin ADE injection treated cattle followed by dewormed cattle. Relatively lower performance of the above traits was noted from controlled cattle.

Table 53. Average body weight gain, milk production and lactation period after deworming at FSRD site, during the years of November 2018 to October 2021.

Treatment	2018-2019				2019 -2020				2020 -2021			
	No. of animal	Av. body wt. gain day^{-1} $animal^{-1}$ (g)	Av. lactation yield (litre day^{-1})	Av. lactation period (day)	No. of animal	Av. body wt. gain day^{-1} $animal^{-1}$ (g)	Av. lactation yield (litre day^{-1})	Av. lactation period (day)	No. of animal	Av. body wt. gain day^{-1} $animal^{-1}$ (g)	Av. lactation yield (litre day^{-1})	Av. lactation period (day)
Controlled cattle	10	166	0.95	165	6	168	1.1	162	5	220	1.20	-
Dewormed cattle	10	292	1.20	180	6	253	1.39	210	5	310	1.50	-
Dewormed + vitamin ADE injected treated cattle	10	375	1.50	210	6	343	1.60	214	5	420	1.75	-

FSRD Site, Sholakundu, Faridpur

Deworming and Vitamin feeding technologies are encouraging on cattle health and found easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested in adopted this technology as per routine work. The performance of body weight gain, milk production and laction period after deworming and vitamin feeding have been presented in Table 54. It was indicated that maximum body weight gain (110-160 g $day^{-1}animal^{-1}$), milk production (2.65 L day^{-1}) and lactation period (210 days) was obtained from deworming and vitamin feeding treated cattle followed by dewormed cattle and minimum from controlled cattle.

Table 54. Average body weight gain, milk production and lactation period after deworming at FSRD site during the years of November 2018 to October 2021.

Treatment	No. of animal	Av. Body wt. gain $day^{-1}animal^{-1}$ (g)	Av. Lactation yield (litre day^{-1})	Av. Lactation period (day)
Controlled Cattle	10	85-90	1.55	175
Dewormed Cattle	10	110-125	2.20	188
Dewormed+ Vitamin feeding treated Cattle	10	140-160	2.65	210

FSRD Site, Atia, Tangail

Deworming and Vitamin ADE injection technologies are encouraging on cattle health and found easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested in adopted this technology as per routine work. The performance of body weight gain, milk production and laction period after deworming and vitamin ADE injection have been presented in Table 55. It was indicated that maximum body weight gain (165-175 g day^{-1} $animal^{-1}$), milk production (2.55 L day^{-1}) and lactation period (215 days) was obtained from deworming and vitamin ADE injection treated cattle followed by dewormed cattle and minimum from controlled cattle.

Table 55. Average body weight gain, milk production and lactation period after deworming at FSRD site, Atia, Tangail during the years of November 2018 to October 2021.

Treatment	No. of animal	Av. Body wt. gain $day^{-1}animal^{-1}$ (g)	Av. Lactation yield (litre day^{-1})	Av. Lactation period (day)
Controlled Cattle	06	75-80	1.60	170
Dewormed Cattle	06	120-130	2.10	195
Dewormed + Vitamin ADE injection treated Cattle	06	165-175	2.55	215

FSRD Site, Tarakandi, Sherpur

Deworming technology are encouraging on cattle health and found easy to adopt with minimum cost involvement. That's why the cooperator farmers were interested in adopted this technology as per routine work. The performance of body weight, milk production and lactation period after deworming has been presented in Table 56. It was indicated that maximum body weight gain (60-75 g $day^{-1}animal^{-1}$), milk production (1.5 L day^{-1}) and lactation period (205 days) was obtained from deworming treated cattle followed by dewormed cattle and minimum from controlled cattle.

Table 56. Average body weight gain, milk production and lactation period after deworming at FSRD site, Tarakandi, Sherpur during the years of November 2018 to October 2021.

Treatment	No. of animal	Av. Body wt. gain $day^{-1}animal^{-1}$ (g)	Av. Lactation yield (litter day^{-1})	Av. Lactation period (day)
Controlled Cattle	12	25-30	1.2	180
Dewormed Cattle	30	60-75	1.5	205

VI. Cattle fattening

Activity-39: Cattle fattening program at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur Rangpur

Cattle were dewormed and vaccinated under beef fattening program and supplied balance and improve feed. It was found that body weight of cattle under the program, increased rapidly (Table 57). Market value was estimated and found that it was increased on an average 65%.

Table 57. Body weight and market value for beef fattening.

Year	No. of breed	Initial body wt. (kg)	Body wt. after 90 days (kg)	Body wt. increase over Initial (%)	Initial value (Tk)	Present value (Tk)	Market value Increment (%)
2018-19	1	56	70	25	22000	32000	45.45
2019-20	3	32	48	50	18000	33000	83.33
2020-21	2	60	98	63	15000	25000	66.67
Average	*2*	*49*	*72*	*46*	*18333*	*30000*	*65.15*

FSRD Site, Gangarampur, Pabna

Beef fattening program was conducted during three consecutive years. Fourteen cooperator farmers were selected for beef fattening program during the years of 2018 to 2020. Cattle were dewormed and vaccinated under beef fattening program and supplied balance and improved feed. It was found that body weight of cattle increased due to fattening program (Table 58). Market value was estimated and found that it was increased around 77-197% as compared initial value of the cattle.

Table 58. Body weight and market value for beef fattening at FSRD site Pabna during the years of November 2018 to October 2021

Year	Farmer	No. of breed	Initial body wt. (kg)	Body wt. after 180 days (kg)	Body wt. increased over initial (%)	Initial value (tk)	Present value (tk)	Market value increased (%)
Feb 2018 to Jan 2019	Farmer-1	2	285	415	46	62300	140200	125
	Farmer-2	1	177	297	68	58500	103500	77
	Farmer-3	1	212	342	61	59300	115500	95
Feb 2019 to Jan 2020	Farmer-1	2	301	482	60	60500	160600	165
	Farmer-2	1	255	362	42	52000	125500	141
	Farmer-3	2	10	315	75	56500	112000	98
Feb 2020 to Jan. 2021	Farmer-1	1	145	250	72	49600	92500	86
	Farmer-2	2	160	375	134	44000	130500	197
	Farmer-3	2	163	292	79	48500	102300	111

FSRD Site, Atia, Tangail

Calf was dewormed and vaccinated under beef fattening program and supplied balance and improve feed. It was found that body weight of calf under the program, increased rapidly (Table 59). Market value was estimated and found that it was increased by 60%.

Table 59. Body weight and market value for beef fattening at FSRD site. Atia, Tangail during the months of November 2018 to October 2021.

Year	No. of breed	Initial body wt. (kg)	Body wt. after 90 days (kg)	Body wt. increase over Initial (%)	Initial value (Tk.)	Present value (Tk.)	Market value Increment (%)
2018-19	1	120	154	28	36000	56000	56
2019-20	1	116	144	24	35000	55000	57
2020	1	128	169	32	38000	63000	66
Average	1	121	156	28	36333	58000	60

FSRD Site, Tarakandi Sherpur

The program was started at May 2020 and continued up to January 2021. One bullock was included in this program. Initial body weight of the bullock was 82 kg. After 6 months body weight gained107 kg due to improved feed management and vaccination as well as increased market price (Table 60).

Table 60. Body weight increased and market value for beef fattening.

Year	No. of breed	Initial body wt. (kg)	Body wt. after 180 days	Body wt. increase over initial (%)	Initial value	Present value	Market value increment (%)
2018-19	-	-	-	-	-	-	-
2019-20	-	-	-	-	-	-	-
2020-21	1	82	107	30	37000	47500	28
Average	1	82	107	30	37000	47500	28

VI. Calf rearing

Activity-40: Calf rearing program at different FSRD sites during the years of 2018 to 2021.

FSRD Site, Gangarampur, Pabna

Calf rearing was initiated with six co-operator farmers at FSRD site, Gangarampur. A total of eight calves were selected for rearing during 2019-2020. The information on farmers' name, no. of calf, date of starting of rearing, species of calf, age of calf at starting, initial body weight, feed management, present body weight etc. are presented in Table 61. Age and initial body weight of calf were little differed among the co-operator farmers. However, feed management was done as per consultation with the livestock personnel. The selected calves were gradually gained body weight. The range of increase in body weight of calf was recorded 50-188 kg. This variation in increase of body weight might be due to differences of calf age, feed intake and nursing.

Table 61. Calf rearing status at FSRD site, Gangarampur, Pabna during the years of November 2018 to October 2021.

Name of farmers and address	No. of cattle	Species	Date of starting	Age during starting date	Initial weight (kg)	2019-2020		2020-2021	
						Present weight (kg) 29.4.19	Weight increased (kg)	Present weight (kg) 20.12.20	Weight increased (kg)
1. Md Akul Sordar Pirpur	1	Songkor	14.11.19	3 months	44	67	23	112	68
2. Md. Abdul Baki Pirpur	1	Shawal	14.11.19	5 months	75	112	37	125	50
3. Md. Jilal Pirpur	1 1	Freejian Jursey	14.11.19 14.11.19	2 months 8 months	46 82	120 144	74 62	234 263	188 181
4. Md. Altaf Pirpur	1 1	Sahiwal Freejian	14.11.19 14.11.19	6 months 7 months	104 95	141 160	37 65	170 192	66 97
5. Md. Sadek Ali Kasarpur	1	Local	14.11.19	8 moths	76	138	62	165	89
6. Md. Abdul Molla Kasarpur	1	Local	14.11.19	8 months	67	95	28	120	53

VI. Goat rearing

Activity-41: Goat rearing in the farmer's household for increase income of farmers

Goats were supplied 7 farmers at FSRD site, Tarakandi, Sherpur. Each farmer received one female goat. Average initial body weight of the supplied goat was 9.5 kg. Survival rate of the supplied goat was 100%. After 6 months of goat rearing farmers get on an average gross margin Tk. 2247 (Table 62).

Table 62. Performance of goat at farmers level at FSRD site, Tarakandi, Sherpur during the years of November 2018 to October 2021.

Description of Items	February 19-January 20	February 20-January 21
Number of farmers	3	4
Number of goats supplied per farmer	1	1
Date of supplied	November	October
Age of goat during distribution	13 months	13 months
Initial body wt. goat^{-1} (kg)	10 Kg	9 Kg
Procurement price goat^{-1} (Tk.)	4000/-	3500/-
No of goat survive	100%	100%
Wt. gained/goat after 6 months	4 kg	1 kg (after 2 month)
Total number of kids born (Feb. 18- Dec. 20) per farmer	2	1
Total return (Tk.) per farmer	6033/-	5960
Total variable cost (Tk.) per farmer	4000/-	3500/-
Gross margin (Tk.) per farmer	2033/-	2460/-

IX. Turkey bird rearing

Activity-42: ***Performance of Turkey at farmer's level for egg and meat purpose***

FSRD site, Ajoddhapur, Rangpur

Among the twelve cooperators farmers, twelve Turkey birds in 2019-20 and 5 birds in 2020 were distributed per household. Table 63 shows no. of Turkey bird survive body weight of initial and after five months. The average body weight gained from those Turkey birds was about 4.65 kg. The average gross margin obtained per family after five months rearing was calculated as Tk. 6700.

Table 63. Average performances of Turkey at farmers' level up at 12 months of rearing at FSRD site during the years of November 2018 to October 2021.

Description of Item	February 2018 – January 2019	February 2019 – January 2020	February 2020 – January 2021	*Average*
Number of farmers	-	12	12	*12*
No of birds supplied	-	144	60	*102*
No of birds survived	-	141	58	*99.5*
Age of supplied bird (days)	-	45	46	*45.5*
Initial wt. bird^{-1} (kg)	-	0.25	0.3	*0.28*
Initial value bird^{-1} (Tk.)	-	200	200	*200*
Rearing period (month)	-	5	5	*5*
Feed supplements bird^{-1}day^{-1} (g)	-	40	40	*40*
Feed supplements cost bird^{-1}(Tk.)	-	300	300	*300*
Present wt. bird^{-1} (kg)	-	4.75	5.1	*4.93*
Weight gained bird^{-1} (kg)	-	4.5	4.8	*4.65*
Gross return (Tk. Family^{-1})	-	11500	5000	*8250*
Total cost (Tk. Family^{-1})	-	1600	1500	*1550*
Gross margin (Tk. Family^{-1})	-	9900	3500	*6700*

X. Sonali chicken rearing in the farmer's household

Activity 43: Performance of Sonali chicken at different FSRD sites, 2018 to 2021.

FSRD Site, Gangarampur, Pabna

The cooperator farmers of FSRD site Gangarampur, Pabna were interested to rear poultry for meet purpose. Five to twelve farmers were selected for poultry rearing and each farmer was supplied 25 number of Sonali chicks (ratio between male and female is 1:9) which was purchased from Poultry Farm. BCRDV and booster dose of BCRDV vaccine was provided in schedule time and Gumboro vaccine was provided at due time. The family members constructed a small house (5ft x 8ft) with bamboo, tin or wood near their own living house. The initial weight of Sonali breed provided to the cooperator farmer was about 0.6-0.72 kg and average final body obtained from those chickens was about 1 to 1.5 kg. It was found that gross margin per farm was Tk.7800-28700 (Table 64). Farmers showed their interest in rearing Sonali chick because of better production of egg and meat.

Table 64. Performance of Sonali chicken at farmers level for egg and meat purpose during the years of November 2018 to October 2021.

Description of Item	2018-2019	2019-2020	2020-2021	
			1st package	2nd package
Number of farmers	12	5	5	3
No. of bird supplied	300	125	125	75
Date of supplied period	1.11.18 to 27.1.19	4.11.19	4.11.19	30.6.20
Initial body weight (kg)	0.6	0.72	0.72	0.70
Procurement price bird^{-1} (Tk.)	35	180	180	180
No. of chicken survived	280	21	21	22
Date of delivery egg	-	-	5.1.20 to 20.12.20	10.12.20
Egg production (number)	-	-	5150	240
Consumption	-	-	1320	32
Sale	-	-	3780	204
Distribution	-	-	50	4
Total number of eggs	-	-	5150	240
Performance of bird		-		
Weight gained bird^{-1} (kg)	1.04	0.380	1.58	1.00
Consumption	21	-	-	-
Sale	257	-	-	-
Distribution	2	-	-	-
Total number	280	-	-	-
Total income from bird (Tk.)	59200	-	7250	5950
Total variable cost (Tk.)	30500	-	50950	13500
Total return farm^{-1} (Egg & Meat)	-	-	58750	8350
Gross margin	28700	-	7800	-5150

FSRD Site, Sholakundu. Faridpur

This program was initiated at the FSRD site, Sholakundu, Faridpur district. Twelve farmers were selected in the village for poultry rearing and each farmer was supplied 10 number of Sonali chicks (ratio between male and female is 1:9) which was purchased from Poultry Farm. BCRDV and booster dose of BCRDV vaccine was provided in schedule time. The family members constructed a small house (5ft X 8ft) with bamboo, tin or wood near their own living house. Twenty (20) kg initial feed, one feed pot and one water pot were supplied to the farmer at the time of chick supply. The birds were also vaccinated timely and treated against different diseases. It was found that initial body weight was 0.69-0.72 kg per bird which after 160-163 days raised to 1.01-1.16 kg, respectively. Number of eggs per bird was given 38-133 and total value of egg per bird was TK. 380-1330 The average consumption of eggs per farm family was 52 during laying period up to 15 January 2021. It was found that total return per farm was Tk.7170-8568 and gross margin was Tk. 4151-4165 (Table 65). Farmers showed their interest in rearing Sonali chick for their growth and number of egg and meat.

Table 65. Average performances of Sonali breed at farmers' level up at 12 months of rearing at FSRD site during the years of November 2018 to October 2021.

Description of Item	2019 –2020	2020 –2021	2020 –2021
Number of farmers	12	12	12
No of birds supplied (3 times)	120	120	120
Date of supplied period	9 Oct 2019	15 Mar 2020	10 Sep 2020
Initial body wt. bird^{-1} (kg)	0.69-0.72	0.70	0.66
Procurement price bird^{-1} (Tk.)	138	140	148
No of chicken survive farm^{-1}	4	5	6
Date of delivery egg	18.2.19 to 15.12.20	27.6.2020 – 15.12.2020	-
Egg Production (Number of egg bird^{-1})	--	76	-
Consumption	346	281	-
Sale	170	85	-
Distribution	16	12	-
Total number of egg farm^{-1}	532	378	-
Performance of Bird	--	--	-
Weight gained/bird (kg)	1.16	1.01	-
Consumption (kg)	2.25	4.00	-
Sale (kg)	7.00	19.94	-
Distribution (kg)	--	--	-
Total weight (kg)	9.25	23.94	-
Total return farmer^{-1} in Tk. (Market value of egg + meat)	7170	8568	-
Total variable cost (Tk.)	3005	4417	-
Gross margin (Tk.)	4165	4151	-

FSRD Site, Atia, Tangail

This program was initiated at Mahmudpur and Hinghnagor village of Delduar upazila under Tangail district. Ten farmers were selected in the village for poultry rearing and each farmer was supplied 10-20 number of Sonali chicks (ratio between male and female is 1:9) which was purchased from Poultry Farm. BCRDV and booster dose of BCRDV vaccine was provided in schedule time and gumboro vaccine was provided at due time. The family members constructed a small house (5ft X 8ft) with bamboo, tin or wood near their own living house. Twenty (20) kg initial feed, one feed pot and one water pot were supplied to the farmer at the time of chick supply. The birds were also vaccinated timely and treated against different diseases. It was found that initial body weight was 0.57-0.58 kg per bird which after 8 months raised to 2.10-2.38 kg, respectively. Number of eggs per bird was given 40-92 and total value of egg per bird was Tk. 400-920. The average consumption of eggs per farm family was 74 during laying period. It was found that total return per farm was Tk.11967-16929 and gross margin was Tk.4822-11784 (Table 66). Farmers showed their interest in rearing Sonali chick for their growth and number of egg and meat.

Table 66. Average performances of Sonali breed at farmers' level up at 12 months of rearing at FSRD site, Atia, Tangail during the years of November 2018 to October 2021.

Description of Item	2018 –2019	2019 –2020	2020 –2021
Number of farmers	10	10	10
No of birds supplied	100	200	100
Date of supplied period	18.10.2018	18.06.2019	12.03.2020
Initial body wt. bird^{-1} (kg)	0.57	0.58	0.57
Procurement price bird^{-1} (Tk.)	200	180	190
No of chicken survive	92	190	85
Date of delivery egg	23.12.18 to 01.02.19	23.10-19 to 31.01.20	15.09.20 to 15.12.20

Description of Item	2018 –2019	2019 –2020	2020 –2021
Egg Production (Number of egg bird^{-1})	40	90	92
Consumption	56	128	133
Sale	258	487	591
Distribution	06	15	12
Total number of egg farm^{-1}	320	630	736
Performance of Bird			
Weight gained bird^{-1} (kg)	2.10	2.38	2.12
Consumption	02	02	01
Sale	07	07	07
Distribution	0	0	0
Total number	9	9	8
Total income (Tk.) from bird farm^{-1}	2064	3896	4728
Total variable cost (Tk.) farm^{-1}	7145	5145	5318
Total return farm^{-1} in Tk. (Market value of egg + meat)	11967	16929	14967
Gross margin (Tk.)	4822	11784	9649

FSRD Site, Tarakandi, Sherpur

Activity-44: Performance of Naked neck (Garchila) chicken at different FSRD sites during the years of 2018 to 2020.

Data related to performance of foamy and naked neck chick at farmers' level presented in Table 67. It indicated that income generation was higher over the local chick rearing practices. Initial average weight of foamy and naked neck chick was recorded as about 670 g which was increased to an average of about 1.6 kg after 6 months of rearing. Average egg production per bird was 86. From cost analysis, gross margin was calculated as 2473 Tk per farm family. Farmers' opined that foamy and naked neck chick rearing in the semi-scavenging system under village condition is economically viable and it can be strongly recommended for large scale extension to the farmers' level.

Table 67. Performance of foamy and naked neck chicken at farmers level at FSRD site, Tarakandi, Sherpur during the years of November 2018 to October 2021.

Description of Items	February 18-January 19 (Foamy)	February 19-January 20	February 20-January 21
Number of farmers	8	12	12
Number of birds supplied per farmer	10	5	5
Date of supplied period	20.09.2018	01.10.2019	01.10.2019
Initial body wt. bird^{-1} (kg)	0.65	0.69	0.69
Procurement price chicken^{-1} (Tk.)	250/-	220/-	220/-
No. of chicken survive	9	4	39
Wt. gained bird^{-1} after 6 months	0.97	0.85	0.96
Total number of chicks born (Feb. 18-Dec. 20) per farmer	0	25	23
Consumption (meat no of hen)	8	8	12
Consumption (egg no)	88	70	28
Sale (meat no of hen)	5	12	26
Sale (egg no)	325	212	72
Distribution (meat no of hen)	0	1	2
Distribution (egg no)	15	18	12
Total income from bird (Tk.) per farmer	6180/-	4122/-	7163/-
Total variable cost (Tk.) per farmer	6000/-	2420/-	1625/-
Gross margin (Tk.) per farmer	180/-	1702/-	5538/-

X. Duck rearing in the farmer's household

Activity 45. Performance of Khaki Campbell duck at different FSRD sites during the years of 2018 to 2021

FSRD site, Ajoddhapur, Rangpur

Among the twelve, three farmers were reared duck in their homestead using their pond. The average egg laid by the duck 120-210 no. month^{-1}household^{-1} (Table 68). Consumption of egg was 60-65 numbers after starting the duck rearing. Monthly income was calculated about Tk. 1200-2000 month^{-1}household^{-1}.

Table 68. Performance of improved breeds of duck (Khaki Campbell) after 6 months of rearing at FSRD Site during the years of November 2018 to October 2021.

Name of Farmer	No. of ducks survived at present	Body wt. after 6 months (kg)	Production of egg month^{-1}	Consumption of eggs month^{-1}		No. of egg laid month^{-1}	Monthly income (Tk.)
				Before	After		
Farid Ali	9	1.1	180	0	60	180	1800
Kismot	10	1.12	200	0	65	200	2000
Keramot Ali	6	1015	120	0	62	120	1200
Average	*8*	*339*	*167*	*0*	*62*	*167*	*1670*

FSRD Site, Atia, Tangail

The experiment was conducted at Higanagor village of Deduar upazilla in Tangail district during February 2018- January 2021. Eight farmers were selected for duck rearing. The family members made a small house (7ft X 6ft) with bamboo and tin near their own living house. Each farmer was given 10 ducks of 4-months old. Average survival rate of duck was 75% at FSRD site Atia, Tangail during the years of 2018 to 2020 (Table 69). The ratio of male and female was 1:5. Twenty kg of initial feed, one feed pot and one water pot were supplied to initiate the experiment. A group discussion was held about management of duck rearing before distribution. Rice husk with sand used as litter materials and changed twice every week. The ducks were kept in the backyard pond during day and kept inside in the house at night. The results showed that ducks started lying egg after six months of age and average egg production was 25 eggs month^{-1}duck^{-1}. Each farm family has gained more than 160 eggs from a month (25 eggs month^{-1}duck^{-1}). On an average, it was observed that the cooperative farmers sell some eggs and earned Tk. 1680 month^{-1}farm^{-1} from rearing of duck. The average consumption of eggs per farm family was 25 after rearing and it was only 12 before rearing. One important thing is that the consumption rate of egg per farm family was increased due to laying egg of their own ducks. As a result, project objective was achieved due to livelihood improvement of the rural people by duck rearing.

Table 69. Performance of improved breeds of duck (Khaki Campbell) after 6 months of rearing at FSRD Site, Atia, Tangail during the years of November 2018 to October 2021.

Year of rearing duck	No. of Farmer	No. of ducks survived at present	Body wt. after 6 months (kg)	Production of egg monthly^{-1} duck^{-1}	Consumption of egg month^{-1}		No. of egg laid month^{-1}	Monthly income farm^{-1} (Tk.)
					Before	After		
Feb 2018-Jan. 201	04	33	2.95	24		20	672	1680
Feb 2019-Jan.202	10	100	3.25	26	12	30	2210	1800
Feb 2020- Jan.202	10	92	3.16	24		25	1920	1560
Average	*8*	*75*	*3.12*	*24.67*	*12*	*25*	*1601*	*1680*

FSRD Site, Tarakandi, Sherpur

Data related to performance of Grinding breed at farmers' level is presented in Table 70. It was observed that, income generation was higher over the local breed rearing practices. Initial average weight of Ginding breed was recorded as about 750 g which was increased to an average of about 1.69 kg after 6 months of rearing. Average egg production per bird was 72. From cost analysis, gross margin was calculated as 7630 Tk per farm family. The introduction of Ginding breed with scientific management systems performed better over the local breed as well as traditional rearing practices. Egg laying capacity also increased significantly as a consequence of proper feeding and management. Farmers showed their keen interest for rearing of Ginding both meat and egg purpose. They opined that, they had a little knowledge about modern disease and feed management technology. Hence more motivation and awareness build up programs should be taken for greater extension of the technology. Farmers especially women and children expressed satisfaction of duck rearing by improved rearing system and commercially profitable.

Table 70. Performance of alternate breeds of duck (Ginding) after 6 months of rearing at FSRD Site, Tarakandi, Sherpur during the years of November 2018 to October 2021.

Name of Farmer	No. of ducks survived at present	Body wt. after 6 months (kg)	Egg production month^{-1}	Egg Consumption month^{-1}		No. of egg laid month^{-1}	Monthly income (Tk)
				Before rearing	After rearing		
Md. Nurul Islam	9	1.69	102	10	25	102	1020
Md. Nur Islam	8	1.66	104	15	28	104	1040
Md. Tota mia	9	1.68	120	11	33	120	1200
Md. Nasmul Islam	10	1.72	115	18	34	115	1150
Average	*9*	*1.69*	*110*	*13.5*	*30*	*110*	*1102.5*

XII. Rearing of pigeon at farmers household

Activity-46: Performance of pigeon rearing at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Among the twelve cooperators farmers, Pigeons were distributed on-test basis two pairs per household and thereafter four pairs during 2019-20. Table 71 shows no. of Pigeon survive, initial body weight, squab production and intake by the household members. Pigeon rearing might be a profitable business. The average weight per bird during supply was on an average 180 g. The average squab production per family was 54 and intake of squab by the household family was 13. The average income from pigeon rearing was Tk. 1250 household^{-1}.

Table 71. Performance supplied pigeons to different farmers household at FSRD site during the years of November 2018 to October 2021.

Year	No. of Pigeon Family^{-1}	Average weight (g)	No. of Squab Born	Pigeon died	Squab Intake	Sell	Cash income (Tk.)
2018-19	-	-	-	-	-	-	-
2019-20	12	0.16	48	3	12	4	500
2020-21	12	0.20	60	3	14	16	2000
Average	*12*	*0.18*	*54*	*3*	*13*	*10*	*1250*

FSRD Site, Gangarampur, Pabna

Every year two farmers were selected for pigeon rearing. Around 16-30 pigeon per farm was selected for rearing. Optimum feed management and other nursing was provided pigeon rearing. The body weight of pigeon provided to the cooperator farmer was about 170-210 g and each family get 20-65 squab per year. It was found that income per family from rearing pigeon was recorded Tk.2160-4440 (Table 72).

Table 72. Performance of pigeons at farmers household at FSRD site, Gangarampur, Pabna during the years of November 2018 to October 2021.

Year	Farmes	No. of pigeon Fmily^{-1}	Average weight (gm)	No. of Squab born	No. of pigeon died	No. of pigeon Consumed	No. of pigeon Selling	Income (Tk)
Feb 2018 to Jan 2019	Farmer-1	30	180	65	10	20	37	4440
	Farmer-2	30	180	50	12	28	18	2160
Feb 2019 to Jan 2020	Farmer-1	28	170	60	6	18	48	5760
	Farmer-2	28	170	66	5	28	41	5330
Feb 2020 to Jan. 2021	Farmer-1	16	210	26	2	14	20	2500
	Farmer-2	20	200	22	2	6	24	3050

FSRD Site, Tarakandi Sherpur

Pigeon were supplied 4 farmers at FSRD site, Tarakandi, Sherpur. Each farmer received 2 pair pigeon. Average weight of the supplied pigeon was 190 g. Average nine pairs of squabs was born of four farmers after six month and the farmers kept them to add another pigeon pair and some of them were sold. Finally, total six pairs of squabs were borned per family. Before intervention the farmers have no pigeon and income. But due to rearing of pigeon, per farmer earned Tk. 1500 (Table 73).

Table 73. Performance supplied pigeons to different farmer's household at FSRD site, Tarakandi, Sherpur during the years of November 2018 to October 2021.

Year	No. of Pigeon Family^{-1}	Average weight (g)	No. of Squab born	Pigeon died	Squab Intake	Sell	Income (Tk.)
2018-19	-	-	-	-	-	-	-
2019-20	-	-	-	-	-	-	-
2020-21	2 pair	0.19	9 pair (Av.)	Squab 3 (av.)	3	12	1500
Average	2 pair	0.19	9 pair	Squab 3	3	12	1500

VII. Green fodder production

Activity-47: Performance of green fodder production at household level

FSRD site, Ajoddhapur, Rangpur

The production of Napier grass was 80 and 68 t ha^{-1} and the average gross margin was calculated Tk. 38000 and 2800 ha^{-1} in 2019-20 and 2020-21, respectively (Table 74). The average green fodder yield was 74 t ha^{-1} and average gross margin was Tk. 33000 ha^{-1}. The last year yield was hampered due to flood.

Table 74. Average performances of Napier grass production

Year	No. of harvesting	Green fodder yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
2018-19	-	-	-	-	-
2019-20	17	80	80000	42000	38000
2020-21	14	68	68000	40000	28000
Av.	*16*	*74*	*74000*	*41000*	*33000*

FSRD Site, Atia, Tangail

Green fodder production in the homestead or nearby homestead area or road side was found as a promising technology for maintaining farmers own cattle as well as earning a handsome amount of money. On an average, six farmers were produced Napier grass as green fodder at Napier FSRD site, Atia, Tangail during February 2019 to January 2021. The average green fodder yield was 32.22 t ha^{-1} obtained from 6 times harvest in a year with average gross margin Tk. 38447 ha^{-1} (Table 75).

Table 75. Average performances of Napier grass production at FSRD site, Atia, Tangail during the years of November 2018 to October 2021.

Year	No. of farmers	No. of harvesting	Green fodder yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Feb. 2018- Jan. 19	-	-	-	-	-	-
Feb. 2019- Jan. 20	05	3	33.90	84750	43390	41360
Feb. 2020-Jan. 21	07	5	30.54	76350	40830	35520
Average.	*06*	*4*	*32.22*	*80550*	*41000*	*38440*

VIII. Compost production

Activity 48. Performance of Farm Yard Manure production at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Farm Yard Manure (FYM): Farm yard manure was producing by using cowdung and homestead wastage at the homestead area during the year of February 2018 to January 2021. The average production of FYM per homestead was 3050 kg and the gross margin was equivalent to Tk.5400 homestead^{-1} (Table 76).

Table 76. Average performances of compost production and utilization.

Year	Intervention	Total compost produce (kg homestead^{-1})	Use for crop production (kg farmer^{-1})	Distribution (kg farmer^{-1})	Sell (kg farmer^{-1})	Value of total compost produce per year (Tk. Homestead^{-1})	TVC (Tk. Homestead^{-1})	Gross margin (Tk. homestead^{-1})
2018-19	Before	-	-	-	-	-	-	-
	After	-	-	-	-	-	-	-
2019-20	Before	2200	2200	0	0	4400	500	3900
	After	3250	3000	0	250	6500	700	5800
2020-21	Before	2200	2200	0	0	4400	500	3900
	After	2850	2650	0	200	5700	700	5000
Av.	Before	2200	2200	0	0	4400	500	3900
	After	3050	2825	0	225	6100	700	5400

Vermicompost

Activity-49: Performance of vermicompost production at different FSRD sites during the years of 2018 to 2021.

Vermicompost was produced in six farmers homestead area using cement ring. The total vermicompost production was 320 kg homestead^{-1} (Table 77). Gross margin was calculated Tk. 840 homestead^{-1} after first time production.

Table 77. Average performances of vermicompost production and utilization

Farmers involve (no.)	No. of ring homestead^{-1}	Total vermicompost produce (kg homestead^{-1})	Use for crop production (kg farmer^{-1})	Distribution (kg farmer^{-1})	Sell (kg farmer^{-1})	Value of produce vermicompost per year (Tk.)	TVC (Tk. homestead^{-1})	Gross margin (Tk. homestead^{-1})
6	2	320	320	-	-	2240	1400	840

D. FISHERIES SYSTEM

Activity-50: Maximization of farmers' income through monoculture technique

I. Production program of Pabda fish

FSRD site, Ajoddhapur, Rangpur

Pabda fish was cultured in one pond as a test case at FSRD site Ajoddhapur, Rangpur during 2018-19. Information on pond area, fry amount and weight, final total amount and number of fish, survival rate has been shown in Table 78a. The pond was mostly seasonal, but water was supplemented for a certain duration. The pond was 8 decimals sized with approximately 3 m depth. The results revealed that, in Pabda fish culture the survival rate was 85%.

Yield and economic analysis are shown in Table 78b. The yield of fish was obtained 49 kg per pond with the gross margin Tk. 9550 per pond.

Among the total production they consumed, distributed to relatives and sold their products in local market (Table 78bc). It was observed that, farmers sold most of the fish (61%), consumed about 35% and distributed about 4% through their neighbors, relatives and well-wishers of the produced fish. The fish feed price in the market is high, so, farmer was less interested to supplement feed through purchasing from the market. As a result, the yield was relatively low.

Table 78a. Performance *Pabda* fish farming at FSRD site Ajoddhapur, Rangpur during the year of 2018-2019.

No. of pond	Area and depth of pond (decimal)	Amount and number of fries	Av. weight of fry (gm)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
1	08 dec. and 3m	7.6 kg #512	14.84	112	49kg #435	85

Table 78b. Production and Economics of *Pabda* farming at FSRD site Ajoddhapur, Rangpur during the year of November 2018 to October 2021.

No. of pond	Total yield (kg pond^{-1})	Total cost (Tk pond^{-1})	Gross return (Tk pond^{-1})	Gross margin (Tk pond^{-1})	BCR
1	49	7600	17150	9550	2.26

Table 78c. Utilization pattern of harvested *Pabda* fish at FSRD site Ajoddhapur, Rangpur during the year of November 2018 to October 2021.

No. of pond	Total yield (kg pond^{-1})	Consumption (kg)	Distribution (kg)	Selling (kg)
1	49	17	2	30

II. Production program of Shing fish

FSRD site, Ajoddhapur, Rangpur

Shing fish was cultured in three ponds as a test case at FSRD site Ajoddhapur, Rangpur during 2018-19. Information on ponds area, fry amount and weight, final total amount and number of fish, survival rate has been shown in Table 79a. There were three ponds selected for 'Shing' production in seasonal ponds'. The ponds were av. 8.5 decimal sized with av. 3.5 m depth. The results revealed that the av. survival rate was 88%.

Yield, cost and return analysis are shown in Table 79b. The yield of fish was obtained 35.5 kg per pond with the gross marg in Tk. 6125 per pond.

Among the total production farmer consumed, distributed to relatives and sold their products in local market (Table 79c). It was observed that, farmers sold most of the fish (65%), consumed about 27% and distributed about 8% through their neighbors, relatives and well-wishers of the produced fish.

Table 79a. Performance of *Shing* fish farming at FSRD site Ajoddhapur, Rangpur during the year of November 2018 to October 2021.

No. of pond	Area and depth of pond	Amount and number of fries	Average weight of fry (g)	Final average weightand length of fish (g andcm)	Total amount and number of fish	Survival rate (%)
3	8.5dec. and 3.5m	2.9 kg #298	9.73	135g and 19cm	35.5 kg #262	88

Table 79b. Total production and economics of *Shing* fish farming at FSRD site Ajoddhapur, Rangpur during the year of November 2018 to October 2021.

No. of pond	Total yield (kg $pond^{-1}$)	Total cost (Tk. $pond^{-1}$)	Gross return (Tk. $pond^{-1}$)	Gross margin (Tk. $pond^{-1}$)	BCR
3	35.5	6300	12425	6125	1.97

Table 79c. Utilization pattern of harvested Shing fish at FSRD site Ajoddhapur, Rangpur during the year of November 2018 to October 2021.

No. of pond	Total yield (kg $pond^{-1}$)	Consumption (kg)	Distribution (kg)	Selling (kg)
3	35.5	9.5	3	23

III. Maximization of farmers' income through Shing, Tengra and monosex Telapia culture

Information on ponds area, fry amount and weight, final total amount and number of fish, survival rate of Shing and Tengra fish has been shown in Table 80a. There were two ponds selected for each of Shing and Tengra fish. The average size of the ponds was around 10 decimals with average depth of 1.2 meter. There were three ponds selected for monosex Telapia. The sizes of the ponds were av. 9 decimal sized with av. 1.57 m depth. The results revealed that the average survival rate of Shing and Tengra was around 85% whereas the av. survival rate of monosex Telapia was 91%.

Yield and economic analysis are shown in Table 80b.The yield and gross margin of fish varied from pond to pond due to its size. Total yield of Shing, Tengra and monosex Telapia was recorded 45, 36 and 68 kg $pond^{-1}$ and gross margin was recorded Tk. 9050, Tk. 4700 and Tk 5808 $pond^{-1}$ respectively. Consumption, distribution, selling, total production, net income and BCR increased due to intervention of new technology (Table 80c and 80d).

Table 80a. Performance Shing, Tengra and monosex Telapia fish at FSRD site Gangarampur, Pabna during the year of November 2018 to October 2021.

Fish	Area and depth of pond	Amount and number of fries	Av. weight of fry (gm)	Final average wt. of fish (g)	Total amount and no. of fish	Survival rate (%)
Shing	15 Dec. 1.2 m	14 kg and 1400	10	53	60 kg and 1120	80
	6 Dec. 1.2 m	6 kg and 600		55	30.8 kg and 560	93
Tengra	10 Dec. 1.2 m	5 kg and 1000	5	42	34 kg and 820	82
	10 Dec. 1.2 m	5 kg and 1000		44	38 kg and 865	86
Telapia	15 Dec. 2 m	16 kg and 320	50	385	116 kg and 302	94
	8 Dec. 1.5 m	8 kg and 160		390	56 kg and 145	90
	5 Dec. 1.2 m	5 kg and 100		365	33 kg and 90	90

Table 80b. Production and Economics of Shing, Tengra and Telapia at FSRD site Gangarampur, Pabna during the year of November 2018 to October 2021.

Fish	Total yield (kg $pond^{-1}$)	Total cost (Tk. $pond^{-1}$)	Gross return (Tk. $pond^{-1}$)	Gross margin (Tk. $pond^{-1}$)	BCR
Shing	45	2200	11250	9050	5.12
Tengra	36	2500	7200	4700	2.88
Telapia	68	2392	8200	5808	3.42

Prize (Tk. kg^{-1}): Shing= 250, Tengra= 200

Table 80c. Utilization pattern of harvested fish at FSRD site Gangarampur, Pabna.

SL No.	Consumption (kg)	Distribution (kg)	Selling (kg)
1. Tengra	5	2	29
2. Shing	6	2	37
3. Telapia	20	8	40

Table 80d. Total fish production, utilization pattern and income before and after intervention at FSRD site during November 2018 to October 2021.

Description	Before intervention	After intervention				
		February 2018 to December 2019		2019-2020	2020-2021	Average
Consumption	40	Tengra	5	72	123	75
		Shing	6			
		Tilapia	20			
Distribution	10	Tengra	2	7	12	11
		Shing	2			
		Tilapia	8			
Selling	65	Tengra	29	63	80	115
		Shing	37			
		Tilapia	40			
Total production	115	Tengra	36	142	215	201
		Shing	45			
		Tilapia	68			
Gross return (tk)	13225	18450		18460	32250	23053
Total cost (tk)	6850	7700		10200	15900	11267
Net return (tk)	6375	13750		8260	16350	11786
BCR	1.93	2.4		1.81	2.03	2.05

III. Production program of carp polyculture in seasonal pond

Activity-51: Maximization of farmers' income through carp polyculture technique at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur. Rangpur

Mixed carp polyculture was conducted at 8 ponds during 2018-19 and 12 ponds during 2019-20 and 2020-21 of the 12 cooperators farmers' pond. Ponds area, fry amount and weight, final total amount and number of fish, survival rate etc. has been presented in Table 81a. The ponds were av. 13 decimal sized with av. 3.2 m depth. The results revealed that, in polyculture of carp fishes, the survival rate was 80-93%.

Yield, cost and return analysis are shown in Table 81b. The av. yield of fish after intervention was obtained 99 kg per pond with the gross margin Tk. 10208 per pond.

Among the total production they consumed, distributed to relatives and sold their products in local market (Table 81b. It was observed that, farmers sold most of the fish (63%), consumed about 33% and distributed about 4% through their neighbors, relatives and well-wishers of the produced fish. The farmers were benefitted by carp polyculture system and they showed further interest for farming of carp polyculture.

Table 81a. Performance of carp polyculture fish farming at FSRD site Ajoddhapur, Rangpur during the years of November 2018 to October 2021.

SL No.	Area and depth of pond (dec andm)	Amount and number of fries	Av. weight of fry (gm)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
2018-19	14 dec. and 3.6m	6-10 kg	30	480	98kg and 204#	85
2019-20	13 dec. and 3m	8-12 kg	35	471	105kg and 223#	93
2020-21	13 dec. and 3m	7-11 kg	28	495	95kg and 192#	80
Average	*13 dec. and 3.2m*	*07-11 kg*	*31*	*481*	*99kg and 206#*	*86*

Table 81b. Total fish production, utilization pattern and income before and after Intervention at FSRD site Ajoddhapur, Rangpur during the years of November 2018 to October 2021.

Description	Before Intervention (kg ha^{-1})	After Intervention (kg ha^{-1})			
		February 2018-January 2019	February 2019-January 2020	February 2020 -January 2021	*Average*
Consumption	10	24	35	40	*33*
Distribution	1	3	5	5	*4*
Selling	24	71	65	50	*62*
Total production	35	98	105	95	*99*
Gross return (Tk.)	5250	14700	15750	16625	*15692*
Total variable cost (Tk.)	1800	5400	5550	5500	*5483*
Gross margin (Tk.)	3450	9300	10200	11125	*10208*

FSRD Site, Gangarampur, Pabna

Information on ponds area, fry amount and weight, final total amount and number of fish, survival rate has been shown in Table 82. There were five ponds selected for polyculture of carp fishes during 2019-20 and 2020-21. The ponds were av. 10 decimal sized with av. 2.0 m depth. The results revealed that in polyculture of carp fishes the av. survival rate was 91%.

Yield and economic analysis are shown in Table 82. The yield of fish was obtained 142 kg and 215 kg per pond during 2019-20 and 2020 with the net return of Tk. 8260 and Tk. 16350 per pond.

Among the total production farmers consumed, distributed to relatives and sold their products in local market (Table 11b). It was observed that, farmers consumed average about 37%, sold about 58% and distributed about 5% to their neighbor's, relatives and well-wishers of the produced fish. The marginal farmers were benefitted by carp polyculture system and they showed further interest for farming of carp polyculture.

Table 82. Performance of carp polyculture fish farming at FSRD site during the years of November 2018 to October 2021.

Sl. No/Year	Area and depth of pond (dec. and m.)	Amount and number of fries	Av. weight of fry (g)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
Feb 2019 to Jan 2020	9 dec. and 2m	37 kg #250	148	747	142 kg #190	92
Feb 2020 to Jan. 2021	10 dec. and 2m	55kg #272	202	1113	215 kg #193	90

FSRD Site, Sholakundu, Faridpur

There were four ponds selected for carp polyculture production in perennial ponds. The ponds were average 10 decimal sized with average depth of water was 2.25 m. After 7 days of pond preparation, fingerlings were released in the pond with the acclimatization of pond water. The average initial weight of fry (30.80 g), final average weight (570 g), total amount and number of fry (141 kg and 248) and survival rate (75 %) are shown in Table 83a. Average body weight was increased 1745 % over initial body weight (Table 83b). The results revealed that average yield of fish after intervention was obtained 141 kg per pond which was 59% higher than before intervention with an average gross margin of Tk. 16828 per pond which was 77% higher over before intervention. Among the average production they consumed, distributed to relatives and sell their products in local market. It was observed that, farmers average sold most of the fish (85%), consumed about 13% and distributed about 2% through their neighbors, relatives and well-wishers of the produced fish (Table 83c). The farmers were benefitted by carp polyculture system and they showed their interest in farming of carp polyculture.

Table 83a. Performance of carp polyculture fish farming at FSRD site during the years of November 2018 to October 2021.

Year	Area and depth of pond (dec and m)	Amount and number of fries	Av. weight of fry (g)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
2018-19	10 dec and 2.25	8.48 kg and 353 nos.	24.00	445	111 kg and 251 nos	71
2019-20	10 dec and 2.25	10.50 kg and 318 nos.	33.00	617	148 kg and 243 nos	76
2020-21	10 dec and 2.25	11.50 kg and 320 nos.	35.50	648	164 kg and 250 nos	78
Average	10 dec and 2.25	10.16 kg and 330 nos.	30.80	570	141 kg and 248 nos	75

Table 83b. Average performance of carp polyculture fish farming at FSRD site during the years of November 2018 to October 2021.

Breed	Initial size (cm)	Initial wt (g)	Size after 60 days(cm)	Weight after 60 days (g)	Size after 180 days(cm)	Weight after 180 days (g)	Body wt. increase % over initial	Survival rate (%)
Silver carp	14	34	20	165	28	640	1782	75
Catla	12	28	18	140	24	480	1614	
Ruhi	13	30	19	158	28	560	1766	
Mrigel	14	36	20	195	29	690	1816	
Rajputi	10	26	14	136	20	480	1746	
Average	12.60	30.80	18.20	158.80	25.80	570	1745	75

Table 83c. Total fish production, utilization pattern and income before and after Intervention at FSRD site during the years of November 2018 to October 2021.

Description	Before Intervention (kg ha^{-1})	After Intervention (kg ha^{-1})			
		2018-2019	2019-2020	2020-2021	Average
Consumption	275	415	462	491	456
Distribution	42	63	72	80	72
Selling	1908	2297	3166	3529	2997
Total production	2225	2775	3700	4100	3525
Gross return (Tk.)	311500	402375	555000	631400	529592
Total cost (Tk.)	73917	100960	108930	118310	109400
Net return (Tk.)	237583	301415	446070	513090	420192

FSRD Site, Atia, Tangail

There were four ponds selected for carp polyculture production in seasonal ponds. The ponds were average 22 decimal sized with average depth of water was1.52 m. After 7 days of pond preparation, fingerlings were released in the pond with the acclimatization of pond water. The average initial weight of fry (6.76 g), final average weight (745 g), total amount and number of fry (793 kg and 1071) and survival rate (77 %) are shown in Table 84a. The results revealed that average yield of fish after intervention was obtained 190 kg per pond which was 52% higher than before intervention with an average gross margin of Tk. 12809 per pond. Among the average production they consumed, distributed to relatives and sell their products in local market. It was observed that, farmers sold most of the fish (48%), consumed about 40% and distributed about 12% through their neighbours, relatives and well-wishers of the produced fish (Table 84b). The farmers were benefitted by carp polyculture system and they showed their interest in farming of carp polyculture.

Table 84a. Performance of carp polyculture fish farming at FSRD site, Atia, Tangail during the years of November 2018 to October 2021.

Year	Area and depth of pond (dec andm)	Amount and number of fries	Av. weight of fry (g)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
Feb 2018-Jan. 2019	22 dec, and 1.5 m	9.0 kg and 1420	6.35	670	750 kg and 1120	79
Feb 2019-Jan.2020	22 dec, and 1.5 m	9.2 kg and 1370	6.71	824	840 kg and 1020	74
Feb 2020-Jan.2021	22 dec, and 1.56 m	10 kg and1390	7.23	742	790 kg and1073	77
Average	22 dec, and 1.52 m	9.4 kg and 1393	6.76	745	793kg and 1071	77

Table 84b. Total fish production, utilization pattern and income before and after intervention at FSRD site, Atia, Tangail during the years of November 2018 to October 2021.

Description	Before Intervention (kg ha^{-1})	After Intervention (kg ha^{-1})		
		2018-2019	2019-2020	2020-2021
Consumption	35	70	90	66
Distribution	12	20	28	17
Selling	78	98	92	90
Total production	1403	2111	2358	1942
Gross return (Tk.)	154375	232210	259380	213620
Total cost (Tk.)	80210	84290	88210	88960
Net return (Tk.)	74165	147920	171170	112345
BCR	1.92	2.75	2.94	2.26

FSRD Site, Tarakandi, Sherpur

The program of carp poly culture in sea ponds was undertaken at the FSRD sites with the objectives of increasing farmer's income and to remove protein deficiency of rural people. Fish fries/fingerlings were given among the four selected farmers of two villages under this program. Periodic checking was done after every 15 days interval to measure the growth and weight of fish. For fish cultivation, weeds and wild fishes were removed from the pond, Lime was given at the rate of 1 kg decimal^{-1} as well as prepared for stocking with organic manure (cowdung) at the rate of 3 kg decimal^{-1} (Table 85a).

Average size of the ponds was 16.75 decimal with 1.5 m depth. The result revealed that average survival rate was 86%. Average yield and number of fish was 291 and 358 kg pond^{-1}, respectively. Total production, consumed, distribution, selling and economic analysis are shown in Table 85b. It was observed that in Tarakandi, Sherpur total production was 4114 kg ha^{-1} with the gross margin of 264491 Tk. ha^{-1}. The farmers were benefitted by carp polyculture system and they showed interest for farming of carp polyculture.

Table 85a. Performance of carp polyculture fish farming at FSRD site, Tarakandi, Sherpur during the years of November 2018 to October 2021.

SL No.	Area and depth of pond (dec and m)	Amount and number of fries	Av. weight of fry (g)	Final average weight of fish (g)	Total amount and number of fish	Survival rate (%)
2018-19	16.75 dec. and 1.5 m	20-25 kg	86	950	291 kg and 310#	95
2019-20	16.75 dec. and 1.5 m	18-20 kg	79	890	296 kg and 305#	96
2020-21	16.75 dec. and 1.5 m	22-26 kg	91	532	288 kg and 460#	90
Average	16.75 dec. and 1.5 m	-	*85*	*615*	*291 kg and 358#*	*86*

Table 85b. Total fish production, utilization pattern and income before and after Intervention at FSRD site Tarakandi, Sherpur during the years of November 2018 to October 2021.

Description	Before Intervention (kg ha^{-1})	After Intervention (kg ha^{-1})			
		2018-2019	2019-2020	2020-2021	*Average*
Consumption	630	738	720	700	*719*
Distribution	95	160	150	105	*138*
Selling	2710	3420	3250	3100	*3257*
Total production	3435	4318	4120	3905	*4114*
Gross return (Tk.)	412200	680026	556166	507650	*581281*
Total variable cost (Tk.)	250000	370370	300000	280000	*316790*
Gross margin (Tk.)	162200	309656	256166	227650	*264491*

Average pond size = 16 .75 Decimal. Price of fish=130 Tk. kg^{-1}

E. OFF-FARM ACTIVITIES

Activity-52: Maximization of farmers' income through Off-farm activities at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Initially one household was started handicrafts making and finally most of the households were practiced handicrafts besides of other off-farm activities.

It was found that after intervention the av. net return increased 89%, with the av. net return of Tk. 6226 (Table 86). So, if all households could introduce some off-farm activities, it would be helpful to increase total farm income.

Table 86. Cost and return of off-farm activities

Activities	Before intervention	After intervention			
		2018-2019	2019-2020	2020-2021	*Average*
Khata making, Handicrafts etc.	Kantha making, Irrigation, Cooking	Handicrafts, Sewing, Kantha making, rrigation, Cooking	Handicrafts, Sewing, Kantha making, rrigation, Cooking	Handicrafts, Sewing, Kantha making, rrigation, Cooking	*Handicrafts, Sewing, Kantha making, rrigation, Cooking*
Production cost	1833	3583	3455	3333	*3457*
Sale value (Tk.)	5133	10583	9250	9217	*9683*
Net return (Tk.)	3300	7000	5795	5883	*6226*

FSRD Site, Gangarampur, Pabna

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Three households were practiced with off-farm activities such as sewing clothes, making of kumara bora and puffed rice, seedling raising in nursery, preparation of Jam/Jelly/Acher, Tailoring, Mudi shop etc. It was found that some off farm activities exhibited good cash income which contributed livelihood of the resource poor farmers to some extent. After intervention net benefit from off- farm activities were recorded Tk. 5765 farm^{-1} (Table 87). So, if all households could introduce some off-farm activities, it would be helpful to increase their total farm income which eventually contributes livelihood improvement of the rural household.

Table 87. Cost and return of off-farm activities at FSRD site, Gangarampur, Pabna during the years of November 2018 to October 2021.

Activities	Before intervention			After intervention								
				2018-2019			2019-2020			2020-2021		
	Total income	Cost	Net income	Total income	Cost	Net income	Total income	Cost	Net income	Total income	Cost	Net income
Sewing katha	666	320	346	4000	2000	2000	11000	3500	7500	7650	4500	3150
Puffed rice (Muri vaja)/ Kumra bora	483	230	253	2500	1050	1450	2300	1050	1250	1430	820	610
Seedling nursery	200	50	150	800	200	600	1400	652	750	1740	650	1090
Jam jelly	20	15	5	80	20	60	1620	550	1070	650	290	360
Tailoring	46	20	26	200	60	140	5750	1420	4330	3120	750	2370
Mudi shop	100	50	50	500	200	300	22800	14150	8650	35500	19300	16200
Total	1515	685	830	8080	3530	4550	44870	21322	23550	50090	26310	23780
Average	505	228	277	2693	1176	1517	14956	7107	7850	16697	8770	7927

FSRD Site, Sholakundu, Faridpur

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Four households were practiced with off-farm activities such as vermicompost production and honey production using honey box. It was found that gross margin of Tk. 4600 obtained after intervention of vermicompost the (Table 88) as well as farmers using this product to their homestead gardening. Honey production just started previous rabi season (2019-20) and farmers hoped profit will come from next rabi season. So, if all households could introduce some off-farm activities which would be helpful to increase total farm income.

Table 88. Cost and return of off-farm activities.

Activities	Economy	Before intervention	After intervention			
			Feb.18-Jan. 19	Feb.19-Jan. 20	Feb.- Dec. 20	Total
Vermicompost production	Production cost	--	--	4100	800	4900
	Sale value (Tk.)	--	--	5300	4200	9500
	Net return (Tk.)	--	--	1200	3400	4600
Honey production	Production cost	--	--	7500	--	7500
	Sale value (Tk.)	--	--	4200	--	4200
	Net return (Tk.)	--	--	--	*	--

*Honey box will be used for next year honey production so; net return cannot be included.

FSRD Site, Atia, Tangail

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Two households were practiced with off-farm activities such as hatching eggs by incubator and vermicompost production. It was found that after intervention the gross margin increased 40 % with the gross margin of Tk. 27902 (Table 89). So, if all households could introduce some off-farm activities which would be helpful to increase total farm income.

Table 89. Cost and return of off-farm activities at FSRD site, Atia, Tangail during the years of November 2018 to October 2021.

Activities	Before intervention	After intervention			
		2018-2019	2019-2020	2020-2021	Average
Hatching eggs and Vermicompost	Hatching eggs 2160 and vermicompost 1340 kg	Hatching eggs 5760 and vermicompost 2340 kg	Hatching eggs 6480 and Vermicompost 2964kg	Hatching eggs 5040 and Vermicompost 2730kg	Hatching eggs 5760 and Vermicompost 2678kg
Production cost	23300	37275	36675	30928	34959
Sale value (Tk.)	43200	58800	70464	59320	62861
Net return (Tk.)	19900	21525	33789	28392	27902

FSRD Site, Tarakandi, Sherpur

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. It was found that after intervention the income increased than before intervention. After intervention average net income was Tk.4500 whereas before intervention only Tk.2000. So, FSRD site team of Tarakandi, Sherpur could introduced some off-farm activities at their projected area, it would be helpful to increase total farm income (Table 90).

Table 90. Cost and return of off-farm activities.

Activities	Before intervention	After intervention			
		Feb.2018-Jan. 2019	Feb.2019-Jan. 2020	Feb.2020- Jan. 2021	*Average*
Kantha making, making Coconut strick etc.	Kantha making, making Coconut strick	Kantha making, making Coconut strick	Kantha making, making Coconut strick	Kantha making, making Coconut strick	Kantha making, making Coconut strick
Production cost	11000	12000	9000	9500	*10166*
Sale value (Tk.)	13000	16000	13000	15000	*14666*
Net return (Tk.)	2000	4000	4000	5500	*4500*

Income enhancement

FSRD site, Ajoddhapur, Rangpur

By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, Carp polyculture, the resources (land, labour, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. Before intervention of the project, an average per farm gross margin was Tk. 45433 whereas it was Tk. 107512, 209919 and Tk. 221168 during 2018-19, 2019-20 and 2020-21, respectively after intervention of the project activities (Table 91). The average increment of gross margin after intervention was 167% compared to before intervention.

Table 91. Technologies used and returned from different sub-systems of integrated farming systems at FSRD site Ajoddhapur, Rangpur during the years of November 2018 to October 2021.

Component	Before intervention (Tk.)			After intervention (Tk.)									Gross margin increased (%)			
	Gross return	Total variable cost	Gross margin	Gross return			Total variable cost			Gross margin			2018-2019	2019-2020	2020-2021	Av.
				2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21				
Homestead	7308	1900	5408	18842	33990	30719	5895	5979	5630	12947	28011	25089	139	418	364	307
Field crop	54725	43800	10925	110540	222863	226618	66625	92450	89000	43915	130413	137618	302	175	190	222
Livestock	27850	5500	22350	45500	46650	57955	11150	11150	16452	34350	35500	41503	54	51	77	61
Fisheries	5250	1800	3450	14700	15750	16625	5400	5550	5550	9300	10200	11075	170	136	156	154
Off-farm	5133	1833	3300	10583	9250	9217	3583	3455	3333	7000	5795	5883	112	76	78	89
Total	*100267*	*54833*	*45433*	*200165*	*328503*	*341134*	*92653*	*118584*	*119965*	*107512*	*209919*	*221168*	-	-	-	*150*

FSRD Site, Gangarampur, Pabna

Integrated farming with holistic approach exhibited remarkable improvement in overall farm productivity and income. By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labour, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. It was observed that maximum return was recorded from the field crop followed by livestock during three consecutive year's which was around 73% and 60% higher over previous intervention status of field crop and livestock, respectively. However, year-round vegetables and fruits in homestead also exhibited remarkably higher economic return which was 64% higher over previous intervention. Regarding increase (%) of different component over previous status, fisheries sector demonstrated maximum increase (412%) in return over previous status followed by off-farm activities (105%) (Table 92).

Table 92. Technologies used and return from different sub-systems of integrated farming systems during the years of November 2018 to October 2021.

Component	Before intervention (Tk)			After intervention (Tk)									Gross margin increased (%)			
				Gross return			Total variable cost			Gross margin						
	Gross return	TVC	Gross margin	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-2019	2019-2020	2020-2021	Av. of 3 years
Homestead	27247	5982	21265	45900	41900	46695	10148	9300	10352	35752	32600	36343	68	53	71	64
Field crop	139500	70300	69200	220700	230500	255500	99500	120000	127300	121200	110500	128200	75	60	85	73
Livestock	125450	62500	62950	201000	172800	233100	79800	81100	144500	121245	91700	88600	93	46	41	60
Fisheries	4350	2500	1850	7050	18460	32250	3230	10200	15900	3820	8260	16350	106	347	783	412
Off-Farm	12500	1250	11250	20380	14956	50090	2750	7107	26310	17630	7850	23780	57	249	111	105
Total	309047	142532	166515	495030	478616	617635	195428	227707	334362	299602	250910	293273	80	51	76	69

FSRD Site, Sholakundu, Faridpur

By integration of year-round vegetables production, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labour, capital) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. It was observed that maximum return recorded from the crop sector area which was 204% increased after intervention of technologies. The second highest gross margin increased in homestead that was 195% followed by fisheries (77%). The livestock component and off-farm activities contributed a good amount to increase farm income (Table 93).

Table 93. Technologies used and return from different sub-systems of integrated farming systems at FSRD site Sholakundu, Faridpur during the years of November 2018 to October 2021.

Component	Before intervention (TK.)			After intervention (Tk.) average of three years									% increased of GM with before intervention			
				GR			TVC			GM						
	GR	TVC	GM	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	Feb 18-Jan. 19	Feb. 19-Jan. 20	Feb. 20-Jan. 21	Avr
Crop sector	123100	95300	27800	163400	198400	223600	102630	110960	118425	60770	87440	105175	119	215	278	204
Homestead	6268	556	5712	13893	19466	25095	2350	2373	3148	11543	17093	21947	102	199	284	195
Livestock	3605	1365	2240	5390	7170	8568	2150	3005	4417	3240	4165	4151	45	86	85	72
Fisheries	12460	2957	9503	16095	22200	25256	4038	4357	4732	12057	17843	20524	27	88	116	77
Off-farm	0	0	0	0	5300	4200	0	4100	800	0	1200	3400	--	--	--	--
Total	145433	100178	45255	198778	252536	286719	111168	124795	131522	87610	127741	155197	94	182	243	173

FSRD Site, Atia, Tangail

By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labour, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. It was observed that maximum return recorded from the homestead area which was 288% increased after intervention of technologies. The second highest gross margin increased in livestock sector that was 81% followed by field crop (66%). The fisheries component and off-farm activities contributed a good amount to increase farm income (Table 94).

Table 94. Technologies used and return from different sub-systems of integrated farming systems during the years of November 2018 to October 2021.

Component	Before intervention (Tk)			After intervention (Tk)									Gross margin increased (%)			
	Gross return	TVC	Gross margin	Gross return			Total variable cost			Gross margin			2018-2019	2019-2020	2020-2021	Av. of 3 years
				2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21				
Homestead	2026	573	1453	6630	8144	8529	1800	2420	2146	4830	5724	6383	232	294	339	288
Field crop	53870	35170	18700	66838	70188	65299	36735	40186	32307	30103	30002	32992	61	60	76	66
Livestock	39000	23850	15150	54185	58290	70649	28319	30480	42120	25866	27810	28529	71	84	88	81
Fisheries	16832	7144	9688	20680	23100	21780	7650	8089	8025	13030	15011	13755	35	55	42	44
Off-Farm	43200	23300	19900	58800	70464	59320	37275	36675	30928	21525	33789	28392	08	70	43	40
Total	154928	90037	64891	207133	230186	225577	111779	117850	115526	95354	112336	110051	47	73	70	63

FSRD Site, Tarakandi, Sherpur

By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labour, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased, which may lead to improve livelihood. It was observed that maximum return recorded from crop sector and homestead area which was 334% and 802% inceased after intervention of technologies. Before intervention of the project, an average per farm gross margin was Tk. 267204 whereas it was Tk. 699029, 11988889 and 1124616 during the years of 2018-19, 2019-20 and 2020-21, respectively after intervention of the project activities. The average increment of gross margin after intervention was 277% compared to before intervention (Table 95).

Table.95. Technologies used and return from different sub-systems of integrated farming systems at FSRD site Tarakandi, Sherpur during the years of November 2018 to October 2021.

Component	Before intervention (TK.)			After intervention (Tk.)									Gross margin increased (%)			
	Gross return	Total variable cost	Gross margin	Gross return			Total variable cost			Gross margin			2018-2019	2019-2020	2020-2021	Av.
				2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21				
Homestead	1004	510	494	2804	8830	15534	765	4350	9396	2039	4480	6138	312	806	818	753
Field crop	334055	237825	96230	832236	1870553	1650358	403245	944143	774948	428991	926410	875410	532	862	504	734
Livestock	11,080	4800	6,280	20580	13093	16907	12000	5260	6989	8580	7833	9918	36	25	56	40
Fisheries	412200	250000	162200	680026	556166	507650	370370	300000	280000	309656	256166	227650	91	58	40	63
Off-farm	7000	5000	2000	16,000	13000	15000	12000	9000	9500	4000	4000	5500	100	100	175	125
Total	*765339*	*498135*	*267204*	*1551646*	*2461542*	*2205449*	*76601361*	*1262753*	*1080833*	*699029*	*1198889*	*1124616*	*162*	*349*	*321*	*277*

F. DEVELOPMENT OF LOCAL SERVICE PROVIDER (LSP)

Activity-53: Development of Local Service Provider at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

One co-operative farmer is acted as male LSP and one is acted as female LSP at the project area. The male LSP produced different types of vegetables and fruits seedling in his own nursery and also collected seeds and seedlings from other source and supplied to the project farmers and remaining part sold to the neighbour other farmers. The beneficiary farmers are return back some parts of their produce (vegetables/fruits/seeds) to the LSP. The female LSP provided training on handicrafts production and sewing by sewing machine to the other female farmers and also discussed with women regarding nutrition and sanitation. These activities were found a suitable practice for the sustainable farming activities. Table 96a shows the activities of male LSP and 96b shows the activities of female LSP.

Table 96a. Activities of male Local Service Provider (LSP) at FSRD site Ajoddhapur, Rangpur during the years of November 2018 to October 2021.

Activities/crop	No. of seedling produce		Supply to homestead member (no.)		Sell to other farmer (no.)		Gross return (Tk)		Total variable cost (Tk)		Gross margin (Tk.)		
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	Av.
Bottle gourd	750	700	12	12	13	13	1500	1400	550	550	950	850	900
Bitter gourd	380	450	12	12	9	9	760	900	300	300	460	600	530
Brinjal	5000	4500	12	12	11	11	5000	4500	600	600	4400	3900	4150
Tomato	6000	5400	12	12	16	16	6000	5400	600	600	5400	4800	5100
Cabbage	3000	3200	12	12	11	11	6000	6400	1600	1600	4400	4800	4600
Cauliflower	2500	3000	12	12	7	7	5000	6000	1500	1500	3500	4500	4000
Chilli	5000	4800	12	12	20	20	5000	4800	800	800	4200	4000	4100
Napier cutting	200	250	12	12	0	0	400	500	50	50	350	450	400
Sugarcane seedling	-	50	-	12	-	4	-	250	-	50	-	200	200
Dragon fruit seedling	-	55	-	12	-	10	-	1100	-	165	-	935	935
Total		22405		120		101	29660	31250	6000	6215	23660	25035	24348

Table 96b. Activities of female Local Service Provider (LSP) at FSRD site Ajoddhapur, Rangpur during the years of November 2018 to October 2021.

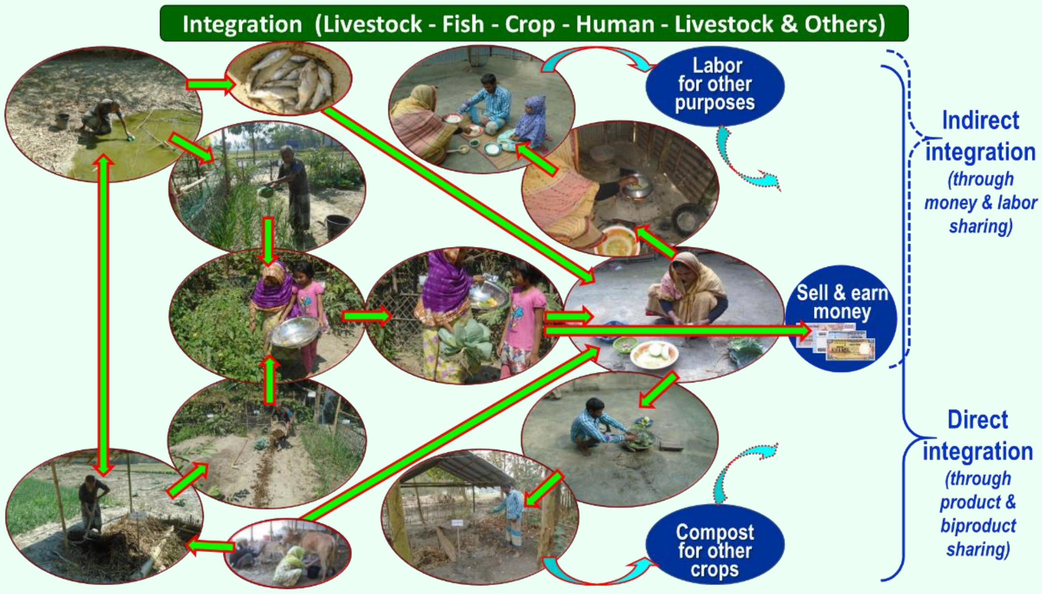
Sl no.	Activities	No. of female trainee
1	Training on handicrafts preparation	15
2	Training on Sewing machine	26

G. INTEGRATION AMONG DIFFERENT COMPONENTS

Activity-54: Feasibility study on integration among different household components at different FSRD sites during the years of 2018 to 2021.

FSRD site, Ajoddhapur, Rangpur

Several enterprises of a farmer like home gardening with vegetables and fruits, crops and cropping system, dairying, poultry, fishery, etc. are interrelated. The end product and wastage of one enterprise was used as inputs in another enterprise. Moreover, judicious use of farm resources can reduce production cost and can help to keep clean the environment. In integrated farming, the contribution of one component on other component ('s) is important consideration for sustainable farming. Two types of integration were found among the different components of a farm, one is direct integration, and another is indirect integration. The direct integration was conducted through sharing of the product or by product directly with each other and in case of indirect integration, it was happened through sharing money or nutrition or labor with each other.



Direct and indirect integration among the farm components

Livelihood improvement (sustainability)

Livelihood improvement is a very complex system and an individual's livelihood involves the capacity to acquire basic necessities in order to satisfy the basic needs. Increasing the capability of sufficient earning, security of nutritional and safe food, medical care, education, assets, acceptable life leading with social status may involve with the livelihood improvement (Table 97). However, the parameters that were considered for the sustainability of livelihood improvement under different FSRD sites are given below.

Table 97. The following information on livelihood improvement parameters (sustainability) have been made after intervention of the project activities at different FSRD sites during the years of November 2018 to October 2021.

Sl. No.	Area of consideration	Impact created	Indicator to assess the sustainability
1	Income enhancement	Gross margin increased by 59-385%	-Production of vegetables and fruits in homestead area considering time and space properly -Production was done in integrated way to minimize production cost and maximize yield -Used FRG for balanced fertilization of crops (Cereals, Oilseeds, Vegetables etc.) -Used of modern varieties -Innovative technologies -Used fallow land under cultivation - Increased production skill due to training
2	Family nutrition	Improved satisfactoril y	-Vegetable intake from homestead source increased 163-1528% -Fruit intake from homestead source increased 16-131% -Fish and poultry meat and egg production and intake increased remarkably -Changed in consumption habit towards vegetables and fruit -Reduced no. of attack and frequency of diseases
3	Soil health	Maintenanc e/ Increased	-Used of organic matter (FYM, vermicompost, green manure) -Decreased the use of insecticides/chemicals due to use of organic matter and IPM technology
4	Resource use pattern	Increased	-Used homestead (100%) -Introduction of homestead vegetables production model for respective site using 8 to 10 production niches.

Sl. No.	Area of consideration	Impact created	Indicator to assess the sustainability
5	Technical knowledge	Increased sharply	-Young girls and boys are engaged for implementation of new technologies -Training, field days, LSP activities, fortnightly meeting with field staffs and farming group and exchange of views with different type of peoples.
6	Adaptation innovation	Increase of 60-70%	-New crops, varieties are used -Used of recommended fertilizers -Used of different preservation and curative measures of food and seeds - LSP activities
7	Employment	Increased	-Used of unutilized family labor -Women participation in Agricultural activities (Homestead vegetables, livestock, duck and poultry rearing, compost making) the new technology and created employment. - Male in female LSP development
8	Micro-environment	Improved	-Household wastes being used for composting and their used in crops -Used of IPM/bio-pesticides saved environment from pollution. -New plantation and increased vegetables contribute to favorable environment
9	Housing	Improved	New house and repairing of house helps in improve living
10	Social status	Improved	-Increased access of better living standard to people -Improved mental strength due to higher income, development of skill on technologies and public conduct.
11	Education	Improved	-Women empowerment especially increased income made them to educate their children for a better future.
12	Women participation	Increased	-Homestead vegetables cultivation -Tree plantation and nursing -Composting -Seed preservation - Homestead mini nursery -Cow, Poultry and Duck rearing -Female LSP development -All these ensured women empowerment

Lessons Learned

i. There is plenty scope to utilize the rural farm household all over the country to produce vegetable and fruits and increase farm income.

ii. Home gardening with vegetables and fruits will lessen the pressure on mainland.

iii. Inclusion of proper variety, quality seed and improved crop management can enhance cropping intensity and productivity compared to existing cropping practice.

iv. Proper utilization of farm resources could help income enhancement compared to existing condition.

v. Changed in consumption habit with vegetables and fruits due to availability of diversified vegetables and fruits round the year and it also influence the nutritional status of the rural people.

vi. Turkey should be reared in semi scavenging system to protect the homestead vegetables.

vii. In case of pigeon rearing, partial feed should be supplied regularly to tame.

viii. Regular vaccine should be applied at early in the morning to poultry and livestock for more success.

ix. Proper management of compost pit and its utilization can help to produce safe and nutritious vegetables.

x. Water needs to supplement in seasonal pond during dry season for optimum growth of fish.

Conclusion

The vital indicator for livelihood improvement is increasing income compared to existing condition, which was found increasing trend in the program. So, the proper utilization of farmers' resources could help them in this area. Generally, most of the homestead area of the farmers was unproductive and unused, female labor was less or unused and vegetables & fruit intake was very low. Farmers did not follow recommended management practices or newly released technologies for crop production, fish culture and livestock production. As a result, existing farming system was not efficient. The integrated farming by reorganization of year round homestead vegetables production, improved cropping pattern, and recommended management practices, De-worming and vaccination program, carp polyculture, off-farm activities etc. have influenced farms income at different site. Integrated farming is a holistic approach and the components of integrated farming like home gardening, cropping system, livestock, fisheries, etc. are found interrelated. The waste of dairy like dung, urine, refuse etc. is used for preparation of FYM, which is an input in cropping systems. The straw obtained from the crops is used as fodder for cattle's. However, establishment of a local service provider (LSP) is important at all farming systems research and development sites for the successful and sustainable integrated farming activities.

LIVELIHOOD IMPROVEMENT OF FARMERS THROUGH INTEGRATED FARMING SYSTEM RESEARCH AND DEVELOPMENT OF DROUGHT AND RAINFED ECOSYSTEM

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Abstract

Prolonged drought, high temperatures, irregular rainfall distribution owing to climate change, soil acidity, and low soil fertility are all key factors that affect agricultural performance in drought and rainfed ecosystems. Due to the growing human population and shrinking agricultural land, it is vital to utilize an integrated strategy to manage all of the resources of poor farm households. From 2019 to 2022, integrated farming activities were carried out at the Farming Systems Research and Development (FSRD) Sites of Basantapur (Rajshahi), Amnura (Chapainawabganj), Chanduria (Rajshahi), Jiarokhi (Kushtia), and Kamalbazer (Sylhet) in order to develop integrated farming technologies, fine-tune NARS institutes' technologies, integrate component technologies with efficient use. Homestead production system, ii) Crops and cropping system, iii) Poultry and Livestock production system, iv) Fisheries production system, and v) Off-farm activities were among the research topics. In each site, two communities have been considered for FSRD activities. Sixty (60) farm homes were chosen from all sites, with twelve (12) from each site. Farmers need-based technologies were acted upon among small, marginal, and medium-sized resource-poor farmers based on the PRA and baseline survey data. The production of year-round domestic vegetables and fast-growing fruits was begun. For each site, two enhanced cropping patterns have been chosen. The initiative has included fodder production, a deworming and immunization program, and fish (carp polyculture) culture. All aspects of integrated farming, including vegetables, fruits, cereal crops, livestock, fish, and off-farm activities, were improved technologically, and as a result, income from these areas grew. At the FSRD sites of Basantapur, Amnura, Chanduria, Jiarokhi, and Kamalbazer, the average homestead size was 0.05, 0.05, 0.04, 0.13, and 0.07 ha, respectively. After intervention (AI), the average annual vegetable production per household increased to 645 kg, up from 85 kg before intervention (BI). During AI, vegetable production climbed by 659 percent compared to BI. During AI, the average vegetable consumption was 209 g $head^{-1}day^{-1}$, which was 465 percent greater than during BI. Due to poor management, the average fruit produced per homestead was 389 kg, down from 108 kg during BI. Fruit consumption increased significantly (avg. 197%) during AI compared to BI. Existing fruit tree management and new plantation have had a positive influence on farm households: around 1186 fruit trees have been brought under pest management, and a total of 4312 saplings of various fruits have been distributed over the locations. In Basantapur, Amnura, Chanduria, Jiarokhi, and Kamalbazer, the average crop land size was 0.91, 1.06, 0.61, 0.61, and 0.54 ha, respectively. In the case of field crops, farmers achieved higher yields and economic returns from their alternative or improved cropping pattern, which included improved variety(s) and better management practices. The improved cropping pattern increased rice equivalent yield by 50-100 percent over the existing pattern. For irrigated Barind, Mustard (BARI Sarisha-17/14)- Boro (BRRI dhan81) and T. Aman rice (BRRI dhan49) is recommended and Lentil, (BARI Masur-8) -Fallow-T. Aman rice (BRRI dhan51) can be a potential planting pattern for the rainfed Barind area. Similarly, Mustard (BARI Sarisha-18)-T. Aus (BRRI dhan82)-T. Aman (BRRI dhan87) for level Barind tract; Lentil (BARI Masur-8)-Sesame (BARI Til-4)-T. Aman (BRRI dhan75) for High Ganges River Floodplain (Kustia) and Potato (BARI Alu-41)-T. Aus (BRRI dhan65)-T. Aman rice (BRRI dhan57) for Eastern Surma Kushiyara Floodplain (Sylhet) can be recommended. BARI Hybrid Tomato-11 produced a better fruit output (38 t ha^{-1}) and gross margin in the production program (Tk. 1470000 ha^{-1}). Furthermore, BARI Masur-8 and BARI Sarisha-17 are gaining popularity due to their high financial returns. The frequency of key cattle diseases (Anthrax, FMD, and BQ) was reduced below 5% in the livestock component through deworming and immunization. Farmers were interested in cattle fattening programs since a 6-month program resulted in a notable growth in body weight (45-55 percent) and a greater gross margin (Tk. 25000 $cattle^{-1}$). After vaccination, poultry mortality is reduced by 76-88 percent. Moreover, the production and use of farm yard manure (FYM) is continuing among farm families. Green fodder (Napier grass) production continues on the homestead's pond bank, roadside, and fallow space. Farmers rarely use their seasonal ponds in a scientific way. They were placed under best management practices as a result of the project. Over the location, the average pond size was 0.03-0.05 ha. At the farmer level, carp polyculture yielded a reasonable gross margin (Tk. 8000-15000 $pond^{-1}$). Farmers also made some extra money from off-farm activities (Tk. 25000-35000 $household^{-1}$). Women's participation in agricultural activities was found to be exceptional, which could help to improve gender equity within the family. On a custom hiring basis, local service providers (LSP) provided seeding services for crops under the conservation agriculture system. According to the findings of FSRD operations, adopting an integrated farming program at FSRD sites has created an opportunity to improve the livelihood of resource-poor farmers.

Introduction

Bangladesh is a predominantly agricultural country. Livelihood of most people, particularly in rural area, depends largely on agriculture. The area under crop production is anticipated to be 8 million ha. Drought-prone areas are largely found in Bangladesh's northwestern region (the high Barind tract of Rajshahi, Chapai Nawabganj, and Kushtia), as well as the rainfed areas of Sylhet and Bandarban. A combination of high temperature, low and erratic annual rainfall and soil moisture deficiencies, causing drought and rainfed ecosystem, have a devastating impact on agricultural production and threaten small scale farmers. During the rabi, pre-kharif, and kharif seasons, an estimated 5.97 million ha of cultivated land is affected by drought, with 1.22 million ha experiencing severe to very severe drought, primarily in the northwestern districts of Chapai Nawabganj, Naogaon, Rajshahi, Natore, Rangpur, Dinajpur, Joypurhat, Pabna, Bogura, Chuadanga, and Kushtia.

The high Barind tract (HBT) of north-west Rajshahi division stands apart from other regions of the country due to terraced land, high temperature; and low and erratic annual rainfall (1200 mm ± 300). The soil of this area is compact, low fertile, limited soil moisture storage and acidic in nature. In addition, the HBT contains no rivers or water bodies. In comparison to other sections of the country, vegetation is also sparse. As a result, the HBT is recognized as drought prone area of Bangladesh. The main crop and backbone of the rural economy is T.aman rice. Drought can reduce rice harvests by 45-70 percent in extreme cases. Due to the short monsoon and weak water holding capacity of soil, the land remains fallow in the rabi and kharif-1 seasons after the harvest of T.aman rice. Non-rice crops and Boro rice have recently taken the position immediate after harvesting of T. Aman rice in the BMDA commanded region. Irrigated Boro crops may be harmed if the water table drops due to excessive groundwater pumping and a lack of rain at such a stressful period. Low-water-demanding crops such as pluses, oilseeds, wheat, and potatoes have thus been given preference for fallow land cultivation during the rabi season. On the other hand, the Barind area's homestead land is unutilized. As a result, there is a severe lack of vegetables in these areas. In the homestead area, as well as in the fallow ground, there is potential for growing vegetables and fruits. Every home has a pond, but they do not cultivate fish in a scientific way rather follow the traditional fish culture method still remaining. The majority of the cattle are sick due to worms and a lack of fodder. Cattle productivity could be improved by implementing proper technologies.

Greater Kushtia belongs to Agro Ecological Zone (AEZ) 10, 11 and 12. In this region terminal drought occurs frequently in T. Aman crop. The main crops of this area are aus rice, aman rice, boro rice, wheat, onion, maize, pulses, oil seed and vegetables. Various types of fruits namely mango, jackfruit, banana, guava, litchi, lime and papaya are grown here. There is a scope of year-round vegetable production in the homestead as well as field since the land type is high and medium high which could play a significant role in reducing malnutrition and increasing farmer's income. Cattle, Black Bengal Goat, especial type of sheep called locally as *garol* and chicken are predominant in livestock and poultry production system. Farmers of Kushtia region have been growing fodder crops in their fallow land for beef fattening and milk production. Farmers gain some additional income from excess fodder grown in their fallow land, which is readily sold in the local market of Kushtia. Fish culture is also practiced in perennial ponds and seasonal water bodies.

Almost 95-98% area of Sylhet belongs to AEZ 20 (Surma Kushiyara Floodplain). The region occupies the eastern part of the country where the rain starts earlier and usually heavier than any other region. According to last 30 years observation, late season drought in mid-September to October, coinciding with flowering and grain filling stage of aman rice occurs more frequently mainly due to the early withdrawal of rainfall. As a result, yield of aman rice reduce drastically and sometimes damaged completely. The soils here are generally heavy silty clay loams and clays with small areas of loam soils. The top soils dry quickly at the end of the rainy season. So, it is not possible to grow field crops during rabi season. The dominant cropping pattern is Fallow-T.aus-T.aman. Homestead vegetables, fruit production, cultivation of high yielding nutritious vegetables and fruit in the fallow land could play a significant role in reducing malnutrition. Cattle goat, chicken and duck are dominated in livestock and poultry production system. Just after harvesting of T. aman cattle are set freed to graze in the crop land.

In general drought not only impact on yield of standing crops but also lessen fisheries production since the ponds become dry due to the lack of water. Animal may suffer from shortage of forage and drinking water. It becomes difficult for the trees to survive fighting with drought. Farm laborers may lose their job due to reduction in crop productivity. Employment opportunities based on agriculture decreases. All of these create immense pressure on lives and livelihoods of rural people and their income. It is important to develop technologies and disseminate the technologies among the stakeholder that will help to overcome the potential impact of drought sustainability. In these circumstances, a project was undertaken entitled "Livelihood Improvement of farmers through Integrated Farming System Research and Development of Drought and Rainfed Ecosystem" funded by NATP Phase-2, BARC during October 2019 to September 2022. It has partners namely, BARC, BARI and BLRI. BARI is working at Rajshahi, ChapaiNawabgonj, Kushtia and Sylhet. During the project period BARI developed some location specific technologies which was generated in participatory research with famers

Methodology

For the successful implementation of the proposed integrated farming systems research and development program, the following methods were considered-

Specific Methodology

The integrated farming research and development activities were executed at the Drought and Rainfed ecosystems (FSRD sites Basantapur, Rajshahi; Amnura, ChapaiNawabgonj; Chanduria, Rajshahi; Jiarokhi, Kushtia and Kamal Bazar, Sylhet) during the years of October 2019 to May 2022 to improve the livelihoods of rural households through the generation and adoption of farming system technologies, especially integrated farming technologies and the technologies generated by NARS institutes. The program was executed in a participatory approach, where critical inputs and technological suggestions were provided by BARI personnel and other commodities were used from the farmer's own sources. Based on farmers' traditional practices, their needs and choices, several alternatives for technologies of crops, livestock, fisheries, off-farm activities and other components were incorporated with the active participation of the farmers. The program's goal was to target resource poor farmers-marginal, small, and medium with major components of farming and sizeable homesteads under single ownership—and twelve farm households from two villages were chosen at each site (Table 2.1).

Table 2.1. Category-wise selected farmers information of different FSRD sites.

FSRD site	Categories	No. of Farmer	Av. family size (no.)	Av. crop land size (ha)	Av. homestead area (ha)	Av. pond area (ha)
Basantapur, Rajshahi	Marginal	4	5.00	0.48	0.044	0.020
	Small	4	4.00	0.88	0.050	0.024
	Medium	4	5.75	1.38	0.044	0.052
Amnura, ChapaiNawabgonj	Marginal	4	6.00	0.37	0.032	0.021
	Small	4	4.50	0.87	0.048	0.020
	Medium	4	5.25	1.95	0.074	0.035
Chandura, Rajshahi	Marginal	4	5.60	0.12	0.028	0.028
	Small	4	6.20	0.37	0.040	0.037
	Medium	4	4.00	1.35	0.048	0.06
Ziaroki, Kushtia	Marginal	4	6.50	0.19	0.11	0.025
	Small	4	4.66	0.58	0.13	0.05
	Medium	4	5.0	1.05	0.16	0.05
Kamalbazar, Sylhet	Marginal	1	4.00	0.06	0.06	0.021
	Small	8	4.38	0.45	0.064	0.048
	Medium	3	5.33	1.12	0.08	0.08

A training program was arranged to build farmers' capacity and to develop awareness regarding nutrition and crop production. An individual household survey (Benchmark survey) was carried out before starting the project activities. The details of the information regarding livelihood patterns were documented. The total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, and labor availability of the farms of the previous year were accounted for by a detailed households' case study with intensive visits and cross examinations for authentication of the data before intervention. Based on the potential, suitable technological options were addressed to the farmers, and accordingly, farmers selected suitable technologies based on their need for livelihood improvement. Year-round vegetable production followed by a respective location-wise model in each homestead; fruit tree management and new plantation; crops and cropping system improvement through improved cropping pattern development and promising variety piloting; vaccination of poultry and livestock; rearing of poultry; pigeon and cattle fattening; green fodder production; fish culture; and some off-farm activities were identified as their major potential areas.

During the implementation period of project activities, a site working group meeting, PRA, base line survey, and field visit were done, and field staff were organized. The On-Farm Research Division (OFRD) team facilitated the cooperators for technological intervention to maximize the productivity of the components. However, season-wise (Rabi = October-March, Kharif I = April-June, and Kharif II = July-September) data on production, farm level utilization with disposal pattern, possible integration among the components, economic return focusing on income and expenditure, and other socio-economic information were collected and tabulated accordingly.

A. Homestead Production System

A benchmark survey was conducted before the program was implemented to learn about the current agricultural situation in the pilot areas for technology intervention. Twelve farmers were chosen from various categories based on available resources and potential for homestead farming, and their averages are given here. Each agricultural family has an average of five members. The FSRD team gave training and recommendations to the selected farmers on how to cultivate year-round vegetables and quick-growing fruits using the appropriate site-based production model. Following that, the taught farm family grew vegetables and fruits in their homestead area using a site-by-site model. A homestead consists of a farmhouse and the land surrounding it. The land beneath a farmhouse is a great resource for resource-strapped agricultural households, as it may be used to grow a variety of vegetables and fruits.

a) Vegetables

The vegetables production models of various areas were developed and followed based on farmer preferences and agro-ecological appropriateness.

Table 2.2 Barind model (Modified) (followed at 3 sites namely Basantapur and Chanduria, Rajshahi, and Amnura, ChapaiNawabgonj)

Sl No.	Spaces	Cropping patterns		
		Rabi	Kharif-1	Kharif-11
1.	Open sunny land			
	Bed 1	Brinjal	Kangkong	Kangkong
	Bed 2	Spinach-Spinach	Indian spinach	Red amaranth
	Bed 3	Radish-Red amaranth	Stem amaranth (Katua data)	Green Shak
	Bed 4	Cabbage	Onion	Red amaranth/Jute shak
	Bed 5	Cauliflower-Red amaranth	Okra	Red amaranth/Jute shak
2.	Fence	-	Bitter gourd, yard long bean	Sponge gourd
3.	Trellis	Country bean, bottle gourd	Pointed gourd, snake gourd, ridge gourd	sponge gourd
4.	Roof	Country bean, bottle gourd	Sweet gourd, White gourd	White gourd
5.	Tree support	-	White gourd, potato yam, sponge gourd	sponge gourd
6	Partial shady area	Coriander leaf	Turmeric, Aroids	Turmeric, Aroids
7.	Homestead boundary/back yard	Plantain banana Papaya Drumstick	Plantain banana Papaya Drumstick	Plantain banana Papaya Drumstick
8.	Pond/ ditch banks and slope	Bottle gourd	Snake gourd, Bitter gourd	-
9.	Others	-	Fodder, chewing sugarcane	Fodder, chewing sugarcane

Table 2.3 Goyeshpur model *(*Jiarokhi, Kushtia*)*

Niche/space				Cropping patterns		
				Rabi	Kharif-I	Kharif-II
1.	Open sunny space	Bed-1	:	Radish	Stem Amaranth	Indian spinach
		Bed-2	:	Cabbage	Brinjal	Red Amaranth
		Bed-3	:	Tomato	Spinach	Okra
2.	Fence		:	Bitter gourd	Yard long bean	Bitter gourd
3.	Trellis		:	Bottle gourd	Sweet gourd	Sweet gourd
4.	Roof		:	Bottle gourd	Wax gourd	Wax gourd
5.	Tree support		:	Bitter gourd	Ridge gourd	Sponge gourd
			:	Potato yam	Snake gourd Potato yam	Potato yam
			:	Country bean	Yard long bean	Yard long bean/Country bean
6.	Partial shady area		:	Elephant foot yam		
			:	Leaf aroid (moulavi kachu)		
			:	Turmeric		
			:	Perennial chilli		
7.	Marshy land		:	Pani kachu (Latiraj)		
8.	Homestead boundary		:	Papaya(3-5 plant)		
			:	Guava(1-2 plant)		
			:	Lemon(1-2 plant)		
9.	Back yard /waste land		:	Laizna (1-2 tree)		
			:	Banana		

Table 2.4 Golapgonj model *(*Kamalbazar, Sylhet*)*

Sl. No.	Niches/space		Year-round homestead vegetables and fruits pattern		
			Rabi (October- March)	**Kharif-I** (April-June)	**Kharif-II** (July-Sep)
1	Open sunny land	Bed-1	Radish/Indian Spinach	Indian Spinach	Kang Kong
		Bed-2	Radish/Tomato	Red amaranth/Okra	Indian Spinach
		Bed-3	Bush bean	Kang Kong	Brinjal
		Bed-4	Dhonia/ Laishak	Dhonia	Amaranth
2	Cottage roof/top		Country bean/Bottle gourd	Ash gourd	-
3	Trellis		Country Bean/Bottle gourd	Shake gourd	Ridge gourd
4	Fences/Boundary wall		Bitter gourd	Bitter gourd	-
5	Non-fruit trees		-	Ridge gourd	Ridge gourd
6	Partially shady land		Bilati Dhonia	Turmeric/Ginger	Turmeric/Ginger
7	Homestead areas		Papaya	Papaya	Papaya
8	Marshy land		Water 548aro(Kalakachu), Aroid (Latiraj)		
9	Backyard		Papaya, Banana, Guava, Mango, Lemon, Sugarcane, Satkora, malta		

b) Fruits

Fruit saplings were delivered and planted in the homestead area based on farmers' preferences, agro-ecological compatibility, and human nutrition requirements. At each location, a mixed fruit garden was also established. This program included irrigation, fertilizing, pest control, and other care of new and existing fruit trees.

B. Crops and Cropping System

a) Improvement or development of cropping pattern

Different sorts of cropping patterns could be found in various regions. Cropping patterns that were formerly dominant were investigated for improvement or were replaced by more profitable cropping patterns. Two to three cropping patterns were explored for development at each FSRD site in drought and rainfed habitats to boost crop productivity (Table 2.5).

Table 2.5 Activities for improvement or development of cropping pattern under drought and rainfed ecosystem.

Location	Observation	Improved cropping pattern			Existing cropping pattern		
Basantapur, Rajshahi	Cropping Pattern-I						
	Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
	Variety	BARI Sarisha-17	BRRI dhan81	BRRI dhan49	BRRI dhan28	-	Swarna
	Date of sowing/ Transplanting	3-6 Nov	05-10 Feb	12-15 Jul	26-31 Jan		23-26 Jul
	Seed rate (kg ha^{-1})	7.5	50	40	60		50
	Spacing (cm)	Broadcast	20×15	20×15	20×15		20×15
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	90-22-45-27-2-1.5	100-15-37-12	86-13-15-10	120-20-35-13	-	80-12-25-10
	Date of harvesting	1-3 Feb	9-12 May	25-28 Oct	1-4 May	-	20-25 Nov
	Field duration (days)	90-92	91-93	108-111	95-100	-	120-125
	Turnaround time (days)	5-8	5-7	62-65	66-68	-	85-88
	Cropping Pattern-I1						
	Crop	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman

Location	Observation	Improved cropping pattern			Existing cropping pattern		
	Variety	BARI Gom-30	BARI Til-4	BRRI dhan51	BARI Gom-28	-	Swarna
	Date of sowing/ Transplanting	20-22 Nov	29-30 March	12-15 July	5-7 Dec	-	20-25 July
	Seed rate (kg ha^{-1})	120	7.5	40	150	-	50
	Spacing (cm)	20 X Cont (Strip tillage)	Broadcast	20 X 15	Broadcast	-	20 X 15
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	103-25-41-27-2-1.5	60-15-37-12	86-13-15-10	90-20-41-27	-	80-12-25-10
	Date of harvesting	20-23 Mar	20-22 June	10-12 Nov	3-5 April	-	22-25 Nov
	Field duration (days)	120-124	83-85	123-125	123	-	130-132
	Turnaround time (days)	10-12	6-7	22	6		113
Amnura, ChapaiNawabgonj	Cropping pattern-I						
	Crop	Wheat	Mungbean	T. Aman	Wheat	Fallow	T. Aman
	Variety	BARI Gom-30	BARI Mung-6	BRRI dhan51	BRRI dhan28	-	Swarna
	Date of sowing/ Transplanting	18-20 Nov	25-28 March	22-26 July	3-5 Dec	-	25-28 July
	Seed rate (kg ha^{-1})	120	35	40	150	-	50
	Spacing (cm)	20 X Cont. (Strip tillage)	Broadcast	20 X 15	Broadcast	-	20 X 15
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	100-25-40-27-2-1.5	20-20-20	86-13-15-10	88-20-40-25	-	80-12-25-10
	Date of harvesting	18-22 Mar	05-15 June	12-15 Nov	4-5 April	-	20-25 Nov
	Field duration (days)	120	75	120	122	-	120
	Turnaround time (days)	11	7	37		-	81
	Cropping pattern-II						
	Crop	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
	Variety	BARI Masur-8	-	BRRI Dhan51	-	-	Swarna
	Date of sowing/ Transplanting	20-21 Nov	-	15-20 July	-	-	23-25 July
	Seed rate (kg ha^{-1})	50	-	40	-	-	50
	Spacing (cm)	Broadcast	-	20 X 15	-	-	20 X 15
	Fertilizer dose (N-P-K-S-Zn-B, kg ha^{-1})	20-20-20—0-0-1	-	86-13-15-10	-	-	80-12-25-10
	Date of harvesting	08-10 Mar	-	5-7 Nov	-	-	20-24 Nov
	Field duration (days)	110	-	112	-	-	123
	Turnaround time (days)			128			242
Chanduria, Rajshahi	Cropping pattern-I						
	Crop	Lentil	Maize	T. Aman	Fallow	Boro	T.aman
	Variety	BARI Masur-8	Laltir 339	BRRI dhan87	-	BRRI dhan28	Swarna
	Date of sowing/ Transplanting	20 Nov	05 April	25 July	-	25-28 Feb	20-25 July
	Seed rate (kg ha^{-1})	35	25	35	-	35	35
	Spacing (cm)	Broadcast	60 x 20	20 x 15	-	20 x 15	20 x 15

Location	Observation	Improved cropping pattern			Existing cropping pattern		
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	18-30-25-18-1-1	152-52-74-26-2.5-1.2	90-10-25-12-1-0	-	120-15-60-13-3-0	96-18-28-8-0-0
	Date of harvesting	15-17 March	15-17 July	30-31 Oct.	-	20-23 Jun	7-10 Nov
	Field duration (days)	117	102	98	-	117	111
	Turnaround time (days)	19	20	09	-	108	29
	Cropping pattern-II						
	Crop	Mustard	T.Aus	T.Aman	Fallow	Boro	T.aman
	Variety	BARI Sarisha-18	BRRI Dhan82	BRRI Dhan87	-	BRRI dhan28	Swarna
	Date of sowing/ Transplanting	11-13 Nov	16-17 March	27-29 June	-	25-28 Feb	20-25 July
	Seed rate (kg ha^{-1})	07	35	35	-	35	35
	Spacing (cm)	Broadcast	20 x 15	20 x 15	-	20 x 15	20 x 15
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	126-35-46-29-2.5-2	76-11-38-6.4-0-0	90-10-25-12-1-0		120-15-60-13-3-0	96-18-28-8-0-0
	Date of harvesting	21-23 Feb	15-17 June	07-09 Oct	-	20-23 Jun	7-10 Nov
	Field duration (days)	103	92	102	-	117	111
	Turnaround time (days)	34	23	11	-	108	29
Jiarokhi, Kushtia	Cropping pattern-I						
	Crop	Lentil	Sesame	T. Aman	Lentil	Sesame	T. Aman
	Variety	BARI Masur-8	BRRI Til-4	BRRI dhan-75	BARI Masur-6	Local	BRRI dhan-39
	Date of sowing/ Transplanting	23-25 Nov	22-25 March	3-4 Aug	20-24 Nov	12-15 March	30-35 July
	Seed rate (kg ha^{-1})	30	7	22	35	8	30
	Spacing (cm)	Broadcast	Broadcast	20×15	Broadcast	Broadcast	20×15
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	21-17-17.5-9.36-0-1	55-28-22.5-19-1.8-1.7-0	115-27-44-13-1-0	20-17-17.5-9-0-1	50-25-20-15-0-0	115-27-44-13-1-0
	Date of harvesting	15-17 March	16-18 July	30-31 Oct	7-9 March	15-17 July	03-05 Nov
	Field duration (days)	112	114	87	103	120	93
	Turnaround time (days)	16	7	18	21	8	10
	Cropping pattern-II						
	Crop	Onion	Sweet gourd	T. Aman	Onion	Sweet gourd	T. Aman
	Variety	BARI Piaz-4	Local hybrid	BRRI dhan-75	Local	Local hybrid	BRRI dhan-39
	Date of sowing/ Transplanting	05-07 Dec	26-28 January	20-22 July	06-10 Dec	26-28 January	25-28 July
	Seed rate (kg ha^{-1})	7.5	6	30	7.5	6	30
	Spacing (cm)	25 line	300×300	20x15	25 line	300×300	20x15
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	110-52-75-20-1-0.5	80-80-75-18-3.5-1.7	115-27-44-13-2.5	110-52-75-20-1-0.5	80-80-75-18-3.5-1.7	115-27-44-13-2.5
	Date of harvesting	28 March, 2021	05 May-05 July, 2021	10 Nov. 2020	28 March, 2021	05 May-05 July, 2021	14 Nov. 2020

Location	Observation	Improved cropping pattern			Existing cropping pattern		
	Field duration (days)	113	100-120	110	112	100-130	109
	Turnaround time (days)	20	-	15	20	-	20
Kamal Bazar, Sylhet	Cropping pattern-I						
	Crop	Potato	T.Aus	T.Aman	Fallow	T.Aus	T.Aman
	Variety	BARI Alu-41	BRRI Dhan-65	BRRI Dhan-57	-	BR-26	BRRI Dhan-33
	Date of sowing/ Transplanting	22-11-19	25-04-19	31-07-19	-	17-04-19	03-08-19
	Seed rate (kg ha^{-1})	1500	26	26	-	26	26
	Spacing (cm)	45 x 15	20 x 15	20 x 15	-	20 x 15	20 x 15
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	115-30-175-22-4-2	134-53-83-60-0-0	150-53-83-60-0-0	-	134-53-83-60-0-0	165-60-105-86-0-0
	Date of harvesting	27-02-20	28-07-19	01-11-19	-	30-07-19	17-11-19
	Field duration (days)	98	93	90	-	103	104
	Turnaround time (days)	56	4	21	-	5	150
	Cropping pattern-II						
	Crop	Mustard	T. Aus	T. Aman	Mustard	T. Aus	T. Aman
	Variety	BARI Sarisha-14	BRRI Dhan-65	BRRI Dhan-57	Tori-7	BR-26	BRRI Dhan-33
	Date of sowing/ Transplanting	15-11-20	23-04-20	02-08-20	29-11-19	16-04-20	01-08-20
	Seed rate (kg ha^{-1})	7.5	26	26	7.5	26	26
	Spacing (cm)	-	20 x 15	20 x 15	-	20 x 15	20 x 15
	Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	115-30-43-27-18-1.7	134-53-83-60-0-0	150-53-83-60-0-0	115-30-43-27-18-1.7	134-53-83-60-0-0	165-60-105-86-0-0
	Date of harvesting	10-02-21	27-07-20	03-11-20	08-02-21	25-07-20	18-11-20
	Field duration (days)	85	94	91	76	105	108
	Turnaround time (days)	72	6	12	61	4	11

b) On-farm verification/production program

Bangladesh Agricultural Research Institute and other NARS Institutes have developed a large number of modern varieties of different crops, which are high yielding as well as short in duration. To identify the suitable crops and varieties, an on-farm verification trial was conducted during the years of 2019–20 and 2020–21 with different types of crops, e.g., mustard, potato, tomato, wheat, mungbean, sesame, lentil, barley, etc. The identified suitable varieties were brought under production programs at each location in the following years. The details of crop management are given in the result part.

Table 2.6 Different operations conducted for production program at different FSRD sites under drought and rainfed ecosystem during the years of 2019 to 2022.

Location	Crop	Variety	No. of farmers	Total area (ha)	Date of sowing/ transplanting	Date of harvesting
Basantapur, Rajshahi	Lentil	BARI Masur-8	6	1.5	Mid Nov	Mid Mar
	Chickpea	BARI Chola-5	6	1	Mid Nov	Mid Mar
	Summer Tomato	BARI Hybrid Tomato-8	1	0.15	Late Jul to early Aug	Oct- Dec
	Mustard	BARI Sarisha-17	7	2.0	Early Nov	Early Feb
		BARI Sarisha-14	03	1.0	Early Nov	Late Jan
		BARI Sarisha-18	6	2	Late Oct	Mid Feb
	Potato	BARI Alu-7	1	0.13	Late Nov	Early Mar
		BARI Alu-25				
		BARI Alu-36				
		BARI Alu-41				
		BARI Alu-46				
Amnura, Chapai Nawabgonj	Lentil	BARI Masur-8	7	3.0	Late Nov	Mid Mar
	Chickpea	BARI Chola-5	8	3.0	Late Nov	Late Mar
	Wheat	BARI Gom-30	4	1.0	Late Nov	Late Mar
	Mustard	BARI Sarisha-18	6	2	Late Oct	Mid Feb
		BARI Sarisha-17	10	4.0	Early Nov	Early Feb
		BARI Sarisha-15	4	1.0	Early Nov	Late Jan
		BARI Sarisha-14	14	5.0	Early Nov	Late Jan
Chanduria, Rajshahi	Lentil	BARI Masur-8	06	01	Mid Nov	Mid Mar
	Wheat	BARI Gom-30	08	1.33	Late Nov	Late Mar
	Sesame	BARI Til-4	2	0.267	Late March	Late June
	T. Aus rice	BRRI dhan82	1	0.267	Mid May	Mid Aug
	Potato	BARI Alu-7	06	0.5	Late Nov	Early Mar
		BARI Alu-37	06	0.5		
		BARI Alu-40	03	0.5		
		BARI Alu-7	06	0.5		
	Mustard	BARI Sarisha-11	06	0.5	Late Nov	Mid Mar
		BARI Sarisha-14	45	7.33	Mid Nov	Early Feb
		BARI Sarisha-16	06	0.5	Late Nov	Mid Mar
		BARI Sarisha-18	06	1.0	Late Nov	Mid Mar
Jiarokhi, Kushtia	Lentil	BARI Masur-8	4	0.91	Late Nov	Late Feb
	Mustard	BARI Sarisha-18	4	1.00	Late Nov	Late Feb
	Potato	BARI Alu-7	3	1.00	Early Dec	Mid Mar
		BARI Alu-53	5	0.50	Early Dec	Mid Mar
Kamal Bazar, Sylhet	Tomato	BARI Hybrid tomato-5	2	0.3	Early Oct	Dec to Jan
	Mustard	BARI Sharisa-14	3	0.6	Mid Nov	Mid Feb
	Potato	BARI Alu-53	3	0.7	Late Nov	Late Feb
	Sunflower	BARI Surjomukhi-2	4	0.5	Early Dec	Early Feb
	Potato	BARI Alu-41	3	0.5	Late Nov	Mid Feb
		BARI Alu-46	4	0.7	Late Nov	Mid Feb
	Bottle gourd	BARI Lau-4	4	0.4	Late Apr	Jul to Aug
	Country bean	BARI Sheem-6	3	0.4	Late Sep	Dec to Jan
	Brinjal	BARI Begun-12	2	0.3	Late Oct	Jan to Feb

C. Livestock Component

Livestock operations are profitable enterprises, and their success is largely determined by good feeding, care, and management. Almost all cooperative farmers used to raise their animals using traditional methods. From 2019 to 2022, enhanced cattle rearing system was implemented in several FSRD sites, which included deworming, vaccination, adequate housing, a balanced ration, and sufficient health care. Broad spectrum anthelmintic were used to deworm livestock, particularly cattle, sheep, goats, and other poultry species, according to recommendations for body weight and age. Vitamin A, D, and E-containing injections were also given to cattle after deworming. Cattle mortality may be reduced if they were properly vaccinated against four primary diseases. The Anthrax vaccination, Foot and Mouth Disease (FMD) vaccine, Black Quarter (BQ) vaccine, and Hemorrhagic Septicemia (HS) vaccine were all administered according to the recommended schedule in the vaccinated group. In some regions, cattle fattening and calf rearing activities were also continued. Cowdung, in addition to cattle products, is a significant by-product for integrated farming, and farmers were encouraged to use it for the manufacture of farmyard manure (FYM), as well as other homestead waste, rather than utilizing it as fuel. The green fodder Napier grass was found as a good and profitable crop to grow on the farmhouse and its adjacent areas, particularly along the pond bank. Farmers were urged to use FYM after each grass cut. It was introduced to farmers as part of a campaign to help them produce it for cow feed. Poultry farming is a popular practice in Bangladesh's rural areas. Chicken rearing is highly frequent across a variety of species. Because it contains comparatively high protein and low-fat percentages, as well as vitamins and minerals, chicken egg is considered a complete food, and chicken meat is regarded a very healthy food. In addition, as compared to pork and beef, it has fewer religious limitations. Poultry disease is the most common difficulty that poultry farmers confront when raising chickens. Only effective immunization can reduce poultry mortality. This program was undertaken in the farmer's field to minimize the mortality rate and investigate the efficiency of chicken vaccine at the farmer's level. During the project's duration, a large number of poultry birds were vaccinated. BCRDV, RDV, Fowl pox, Fowl cholera, and Duck plague vaccinations were given to the vaccinated group according to the prescribed schedule. The facilitator team kept in touch with them on a regular basis to offer advice on how to handle their challenges.

D. Fisheries Component

Improved fish farming technology has the potential to enhance farmers income and livelihood. However, the main impediment to the viability of fish farming in a pond at the homestead area is poor management. At the FSRD locations, a carp polyculture program was implemented in seasonal ponds with the goal of increasing farmer's income and alleviating rural people's protein deficiency. At first, seasonal ponds were selected from two project villages, weeds and wild fishes were removed from the ponds using both physical and chemical methods, lime was applied at a rate of 1kg per decimal, as well as the pond was prepared for stocking fingerlings with organic manure (cow dung). The size, species, pond depth, feed availability, and other factors influences fingerling stocking density. However, in this carp polyculture system, silver carp, rui, mrigal, grass carp, katla and rajputi was stocked based on their feeding behavior (surface, column and bottom feeder) at the rate of 20–30 fingerlings/decimal. Farmers mostly applied home-made feed using Rice and wheat bran, mustard oil cake, salt and molasses to reduce the production cost and utilize the byproducts whereas lime and fingerlings were supported from the program. The fish feed formula, periodic checking and suggestions for the cure of fish disease and water quality problems was provided by the project personnel on a regular basis.

E. Off-Farm Activities

Off-farm (non-farm) income refers to the portion of farm household income that comes from sources other than the farm, such as nonfarm wages and salaries, pensions, and interest income. Since the last three decades or more, there has been mounting evidence that small-holder farm households in developing nations rarely rely solely on agriculture, but rather maintain a diverse income portfolio that includes off-farm activities (Barrett et al., 2001). Off-farm activities were being pursued by several farm families, particularly the women. In their leisure time, some farmers created small food businesses and mastered weaving Katha and machine stitching. Commercial cooking is also done by men in some circumstances. During their spare time, ladies worked on Kumra bora, Pilo covers, rope crafts, plastic balls, and other crafts, while men worked on basket weaving and van/rickshaw pulling.

F. Local Service Provider (LSP)

Two farmers from the area were chosen as Local Service Providers (LSP) to improve the execution of farming activities and expand the scope of automation. The LSPs were chosen based on their level of knowledge, eagerness, technological understanding and distribution capability, local and social acceptance, and other factors. They received training from BARI-FMPE, which was supported by the KGF initiative.

G. Integration Among Different Components

Integrated farming encompasses a variety of businesses, including home gardening with vegetables and fruits, crops and cropping systems, dairying, poultry, and fisheries, among others, all of which are interconnected. The waste and end product of one business could be utilized as inputs in another. Dairy waste, such as dung, urine, and garbage, is used to make FYM, which is utilized as an input in cropping systems. The straw from the crops is utilized as food for the cattle, which are intimately linked. Furthermore, careful use of farm resources can help keep the environment clean while lowering production costs. The impact of one component on other components is an important factor in integrated farming for long-term sustainability.

Results and Discussion

Farming system involves several components and those are interrelated. However, different location and component-wise findings are discussed underneath.

A. Homestead Production System

3.1 Year-round vegetables and fruits production in homestead area during the years of 2019 to 2022

FSRD Site: Basantapur, Rajshahi

Vegetables production: During 2019-2022, the "Barind Model" was used to implement a vegetable production program in the homestead area at the FSRD site in Basantapur, Rajshahi. The three-year average annual vegetable production was shown to be much larger after intervention (833 kg/homestead) than before intervention (99 kg/homestead) (Table 3.1.3). After intervention, vegetable production grew by 741 percent compared to before intervention. Using all niches of the homestead, updated technologies, and smart time management could help to increase vegetable production in the homestead area. After intervention, overall annual vegetable production increased in each year (784, 812, and 902 kg/homestead in Yr1, Yr2, and Yr3, respectively) (Table 3.1.2). On the cottage roof and homestead boundary, creeping vegetables (country bean, ash gourd, and so on) were customarily grown (moringa). Among the many niches, the open bright area (414.67 kg/homestead) is the most suitable, accounting for 50% of total production (Table 3.1.2). Unfortunately, it remained fallow until the project's operations intervened. The second largest vegetable production was due to the cottage roof (110.67 kg/homestead) and trellis (85.33 kg/homestead). Rabi had the highest yield (374 kg/homestead), followed by Kharif-1 (237.67 kg/homestead), and Kharif-2 (250 kg/homestead) in terms of cropping season (Table 3.1.1). During the rabi season, weather conditions were generally good, resulting in enhanced vegetable production.

Utilization of vegetable: With the cooperation of the co-operator farmers, the disposal pattern of various vegetables grown in the homestead area was periodically recorded. The findings revealed that following intervention, the pattern of vegetable disposal changed (Table 3.1.3). After program intervention, the average vegetable intake per farm family increased by 444 kg to 517 kg per year, compared to 95 kg per year before intervention. The consumption of vegetables by farm family members grew dramatically. During the study period, the distribution of vegetables was 97.67 kg, and the selling of vegetables was 218 kg after program intervention. Increased vegetable production enabled farm families to give away more vegetables to their relatives and neighbors, which might help them strengthen their bonds while also earning money from more vegetable sales. More vegetable production and subsequent consumption, distribution, and sale were aided by greater exploitation of homestead acreage and optimum management by effective farm family labor.

Fruits production: Pruning, pest management, fertilizer, and irrigation were used to manage rapidly growing fruit trees (Papaya, Lemon, and Banana, for example) as well as existing fruit trees (Mango, Coconut, Wood Apple, and so on). Fruit output has expanded dramatically since the introduction of established and enhanced technologies in the household. When compared to farmers' practice (135 kg/homestead), enhanced technologies resulted in a higher quantity of average fruit production (455 kg/homestead) (Table 3.1.3). Fruit yield increased by 237 percent after intervention compared to before intervention. Fruit output grew sequentially in each year after intervention, similar to vegetables (425, 462, and 478 kg/homestead in Yr1, Yr2, and Yr3, respectively) (Table 3.1.2). The use of new technologies in fruit production, such as prudent fertilizer and pest management, has resulted in a rational rise in output. Kharif-1 had the highest average fruit production (296 kg/homestead), followed by Kharif-2 (112.67 kg/homestead), and Rabi season (46.33 kg/homestead) (Table 3.1.1). Mangoes are harvested in June, resulting in the highest output of the Kharif-1 season.

Utilization of fruits: Because Bangladesh's principal fruit (mango) is cultivated in June, Rabi was a slow season for fruit output. A minor number of fruits were produced during the season. The disposal pattern of several fruits grown in the homestead area was meticulously recorded. Farm families consumed most of the fruits generated during the years; it was 274.33 kg/homestead, selling was 129.33 kg/homestead, and distribution was just 51.33 kg/homestead (Table 3.1.3). Both intake and sold value were higher than before the project's involvement.

Income: After intervention, the average gross return, total variable cost, and gross margin for vegetables in a homestead production system were Tk. 16653, 2255, and 14398, respectively (Table 3.1.3). The increase in gross margin after intervention was 470 percent more than it was before. In the case of the fruit sector, gross margin per farm increased to Tk. 7450 after program intervention, compared to Tk. 2375 before intervention. The gross margin increased by 873 percent (Table 3.1.3). After intervention, the average gross return, variable cost, and gross margin per homestead in the fruit industry were Tk.9100, 1217, and 7883, respectively.

Table 3.1.1 Season wise vegetables and fruits production per homestead area during 2019 to 2022 at FSRD Site, Basantapur, Rajshahi.

Niches/production unit	Rabi				Kharif-1				Kharif-2			
	October- March				April-June				July-September			
	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.
Open sunny place	198	215	219	210.67	97	112	102	103.67	101	95	105	100.33
Roof	54	55	69	59.33	11	17	26	18.00	25	29	36	30.00
Trellis	36	25	29	30.00	32	19	26	25.67	22	27	40	29.67
Fence	10	11	14	11.67	21	17	14	17.33	10	18	21	16.33
Tree support	21	16	14	17.00	14	20	18	17.33	8	14	16	12.67
Marshy land	6	12	16	11.33	8	11	0	6.33	0	0	0	0.00
Backyard	14	17	11	14.00	21	16	30	22.33	17	13	19	16.33
Partially shady place	0	0	0	0.00	12	16	21	16.33	0	0	0	0.00
House boundary	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
Pond bank	14	15	31	20.00	14	6	12	10.67	18	16	13	15.67
Total (vegetable)	353	366	403	374.00	230	234	249	237.67	201	212	250	221.00
Fruits	35	56	48	46.33	275	301	312	296.00	115	105	118	112.67
Total (vegetables +fruit)	388	422	451	420.33	505	535	561	533.67	316	317	368	333.67

Table 3.1.2 Year wise vegetables and fruits production at homestead during 2019- 2022 (Per homestead) at FSRD Site, Basantapur, Rajshahi.

Niches/production unit	Production (Kg)			
	Year I	Year II	Year III	Avg. of total
Open sunny place	396	422	426	414.67
Roof	90	111	131	110.67
Trellis	90	71	95	85.33
Fence	41	46	49	45.33
Tree support	43	50	48	47.00
Marshy land	14	37	16	22.33
Backyard	52	46	60	52.67
Partially shady place	12	16	21	16.33
House boundary	0	0	0	0.00
Pond bank	46	37	56	46.33
Total (vegetable)	784	836	902	840.67
Fruits	425	462	478	455.00
Total (vegetables +fruit)	1209	1274	1380	1287.67

Table 3.1.3 Year round vegetables & fruits production, utilization pattern and income before and after intervention during 2019 to 2022 at FSRD Site, Basantapur, Rajshahi.

Description	Before Intervention		After Intervention							
	Vegetables (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			Year I	Year II	Year III	Avg. three years	Year I	Year II	Year III	Avg. three years
Consumption	85	95	486	511	554	517.00	255	288	280	274.33
Distribution	14	40	106	75	112	97.67	50	44	60	51.33
Selling	0	0	192	226	236	218.00	120	130	138	129.33
Total production	99	135	784	812	902	832.67	425	462	478	455.00
Gross return (Tk.)	1980	2700	15680	16240	18040	16653.33	8500	9240	9560	9100.00
Variable cost (Tk.)	500	325	2125	2140	2500	2255.00	1050	1250	1350	1216.67
Gross margin (Tk.)	1480	2375	13555	14100	15540	14398.33	7450	7990	8210	7883.33

FSRD site: Amnura, Chapainawabganj

Vegetables production: Following the Barind model, available and utilizable production niches of the homestead areas were brought under cultivation with the specified vegetables and fruits. In the Barind model, nine niches were used to use fallow and under-utilized homestead areas scientifically, considering time and space. Vegetable output has expanded greatly in the homestead after the implementation of proven and enhanced technology between 2019 and 2022. The average annual vegetable yield after intervention with better technology (658 kg/homestead) was much higher than before intervention (85 kg/homestead) (Table 3.1.6). After intervention, vegetable production increased by 674 percent compared to before. The Kharif season is always a bleak time for vegetable production, with seasonal drought wreaking havoc on crops. It's possible that the overall number of accessible production niches has something to do with it. Following intervention, the Rabi season produced the most (268 kg/homestead), followed by Kharif-II (196 kg/homestead) and Kharif-I (193 kg/homestead) (Table 3.1.4). The significant increase in vegetable production in the homestead area might be attributed to the use of upgraded technology and careful time management.

Utilization of vegetables: With the cooperation of the co-operator farmers, the disposal pattern of various vegetables grown in the homestead area was periodically recorded. The findings revealed that following intervention, the pattern of vegetable disposal changed (Table 3.1.4). During the study period, the average annual household vegetable intake per farm family was 439 kg after program intervention, compared to only 68 kg before program intervention. Following the program's implementation, the annual distribution of vegetables was 67 kg, and the annual sale of vegetables was 152 kg. Increased vegetable production prompted farm families to give out more produce to their relatives and neighbors, which might help them strengthen their bonds while also helping them make more money. from selling of additional vegetables.

Fruits production: Fast-growing fruit trees including guava, papaya, lemon, ber, and banana, as well as existing fruit trees like mango, jackfruit, coconut, and wood apple, were managed with pruning, pest management, fertilization, and irrigation. After implementing established and upgraded technology in the home, fruit yield increased by 236 percent. Farmers using advanced technology (424 kg/homestead) produced more fruits than those using conventional methods (126 kg/homestead) (Table 3.1.6). The least number of fruits were produced during Rabi season (42 kg/homestead), which is due to a shortage of Rabi (winter) fruit species and varieties, which scientists should focus on increasing. Following intervention, average fruit output in Khari-I and Kharif-II was 271 and 111 kg/homestead, respectively. Improved methods of fruit farming, such as the use of smart fertilizer, have dramatically increased yields.

Utilization of fruits: The pattern of disposal of various fruits produced in the homestead area was meticulously documented. The average annual fruit intake per farm family grew by 185 percent after intervention, from 90 kg before intervention to 257 kg after intervention, thanks to higher total production (Table 3.1.6). Annual fruit distribution was 60 kg after the scheme was implemented, and annual fruit sales were 119 kg. Farm families were encouraged to share their surplus fruit with relatives and neighbors, but farmers were more interested in selling to make money.

Income: In the instance of vegetables, gross return, total variable cost, and gross margin were Tk. 14203, 2468, and 11733, respectively, after the intervention of a homestead production system. The increase in gross margin was 762 percent before and after the intervention (Table 3.1.6).

In case of the fruit industry, after the program's intervention, the gross return per farm was Tk. 9938, with a gross margin of Tk. 8412, up from Tk. 1360 before the intervention. The gross margin increased by 311 percent (Table 3.1.6).

Table 3.1.4 Season wise vegetables and fruits production per homestead area during 2019 to 2022 at FSRD site, Amnura, ChapaiNawabgonj

Niches/production unit	Rabi				Kharif-1				Kharif-2			
	October- March				April-June				July-September			
	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.
Open sunny place	116	127	139	127.33	76	92	101	89.67	91	98	119	102.67
Roof	49	53	47	49.67	15	9	18	14.00	21	24	31	25.33
Trellis	30	27	43	33.33	26	20	14	20.00	19	24	12	18.33
Fence	0	0	0	0.00	06	9	04	6.33	08	7	13	9.33
Tree support	12	8	21	13.67	13	13	17	14.33	06	11	09	8.67
Marshy land	7	7	0	4.67	6	5	11	7.33	02	0	09	3.67
Backyard	16	19	24	19.67	18	13	9	13.33	18	9	13	13.33
Partially shady place	0	0	0	0.00	10	12	6	9.33	0	0	08	2.67
Pond bank	14	22	28	21.33	13	20	23	18.67	16	8	12	12.00
Total (vegetable)	*244*	263	302	269.67	*183*	193	203	193.00	*180*	181	226	195.67
Fruits	*32*	44	49	41.67	*250*	273	289	270.67	*110*	95	129	111.33
Total (vegetables +fruit)	276	307	351	311.33	433	466	492	463.67	290	314	355	319.67

Table 3.1.5. Year wise vegetables and fruits production at homestead during 2019- 2022 (Per homestead) at FSRD site, Amnura, ChapaiNawabgonj

Niches/production unit	Production (Kg)			
	Year I	Year II	Year III	Avg. of total
Open sunny place	283	317	359	319.67
Roof	85	86	96	89.00
Trellis	75	71	69	71.67
Fence	14	16	17	15.67
Tree support	31	32	47	36.67
Marshy land	15	12	20	15.67
Backyard	52	41	46	46.33
Partially shady place	10	12	14	12.00
Pond bank	43	50	63	52.00
Total (vegetable)	607	637	731	658.33
Fruits	392	412	467	423.67
Total (vegetables +fruit)	999	1087	1198	1094.67

Table 3.1.6 Round the year vegetables & fruits production, utilization pattern and income before and after intervention during 2019 to 2022 at FSRD site: Amnura, ChapaiNawabgonj

Description	Before Intervention		After Intervention							
	Vegetables (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			Year I	Year II	Year III	Avg. three years	Year I	Year II	Year III	Avg. three years
Consumption	68	90	421	435	461	439	235	275	262	257
Distribution	17	36	65	67	69	67	46	55	80	60
Selling	0	0	121	135	201	152	111	120	125	119
Total production	85	126	607	637	731	658	392	412	467	424
Gross return (Tk.)	1760	2520	13200	14220	15190	14203	7840	10300	11675	9938
Variable cost (Tk.)	400	475	1950	2580	2875	2468	1380	1590	1610	1527
Gross margin (Tk.)	1360	2045	11245	11640	12315	11733	6460	8710	10065	8412

FSRD Site: Chanduria, Rajshahi

Vegetables production: The vegetables cultivation program at homestead area was carried out at the Farming Systems Research and Development (FSRD) site following the "Barind Model" using the available and utilizable production niches of the homestead areas during 2019-2022. With the consideration of time and space, the fallow and under-utilized homestead areas were utilized scientifically. In the production system at Chanduria, Rajshahi, nine niches were utilized (Table 3.1.7). After intervention of improved technologies, vegetables production has increased significantly, and the most remarkable change was observed in open sunny place (Table 3.1.7). Among the three seasons average, Rabi production (261 kg/homestead) was the highest and it followed by Kharif-1 (196 kg/homestead) and Kharif-2 (196kg/homestead) due to prevailing favorable weather in the rabi season which resulted in higher vegetable production in the season. The total vegetable production was 624 kg, 641 kg, 693 kg per homestead during the year I, year II and year III, respectively which indicates the increasing trend (Table 3.1.8). Among the different niches, the production under open sunny place (349 kg/homestead) was the maximum (53%) and it followed by backyard (113 kg/homestead). The three years average increment of vegetables production over before intervention was 545 kg/homestead which is higher 505% (Table 3.1.9).

Vegetables production in homestead area was enhanced remarkably might be due to effectively use of different production niches, improved technologies, and judicious management.

Utilization of vegetable: Utilization of homestead produced vegetables in the means of consumption, distribution and sold was recorded regularly with the help of the co-operator farmers. From the results it was found that disposal pattern of vegetables varied from year to year (Table 3.1.9). During before intervention, vegetables consumption, distribution and selling was 72 kg, 14 kg and 22 kg, respectively whereas after intervention, it was increased remarkably (Consumption: 391 kg, distribution: 66 kg and selling: 195 kg). The average vegetable intake per year per farm family was increased by 443% after program intervention which helps them become healthy and more active. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent consumption, distribution and sold. Surplus vegetables produced in homestead area helped the farmers to earn more cash money from more selling of vegetables. Increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their inter-relationship.

Fruits production: Improved production technologies like pruning, pest management, judicious and balanced fertilization, and irrigation in quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana) along with other existing fruit trees (Mango, Jackfruit, Coconut) were provided in the existing homestead garden. By using of improved technologies, fruits production has increased tremendously. It is observed in Table 7(a) that maximum fruits were produced during Kharif-1 season (267 kg/homestead) and minimum was Rabi season (49 kg/homestead). It is due to less availability of Rabi (winter) fruits species and varieties, which needs to introduce more winter fruiting fruit trees like Ber, Guava, Multa. After program intervention, fruits yield has also increased significantly. The total fruit production was 390 kg, 405 kg, 511 kg per homestead during Year I, Year II and Year III, respectively which was increasing trend (Table 11.1.8). The average three years increment of fruit production was 435 kg/homestead which is 140% higher over before intervention (181 kg/homestead).

Utilization of fruits: Disposal pattern (consumption, distribution and selling) of fruits were varied year to year (Table 3.1.9). It is found that the higher production resulted the higher consumption. During before intervention, fruits consumption, distribution and selling were 92 kg, 35 kg and 54 kg, respectively whereas after intervention, it was 165 kg, 53 kg, and 217 kg, respectively. After program intervention, the fruits consumption per year per farm family was 147 kg, 155 kg and 194 kg, for Year I, Year II and Year III, respectively. All cases of disposal pattern were found to be increasing trend. Thus, it is concluded that, consumption ratio both in vegetables and fruits was increased year to year. In every homestead, a total of 1088 kg of fruit and vegetables were produced (Table 3.1.8).

Income from fruits and vegetables: After program intervention, it is revealed from the table 7c that the average gross return, total variable cost, and gross margin of vegetables and fruits were Tk. 27466, Tk. 3188, and 24278, respectively (Table 3.1.9). The increment in gross margin after intervention was 469% higher than that of before intervention. Three years average gross return, total variable cost, and gross margin of vegetables were Tk. 11794, Tk. 1965, and Tk. 9829, respectively after intervention, while it was Tk. 1728, Tk. 216, and Tk. 1512, respectively for gross return, total variable cost, and gross margin before intervention. In fruits side, gross return, total variable cost, and gross margin were Tk. 15672, Tk. 1223, and Tk. 14449, respectively after intervention, whereas it was Tk. 6516, Tk. 162, and Tk. 2754, respectively for gross return, total variable cost, and gross margin before intervention.

Table 3.1.7. Round the year vegetables and fruits production from different niches of homestead during the years of 2019-2022 at the FSRD site, Chanduria, Rajshahi

Niches/production unit	Rabi(kg) October- March				Kharif-1(kg) April-June				Kharif-2(kg) July-September			
	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.
Open sunny place	134	141	146	140	108	113	115	112	93	98	100	97
Roof	24	24	26	25	0	0	0	0	17	17	20	18
Trellis	42	42	44	43	24	24	26	25	15	15	16	15
Fence	2	2	2	2	6	6	8	7	0	0	0	0
Tree support	0	0	0	0	0	0	0	0	7	7	10	8
Backyard	28	25	31	28	43	40	45	43	42	40	45	42
Partially shady place	20	20	25	22	3	3	5	4	4	4	5	4
Pond bank	0	3	2	2	0	3	4	2	0	2	3	2
Others (Marshy land)	0	0	0	0	3	3	5	4	9	9	10	9
Total (vegetables)	250	257	276	261	187	192	208	196	187	192	209	196
Fruits	28	58	61	49	301	201	300	267	61	146	150	119
Total (vegetables +fruits)	278	315	337	310	488	393	508	463	248	338	359	315

Table 3.1.8. Round the year vegetables and fruits production from different niches of homestead during the years of 2019-2022 at the FSRD site, Chanduria, Rajshahi

Niches/production unit	Production (Kg)			
	Year I	Year II	Year III	Avg. of total
Open sunny place	335	352	361	349
Roof	41	41	46	43
Trellis	81	81	86	83
Fence	8	8	10	9
Tree support	7	7	10	8
Backyard	113	105	121	113
Partially shady place	27	27	35	30
Pond bank	0	8	9	6
Others (Marshy land)	12	12	15	13
Total (vegetables)	624	641	693	653
Fruits	390	405	511	435
Total (vegetables +fruits)	1014	1046	1204	1088

Table 3.1.9. Round the year vegetables and fruits production and utilization pattern before and after Intervention during the years of 2019-2022 at the FSRD site: Chanduria, Rajshahi

Description	Before Intervention		After Intervention							
			Vegetables				Fruits			
	Vegetables	Fruit	Year I	Year II	Year III	Avg. three years	Year I	Year II	Year III	Avg. three years
Consumption (kg)	72	92	373	385	416	391	147	155	194	165
Distribution (kg)	14	35	74	55	69	66	51	48	61	53
Selling (kg)	22	54	177	201	208	195	192	202	256	217
Total production (kg)	108	181	624	641	693	653	390	405	511	435
Gross return (Tk.)	1728	6516	9984	11538	13860	11794	14040	14580	18396	15672
Variable cost (Tk.)	216	162	1872	1923	2100	1965	1170	1000	1500	1223
Gross margin (Tk.)	1512	2754	8112	9615	11760	9829	12870	13580	16896	14449

FSRD Site: Jiarokhi, Kushtia

Vegetables production: Following the Goyeshpur Model, available and utilizable production niches in household areas were brought under cultivation with the specified vegetables. In terms of time and space, the fallow and under-utilized homestead areas were used scientifically. In the Goyeshpur Model, seven niches were used in the production system. Vegetable production has expanded dramatically since the introduction of established and enhanced technology in the household. Kharif-1 (297 kg homestead-1) had the highest average vegetable production, followed by Kharif-2 (253 kg homestead^{-1}) and Rabi (242 kg homestead^{-1}) seasons (Table 3.1.10). When compared to before the initiative, vegetable production increased by 621 percent after the enhanced technologies were implemented (Table 3.1.12). The remarkable increment of vegetables production in homestead area might be enhanced by using improved technologies and judicious time management.

Utilization of vegetables: With the cooperation of the co-operator farmers, the disposal pattern of various vegetables produced in the homestead area was tracked on a regular basis. The findings revealed that the pattern of vegetable disposal varied depending on the total number of vegetables produced (Table 3.1.12). After program intervention, the average vegetable intake per farm family increased by 422 percent to 522 kg per year, compared to 100 kg per farm family per year before program intervention. A 5-member farm family's vegetable intake was dramatically enhanced, averaging 286 g head^{-1}day^{-1}. Following the program's implementation, the annual distribution of vegetables was 82 kg, and the annual sale of vegetables was 203 kg. Increased vegetable output enabled farm families to give out more veggies to their relatives and neighbors, which might help them strengthen their bonds while also allowing them to earn more money by selling more vegetables. For optimal vegetable production and subsequent intake, distribution, and sale, improved exploitation of homestead area combined with optimum management by effective farm family labor can be attained.

Fruits production: Pruning, pest management, fertilization, and irrigation were used to manage fast-growing fruit trees (guava, papaya, lemon, ber, banana, and so on) as well as existing fruit trees (mango, jack fruit, coconut, wood apple pummelo, and so on). Fruit output has expanded dramatically since the introduction of established and enhanced technologies in the household. Kharif-1 (73 kg homestead^{-1}) had the highest average fruit production, followed by Kharif-2 (65 kg homestead^{-1}) and Rabi (53 kg homestead-1) seasons, which were the opposite of vegetable production (Table 3.1.10). During the Rabi season, less fruits were produced, which is owing to a lack of Rabi (winter) fruit species and kinds, so scientists should focus on developing more winter fruit varieties. Fruit production increased dramatically after the program was implemented compared to before it was implemented (Table 3.1.12). The use of better technologies in fruit production, such as smart fertilizer use, has greatly increased productivity.

Utilization of fruits: The disposal pattern of various fruits produced in the homestead area was meticulously recorded. The average annual fruit intake per farm family was 40 kg after program intervention, compared to 15 kg before intervention, with the 166 percent increase owing primarily to increased total production (Table 11.1.12). Following the program's implementation, annual fruit distribution was 13 kg, and annual fruit sales were 138 kg. Increased fruit output encouraged farm families to share with their relatives and neighbors, while farmers were more interested in selling to make a profit.

Income: After program intervention, from the vegetables production average gross return per farm was recorded as Tk. 16160 with the average gross margin Tk. 10327 which was only Tk. 1040 before intervention. From the fruits sector, after program intervention, average gross return per farm was recorded as Tk. 5750 with the average gross margin of Tk. 4750 which was only Tk. 300 before intervention (Table 3.1.12).

Table 3.1.10. Round the year vegetables and fruits production from different niches of homestead during the years of 2019-2022 at FSRD Site, Jiarokhi, Kushtia

Niches/production unit	Rabi				Kharif-1				Kharif-2			
	October- March				April-June				July-September			
	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.
Open sunny place	40	50	54	48	132	140	148	140	72	78	80	77
Roof	32	35	37	35	20	26	30	25	55	65	70	63
Trellis	40	42	48	43	15	20	24	20	18	22	26	22
Fence	25	30	32	29	18	24	22	21	12	15	20	16
Tree support	5	8	10	8	20	20	24	21	15	18	20	18
Marshy land	0	0	0	0	10	15	18	14	12	14	12	13
Backyard	8	10	14	11	5	8	10	8	4	16	15	12
Partially shady place	4	6	10	7	7	6	10	8	8	11	12	10
House boundary	10	12	15	12	8	10	14	11	8	10	14	11
Pond bank	8	10	14	11	7	12	14	11	8	13	12	11
Total (vegetable)	172	203	234	204	242	281	314	297	212	262	281	253
Fruits	45	52	63	53	50	57	88	65	65	70	85	73
Total (vegetables +fruit)	217	255	297	257	292	388	402	362	277	332	366	326

Table 3.1.11. Round the year vegetables and fruits production from different niches of homestead during 2019-2022 at FSRD Site, Jiarokhi, Kushtia

Niches/production unit	Production (Kg)			
	Year I	Year II	Year III	Avg. of total
Open sunny place	244	268	282	265
Roof	107	126	137	123
Trellis	73	84	98	85
Fence	55	69	74	66
Tree support	40	46	54	47
Marshy land	22	29	30	27
Backyard	17	34	39	30
Partially shady place	19	23	32	25
House boundary	26	32	43	34
Pond bank	23	35	37	32
Total (vegetable)	626	746	826	734
Fruits	160	195	220	192
Total (vegetables +fruit)	786	941	1046	924

Table 3.1.12. Round the year vegetables and fruits production and utilization pattern before and after Intervention during the years of 2019-2022 at FSRD Site, Jiarokhi, Kushtia

Description	Before Intervention		After Intervention							
	Vegetables (kg)	Fruit (kg)	Vegetables (kg)				Fruits (kg)			
			Year I	Year II	Year III	Avg. three years	Year I	Year II	Year III	Avg. three years
Consumption	100	15	450	525	590	522	30	40	50	40
Distribution	12	0	50	100	100	83	10	15	15	13
Selling	0	0	200	210	200	203	120	140	155	138
Total production	112	15	700	835	890	808	160	195	220	192
Gross return (Tk.)	2040	300	14000	16700	17800	16160	4800	5850	6600	5750
Variable cost (Tk.)	1000	0	6000	6000	6500	5833	800	1000	1200	1000
Gross margin (Tk.)	1040	300	8000	10700	11300	10327	4000	4850	5400	4750

FSRD Site: Kamalbazer, Sylhet

Vegetables production: Following the Golapgonj Model, several niches of the homestead areas were brought under cultivation with the specified vegetables. In terms of time and space, the fallow and under-utilized homestead areas were used scientifically. In the Golapgonj Model, nine niches were used in the production system. Vegetable production has increased dramatically in the homestead after the use of proven and alternative methods. It was observed that the average vegetables production was 154 kg homestead^{-1}) in *Rabi* season followed by *Kharif-1* (107 kg homestead^{-1}) and *Kharif-2* (69 kg homestead^{-1}) season. Rabi season yielded the most vegetables, followed by Kharif-1 season. Kharif-2 season was a relatively dull season for vegetable output, with periodic rainfall affecting crops the most. When compared to before the initiative, vegetable production grew dramatically with the use of alternative technology (Table 3.1.15). Using alternative technology and cautious time management, the extraordinary increase in vegetable output in the homestead area might be further boosted.

Utilization of vegetables: The findings revealed that the pattern of vegetable disposal varied depending on the total number of vegetables produced (Table 3.1.15). The average vegetables intake per year per farm family was 121 kg after program intervention whereas intake was only 15 kg per farm family per year before program intervention. Vegetable intake by a number of 5 member's farm family was increased remarkably and it was on an average 153 g head^{-1}day^{-1}. After program intervention, the distribution of vegetables per year was recorded 35 kg and sell of vegetables per year was 174 kg.

Increased vegetable output enabled farm families to give out more veggies to their relatives and neighbors, which might help them strengthen their bonds while also allowing them to earn more money by selling more vegetables. For optimal vegetable production and subsequent intake, distribution, and sale, improved exploitation of homestead area combined with optimum management by effective farm family labor can be attained.

Fruits production: Pruning, pest management, fertilization, and irrigation were used to manage fast-growing fruit trees (guava, papaya, lemon, ber, banana, coconut, multa, and so on) as well as existing fruit trees (mango, jack fruit, pummelo, and so on). Fruit output has increased dramatically in the homestead with the implementation of proven and alternative methods. Higher quantity of average fruits production was found in Kharif-2 (169 kg homestead^{-1}) season followed by Kharif-1 (167 kg homestead^{-1}) and Rabi (114 kg homestead^{-1}) season, which was more or less the reverse scenario of vegetables production (Table 3.1.13). The highest number of fruits were produced during the Kharif-2 season, while the lowest number of fruits were produced during the Rabi season. This is owing to a lack of Rabi (winter) fruit species and kinds, which scientists should focus on developing more winter fruit types. The use of alternative technology in fruit production, such as prudent fertilizer control, has greatly enhanced productivity.

Utilization of fruits: The disposal pattern of various fruits produced in the homestead area was meticulously recorded. The average annual fruit intake per farm family was 280 kg after program intervention, compared to 50 kg before intervention, and the significant increase was due mostly to increased total production (Table 3.1.15). After the program's implementation, the annual distribution of fruits was 72 kg, and the annual sale of fruits was 83 kg. Increased fruit output encouraged farm families to share with their relatives and neighbors, but farmers were more interested in consuming and selling to make money.

Income: After program intervention, from the vegetables production average gross return per farm was recorded as Tk. 10642 with the average gross margin of Tk. 6808 which was only Tk. 270 before intervention. From the fruits sector, after program intervention, average gross return per farm was recorded as Tk. 35493 with the average gross margin of Tk. 25927 which was only Tk. 5220 before intervention (Table 3.1.15).

Table 3.1.13. Round the year vegetables and fruits production from different niches of homestead during 2019 to 2022 at FSRD Site: Kamalbazer, Sylhet

Niches/production unit	Rabi				Kharif-I				Kharif-II			
	October – March				April – June				July - September			
	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.	Year I	Year II	Year III	Total avg.
Open Sunny land	56	105	112	91	17	42	55	38	12	33	34	26.3
Roof	12	27	29	22.7	13	22	24	19.7	1	4	15	6.7
Trellis	10	17	21	16	11	17	19	15.7	5	9	11	8.3
Fence	0	2	4	2	4	7	11	7.3	2	5	6	4.3
Tree support	0	0	0	0	2	5	6	4.3	0	4	9	4.3
Marshy land	0	3	6	3	0	0	0	0	2	8	11	7
Backyard	8	17	19	14.7	11	16	21	16	4	9	9	7.7
Partially shady place	0	6	7	4.3	4	6	7	5.7	2	4	8	4.7
Total (Vegetables)	86	177	198	153.7	63	115	143	107	28	76	103	69
Fruit	55	136	150	113.7	77	195	230	167.3	85	210	213	169.3
Total (Vegetables + Fruit)	141	313	348	267.3	140	310	373	274.3	113	286	316	238.3

Table 3.1.14. Round the year vegetables and fruits production from different niches of homestead during 2019 to 2022 at FSRD Site, Kamalbazer, Sylhet

Niches/production unit	Production (Kg)			
	Year I	Year II	Year III	Avg. of total
Open Sunny land	86	180	201	155.7
Roof	26	53	68	49
Trellis	26	43	51	40
Fence	06	14	21	13.7
Tree support	02	09	14	8.3
Marshy land	02	11	17	10
Backyard	23	42	49	38
Partially shady place	06	16	22	14.7
Total (Vegetables)	177	368	443	329.3
Fruit	217	541	573	443.7
Total (Vegetables + Fruit)	394	909	1016	773

Table 3.1.15. Round the year vegetables and fruits production and utilization pattern before and after Intervention during 2019 to 2022 at FSRD Site, Kamalbazer, Sylhet

Description	Before intervention		After intervention							
	Vegetables (Kg)	Fruit (Kg)	Vegetables (Kg)				Fruit (Kg)			
			Year I	Year II	Year III	Avg.	Year I	Year II	Year III	Avg.
Consumption	15	50	80	130	152	121	170	335	360	280
Distribution	6	24	27	36	42	35	30	91	95	72
Selling	0	10	70	202	249	174	17	115	118	83
Total production	21	84	177	368	443	329	217	541	573	444
Gross return (Tk.)	420	6720	3540	12880	15505	10642	17360	43280	45840	35493
Variable cost (Tk.)	150	1500	1500	4500	5500	3833	7000	10500	11200	9567
Gross margin (Tk.)	270	5220	2040	8380	10005	6808	10360	32780	34640	25927

3.2 Family labor utilization pattern in homestead production system at different FSRD sites during the years of 2019 to 2022

The Homestead production system gave an opportunity for women's employment and empowerment. From Table 3.2.1, it was revealed that women had a good involvement in seed and seedling production and planting, intercultural operation, harvesting and marketing of vegetables and fruits. It is revealed that women are coming forward and participating more in the income generation system. Hard work activities were mostly done by the male workers. Children also help the men and women in production systems, especially in soft-working areas. However, cooking (98%) was done by mainly women, with a little bit of experience. Only 2% of the cooking work was done by men and children when the housewife was sick or absent. So, it was found that homestead gardening has created a good opportunity to utilize the unused labor of women and children properly.

Table 3.2.1. Family labor utilization pattern (Average) for homestead vegetables and fruits production at different FSRD sites

Work area	Men (%)	Women (%)	Children (%)
Land preparation	81	17	2
Seed/seedling production	53	41	6
Sowing/planting	50	43	7
Intercultural operation	37	55	8
Harvesting	27	64	9
Marketing	70	28	2
Cooking	1	98	1

3.3 Plantation and management of fruit tree:

FSRD site: Basantapur, Rajshahi

Sapling/seedling distribution: The number and quality of fruits plants in the homestead should be raised to increase nutrient intake from the fruits sector. A variety of high-quality fruit saplings, such as mango, guava, papaya, malta, sugarcane, and moringa, were delivered to the homestead as a result of this viewpoint. On addition, in the crop area, a mango orchard was planted. Table 3.3.1 shows the total number of saplings of various fruit plants that were delivered.

Table 3.3.1 Number of fruits and other saplings distributed among the farmers at FSRD site, Basantapur, Rajshahi during 2019-2022

Sl. No	Types of fruits sapling	Variety	Number			Mortality (%)
			Year I	Year II	Total	
1	Mango	BARI Aam-4	100	80	180	96
3	Guava	BARI Peyara-2	24	24	48	90
4	Multa	BARI Malta-1	24	24	48	90
6	Papaya	BARI Papaya-1	120	240	360	80
8	Moringa	Local	60	40	100	85
9	Sugarcane	BSRI Akh-42 (Rangbilash)	250	180	430	90
		Total	578	588	1166	

FSRD site: Amnura, Chapainawabganj

To improve nutritional intake from the fruits sector, the number and quality of fruits plants in the home must be raised. A variety of fruit saplings, including mango, guava, papaya, malta, moringa, and sugarcane, were delivered to the household based on this viewpoint. Table 3.3.2 shows the total number of saplings of various fruits plants that were delivered. In addition, a mango grove was planted near a nearby homestead. We also offer professional assistance to farmers for better fruit tree management, including fertilizer, irrigation, and insect and disease control.

Table 3.3.2 Number of fruits and other saplings distributed among the farmers at Amnura, Chapainawabganj during 2019-2022

Sl. No	Types of fruits sapling	Variety	Number			Mortality (%)
			Year I	Year II	Total	
1	Mango	BARI Aam-4	130	86	216	95
3	Guava	BARI Peyara-2	24	24	48	90
4	Multa	BARI Malta-1	24	24	48	90
6	Papaya	BARI Papaya-1	120	180	300	80
8	Moringa	Local	60	60	120	80
9	Sugarcane	BSRI Akh-42 (Rangbilash)	250	180	430	90
			608	554	1162	

FSRD Site: Chanduria, Rajshahi

For increasing nutrient intake of famers from fruits sector, the number and quality of fruits plant in the homestead needs to be increased. Twelve species/varieties of nine fruit and other sapling were distributed among the target farmers of FSRD Site: Chanduria, Rajshahi (Table 3.3.3). Total number of distributed saplings was 816 and mortality rate ranged from 2-10%. Chewing type sugarcane namely BSRI Akh42 (Rangbilash) was also distributed among the farmers.

Table 3.3.3 Distributed of fruit saplings at FSRD Site: Chanduria, Rajshahi during the years of 2019 to 2022

Sl. No	Types of fruits sapling	Variety	Number			Mortality (%)
			Year I	Year II	Total	
1	Mango	BARI Aam-3	36	36	72	5
		BARI Aam-4	24	24	48	5
		BARI Aam-11	24	24	48	5
2	Guava	BARI Peyara-2	24	24	48	10
3	Multa	BARI Malta-1	24	24	48	5
4	Papaya	BARI Papaya-1	108	108	216	10
5	Lemon	BARI Lebu-2	15	15	30	2
6	Bay Leaves	BARI Tejpata-1	12	12	24	2
7	Dragon fruit	BARI Dragon-1	15	15	30	2
8	Pomelo	BARI Batabi Lebu-3	15	15	30	2
9	Sugarcane	BSRI Akh-42 (Rangbilash)	70	80	150	5
		Local	36	36	72	10
		Total	403	413	816	

FSRD Site: Jiarokhi, Kushtia

A variety of fruit saplings, including mango, guava, papaya, malta, moringa, and sugarcane, were delivered to the household based on this viewpoint. Table 3.3.4 shows the total number of saplings of various fruits plants that were delivered. In addition, a mango grove was planted near a nearby homestead. We also offer professional assistance to farmers for better fruit tree management, including fertilizer, irrigation, and insect and disease control.

Table 3.3.4. Distributed of fruit saplings at FSRD Site: Jiarokhi, Kushtia during the years of 2019 to 2022

Sl. No	Types of fruits sapling	Variety	Number			Mortality (%)
			Year I	Year II	Total	
1	Mango	BARI Aam-4	75	85	160	2
2	Litchi	BARI Litchi-3	16	10	26	3
3	Guava	Thai-10	103	70	173	5
4	Malta	BARI Malta-1	12	10	22	2
5	Lime	Thai	4	3	7	1

Sl. No	Types of fruits sapling	Variety	Number			Mortality (%)
			Year I	Year II	Total	
6	Papaya	Shahi	36	40	76	3
7	Dragon fruit	BARI Dragon fruit-1	26	50	76	0
8	Moringa	--	26	20	46	4
9	Sugarcane	BSRI chewing	130	145	275	0
10	Ber	Bol shundori	112	105	217	3
		Total	540	538	1078	-

FSRD Site: Kamalbazer, Sylhet

To increase nutrient intake from fruits sector, it needs to increase the number and quality of fruits plant in the homestead. Based on this viewpoint, a few different fruit saplings were distributed to the households of farming system area e.g., mango, litchi, satkara, jara lebu, litchi, malta, papaya, sugarcane, and battle nut. The supplied total number of saplings of different fruits plants and sugarcane sets are shown in Table 3.3.5. Furthermore, two multa and one jara lebu orchards were established in nearby homestead. We also provided technical support to the farmer for better management of supplied fruit saplings such as fertilization, irrigation and disease pest control.

Table 3.3.5. Distributed of fruit saplings at FSRD site, Kamalbazar, South surma, Sylhet during the years of 2019 to 2022

Sl. No	Types of fruits sapling	Variety	Number			Success (%)
			Year I	Year II	Total	
1	Mango	BARI Aam-3	24	36	60	90
2	Litchi	BARI Litchi-3	20	48	68	85
3	Guava	BARI Payera-2	60	100	160	95
4	Multa	BARI Malta-1	140	200	340	90
5	Papaya	Local	60	30	90	92
6	SaTkora	BARI SaTkora-1	60	80	140	95
7	Jara lebu	BARI Jaralebu-1	80	160	280	98
8	Bettle nut	Local	60	200	260	100
9	Sugarcane	BSRI Akh-42	24	48	72	80
10	Bilimbi	BARI Bilimbi-1	60	40	100	90
			588	942	1570	-

3.4 Pest management activities for increasing fruits production in homestead area during the years of 2019 to 2022

Pest management of fruit tree: Fruit trees, which are abundant in the homestead region, are the best source of human sustenance. Pests were shown to be the primary hindrance to appropriate edible fruit production in most cases, which inhibits farmers from planting fruit trees in their homestead. However, a basic technology (two-time pesticide and fungal sprays, once just before flower blooming and once at pea-size fruit stage) can help with domestic fruit output. Pesticide spraying actions at each FSRD site were conducted safely from these perspectives (Table 3.4.1). A total of 592 fruit trees were sprayed with insecticide and pesticide, with mango trees accounting for the most (220). At Chanduria, Rajshahi FSRD site, a total of 594 fruit trees were sprayed with different pesticides, where the maximum fruit trees were papaya (216) and mango (168).

Table 3.4.1. Number of fruit trees sprayed for hopper and other pest control at different FSRD sites during the year of 2019-2022

FSRD site	Mango	Guava	Multa	Papaya	Coconut	Others*
Basantapur, Rajshahi	100	35	45	60	20	40
Amnura, ChapaiNawabgonj	120	26	30	70	8	38
Chanduria, Rajshahi	168	48	48	216	10	104
Total	388	109	123	346	38	182

CROPS AND CROPPING SYSTEM

I. Improvement of cropping pattern (CP)

FSRD Site: Basantapur, Rajshahi

3.5 Development of alternate cropping pattern Mustard-Boro-T. Aman rice at FSRD Site, Basantapur, Rajshahi under irrigated High Barind Tract during 2019-2022

Improved Pattern (IP): Mustard(BARI Sarisha-17)-Boro (BRRI dhan81)-T. Aman (BRRI Dhan49)
Existing Pattern (EP): Boro (BRRI dhan28) **)**-Fallow-T. Aman (Swarna)

The yield performance, cost and return of the improved pattern (Mustard-Boro-T. Aman rice) against existing pattern (Boro-Fallow- T. Aman rice) is presented in Table 11.5.1, 11.5.2 and 11.5.3. The pattern average rice equivalent yield (REY) of IP was 14.47 t ha^{-1} against 9.65 t ha^{-1} in EP (Table 3.5.3). The increment of REY in IP was 50% over EP due to the introduction of new crop, modern variety, and improved crop management. The average gross margin of IP was Tk. 219210 ha^{-1} while Tk. 131690 ha^{-1} in EP. The MBCR of IP was 3.85 over EP. A similar trend was observed in Yr1 and Yr2 as an average result.

Table 3.5.1. Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Sarisha-17	BRRI dhan81	BRRI dhan49	BRRI dhan28	-	Swarna
Seed/grain yield (t ha^{-1})	1.65	5.60	4.76	5.32	-	4.32
Stover/straw (t ha^{-1})	3.38	6.22	5.80	5.96	-	5.56
Rice equivalent yield (t ha^{-1})	3.71	5.60	4.76	5.32	-	4.32
Whole pattern Rice equivalent yield (t ha^{-1})	14.07			9.64		
Gross return (Tk.ha^{-1})	74250	118220	106800	112360	-	86720
Variable cost (Tk.ha^{-1})	30750	47550	40250	47100	-	41500
Gross margin (Tk.ha^{-1})	43500	70670	66550	65260	-	45220
Total Gross return (Tk.ha^{-1})	299270			199080		
Total variable cost (Tk.ha^{-1})	118550			88600		
Total gross margin (Tk.ha^{-1})	180720			110480		
MBCR	3.34					

Output price (Tk.kg^{-1}). Mustard: 45.00, rice grain: 20, rice straw: 1.00

Table 3.5.2. Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Sarisha-17	BRRI dhan81	BRRI dhan49	BRRI dhan28	-	Swarna
Seed/grain yield (t ha^{-1})	1.70	5.75	4.88	5.38	-	4.28
Stover/straw (t ha^{-1})	3.42	6.18	5.87	6.02	-	5.58
Rice equivalent yield (t ha^{-1})	4.25	5.75	4.88	5.38	-	4.28
Whole pattern Rice equivalent yield (t ha^{-1})	14.88			9.66		
Gross return (Tk.ha^{-1})	110500	143750	122000	134500	-	107000
Variable cost (Tk.ha^{-1})	30750	47550	40250	47100	-	41500
Gross margin (Tk.ha^{-1})	79750	96200	81750	87400	-	65500
Total Gross return (Tk.ha^{-1})	376250			241500		
Total variable cost (Tk.ha^{-1})	118370			88600		
Total gross margin (Tk.ha^{-1})	257700			152900		
MBCR	4.35					

Output price (Tk./kg). Improved and existing: Mustard: 65.00, rice: 25.00, rice straw: 1.00,

Table 3.5.3. Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Sarisha-17	BRRI dhan81	BRRI dhan49	BRRI dhan28	-	Swarna
Seed/grain yield (t ha^{-1})	1.68	5.68	4.82	5.35	-	4.30
Stover/straw (t ha^{-1})	3.40	6.20	5.84	5.99	-	5.57
Rice equivalent yield (t ha^{-1})	3.98	5.68	4.82	5.35	-	4.30
Whole pattern Rice equivalent yield (t ha^{-1})	14.48			9.65		
Gross return (Tk.ha^{-1})	92375	130985	114400	123430	-	96860
Variable cost (Tk.ha^{-1})	30750	47550	40250	47100	-	41500
Gross margin (Tk.ha^{-1})	61625	83435	74150	76330	-	55360
Total Gross return (Tk.ha^{-1})	337760			220290		
Total variable cost (Tk.ha^{-1})	118460			88600		
Total gross margin (Tk.ha^{-1})	219210			131690		
MBCR	3.85					

3.6 Development of alternate cropping pattern Wheat-Sesame-T. Aman rice at FSRD Site, Basantapur, Rajshahi under partial irrigated area at during 2019-2022

Improved Pattern (IP): Wheat (BARI Gom-30)-Sesame (BRRI Til-4)-T. Aman (BRRI Dhan51)
Existing Pattern (EP): Wheat (BARI Gom-28)-Fallow-T. Aman (Swarna)

Tables 3.6.1, 11.6.2, and 11.6.3 show the crop yield and return of the tested patterns. The EP was Wheat-Fallow-T. Aman rice, with another crop, sesame, being added to the IP. Varietal improvement was also carried out in IP. The pattern average REY in IP was found to be 12.87 t ha-1, while the value in EP was 8.87. The productivity increase was 45 percent. The increased output was primarily due to the addition of another crop, improved varietals, and better management. Productivity and economic performance were similar. In IP, the gross margin was Tk. 153465 ha-1, whereas in EP, it was Tk. 111485 ha-1. Over EP, the MBCR in IP was 1.97.

Table 3.6.1. Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Til-4	BRRI Dhan51	BARI Gom-28	-	Swarna
Seed/grain yield (t ha^{-1})	4.30	1.10	5.28	3.70	-	4.86
Stover/straw (t ha^{-1})	5.80	2.11	6.10	5.12	-	6.01
Rice equivalent yield (t ha^{-1})	4.83	2.75	5.28	3.70	-	4.86
Whole pattern Rice equivalent yield (t ha^{-1})	12.86			9.02		
Gross return (Tk.ha^{-1})	96750	55000	111610	83250	-	103210
Variable cost (Tk.ha^{-1})	35625	33750	40250	34600	-	39250
Gross margin (Tk.ha^{-1})	61125	21250	71360	50650	-	63960
Total Gross return (Tk.ha^{-1})	263360			186460		
Total variable cost (Tk.ha^{-1})	109625			73850		
Total gross margin (Tk.ha^{-1})	153735			114610		
MBCR	2.14					

Output price (Tk.kg^{-1}). Wheat: 22.50, Sesame: 50, rice grain: 20, rice straw: 1.00

Table 3.6.2 Yield and economic analysis of improved and existing cropping pattern at the FSRD site, Basantapur , Rajshahi during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Til-4	BRRI Dhan51	BARI Gom-28	-	Swarna
Seed/grain yield (t ha^{-1})	4.12	1.25	5.12	3.46	-	4.82
Stover/straw (t ha^{-1})	5.78	2.32	6.18	5.22	-	5.96
Rice equivalent yield (t ha^{-1})	4.63	3.12	5.12	3.89	-	4.82
Whole pattern Rice equivalent yield (t ha^{-1})	12.87			8.71		
Gross return (Tk.ha^{-1})	92700	62500	107620	77850	-	102360
Variable cost (Tk.ha^{-1})	35625	33750	40250	34600	-	39250
Gross margin (Tk.ha^{-1})	57075	28750	67370	43250	-	63110
Total Gross return (Tk.ha^{-1})	262820			180210		
Total variable cost (Tk.ha^{-1})	109625			73850		
Total gross margin (Tk.ha^{-1})	153195			108360		
MBCR	1.80					

Output price (Tk.kg^{-1}). Wheat: 22.50, Sesame: 50, rice grain: 20, rice straw: 1.00

Table 3.6.3. Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site, Basantapur, Rajshahi during 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Sesame	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Til-4	BRRI Dhan51	BARI Gom-28	-	Swarna
Seed/grain yield (t ha^{-1})	4.21	1.18	5.20	3.58		4.84
Stover/straw (t ha^{-1})	5.79	2.22	6.14	5.17		5.99
Rice equivalent yield (t ha^{-1})	4.73	2.94	5.20	3.80		4.84
Whole pattern Rice equivalent yield (t ha^{-1})	12.87			8.87		
Gross return (Tk.ha^{-1})	94725.00	58750.00	109615.00	80550.00		102785.00
Variable cost (Tk.ha^{-1})	35625.00	33750.00	40250.00	34600.00		39250.00
Gross margin (Tk.ha^{-1})	59100.00	25000.00	69365.00	46950.00		63535.00
Total Gross return (Tk.ha^{-1})	263090.00			183335.00		
Total variable cost (Tk.ha^{-1})	109625.00			73850.00		
Total gross margin (Tk.ha^{-1})	153465.00			111485.00		
MBCR	1.97					

FSRD site: Amnura, ChapaiNawabgonj

3.7 Development of alternate cropping pattern Wheat-Mungbean-T. Aman rice at FSRD site, Amnura, ChapaiNawabgonj under partial irrigated area during 2019-2022

Improved Pattern (IP): Wheat (BARI Gom-30)-Mungbean (BARI Mung-6)-T. Aman (BRRI Dhan51)

Existing Pattern (EP): Wheat (BARI Gom-28)-Fallow-T. Aman rice (Swarna)

Tables 3.7.1, 3.7.2, and 3.7.3 reveal crop output and economic performance over two years and on average. The EP was Wheat-Fallow-T. Aman rice, with another crop, mungbean, being added to the IP. Mungbean produced grain as well as brown manure, which is beneficial to soil management. Varietal improvement was also carried out in IP. The pattern average REY in IP was found to be 12.58 t ha^{-1}, while the value in EP was 8.58. The increase in productivity was 47 percent. The increased output was primarily due to the addition of another crop, improved varietals, and better management. Economic performance was similar to productivity. The gross margin in IP was Tk. 159107 $ha^{-1}$and it was Tk. 95810 ha^{-1} in EP. The MBCR in IP was 3.47 over EP.

Table 3.7.1 Yield and economic analysis of improved and existing cropping pattern at the FSRD site: Amnura, ChapaiNawabgonj during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Mung	T. Aman	Wheat	Fallow	T. Aman
Variety	BARI Gom-30	BARI Mung-6	BRRI dhan51	BARI Gom-28	-	Swarna
Seed/grain yield (t ha^{-1})	4.15	1.2	5.15	3.80	-	4.32
Stover/straw (t ha^{-1})	5.78	3.0	6.05	5.05	-	5.56
Rice equivalent yield (t ha^{-1})	4.66	3.0	5.15	4.27	-	4.32
Whole pattern Rice equivalent yield (t ha^{-1})	12.81			8.59		
Gross return (Tk.ha^{-1})	93375	60000	115100	85500	-	86720
Variable cost (Tk.ha^{-1})	35125	26250	39780	34500	-	41500
Gross margin (Tk.ha^{-1})	58250	33750	75320	51000	-	45220
Total Gross return (Tk.ha^{-1})	268475			172220		
Total variable cost (Tk.ha^{-1})	101155			76000		
Total gross margin (Tk.ha^{-1})	167320			96220		
MBCR	3.82					

Output price (Tk.kg^{-1}). Wheat: 22.50, Mung: 50, rice grain: 20, rice straw: 1.00

Table 3.7.2 Yield and economic analysis of improved and existing cropping pattern at the FSRD site: Amnura, ChapaiNawabgonj during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Mung	T. Aman	Wheat	Fallow	T. Aman
Seed/grain yield (t ha^{-1})	3.90	1.18	5.01	3.62	-	4.50
Stover/straw (t ha^{-1})	5.46	3.3	6.05	5.05	-	5.56
Rice equivalent yield (t ha^{-1})	4.39	2.95	5.01	4.07	-	4.50
Whole pattern Rice equivalent yield (t ha^{-1})	12.35			8.57		
Gross return (Tk.ha^{-1})	87800	59000	106250	81400	-	90000
Variable cost (Tk.ha^{-1})	38125	24250	39780	34500	-	41500
Gross margin (Tk.ha^{-1})	58250	33750	75320	46900	-	48500
Total Gross return (Tk.ha^{-1})	253050			171400		
Total variable cost (Tk.ha^{-1})	102155			76000		
Total gross margin (Tk.ha^{-1})	150895			95400		
MBCR	3.12					

Output price (Tk./kg). Wheat: 22.50, Mung: 50, rice grain: 20, rice straw: 1.00

Table 3.7.3. Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site: Amnura, ChapaiNawabgonj during 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Wheat	Mung	T. Aman	Wheat	Fallow	T. Aman
Seed/grain yield (t ha^{-1})	4.025	1.19	5.08	3.71		4.41
Stover/straw (t ha^{-1})	5.62	3.15	6.05	5.05		5.56
Rice equivalent yield (t ha^{-1})	4.525	2.975	5.08	4.17		4.41
Whole pattern Rice equivalent yield (t ha^{-1})	12.58			8.58		
Gross return (Tk.ha^{-1})	90587.5	59500	110675	83450		88360
Variable cost (Tk.ha^{-1})	36625	25250	39780	34500		41500
Gross margin (Tk.ha^{-1})	58250	33750	75320	48950		46860
Total Gross return (Tk.ha^{-1})	260762.5			171810		
Total variable cost (Tk.ha^{-1})	101655			76000		
Total gross margin (Tk.ha^{-1})	159107.5			95810		
MBCR	3.47					

3.8 Development of alternate cropping pattern Lentil-Fallow-T. Aman rice at FSRD site, Amnura, ChapaiNawabgonj under rainfed area during 2019-2022

Improved Pattern (IP): Lentil (BARI Masur-8)-Fallow-T. Aman (BRRI Dhan51)
Existing Pattern (EP): Fallow-Fallow-T. Aman rice (Swarna)

The average annual yield and economic performance of IP and EP were presented in Table 3.8.1, 3.8.2, 3.8.3 Amnura is a severely drought prone area. So, a substantial area was under the Fallow-Fallow-T. Aman rice cropping pattern. The project is trying to introduce a low water consuming crop lentil. The result indicated that the pattern average REY in IP was 11.85 t ha^{-1} while the value in EP was 4.89. The increment in productivity was substantial and the value was142%. The yield advantage was mainly due to the inclusion of lentil in the existing cropping sequence as well as the high monetary return from lentil and improved management. The economic performance was similar to productivity. The gross margin in IP was Tk. 163075 ha^{-1}and it was Tk. 67605 ha^{-1} in EP. The MBCR in IP was 3.80 over EP.

Table 3.8.1. Yield and economic analysis of improved and existing cropping pattern at the FSRD site: Amnura, ChapaiNawabgonj during 2019-2020

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
Variety	BARI Masur-8	-	BRRI dhan51	-	-	Swarna
Seed/grain yield (t ha^{-1})	1.92	-	5.10	-	-	4.95
Stover/straw (t ha^{-1})	-	-	6.10	-	-	6.15
Rice equivalent yield (t ha^{-1})	7.20	-	5.10	-	-	4.95
Whole pattern Rice equivalent yield (t ha^{-1})	12.30			4.95		
Gross return (Tk.ha^{-1})	124800	-	114200	-	-	111300
Variable cost (Tk.ha^{-1})	33750	-	39750	-	-	39250
Gross margin (Tk.ha^{-1})	91050	-	74450	-	-	72050
Total Gross return (Tk.ha^{-1})	239000			111300		
Total variable cost (Tk.ha^{-1})	73500			39250		
Total gross margin (Tk.ha^{-1})	165500			72050		
MBCR	3.73					

Output price (Tk.kg^{-1}). Lentil: 65, rice grain: 20, rice straw: 1.00

Table 3.8.2. Yield and economic analysis of improved and existing cropping pattern at the FSRD site: Amnura, ChapaiNawabgonj during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
Seed/grain yield (t ha^{-1})	1.88	-	5.28	-	-	4.82
Stover/straw (t ha^{-1})	-	-	6.35	-	-	6.01
Rice equivalent yield (t ha^{-1})	6.11	-	5.28	-	-	4.82
Whole pattern Rice equivalent yield (t ha^{-1})	11.39			4.82		
Gross return (Tk.ha^{-1})	122200	-	111950	-	-	102410
Variable cost (Tk.ha^{-1})	33750	-	39750	-	-	39250
Gross margin (Tk.ha^{-1})	88450	-	72200	-	-	63160
Total Gross return (Tk.ha^{-1})	234150			102410		
Total variable cost (Tk.ha^{-1})	73500			39250		
Total gross margin (Tk.ha^{-1})	160650			63160		
MBCR	3.87					

Output price (Tk.kg^{-1}). Lentil: 65, rice grain: 20, rice straw: 1.00

Table 3.8.3. Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD site, Amnura, Rajshahi during 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Fallow	T. Aman	Fallow	Fallow	T. Aman
Seed/grain yield (t ha^{-1})	1.90		5.19			4.89
Stover/straw (t ha^{-1})			6.23			6.08
Rice equivalent yield (t ha^{-1})	6.66		5.19			4.89
Whole pattern Rice equivalent yield (t ha^{-1})	11.85			4.89		
Gross return (Tk.ha^{-1})	123500		113075			106855
Variable cost (Tk.ha^{-1})	33750		39750			39250
Gross margin (Tk.ha^{-1})	89750		73325			67605
Total Gross return (Tk.ha^{-1})	236575			106855		
Total variable cost (Tk.ha^{-1})	73500			39250		
Total gross margin (Tk.ha^{-1})	163075			67605		
MBCR	3.80					

FSRD Site: Chanduria, Rajshahi

3.9 Development of alternate cropping pattern lentil-Maize-T. Aman rice at FSRD Site, Chanduria, Rajshahi during the years of 2019 to 2022

Improved cropping pattern (IP): Lentil (BARI Masur-8)-Maize (Laltir339)- T. Aman (BRRI dhan87)

Existing cropping pattern (EP): Fallow- Boro (BRRI dhan28)- T. Aman (Swarna)

Agronomic and economic performance of improved cropping pattern against existing cropping pattern is presented in Table 3.9.1 and 3.9.2. In the IP three crops were accommodated against double cropping existing pattern. In addition, hybrid maize was included in IP which has high yield potentiality. Considering all the component crops, the REY of IP was 15.76 and 16.26 t ha^{-1} $yr.^{-1}$ which was about 74% and 54% higher against EP (9.04 and 10.60 t $ha^{-1}yr^{-1}$). Higher rice equivalent yield indicates higher productivity and efficiency of the IP. It was observed from Table 11.9.3 that on an average, improved cropping pattern produced higher gross margin Tk. 280891 ha^{-1} against EP (GM: Tk. 156912 ha^{-1}) which was about 79% higher than that of existing cropping pattern in two consecutive years. The average marginal benefit cost ratio (MBCR) was obtained 4.67 which was further indicated the superiority to improved cropping pattern over existing pattern.

Table 3.9.1. Yield and Economic analysis of improved and existing cropping pattern at FSRD Site: Chanduria, Rajshahi during the year of 2019-20

Observation	Improved cropping pattern			Existing cropping pattern		
Crop and Variety	Lentil (BARI Masur-8)	Maize (Laltir 339)	T. Aman (BRRI dhan87)	Fallow	Boro (BRRI dhan28)	T.Aman (Swarna)
Field duration(days)	117	102	98	-	117	111
Seed /grain Yield (t ha^{-1})	2.07	7.02	5.2	-	5.68	5.05
Straw yield (t ha^{-1})	-	6.83	5.8	-	6.21	5.78
Rice equivalent yield (t ha^{-1})	5.75	3.62	5.2	-	3.99	5.05
Whole pattern Rice equivalent yield (t ha^{-1})	15.76			9.04		
Gross return (Tk ha^{-1})	155250	120905	163300	-	120340	156580
Total variable cost (Tk ha^{-1})	37810	77200	48950	-	85200	49150
Gross margin (Tk ha^{-1})	117440	43750	114350	-	35140	107430
Whole pattern Gross margin (Tk. ha^{-1})	275495			142570		
MBCR	5.48					

Table 3.9.2. Yield and Economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2020-21

Observation	Improved cropping pattern			Existing cropping pattern		
Field duration (days)	118	105	100	-	119	109
Seed /grain Yield (t ha^{-1})	2.28	10.28	5.41	-	4.95	3.65
Whole pattern Rice equivalent yield (t ha^{-1})	16.26			10.6		
Whole pattern gross return (Tk ha^{-1})	441130			192850		
Whole pattern total variable cost (Tk ha^{-1})	154889			96520		
Whole pattern gross margin (Tk. ha^{-1})	286241			171254		
MBCR	4.25					

Table 3.9.3 Average yield and economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Field duration(days)	118	104	99	-	118	110
Seed /grain Yield (t ha^{-1})	2.18	8.65	5.31	-	5.32	4.35
Whole pattern Rice equivalent yield (t ha^{-1})	16.01			9.82		
Gross return (Tk ha^{-1})	440293			234885		
Total variable cost (Tk ha^{-1})	159425			115435		
Whole pattern Gross margin (Tk. ha^{-1})	280891			156912		
MBCR	4.67					

3.10 Development of alternate cropping pattern Mustard-T. Aus-T. Aman rice at FSRD Site, Chanduria, Rajshahi during the years of 2019 to 2022

Improved cropping pattern (IP): Mustard (BARI Sarisha-18)-T. Aus (BRRI dhan82)- T. Aman (BRRI dhan87)
Existing cropping pattern (EP): Fallow- Boro (BRRI dhan28)- T. Aman (Swarna)

Agronomic and economic performance of improved cropping pattern against existing cropping pattern is presented in Table 3.10.1 and 3.10.2. In the IP, semi-long duration mustard was included, and the EP was remained fallow at that time. The BARI Sarisha-18 yielded 1.92 t ha^{-1} in YrI and it produced Canola standard edible oil. However, considering whole pattern REY of IP was 11.82 and 15.57 t ha^{-1} $yr.^{-1}$ which was about 31 and 42% higher against existing cropping pattern (9.01 and 10.94 t $ha^{-1}yr^{-1}$). Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was observed that improved cropping pattern produced higher gross margin on an average Tk. 205792 ha^{-1} against EP Tk. 109652 ha^{-1} which was 88% higher than existing cropping pattern in two consecutive years. The marginal benefit cost ratio (MBCR) was obtained 3.74 which further indicated the superiority to impro\\ved cropping pattern over existing pattern.

Table 3.10.1. Yield and Economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2019-20

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T.Aus	T. Aman	Fallow	Boro	T.aman
Field duration(days)	103	92	102	-	117	111
Seed /grain Yield (t ha^{-1})	1.92	4.76	5.1	-	5.68	5.01
Straw yield (t ha^{-1})	3.5	5.10	5.34	-	5.81	5.31
Rice equivalent yield (t ha^{-1})	3.55	3.17	5.1	-	3.99	5.01
Whole pattern Rice equivalent yield(t ha^{-1})	11.82			9.01		
Gross return (Tk ha^{-1})	97750	98430	156390	-	119540	153860
Total variable cost (Tk ha^{-1})	52976	57550	48910	-	85100	49100
Gross margin (Tk ha^{-1})	44774	40880	107480	-	34440	104760
Whole pattern Gross margin (Tk. ha^{-1})	193134			139200		
MBCR	3.13					

Table 11.10.2. Yield and Economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2020-21

Parameter	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T.Aus	T. Aman	Fallow	Boro	T.Aman
Variety	BARI Sarisha-18	BRRI dhan82	BRRI dhan87	-	BRRI dhan28	Swarna
Field duration (days)	104	91	103	-	115	107
Seed /grain Yield (t ha^{-1})	2.23	4.85	5.37	-	4.90	3.65
Whole pattern Rice equivalent yield (t ha^{-1})	15.57			10.55		
Whole pattern gross return (Tk ha^{-1})	375160			191750		
Whole pattern total variable cost (Tk ha^{-1})	156710			111646		
Whole pattern gross margin (Tk. ha^{-1})	218450			80104		
MBCR	4.07					

Table 3.10.3. Average yield and economic analysis of improved and existing cropping pattern at FSRD Site, Chanduria, Rajshahi during the year of 2019-2022

Parameter	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T.Aus	T. Aman	Fallow	Boro	T.Aman
Variety	BARI Sarisha-18	BRRI dhan82	BRRI dhan87	-	BRRI dhan28	Swarna
Field duration (days)	104	92	103	-	116	109
Seed /grain Yield (t ha^{-1})	2.08	4.81	5.24	-	5.29	4.33
Whole pattern rice equivalent yield (t ha^{-1})	13.70			9.78		
Whole pattern gross return (Tk ha^{-1})	363865			232575		
Whole pattern total variable cost (Tk ha^{-1})	158073			122923		
Whole pattern gross margin (Tk ha^{-1})	205792			109652		
MBCR	3.74					

FSRD Site: Jiarokhi, Kushtia

3.11 Improvement of existing Lentil-Sesame-T. Aman cropping pattern at FSRD Site, Jiarokhi, Kushtia during the years of 2019-2022

Improved cropping pattern (IP): Lentil (BARI Masur-8)-Sesame (BARI Til-4)- T. Aman rice (BRRI dhan75)

Existing cropping pattern (EP): Lentil (BARI Masur-6)-Sesame (Local)-T. Aman rice (BRRI dhan39)

The crop yield and monetary return of IP and EP for both the years and their average results are presented in Table 3.11.1, 3.11.2 and 3.11.3. From those table, it was found that, newly released varieties from NARS institutes were performed better than that of old one as well as farmer's existing varieties.

The average yield and economy of IP and EP showed that BARI Piaz-4 gave higher bulb yield (20.08 t ha^{-1}) over Local variety (15.07 t ha^{-1}) at FSRD Site: Jiarokhi, Kushtia (Table 23b). In the same way, all the crop varieties in IP performed better than those in EP. The two-year average REY was 13.65 t ha^{-1}in IP while it was 11.22 t ha^{-1} in EP. The IP gave 22% higher REY than that of EP. Whole pattern gross margin was Tk. 902565 ha^{-1} in IP which was much higher than EP (Tk.705215 ha^{-1}). The average MBCR in IP was 1.28 over EP.

The average yield and economy of IP and EP showed that BARI Masur-8 gave higher seed yield (2.05 t ha^{-1}) over BARI Masur-6 (1.75 t ha^{-1}) at FSRD Site: Jiarokhi, Kushtia (Table 11.11.3). In the same way, all the crop varieties in IP performed better than those in EP. The two-year average REY was 13.73 t ha^{-1}in IP while it was 11.72 t ha^{-1} in EP. The IP gave 17% higher REY than that of EP. Whole pattern gross margin was Tk. 295220 ha^{-1} in IP which was much higher than EP (Tk.245830 ha^{-1}). The average MBCR in IP was 1.20 over EP.

Table 3.11.1 Yield and economic analysis of improved and existing cropping pattern at the FSRD Site, Jiarokhi, Kushtia during 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Sesame	T. Aman	Lentil	Sesame	T. Aman
Variety	BARI Masur-8	BRRI Til-4	BRRI dhan75	BARI Masur-6	Local	BRRI dhan39
Seed/grain yield (t ha^{-1})	2.29	1.51	5.55	1.80	1.10	5.50
Stover/straw yield (t ha^{-1})	1.91	2.04	4.39	1.20	1.10	4.85
Rice equivalent yield (t ha^{-1})	5.83	2.35	5.55	4.68	1.54	5.50
Whole pattern Rice equivalent yield (t ha^{-1})	13.73			11.72		
Gross return (Tk.ha^{-1})	186620	75400	209950	150000	49500	208800
Variable cost (Tk.ha^{-1})	41912	40150	80200	40000	38015	80200
Gross margin (Tk.ha^{-1})	144708	35250	129750	110000	11485	128600
Total Gross return (Tk.ha^{-1})	309708			250085		
Total variable cost (Tk.ha^{-1})	162262			158215		
Total gross margin (Tk.ha^{-1})	147446			91870		
MBCR	1.61					

Output price (Tk.kg^{-1}). Lentil: 75.50, Stover=7.00, Sesame=50.00, Rice: 32.00, Rice straw: 7.00

Table 3.11.2. Yield and economic analysis of improved and existing cropping pattern at the FSRD Site, Jiarokhi, Kushtia during 2020-2021

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Onion	Sweet gourd	T. Aman	Onion	Sweet gourd	T. Aman
Seed/grain/bulb yield (t ha^{-1})	20.08	19.00	5.70	15.07	18.00	5.45
Stover/straw yield (t ha^{-1})	-	-	4.48	-	-	4.40
Rice equivalent yield (t ha^{-1})	26.21	5.84	5.70	20.53	5.53	5.45
Whole pattern REY (t ha^{-1})	37.75			31.51		
Gross return (Tk.ha^{-1})	853400	190000	216950	667250	180000	215550
Variable cost (Tk.ha^{-1})	227250	49750	80585	227250	49750	80585
Gross margin (Tk.ha^{-1})	626150	140250	136165	440000	130250	134965
Total Gross return (Tk.ha^{-1})	1260350			1062800		
Total variable cost (Tk.ha^{-1})	357585			357585		
Total gross margin (Tk.ha^{-1})	902565			705215		
MBCR	1.28					

Output price (Tk./kg). Improved and existing: Onion: 42.50, Sweet gourd=10, Rice: 32.50, Rice straw: 7.00

Table 3.11.3. Average yield and eeconomic analysis of improved and existing cropping pattern at the FSRD Site, Jiarokhi, Kushtia during 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Lentil	Sesame	T. Aman	Lentil	Sesame	T. Aman
Seed/grain yield (t ha^{-1})	2.05	1.45	5.55	1.75	1.05	5.40
Stover/straw yield (t ha^{-1})	1.85	2.05	4.40	1.15	1.08	4.65
Rice equivalent yield (t ha^{-1})	5.80	2.30	5.55	4.50	1.52	5.20
Whole pattern Rice equivalent yield (t ha^{-1})	13.65			11.22		
Gross return (Tk.ha^{-1})	185520	74500	205850	148000	46500	204750
Variable cost (Tk.ha^{-1})	45200	40350	85100	38000	35320	80100
Gross margin (Tk.ha^{-1})	140320	34150	120750	110000	11180	124650
Total Gross return (Tk.ha^{-1})	465870			399250		
Total variable cost (Tk.ha^{-1})	170650			153420		
Total gross margin (Tk.ha^{-1})	295220			245830		
MBCR	1.20					

FSRD Site: Kamalbazer, Sylhet

3.12 Development of alternative cropping pattern at FSRD Site: Kamalbazer, Sylhet during the years of 2019 to 2022

Improved cropping pattern (IP): Potato (BARI Alu-41)-T. Aus (BRRI dhan65)-T. Aman (BRRI dhan57)

Existing cropping pattern (EP): Fallow-T. Aus (BR26)-T. Aman (BRRI dhan33)

Agronomic and economic performance of improved cropping pattern against existing cropping pattern are presented in Table 3.12.1. In IP, BARI Alu-41 gave tuber yield 20.35. BRRI dhan65 produced grain yield 3.81 t ha^{-1} which gave 23 % higher yield compared to existing pattern (3.10 t ha^{-1}). BRRI dhan57 gave higher grain yield (4.4 t ha^{-1}) and farmers' existing variety BRRI dhan33 produced lower grain yield (3.80 t ha^{-1}) at the FSRD Site: Kamalbazer, Sylhet. Rice equivalent yield of IP was 28.23 t ha^{-1} yr.$^{-1}$ which was much higher than EP (6.63 t $ha^{-1}yr^{-1}$) due to introduction of potato in IP at fallow period. Higher rice equivalent yield indicates higher productivity and efficiency of the improved pattern. It was observed that improved cropping pattern produced higher gross margin Tk. 359716 ha^{-1} against existing cropping pattern. The marginal benefit cost ratio (MBCR) was obtained 5.13 which further indicated the superiority to improved cropping pattern over existing pattern.

Table 3.12.1. Yield and economic analysis of improved and existing cropping pattern at FSRD Site, Kamalbazer, Sylhet during 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Potato	T.Aus	T.Aman	Fallow	T.Aus	T.Aman
Variety	BARI Alu-41	BRRI dhan65	BRRI dhan57	-	BR26	BRRI dhan33
Seed/grain yield (tha^{-1})	31.2	3.81	4.4	-	3.10	3.80
Straw yield (tha^{-1})	0	4.2	5.4	-	3.7	4.9
REY	20.35	3.48	4.4	-	2.83	6.80
Whole pattern REY	28.23			6.63		
Gross return (TK ha^{-1})	468000	80010+16800 = 96810	101200+21600= 122800	-	65100+14800 =79900	87400+19600= 107000
Total variable cost (Tk ha^{-1})	190500	57240	68320	-	50330	66450
Gross margin (TK ha^{-1})	277500	39570	54480	-	29570	40550
Total Gross return (TK ha^{-1})	649290			152490		
Total variable cost (TK ha^{-1})	289574			42370		
Total Gross margin (TK ha^{-1})	359716			70120		
MBCR	5.13					

Unit price ($TK.kg^{-1}$) Potato: 15.00, Rice Straw: 4.00, T. Aus: 21.00, T. Aman: 23.00

3.13 Improvement of cropping pattern at FSRD Site, Kamalbazer, Sylhet, 2019 to 2022

Improved cropping pattern (IP): Mustard (BARI Sarisha-14)-T. Aus (BRRI dhan65)-T. Aman (BRRI dhan57)

Existing cropping pattern (EP): Mustard (Tori-7)-T. Aus (BR26)-T. Aman (BRRI dhan33)

Agronomic and economic performance of improved cropping pattern against existing cropping pattern are presented in Table 25. In the improved cropping pattern, BARI Sarisha-14 gave seed yield 1.39 t ha^{-1} which was 47 % higher over the farmers' existing variety Tori-7 (0.94 t ha^{-1}). BRRI dhan65 produced grain yield 4.20 t ha^{-1} which gave 34 % higher yield compared to existing pattern (3.46 t ha^{-1}). BRRI dhan57 also gave higher grain yield (4.65 t ha^{-1}) and farmers' existing variety BRRI dhan33 produced lower grain yield (3.89 t ha^{-1}) at the FSRD Site: Kamalbazer, Sylhet. Rice equivalent yield of improved cropping pattern was 12.80 t ha^{-1} $yr.^{-1}$ which was about 22% higher against existing cropping pattern (10.52 t $ha^{-1}yr^{-1}$) due to introduction of high yielding T. Aman and Mustard variety and improved management practices. It was observed that improved cropping pattern produced higher gross margin Tk. 90800 ha^{-1} which was 93 % higher against existing cropping pattern. The marginal benefit cost ratio (MBCR) was obtained 1.93 which further indicated the superiority to improved cropping pattern over existing pattern.

Table 3.13.1. Yield and economic analysis of improved and existing cropping pattern at FSRD Site: Kamalbazer, Sylhet during 2019-2022

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Mustard	T.Aus	T.Aman	Mustard	T.Aus	T.Aman
Variety	BARI Sarisha-14	BRRI dhan65	BRRI dhan57	Tori-7	BR26	BRRI dhan33
Seed/grain yield (tha^{-1})	1.39	4.20	4.65	0.94	3.46	3.89
Straw yield (tha^{-1})	1.41	5.4	5.5	1.1	4.6	4.8
REY	5.14	3.83	4.65	3.47	3.16	3.89
Total REY	12.80			10.52		
Gross return (Tk ha^{-1})	118150+2820 =120970	88200+21600 =109800	106950+22000 =128950	79900 + 2200 =82100	72660+18400 =91060	89470+ 19200 = 108670
Total variable cost (Tk ha^{-1})	55600	68000	80000	49000	68000	78000
Gross margin (Tk ha^{-1})	65370	41800	48950	33100	23060	30670
Total Gross return (Tk ha^{-1})	294400			241960		
Total variable cost (Tk ha^{-1})	203600			195000		
Total Gross margin (Tk ha^{-1})	90800			46960		
MBCR	1.93					

Unit price ($TK.kg^{-1}$) Mustard: 85.00, Mustard straw: 2.00, Rice straw: 4.00, T. Aus: 21.00, T. Aman: 23.00

II. On-farm verification/Production program

3.14 On-farm verification trials with modern verities of cereals, oilseed, pulses, vegetables, spices and tuber crops at different FSRD sites during the years of 2019 to 2022

FSRD Site: Basantapur, Rajshahi

Tables 3.14.1 and 3.14.2 show the yield and economic performance of several crops currently in production or undergoing on-farm verification. Crop varieties are tested over a period of one to three years. The Tables show the results for each year as well as the average of all years. We're talking about average outcomes. BARI Sarisha-17 produced the best seed output (1.71 t ha^{-1}) and monetary benefit (Tk. 72250 ha^{-1}) among the short-duration Mustards, followed by BARI Sarisha-14. The excellent oil seed variety BARI Sarisha-18 produced 1.80 t ha^{-1}. It's a semi-long-lived variety.In the case of summer hybrid tomatoes, BARI Hybrid Tomato-11 (38.0 t ha^{-1}) outperformed BARI Hybrid Tomato-8 in terms of yield (18.50 t ha^{-1}). Farmers are excited about the prospect of growing BARI Hybrid Tomato-11 next year. Potato is not normally grown by farmers in Godagari Upazilla due to soil conditions. In the Barind area, we were seeking to validate five popular and recently introduced kinds. BARI Alu-7 had the largest tuber yield (26.58 t ha^{-1}), followed by BARI Alu-41 (25.26 t ha^{-1}) and BARI Alu-25 with the lowest (BARI Alu-25) (21.83 t ha^{-1}). As a production scheme, BARI Masur-8 was cultivated in the Barind area. With a gross margin of Tk. 95416 ha^{-1}, lentil seed yield was 1.78 t ha^{-1}.

Table 3.14.1. Yield, cost and return of different crops at the FSRD Site: Basantapur,Rajshahi during 2019-2022

Variety	Yield (t ha^{-1})	Gross return (Tk.ha^{-1})	Cost of production (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
Year I - 2019-2020				
BARI Masur-8	1.95	136500	33750	102750
BARI Chola-5	1.52	91200	28500	62700
BARI Hybrid Tomato-8	18.50	1110000	587500	522500
BARI Sarisha-17	1.65	82500	40250	42250
BARI Sarisha-14	1.60	80000	40250	39750
BARI Alu-7	26.00	312000	158000	154000
BARI Alu-25	21.00	252000	158000	94000
BARI Alu-36	24.50	294000	158000	136000
BARI Alu-41	25.23	302760	158000	144760
BARI Alu-46	24.60	295200	158000	137200
Year II - 2020-2021				
BARI Masur-8	1.90	133000	34750	98250
BARI Chola-5	1.55	100750	29500	71250
BARI Sarisha-17	1.75	109375	40250	69125
BARI Sarisha-14	1.65	103125	40250	62875
BARI Hybrid Tomato-11	38.0	2280000	810000	1470000
BARI Alu-7	26.75	321000	158000	163000
BARI Alu-25	22.00	264000	158000	106000
BARI Alu-36	24.75	297000	158000	139000
BARI Alu-41	25.25	303000	158000	145000
BARI Alu-46	25.78	309360	158000	151360
Year III - 2021-2022				
BARI Masur-8	1.50	120000	34750	85250
BARI Chola-5	1.45	108750	29500	79250
BARI Gom-30	3.20	96000	44000	52000
BARI Sarisha-18	1.80	139500	42000	97500
BARI Sarisha-17	1.72	129000	40250	88750
BARI Sarisha-15	1.55	112500	40250	72250
BARI Sarisha-14	1.65	123750	40250	83500

Variety	Yield (t ha^{-1})	Gross return (Tk.ha^{-1})	Cost of production (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
BARI Alu-7	27.00	324000	158000	166000
BARI Alu-25	22.50	270000	158000	112000
BARI Alu-36	24.95	299400	158000	141400
BARI Alu-41	26.20	314400	158000	156400
BARI Alu-46	26.30	315600	158000	157600

Table 3.14.2. Average yield, cost and return of crops at the FSRD Site: Basantapur,Rajshahi during 2019-2022

Variety	Yield (tha^{-1})	Gross return (Tk.ha^{-1})	Cost of production (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
BARI Masur-8	1.78	129833	34416	95416
BARI Chola-5	1.51	100233	29166	71066
BARI Gom-30	3.20	96000	44000	52000
BARI Sarisha-18	1.80	139500	42000	97500
BARI Sarisha-17	1.71	112500	40250	72250
BARI Sarisha-15	1.55	106958.	40250	66708
BARI Sarisha-14	1.67	104375	40250	64125
BARI Hybrid Tomato-8	18.50	1110000	587500	522500
BARI Hybrid Tomato-11	38.0	2280000	810000	1470000
BARI Alu-7	26.58	319000	158000	161000
BARI Alu-25	21.83	262000	158000	104000
BARI Alu-36	24.73	296800	158000	138800
BARI Alu-41	25.56	306720	158000	148720
BARI Alu-46	25.56	306720	158000	148720

FSRD site: Amnura, ChapaiNawabgonj

The yield and economics of several production programs are shown in Tables 3.14.3 and 3.14.4. The results showed that BARI Sarisha-14 (yield 1.57 t ha^{-1}) and BARI Sarisha-17 (yield 1.66 t ha^{-1}) performed better than local varieties in Mustard, and farmers adopted these kinds for planting the following year. BARI Masur-8 produced a good seed production (1.76 t ha^{-1}) among the pulses, and farmers are increasingly interested in farming this variety because of the good market price. Chickpea is a traditional crop in the High Barind region. The BARI Chola-5 is now well-known in the Barind area, thanks to OFRD's efforts. With a good money return, the cultivar produced 1.58 t ha^{-1} seed yield (Tk. 78917ha^{-1}).

Table 3.14.3. Yield, cost and return of crops at the FSRD site: Amnura, ChapaiNawabgonj during 2019-2022

Variety	Yield (tha^{-1})	Gross return (Tk.ha^{-1})	Cost of production (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
Year I - 2019-2020				
BARI Masur-8	1.76	123200	33750	89450
BARI Chola-5	1.55	100750	28500	72250
BARI Sarisha-14	1.50	67500	30750	36750
Year II - 2020-2021				
BARI Masur-8	1.82	127400	34750	92650
BARI Chola-5	1.65	107250	29500	77750
BARI Sarisha-17	1.60	100000	40250	59750
BARI Sarisha-14	1.55	96875	40250	56625
Year III - 2020-2021				
BARI Masur-8	1.70	136000	34750	101250
BARI Chola-5	1.55	116250	29500	86750
BARI Sarisha-17	1.72	129000	40250	88750
BARI Sarisha-14	1.65	123750	40250	83500

Table 3.14.4. Average yield, cost and return of crops at the FSRD site: Amnura, ChapaiNawabgonj during 2019-2022

Variety	Yield (tha^{-1})	Gross return ($Tk.ha^{-1}$)	Cost of production ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
BARI Masur-8	1.76	128867	34417	94450
BARI Chola-5	1.58	108083	29167	78917
BARI Sarisha-17	1.66	114500	40250	74250
BARI Sarisha-14	1.57	96042	37083	58958

FSRD site: Chanduria, Rajshahi

Yield and economic performance of different crops under production or on-farm verification programs (Table 3.14.5 and Table 3.14.6). The crop varieties are trialed for one to three years. Results for each year and the average of all years are presented in the Tables. We are discussing average results. The results revealed that among the short duration Mustard, BARI Sarisha-17 gave the highest seed yield (1.45 t ha^{-1}) and GM (Tk. 79085 ha^{-1}) followed by BARI Sarisha-14 (Table 11.14.5). The BARI Sarisha-18, a quality oil seed variety, yielded 1.93 t ha^{-1}. It is a semi-long duration variety. BARI Sarisha-16 gave the maximum yield (2.01 tha^{-1}). The yield of BARI Gom-30 was better than BARI Gom-33. Among the tested potato varieties BARI Alu-57 gave the highest tuber yield (35.30 t ha^{-1}) followed by BARI Alu-40 (34.77 t ha^{-1}) and the lowest one in BARI Alu-73 (22.50 t ha^{-1}). But BARI Alu-40 gave the highest return (Tk. 244290 ha^{-1}). BARI Masur-8 seed yield was 1.82 t ha^{-1}, with a gross margin of Tk. 101633 ha^{-1}. Farmers of the locality chose the variety for its high yield potential and good market price.

Table 3.14.5. Yield, cost and return of crops at the FSRD Site, Chanduria, Rajshahi during 2019-2022

Variety	Yield (tha^{-1})	Gross return ($Tk.ha^{-1}$)	Cost of production ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
Year I - 2019-2020				
BARI Masur-8	1.93	144750	37700	107050
BARI Sarisha-11	2.02	102250	52985	49265
BARI Sarisha-14	1.42	95850	36515	59335
BARI Sarisha-16	2.04	104315	52985	51330
BARI Sarisha-18	1.91	96800	52985	43815
BARI Gom-30	4.2	100800	48175	62625
BARI Til-4	1.10	66000	25000	41000
BRRI dhan 82	3.30	116250	81750	34500
BARI Alu-7	31.32	375840	172950	202890
BARI Alu-37	32.35	388200	172950	215250
BARI Alu-40	35.42	425040	172950	252090
Year II - 2020-2021				
BARI Masur-8	1.81	135750	37700	98050
BARI Sarisha-11	1.95	98706	52985	45721
BARI Sarisha-14	1.38	93150	36515	56635
BARI Sarisha-16	1.98	100225	52985	47240
BARI Sarisha-18	1.95	98706	52985	45721
BARI Gom-30	4.1	98400	48175	60225
BARI Gom-33	4.01	88750	38765	49985
BARI Til-4	1.20	72000	25000	47000
BARI Alu-7	30.35	364200	172950	191250
BARI Alu-37	31.56	381000	172950	208050
BARI Alu-40	34.12	409440	172950	236490
Year III - 2021-2022				
BARI Masur-8	1.73	138000	38200	99800
BARI Sarisha-14	1.27	101600	36915	64685
BARI Sarisha-17	1.45	116000	36915	79085

Variety	Yield (tha^{-1})	Gross return ($Tk.ha^{-1}$)	Cost of production ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
BARI Sarisha-18	2.02	161600	36915	124685
BARI Alu-35	34.5	414000	260250	153750
BARI Alu-37	32.2	386400	260250	126150
BARI Alu-57	35.3	317700	260250	57450
BARI Alu-73	22.5	270000	260250	9750

Table 3.14.6. Average yield, cost and return of crops at the FSRD Site, Chanduria, Rajshahi during 2019-2022

Variety	Yield (tha^{-1})	Gross return ($Tk.ha^{-1}$)	Cost of production ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
BARI Masur-8	1.82	139500	37867	101633
BARI Sarisha-11	1.99	100478	52985	47493
BARI Sarisha-14	1.36	96867	36648	60218
BARI Sarisha-16	2.01	102270	52985	49285
BARI Sarisha-17	1.45	116000	36915	79085
BARI Sarisha-18	1.93	97753	52985	44768
BARI Gom-30	4.15	99600	48175	61425
BARI Gom-33	4.01	88750	38765	49985
BARI Til-4	1.15	69000	25000	44000
BRRI dhan 82	3.30	116250	81750	34500
BARI Alu-7	30.84	370020	172950	197070
BARI Alu-35	34.50	414000	260250	153750
BARI Alu-37	32.04	385200	202050	183150
BARI Alu-40	34.77	417240	172950	244290
BARI Alu-57	35.30	317700	260250	57450
BARI Alu-73	22.50	270000	260250	9750

FSRD Site: Jiarokhi, Kushtia

Tables 3.14.7. and 3.14.8 show the yield and economics of various production programs. The results revealed that in case of Mustard, BARI Sarisha-18 (yield 1.72 t ha^{-1}) performed better than local varieties and farmers also chose these varieties for next year's cultivation. Among the pulses, BARI Masur-8 gave a good seed yield (2.12t ha^{-1}) and farmers are more interested in cultivating this variety due to higher market price. The yield of BARI Alu-7 and BARI Alu-53 were (22.19t ha^{-1}) and (25.05t ha^{-1}) respectively. In the production program of BARI Surjamukhi-3 gave yield 1.74 t ha^{-1}.

Table 3.14.7. Yield, cost and return of crops at the FSRD Site, Jiarokhi, Kushtia during 2019-2022

Variety	Yield (tha^{-1})	GR ($Tk.ha^{-1}$)	Cost of production ($Tk.ha^{-1}$)	GM ($Tk.ha^{-1}$)
Year I – 2019-2020				
BARI Masur-8	2.17	177025	41912	135113
BARI Sarisha-18	1.68	148000	42360	105640
BARI Alu-7	21.78	217800	139680	78120
BARI Alu-53	24.40	244000	139680	104320
Year II – 2020-2021				
BARI Masur-8	2.05	153750	43250	110500
BARI Sarisha-18	1.75	148750	44265	104485
BARI Alu-7	22.60	226000	145000	81800
BARI Alu-53	25.75	257500	146350	111150
Year III – 2020-2021				
BARI Masur-8	2.15	182750	47520	135230
BARI Sarisha-18	1.72	152000	43750	108250
BARI Alu-53	25.05	250500	147820	102680
BARI Surjamukhi-3	3.20	260800	98104	162696

Table 3.14.8. Average yield, cost and return of crops at the FSRD Site Jiarokhi, Kushtia during 2019-2022

Variety	Yield (tha^{-1})	Gross return ($Tk.ha^{-1}$)	Cost of production ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
BARI Masur-8	2.12	171175	44227	126948
BARI Sarisha-18	1.72	149583	43458	106125
BARI Alu-7	22.19	221900	142340	79560
BARI Alu-53	25.07	250667	144617	106050
BARI Surjamukhi-3	3.20	260800	98104	162696

FSRD Site: Kamalbazer, Sylhet

On-farm verification and production program on different crops (tomato, potato, mustard, sunflower, bottle gourd, country bean and brinjal) was conducted at the FSRD site, Kamalbazer for three years. Results of each year and their average are detailed in Table 3.14.7 and 3.14.8. We are discussing here only average results of three years (Table 11.14.10). The results revealed that in case of potato, BARI Alu-46 gave the highest tuber yield (32.70 t ha-1) followed by BARI Alu-41 (30.40 t ha-1) and the lowest one from BARI Alu-53 (27.03 t ha-1). All the potato variety showed high gross margin more than Tk. 200000 ha-1. Tomato is a high value crop and was taken under production program. BARI Hybrid Tomato-5 has been selected due to it good shelf life and its earliness. The BARI Hybrid Tomato-5 contributed 52.80 t ha-1 with the gross margin Tk. 384567 ha-1. The BARI Sarisha-17 (1.62 t ha-1) and BARI Sarisha-14 (1.45 t ha-1) performed better than that of BARI Sarisha-18 (1.39 t ha-1). The short duration mustard varieties can contribute to meet up the edible oil deficit partially. In case of Sunflower, BARI Surjomukhi-3 (2.12 t ha-1) performed better than BARI Surjomukhi-2 (1.90 t ha-1). Furthermore, the BARI Surjomukhi-3 is a short height variety and less change to lodge. Among the other vegetables the BARI Lau-4, BARI Sheem-6 and BARI Begun-12 yielded 66.05, 17.50 and 48.40 t ha-1, respectively. Among them BARI Begun-12, newly released variety, gave the highest gross return (Tk. 1452000 ha-1) and gross margin (Tk. 1255950 ha-1). Farmers showed positive response towards the variety.

Table 3.14.9. Yield, cost and return of crops in FSRD site, Kamalbazer during 2019 to 2022

Variety	Yield (tha^{-1})	Gross return ($Tk.ha^{-1}$)	Cost of production ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
Year I - 2019-2020				
BARI Hybrid Tomato-5	52.7	527000	210800	316200
BARI Alu-41	30.4	453000	192560	260440
BARI Alu-46	32.2	462250	124900	237350
BARI Alu-53	25.4	338582	135430	203150
BARI Sharisa-14	1.38	117300	46920	70300
BARI Surjomukhi-2	1.9	133000	85255	47745
BARI Surjomukhi-3	2.12	148400	86300	62100
Year II - 2020-2021				
BARI Hybrid Tomato-5	55.8	558400	170000	388400
BARI Alu-41	29.6	394568	157828	236740
BARI Alu-46	35.2	528000	197300	330700
BARI Alu-53	27.8	417000	193000	224000
BARI Sharisa-14	1.44	122400	81420	40980
BARI Sharisa-17	1.62	137700	84680	53020
BARI Lau-4	68.4	640470	256180	384280
BARI Sheem-6	17.5	525000	173620	351380
Year III - 2021-2022				
BARI Hybrid Tomato-5	49.9	748500	299400	449100
BARI Alu-41	31.2	415890	166360	249540
BARI Alu-46	30.7	409230	163690	245540

Variety	Yield (tha^{-1})	Gross return ($Tk.ha^{-1}$)	Cost of production ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
BARI Alu-53	27.9	371910	148760	223150
BARI Sharisa-14	1.52	114000	45600	68400
BARI Sharisa-18	1.39	104250	41700	62550
BARI Lau-4	63.7	596460	238580	357870
BARI Begun-12	48.4	1452000	196050	1255950

Table 3.14.10. Average yield, cost and return of crops in FSRD site, Kamalbazer during 2019 to 2022

Variety	Yield (tha^{-1})	Gross return ($Tk.ha^{-1}$)	Cost of production ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)
BARI Hybrid Tomato-5	52.80	611300	226733	384567
BARI Alu-41	30.40	421153	172249	248907
BARI Alu-46	32.70	466494	161963	271197
BARI Alu-53	27.03	375831	159063	216767
BARI Sharisa-14	1.45	117900	57980	59893
BARI Sharisa-17	1.62	137700	84680	53020
BARI Sharisa-18	1.39	104250	41700	62550
BARI Surjomukhi-2	1.90	133000	85255	47745
BARI Surjomukhi-3	2.12	148400	86300	62100
BARI Lau-4	66.05	618465	247380	371075
BARI Sheem-6	17.50	525000	173620	351380
BARI Begun-12	48.40	1452000	196050	1255950

C. LIVESTOCK SYSTEM

3.15 Vaccination and deworming on cattle at different FSRD sites during the years of 2019 to 2022

FSRD Site: Basantapur, Rajshahi

Vaccination technology was found to be easy to adopt with minimal cost involvement. That's why the cooperating farmers were interested and adopted this technology as per their routine work. Table 3.15.1 shows the information on the number of cattle and goats under the vaccination program, name of the vaccine applied to the selected cattle and goat. The total number of livestock brought under the vaccination program was 110 at the FSRD Site, Basantapur, Rajshahi. The percentage of mortality before and after vaccination was recorded among the cooperator farmers. It was found that before vaccination the mortality rate was higher (15%). After vaccination of cattle and goat, all of the diseases frequency reduced drastically, and the mortality rate was almost nil or around 2-3%.

Table 3.15.1. Mortality information of goat/sheep/cattle before and after vaccination against major diseases at FSRD Site, Basantapur, Rajshahi during 2019 to 2022

Year of vaccination	Name of the vaccine	No. animal vaccinated		Mortality (%)	
		Goat	Cattle	Before vaccination	After vaccination
Year I	Anthrax, FMD, BQ, PPR	100	257	15	3
Year II	Anthrax, FMD, BQ, PPR	110	268		3
Year III	Anthrax, FMD, BQ, PPR	105	270		2
Total		315	795	Avg. 15	Range: 2-3; Avg: 2.5

FSRD site: Amnura, ChapaiNawabgonj

Number of livestock under vaccination program, name of the vaccine applied to the selected cattle and goat are presented in Table 3.15.2. About 1290 numbers of cattle and 410 numbers of goat were vaccinated. Frequency of diseases was listed among the cooperative farmers. It was found that, before vaccination, frequency of different diseases was higher. After vaccination, all of the disease's frequency reduced (Table 11.15.2).

Table 3.15.2. Mortality information of goat/sheep/cattle before and after vaccination against major diseases at FSRD site, Amnura, ChapaiNawabgonj during 2019 to 2022

Year of vaccination	Name of the vaccine	No. animal vaccinated		Mortality (%)	
		Goat	Cattle	Before vaccination	After vaccination
Year I	Anthrax, FMD, BQ, HS, PPR	105	365	18	4
Year II	Anthrax, FMD, BQ, PPR	150	450		3
Year III	Anthrax, FMD, BQ, PPR	155	475		2
Total		410	1290	Avg. 18	Range: 2-4; Avg: 3

FSRD site: Chanduria, Rajshahi

Table 3.15.3 shows the number of cattle vaccinated, the name of the vaccine used on the selected livestock, and the percentage of mortality. In the FSRD site in Chanduria, Rajshahi, a total of 334 livestock were brought in for vaccination. It was discovered that before vaccination, the frequency of various diseases was higher, and the mortality rate was 22%, whereas after vaccination, the frequency of all diseases decreased, and the majority of the treated animals were free of Anthrax, BQ, HS, and FMD. Mortality rate was decreased and ranged 4-5%.

Table 3.15.3. Mortality information of goat/sheep/cattle before and after vaccination against major diseases at FSRD Site, Chanduria, Rajshahi during 2019 to 2022

Year of vaccination	Name of the vaccine	No. of animal vaccinated			Mortality rate (%)	
		Goat (Black Bengal)	Sheep (Deshi)	Cattle (Deshi)	Before vaccination	After vaccination
Year I	Anthrax, BQ, HS, FMD	20	08	80	21	04
Year II	Anthrax, BQ, HS, FMD	17	07	82	23	05
Year III	FMD	32	09	80	22	05
Total		68	24	242	Avg. 22	Range: 4-5; Avg: 4.6

FSRD Site: Jiarokhi, Kushtia

Table 3.15.4 shows the number of cattle enrolled in a deworming and vaccination program, as well as the name of the vaccine used on the selected livestock and the percentage of death. In the FSRD site in Jiarokhi, Kushtia, a total of 175 livestock were brought in for deworming and vaccination. Livestock illnesses, particularly Anthrax, were observed in the study locations before and after immunization. Before deworming and vaccination, the frequency of Anthrax was higher, with a 10% death rate, whereas after deworming and vaccination, the disease frequency decreased, and the majority of the treated animals were Anthrax-free. The death rate has also fallen (2-4 percent).

Table 3.15.4. Mortality information of goat/sheep/cattle before and after vaccination against major diseases at FSRD Site, Jiarokhi, Kushtia during 2019 to 2022

Year of vaccination	Name of the vaccine	No. animal vaccinated			Mortality (%)	
		Goat	Buffalo	Cattle	Before vaccination	After vaccination
Year I	Anthrax+Deworming+Vitamin ADE injection	20	10	30	10	4
Year II	Anthrax+Deworming	25	12	35		3
Year III	Anthrax+Deworming+Vitamin ADE injection	15	8	20		2
Total		60	30	85	Avg. 10	Range: 2-4; Avg: 3

FSRD Site: Kamalbazer, Sylhet

Number of livestock under vaccination program, name of the vaccine applied to the selected livestock and percentage of mortality are presented in Table 3.15.5. Total number of livestock brought under vaccination program was 230 in FSRD Site, Kamalbazer, Sylhet. Livestock diseases (Anthrax and FMD) occurred in the selected areas before and after vaccination was recorded cautiously. It was observed that, before vaccination, frequency of different diseases was higher and mortality rate was 7-10 % while after vaccination of livestock, all of the diseases frequency reduced and most of the treated animals were free from Anthrax and FMD. Mortality rate also decreased (2-3%).

Table 3.15.5. Mortality information of goat/sheep/cattle before and after vaccination against major diseases at FSRD Site, Kamalbazer, Sylhet during 2019-2022

Year of vaccination	Name of the vaccine	No. of animal vaccinated			Mortality (%)	
		Goat	Sheep	Cattle	Before vaccination	After vaccination
Year I	Anthrax, FMD	25	10	30	10	3
Year II	Anthrax, paraclear	30	12	35	8	3
Year III	Anthrax, paraclear FMD	36	12	40	7	2
Total		91	34	105	8.2	2.7

3.16 Vaccination on poultry production at different FSRD sites during the years of 2019 to 2022

FSRD site: Basantapur, Rajshahi

From 2019 to 2022, a chicken vaccination program was carried out at the FSRD site in Basantapur, Rajshahi. Table 3.16.1 displays the number of chickens enrolled in the immunization program, the name of the vaccine used on each chicken, and the mortality rate. There were 1276 vaccinated chickens and 166 ducks in total. Among the cooperative farmers, the mortality percentage of poultry birds against various diseases was reported. It was discovered that before vaccination, poultry bird mortality (percentage) owing to several diseases was higher (25 percent). All diseases were dramatically decreased after poultry immunization, with a death rate of roughly 4-6 percent (Table 3 .16.1).

Table 3.16.1. Mortality information of poultry birds before and after vaccination against major diseases at FSRD Site, Basantapur,Rajshahi during 2019 to 2022

Year of vaccination	Name of the vaccine	No. of poultry birds Vaccinated		Percentage of mortality (%)	
		Chicken	Duck	Before vaccination	After vaccination
Year I	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	398	46	25	6
Year II	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	412	55		5
Year III	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	466	65		4
Total		1276	166	Avg. 25	Range: 4-6; Avg: 5

FSRD site: Amnura, ChapaiNawabgonj

From 2019 through 2022, a chicken immunization program was implemented at the FSRD site in Amnura, ChapaiNawabgonj. Table 3.16.2 displays the number of chickens vaccinated, the name of the vaccine used on each chicken, and the mortality rate. There were 1299 vaccinated chickens and 188 ducks in total. Among the cooperative farmers, mortality percentages of poultry birds against various diseases were reported. It was discovered that the death rate (percentage) of poultry birds owing to various diseases was greater before vaccination (22 percent). All of the diseases were greatly decreased when the poultry were vaccinated, with a death rate of 3–7% documented (Table 11.16.2).

Table 3.16.2 Mortality information of poultry birds before and after vaccination against major diseases at FSRD site, Amnura, ChapaiNawabgonj during 2019 to 2022

Year of vaccination	Name of the vaccine	No. of poultry birds Vaccinated		Percentage of mortality (%)	
		Chicken	Duck	Before vaccination	After vaccination
Year I	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	386	50	22	7
Year II	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	447	68		6
Year III	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	466	70		3
Total		1299	188	Avg. 22	Range : 3-7; Avg: 5

FSRD site: Chanduria, Rajshahi

From 2019 through 2022, a chicken vaccination program was carried out at the FSRD facility in Chanduria, Rajshahi. Table 3.16.3 displays the number of chickens enrolled in the immunization program, the name of the vaccine used on each chicken, and the mortality rate. There were 1244 vaccinated chickens and 162 ducks in total. Among the cooperative farmers, the mortality percentage of poultry birds against various diseases was reported. It was discovered that before vaccination, poultry bird mortality (percentage) owing to several diseases was higher (17 percent). All infections were dramatically decreased after poultry immunization, with a death rate of around 4-5 percent (Table 3.16.3).

Table 3.16.3. Mortality information of poultry birds before and after vaccination against major diseases at FSRD Site, Chanduria, Rajshahi during 2019 to 2022

Year of vaccination	Name of the vaccine	No. of poultry birds Vaccinated		Percentage of mortality (%)	
		Chicken (Sonali)	Duck (Khaki Campbell) _	Before vaccination	After vaccination
Year I	BCRDV, RDV and Duck plague	374	47	17	04
Year II	BCRDV, RDV and Duck plague	445	55	17	04
Year III	BCRDV, RDV and Duck plague	325	60	17	05
Total		1244	162	Avg. 17	Range: 4-5; Avg: 4.33

FSRD Site: Jiarokhi, Kushtia

From 2019 through 2022, a chicken vaccination program was carried out at the FSRD site in Jiarokhi, Kushtia. Table 3.16.4 displays the number of chickens vaccinated, the name of the vaccine used on each chicken, and the mortality rate. There were 455 immunized chickens and 195 ducks in all. Among the cooperative farmers, the mortality percentage of poultry birds against various diseases was reported. It was discovered that before vaccination, poultry bird mortality (percentage) owing to several diseases was higher (20 percent). All diseases were dramatically decreased after poultry immunization, with a death rate of roughly 4-6 percent (Table 3.16.4).

Table 3.16.4. Mortality information of poultry birds before and after vaccination against major diseases at FSRD Site, Jiarokhi, Kushtia during 2019 to 2022

Year of vaccination	Name of the vaccine	No. of poultry birds Vaccinated		Percentage of mortality (%)	
		Chicken	Duck	Before vaccination	After vaccination
Year I	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	140	60	20	6
Year II	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	150	70		5
Year III	BCRDV, RDV, Fowl pox, Fowl cholera and Duck plague	165	65		4
Total		455	195	Avg. 20	Range: 4-6; Avg: 5

FSRD Site: Kamalbazer, Sylhet

Vaccination program of poultry was conducted at FSRD Site, Kamalbazer, Sylhet during 2019 to 2022. The informatiom on number of poultry under vaccination program, name of the vaccine applied to the selected chicken and mortality percentage was presented in Table 3.16.5. The total number of vaccinated chickens was 734 and duck was 397. Mortality percentage of poultry birds against different diseases was recorded among the cooperative farmers. It was found that before vaccination mortality (%) of poultry birds due to different diseases was higher (20%). After vaccination of poultry, all of the diseases reduced drastically, and mortality rate was recorded 5%.

Table 3.16.5. Mortality information of poultry birds before and after vaccination against major diseases at FSRD Site, Kamalbazer, Sylhet during 2019-2022

Year of vaccination	Name of the vaccine	No. of poultry birds vaccinated		Percentage of mortality (%)	
		Chicken	Duck	Before vaccination	After vaccination
Year I	BCRDV Duck plague	170	120	28	7
Year II	RDV Duck plague	294	135	18	6
Year III	BCRDV, RDV Duck plague	270	142	15	3
Total		734	397	20	5

3.17 Cattle fattening program at different FSRD sites during the years of 2019 to 2022

FSRD Site: Basantapur, Rajshahi

From 2019 to 2022, a cattle fattening program was implemented at the FSRD site, Basantapur, and Rajshahi. Adequate green roughage and balanced concentrate feed were supplied under this program along with routine de-warming and vaccination. It was found that the body weight of cattle increased due to the fattening program (Table 3.17.1). Gross margin was found on an Avg. Tk. 26000.

Table 3.17.1 Performance of calf/cattle fattening programme during 2019-2022 at the FSRD Site, Basantapur, Rajshahi (Per family)

Description of item	Year I	Year II	Year III
No. of farmer	2	2	2
No. of calf/cattle selected	2	2	2
No. calf/cattle per farmer	1	1	1
Age of calf/cattle (month)	12	13	12
Avg. wt. of calf/cattle during distribution period (kg)	85	102	98
Avg. procurement price per calf/cattle (Tk.)	38875	47000	45600
Rearing period (month)	6	6	6
Avg. body wt. (Kg) of cattle in selling period	190	211	208
Avg. price of cattle (Tk.)	80000	88000	93600
Total income (Tk.) from alive cattle (sale + consumption+ distribution)	80000	88000	93600
Variable cost (market value of calf/cattle + fed cost + health management cost)	54000	63000	65000
Gross Margin in Tk. (Total income –Variable cost)	26000	25000	28600

FSRD site: Amnura, ChapaiNawabgonj

Cattle were dewormed and vaccinated under the fattening program and supplied balanced ration. It was found that body weight of cattle under the program, increased rapidly (Table 3.17.2). Gross margin was found on an Avg. Tk. 33900.

Table 3.17.2. Performance of calf/cattle fattening programme during 2019-2022 at the FSRD site, Amnura, ChapaiNawabgonj (Per family)

Description of item	Year I	Year II	Year III
No. of farmer	2	3	2
No. of calf/cattle selected	2	3	2
No. calf/cattle per farmer	1	1	1
Age of calf/cattle (month)	12	13	12
Avg. wt. of calf/cattle during distribution period (kg)	85	96	98
Avg. procurement price per calf/cattle (Tk.)	38400	41000	44000
Rearing period (month)	6	6	6
Avg. body wt. (Kg) of cattle in selling period	211	220	208
Avg. price of cattle (Tk.)	88600	95000	93600
Total income (Tk.) from alive cattle (sale + consumption+ distribution)	88600	95000	93600
Variable cost (market value of calf/cattle + fed cost + health management cost)	55000	59500	61000
Gross Margin in Tk. (Total income –Variable cost)	33600	35500	32600

FSRD site: Chanduria, Rajshahi

Between 2019 and 2022, a cattle fattening program was performed at the FSRD site in Chanduria, Rajshahi. This initiative provided cultivated green grasses and Urea Molasses Straw (UMS). It was discovered that cattle's body weight increased as a result of the fattening procedure (Table 3.17.3). On an average Tk. 11760, a gross margin was discovered.

Table 3.17.3 Performance of calf/cattle fattening programme during 2019-2022 at the FSRD site, Chanduria, Rajshahi (Per family)

Description of item	Before intervention	After intervention			
		Year I	Year II	Year III	Avg.
No. of farmer	06	06	10	11	09
No. of calf/cattle reared	08	06	10	11	09
Age of calf/cattle (month)	32	20	20	22	21
Avg. wt. of calf/cattle during first feed distribution period (kg)	99	87	83	92	87
Avg. estimated price per calf/cattle before rearing time (Tk.)	44000	37000	35500	41000	37833
Rearing period (month)	12	06	06	06	06
Avg. body wt. (Kg) of cattle in selling period	125	132	128	141	134
Total income from alive cattle (Tk.)	53000	62900	59000	71500	64467
Total variable cost (market value of calf/cattle + fed cost + health management cost)	47500	51500	49700	56920	52707
Gross Margin (Tk.)	5500	11400	9300	14580	11760

FSRD Site: Jiarokhi, Kushtia

Cattle fattening program was implemented in FSRD Site: Jiarokhi, Kushtia during the years of 2019 to 2022.Adequate green roughage and balanced concentrate feed were supplied under this program along with routine de-warming and vaccination. It was found that body weight of cattle increased due to fattening program (Table 3.17.4). Gross margin was found on an avg. Tk. 28000.

Table 3.17.4 Performance of calf/cattle fattening program during 2019-2022 at the FSRD Site, Jiarokhi, Kushtia (Per family)

Description of item	Year I	Year II	Year III
No. of beef fattening	2	2	2
Age of calf/cattle (month)	15	16	14
Avg. wt. of calf/cattle (kg)	70	75	70
Rearing period (month)	10	11	7
Avg. body wt. (Kg) of cattle in selling period	125	130	0
Avg. price of cattle (Tk.)	62500	66000	0
Total income (Tk.)	62500	66000	0
Variable cost (market value of calf/cattle + fed cost + health management cost)	35000	37500	42300
Gross Margin in Tk. (Total income –Variable cost)	27500	28500	0

3.18 Goat rearing

Goat rearing in the farmer's household for increase income of farmers

At the FSRD location in Basantapur, Rajshahi, two farmers willingly reared male goats as part of a fattening program. Five goats were raised by one farmer, while three were raised by another. As an upgraded technology, the OFRD team created a bamboo slot. The technology protected them from a variety of ailments, and their goat growth accelerated. The goat's initial body weight was 10.0 kg on average. The goat that was provided had a 100% survival rate. After ten months of growing, the goats reached a weight of 24.0 kg, resulting in a gross margin of Tk. 6700/- each goat, and a total of Tk. 26800/- for the rearing of four goats. (Table 3.18.1)

Table 3.18.1. Performance of goat at farmers level at FSRD Site, Basantapur, Rajshahi during the years of 2020 to 2021

Description of Items	Average year^{-1}
Number of farmers	2
Number of goats reared	4
Date of supplied	September 2020
Age of goat during distribution	5-6 months
Initial body wt. goat^{-1} (kg)	10 Kg
Procurement price goat^{-1} (Tk.)	5000/-
No of goat survive	100%
Wt. gained/goat after 10 months	14 kg
Total return (Tk.) goat^{-1}	13500/-
Total variable cost (Tk.) goat^{-1}	6800/-
Gross margin (Tk.) goat^{-1}	6700/-
Total Gross Margin (Tk.) per farmer for 4 goat rearing	26800/-

FSRD Site: Chanduria, Rajshahi

Four farmers reared male and female goats/sheeps willingly under fattening program at FSRD site, Chanduria, Rajshahi. Each farmer reared one goats/sheeps. OFRD team provided a improved technology. The technology protected them from different diseases and goat growth enhanced rapidly. Survival rate was 100%. After 6-10 months rearing, the goat weight was increased. On an average gross margin was found Tk. 2750/- from each goat and accordingly all farmer earned Tk. 11000/- for rearing of 4 goats (Table 3.18.2).

Table 3.18.2 Performance of goat/sheep rearing at farmers level at FSRD Site Chanduria, Rajshahi during the years of 2019 to 2022

Description of Items	Average year^{-1}
Number of farmers	4
Number of goats/sheeps reared	4
Procurement price goat^{-1} (Tk.)	3750/-
No. of goat survive	100%
Total return (Tk.) goat^{-1}	7250/-
Total variable cost (Tk.) goat^{-1}	4500/-
Gross margin (Tk.) goat^{-1}	2750/-
Total Gross Margin (Tk.) for 4 farmer of 4 goat rearing	11000/-

3.19 Performance of Sonali chicken at different FSRD sites during the years of 2019 to 2022

FSRD Site: Basantapur, Rajshahi

At the FSRD site in Basantapur, Rajshahi, the Sonali chicken rearing program was held. Ten farmers in the hamlet were chosen for poultry production, and each received about 13 Sonali chicks per year from a regional government chicken farm (male to female ratio is 1:10). All Sonali chicken, as well as deshi chickens, were vaccinated according to the recommended timetable. The initial body weight of each bird was 0.37-0.52 kg. In the first, second, and third years, a total of 1385, 1125, and 1280 eggs were produced, respectively. In the first, second, and third years, total income per household was Tk. 14887, 12850, 14090, and gross margin was Tk. 9287, 7700, 8590, respectively (Table 3.19.1). Farmers showed their interest in rearing Sonali chicken due to their growth and number of eggs.

Table 3.19.1. Performance of Sonali chicken rearing programme during 2019-2022 at the FSRD Site, Basantapur,Rajshahi (Per family)

Description of item	Year I	Year II	Year III
No. of farmer	12	8	10
No. of bird distributed	192	96	120
No. bird /farmer distributed	16	12	12
Age of bird (month)	2	3	3
Avg. wt. of bird during distribution period (kg)	0.37	0.51	0.52
Avg. procurement price per bird (Tk.)	100	120	125
Rearing period (month)	9	8	8
Total egg production (No.)	1385	1125	1280
Income (Tk.) from egg (sale + consumption+ distribution)	10387	9000	10240
Avg. price of bird (Tk.)	300	350	350
Income (Tk.) from alive bird (sale + consumption+ distribution)	4500	3850	3850
Total income in Tk. (Egg + bird)	14887	12850	14090
Variable cost (Purchase value of chicken/bird + fed cost + health management cost)	5600	5150	5500
Gross Margin in Tk. (Total income –Variable cost)	9287	7700	8590

A comparison between before and after intervention in income from egg and bird are shown in Table 3.19.2. Before intervention, income from egg was Tk.688 and from bird it was Tk. 1450 which turned into Tk. 10104 from egg and Tk.4020 from bird after intervention. Total income from chicken was increased by 561%.

Table 3.19.2. Comparative income information (before intervention and after intervention) on chicken rearing

Description of item	Before intervention		After intervention		Increment over before intervention		% Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg								
Sale	50	400	740	5920	690	5520	1380	1380
Consumption	36	288	490	3920	454	3632	1261	1261
Distribution	-	-	33	264	33	264		
Total income from egg	86	688	1263	10104	1177	9416	1369	1369
Bird								
Sale	2	580	8	2680	6	2100	300	362
Consumption	3	870	4	1340	1	470	33	54
Distribution	-	-	-	-	-	-	-	-
Total income from bird	5	1450	12	4020	7	2570	140	177
Total income from Chicken	5	2138	15	14124	10	11986	200	561

FSRD site: Amnura, ChapaiNawabgonj

The Sonali chicken rearing program was initiated at the FSRD site: Amnura, ChapaiNawabgonj. Ten farmers in the village were chosen for Sonali chicken rearing, and each farmer received nearly 13 Sonali chicks per year (male to female ratio is 1:10) purchased from a regional government poultry farm. All purchased Sonali chickens, along with Deshi birds, were vaccinated as per the recommended schedule. The initial body weight was 0.37–0.52 kg per bird. The total number of eggs produced was 1405, 1150, and 1300 in the first, second, and third years, respectively. It was found that total income per family was Tk. 15740, 13050, and 14250 and gross margin was Tk. 10140, 7900, and 8750 in the first, second, and third years, respectively (Table 3.19.3).

Table 3.19.3. Performance of Sonali chicken rearing programme during 2019-2022 at the FSRD site: Amnura, ChapaiNawabgonj (Per family)

Description of item	Year I	Year II	Year III
No. of farmer	12	8	10
No. of bird distributed	192	96	120
No. bird /farmer distributed	16	12	12
Age of bird (month)	2	3	3
Avg. wt. of bird during distribution period (kg)	0.37	0.51	0.52
Avg. procurement price per bird (Tk.)	100	120	125
Rearing period (month)	9	8	8
Total egg production (No.)	1405	1150	1300
Income (Tk.) from egg (sale + consumption+ distribution)	11240	9200	10400
Avg. price of bird (Tk.)	300	350	350
Income (Tk.) from alive bird (sale + consumption+ distribution)	4500	3850	3850
Total income in Tk. (Egg + bird)	15740	13050	14250
Variable cost (Purchase value of chicken/bird + fed cost + health management cost)	5600	5150	5500
Gross Margin in Tk. (Total income –Variable cost)	10140	7900	8750

A comparison between before and after intervention in income from egg and bird are shown in Table 3.19.4. Before intervention, income from egg was Tk.1200 and from bird it was Tk. 1740 which turned into Tk. 10280 from egg and Tk.4020 from bird after intervention. Total income from chicken was increased by 386%.

Table 3.19.4. Comparative income information (before intervention and after intervention) on chicken rearing

Description of item	Before intervention		After intervention		Increment over before intervention		% Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg								
Sale	100	800	800	6400	700	5600	700	700
Consumption	50	400	400	3200	350	2800	700	700
Distribution	-	-	85	680	85	680		
Total income from egg	150	1200	1285	10280	1135	9080	757	757
Bird								
Sale	2	580	8	2680	6	2100	300	362
Consumption	4	1160	4	1340	0	0	0	0
Distribution	-	-	-	-	-	-		
Total income from bird	6	1740	12	4020	6	2280	100	131
Total income from Chicken	6	2940	12	14300	6	11360	100	386

FSRD site: Chanduria, Rajshahi

The program was conducted at the FSRD site, Chanduria, Rajshahi. Twelve farmers were selected from two villages for poultry rearing and average 19 numbers of Sonali chicks were supplied each farmer every year (ratio between male and female is 1:10) which was purchased from regional government poultry farm. All purchased Sonali chicken along with deshi birds were vaccinated as per recommended schedule. The initial body weight was 0.29 kg per bird. Avg. 1042 number of eggs produced from each family. It was found that after intervention, Avg. income per family was Tk.17550 and Avg. gross margin was Tk. 15050 (Table 3.19.5) which is higher than that of before intervention (Income: Tk. 2960 and GM: Tk. 2360/family).

Table 3.19.5. Performance of Sonali and Improved Deshi chicken rearing programme during 2019-2022 at the FSRD site, Chanduria, Rajshahi

Description of item	Before intervention (Deshi)	After intervention			
		Year I (Sonali)	Year II (Sonali)	Year III (Improved Deshi)	Avg.
No. of farmer	12	12	12	12	12
Total no. of bird distributed	72	216	240	216	224
Avg. no. of bird distributed /family	-	18	20	18	19
Age of bird (month)	2.5	2.5	02	2.5	2.3
Avg. wt. of bird during distribution period (kg)	-	0.30	0.25	0.31	0.29
Avg. procurement price per bird (Tk.)	200	140	120	200	153
Rearing period (month)	12	04	06	06	5.3
Total egg production (No./family)	56	1075	1189	862	1042
Income from egg (sale + consumption+ distribution) (Tk./family)	560	10750	11890	8625	10422
Avg. price of bird (Tk.)	400	450	460	485	465
Income from alive bird (sale + consumption+ distribution) (Tk./family)	2400	6750	7360	7275	
Total income in Tk. (Egg + bird)	2960	17500	19250	15900	17550
Total variable cost (Purchase value of chicken/bird + fed cost + health management cost) (Tk./family)	600	2500	3500	1500	2500
Gross Margin (Tk./family)	2360	15000	15750	14400	15050

* Year I= Oct. 2019- Sep. 20; Year II= Oct. 2020- Sep. 2021; Year III= Oct. 2021- March 2022

Comparison between before and after intervention in income from egg and bird are shown in (Table 3.19.6). Before intervention, income from egg was Tk.560 and from bird was Tk. 2400 which turned into Tk. 10420 from egg and Tk.7200 from bird after intervention. Total income from chicken was increased by 495%.

Table 3.19.6. Comparative income information (before intervention and after intervention) on chicken rearing

Description of item	Before intervention		After intervention		Increment over before intervention		% of Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg	56	560	1042	10420	986	9860	1761	1761
Sale	20	200	715	7150	695	6950	3475	3475
Consumption	36	360	327	3270	291	2910	808	808
Distribution	-	-	-	-	-	-	-	-
Total income from egg	56	560	1042	10420	986	1120	1761	200
Bird	6	2400	16	7200	10	4800	167	200
Sale	4	1600	12	5400	08	3800	200	236
Consumption	2	800	04	1800	02	1000	100	125
Distribution	-	-	-	-	-	-	-	-
Total income from bird	06	2400	16	7200	10	4800	167	200
Total income from chicken	06	2960	16	17620	10	14660	167	495

FSRD Site: Jiarokhi, Kushtia

This event took place at the FSRD location in Jiarikhi, Kushtia. Twelve farmers in the hamlet were chosen for poultry breeding, and each was given an average of ten Sonali chicks per year (male to female ratio is 1:10), which were obtained from a regionally known chicken farm. All Sonali chicken and deshi birds were vaccinated according to the approved schedule. The original body weight of each bird was 0.50-0.55 kg. In the first, second, and third years, the total number of eggs produced was 750, 650, and 700, respectively. In the first, second, and third years, total income per farm was Tk. 39696, 34684, 37324, and gross margin was Tk. 18096, 17404, 17884, respectively (Table 3.19.7).

Table 3.19.7. Performance of Sonali chicken rearing program during 2019-2022 at the FSRD site, Jiarokhi, Kushtia (Per family)

Description of item	Year I	Year II	Year III
No. of farmer	12	12	12
No. of bird distributed	120	96	108
No. bird /farmer distributed	10	8	9
Age of bird (month)	1	1	1
Avg. wt. of bird during distribution period (kg)	0.50	0.55	0.50
Avg. procurement price per bird (Tk.)	130	135	140
Rearing period (month)	6	6	6
Total egg production (No.)	750	650	700
Income (Tk.) from egg (sale + consumption+ distribution)	6000	5200	5600
Avg. price of bird (Tk.)	312	324	308
Income (Tk.) from alive bird (sale + consumption+ distribution)	33692	29484	31724
Total income in Tk. (Egg + bird)	39696	34684	37324
Variable cost (Purchase value of chicken/bird + fed cost + health management cost)	21600	17280	19440
Gross Margin in Tk. (Total income –Variable cost)	18096	17404	17884

Comparison between before and after intervention in income from egg and bird are shown in Table 3.19.8. Before intervention, income from egg was Tk.2700 and from bird was Tk. 14000 which turned into Tk. 6750 from egg and Tk. 35568 from bird after intervention.

Table 3.19.8. Comparative income information (before intervention and after intervention) on chicken rearing Jiarokhi, Kushtia

Description of item	Before intervention		After intervention		Increment over before intervention		% Increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg	300	2700	750	6750	450	4050	150	150
Sale	100	900	400	3600	300	2700	300	300
Consumption	200	1800	300	2700	100	900	50	50
Distribution	0	0	50	450	50	450	100	100
Total income from egg	300	2700	750	6750	450	4050	150	150
Bird	50	6500	120	15600	70	9100	140	140
Sale	30	8400	60	18720	30	10320	100	123
Consumption	20	5600	44	13728	24	8128	120	145
Distribution	0	0	10	3120	10	3120	100	100
Total income from bird	50	14000	114	35568	64	19968	128	143

FSRD Site: Kamalbazer, Sylhet

Sonali chicken rearing program was conducted at the FSRD Site: Kamalbazer, Sylhet. Two households were selected in the village for poultry rearing and in an average each farmer was supplied almost 50 number of Sonali chicks every year with maintaining the male and female ratio of 1:10, which was purchased from nearby recognized poultry farm. All purchased Sonali chicken along with deshi birds were vaccinated as per recommended schedule. The initial body weight was 0.25 kg per bird. Total number of eggs produced was 2562, 4480, 5039 in first, second and third year respectively. It was found that total income per family was Tk.58744, 88160,103668 and gross margin was Tk. 35246, 52896, 62200 in first, second and third year respectively (Table 3.19.9).

Table 3.19.9. Performance of Sonali chicken rearing programme during 2019-2022 at FSRD Site, Kamalbazer, Sylhet during 2019-2022

Description of Item	Year I	Year II	Year III
Numbers of farmers	1	2	3
No of birds distributed	70	86	108
No of birds/farmers distributed	70	43	36
Age of bird (month)	1	1	1
Avg. wt. of bird during distributed period (Kg)	0.25	0.25	0.25
Avg. procurement price per bird (Tk.)	130	130	130
Rearing period (month)	8	8	8
Total egg production (No.)	2562	4480	5039
Income (Tk.) from egg (sale + consumption + distribution)	30744	53760	60468
Avg. price of bird (Tk.)	400	400	400
Income (Tk.) from alive bird (sale + consumption + distribution)	28000	34400	43200
Total income in Tk. (egg + bird)	58744	88160	103668
Variable cost (Purchase value of chicken/bird + fed cost + health management cost)	23498	35264	41467
Gross margin in Tk. (Total income – variable cost)	35246	52896	62200

Comparison between before and after intervention in income from egg and bird are shown in Table 11.19.10. Before intervention, income from egg was Tk.30744 and from bird was Tk. 28000 which turned into Tk. 53760 from egg and Tk.34400 from bird after intervention.

Table 3.19.10. Comparative income information (before intervention and after intervention) on chicken rearing

Description of Item	Before intervention		After intervention		Increment over before intervention		% Of increment over before intervention	
	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)	No.	Income (Tk.)
Egg								
Sale	1767	21204	3449	41388	1682	20184	95	95
Consumption	695	8340	900	10800	205	2460	29	29
Distribution	100	1200	131	1572	31	372	31	31
Total income from egg	2562	30744	4480	53760	559	23016	22	22
Bird								
Sale	55	22000	63	25200	8	3200	15	15
Consumption	13	5200	21	8400	8	3200	62	62
Distribution	2	800	2	800	0	0	0	0
Total income from bird	70	28000	86	34400	16	6400	23	23

3.20 Performance of Khaki Campbell duck at different FSRD sites during the years of 2019 to 2022

FSRD site: Basantapur

Among the twelve, two farmers were reared duck in their homestead using their pond. The average egg laid by the duck 120-210 no. month^{-1}household^{-1} (Table 3.20.1). Consumption of egg was 60-65 numbers after starting the duck rearing. Monthly income was calculated about Tk. 1800-2000 month^{-1}household^{-1}.

Table 3.20.1 Performance of improved breeds of duck (Khaki Campbell) after 6 months of rearing at FSRD Site during the years of February 2018 to December 2020.

Name of Farmer	No. of ducks survived at present	Body wt. after 6 months (kg)	Production of egg month^{-1}	Consumption of eggs month^{-1}		Monthly income (Tk.)
				Before	After	
Rony	9	1.1	180	0	60	1800
Al-Amin	10	1.12	200	0	65	2000
Average	9	1.11	190	0	62	1900

FSRD site: Chanduria, Rajshahi

Among the twelve, six farmers reared duck in their homestead using their pond only nine months. The average egg production was found to be 260 no. household^{-1} (Table 3.20.2). Consumption of egg was 55 numbers month^{-1} homestead^{-1} after starting the duck rearing. Income was calculated about Tk. 4350 household^{-1}.

Table 3.20.2. Performance of improved breeds of duck (Khaki Campbell) after 6 months of rearing at FSRD Site during the years of February 2018 to December 2020.

No. of duck farmer	No. of ducks per homestead	Duck rearing month	Avg. Production of egg (No. homestaed^{-1})	Consumption of eggs month^{-1}		Income (Tk. homestead^{-1})
				Before	After	
6	5	9	260	0	55	4350

FSRD site: Kamalbazar, Sylhet

Among the twelve, two farmers were reared duck in their homestead using their pond. The average egg laid by the duck 230-242 no. month^{-1}household^{-1} (Table 3.20.3). Consumption of egg was 84-120 numbers during the period of duck rearing. Monthly income was calculated about Tk. 4650-7920 month^{-1}household^{-1}.

Table 3.20.3 Performance of improved breeds of duck (Khaki Campbell) after 8 months of rearing at FSRD site, Kamalbazar during the years of March 2020 to November 2020.

Name of Farmer	No. of ducks survived at present	Body wt. after 8 months (kg)	Production of egg month^{-1}	Consumption of eggs month^{-1}		Monthly income (Tk.)
				Before	After	
Ibrahim	30	2.34	230	0	84	7920
Anser Ali	25	2.54	242	0	120	4650
Average	27.50	2.44	236	0	144	6285

3.21 Performance of pigeon rearing at different FSRD sites, Basantapur, Rajshahi during the years of 2019 to 2022

On an average, each farmer had 5 pairs of pigeon. The pigeon gave 1 pair of squabs in each 2 months. So, farmer earned av. Tk. 2600/- during the activities from rearing of pigeon (Table 3.21.1).

Table 3.21.1 Performance of pigeons at farmers household at FSRD Site: Basantapur,Rajshahi during 2019-2022

Farmer	No of pigeon/family	Average body wt. (g)	No. of Squab born	Pigeon died	Squab intake	Sell	Income (Tk)
Farmer (Av.)	10	400	30	04	14	12	2600

3.22 Performance of green fodder production at household level

FSRD Site: Basantapur, Rajshahi

The production of Napier grass was 80 and 68 t ha^{-1} and the average gross margin was calculated Tk. 38000 and 2800 ha^{-1} in 2019-20) and 2020, respectively (Table 3.22.1). The average green fodder yield was 74 t ha^{-1} and average gross margin was Tk. 33000 ha^{-1}. The last year yield was hampered due to flood.

Table 3.22.1. Average performances of Napier grass production

Year	No. of harvesting	Green fodder yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
2019-20	-	-	-	-	-
2020-21	17	80	80000	42000	38000
2021-22	14	68	68000	40000	28000
Av.	*16*	*74*	*74000*	*41000*	*33000*

3.23 Performance of Farmyard Manure production at different FSRD sites during the years of 2019 to 2022

FSRD Site: Basantapur, Rajshahi

Farmyard Manure (FYM): Farmyard manure was producing by using cowdung and homestead wastage at the homestead area during 2019-2022. The average production of FYM per homestead was 1050 kg and the gross margin was equivalent to Tk.1400 homestead^{-1} (Table 3.23.1).

Table 3.23.1. Average performances of compost production and utilization per year per homestead

Intervention	Total compost produce (kg homestead^{-1})	Use for crop production (kg farmer^{-1})	Distribution (kg farmer^{-1})	Sell (kg farmer^{-1})	Value of total compost produce per year (Tk. Homestead^{-1})	TVC (Tk. Homestead^{-1})	Gross margin (Tk. homestead^{-1})
Before	320	320	0	0	640	200	440
After	1050	720	0	330	2100	700	1400

FSRD site: Chanduria, Rajshahi

Farmyard Manure (FYM): Farmyard manure was producing by using cow dung and homestead wastage at the homestead area during 2019-2022. The average production of FYM per homestead was 800 kg and the gross margin was equivalent to Tk.1000 homestead^{-1} (Table 3.23.2).

Table 3.23.2. Average performances of compost production and utilization per year per homestead

Intervention	Total compost produce (kg homestead^{-1})	Use for crop production (kg farmer^{-1})	Distribution (kg farmer^{-1})	Value of total compost produce per year (Tk. Homestead^{-1})	TVC (Tk. Homestead^{-1})	Gross margin (Tk. homestead^{-1})
Before	0	0	0	0	0	0
After	800	650	150	1200	200	1000

D. Improvement of Fisheries Production System

3.24 Maximization of farmers' income through carp polyculture technique at different FSRD sites during the years of 2019 to 2022

FSRD Site: Basantapur, Rajshahi

Carp polyculture program was conducted at 9 ponds of the cooperator farmer's homestead area in 2019-20 and 10 ponds in 2020-21 and 2021-22. Table 3.24.1 shows the average area of the ponds, the number of fry and their weight, the total number of fish, the survival rate, and so on. The ponds were 6.5 decimal in area and 1.60 meters in depth on an average. The survival rate of carp fishes in polyculture system was found to be 80-85 percent.

Table 3.24.2 indicates the average performance of individual carp species. Average weight of silver carp was 1156 g after 180 days from stocking whereas maximum body weight increase was found from Ruhi (673%). Table 3.24.3 presents yield, cost, and return analysis. After intervention, the average fish yield was 119 kg per pond with a gross margin of Tk. 10102 per pond. Farmers consumed a portion of the total production, gave it to relatives, and sold it on the local market. Farmers sold the majority of the fish (50 percent), consumed approximately 42 percent, and distributed around 8 percent of the fish to their neighbors, family, and well-wishers. Farmers benefited from the carp polyculture system, and they expressed an increased interest in carp polyculture farming.

Table 3.24.1 Performance of fish farming (carp polyculture) at FSRD Site, Basantapur, Rajshahi during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year I	6.5 and 1.60	22.50 kg and 170 nos.	130.00	850	110 kg and 136 no.	80
Year II	6.5 and 1.60	23.00 kg and 165 nos.	135.00	870	126 kg and 144 no.	85
Year III	6.5 and 1.60	23.00 kg and 172 nos.	133.00	860	122 kg and 141 no.	82
Average	6.5 and 1.60	22.83 kg and 169 nos.	132.67	860	119 kg and 140 no.	82

Table 3.24.2. Average performance of individual carp species under polyculture system at FSRD site, Basantapur, Rajshahi during 2019 to 2022

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase % over initial
Silver carp	21.5	208	39.5	1156	456
Ruhi	14.8	97	32.0	750	673
Mrigal	16.5	93	31.0	675	626
Average	17.60	133	34	860	547

Table 3.24.3 Fish production, and income before and after Intervention at FSRD site, Basantapur, Rajshahi during 2019 to 2022

Description	Production Before intervention (kg)		Production after Intervention (kg)				
			Production kg pond^{-1}				Average production kg ha^{-1}
	pond^{-1}	ha^{-1}	Year I	Year II	Year III	Average	
Total production (kg)	28	1064	110	126	122	119	4522
Gross return (Tk.)	3360	127680	13200	16380	15860	15147	575573
Total cost (Tk.)	1150	43700	4525	5240	5370	5045	191710
Gross margin (Tk.)	2210	83980	8675	11140	10490	10102	383863

Table 3.24.4 Utilization pattern of fishes before and after Intervention at FSRD site, Basantapur, Rajshahi during 2019 to 2022

Description	Before Intervention (kg Pond^{-1})	After Intervention (kg pond^{-1})				
		Year I	Year II	Year III	Average	Average (%)
Consumption (kg)	22	50	52	48	50	42
Distribution (kg)	6	8	10	9	9	8
Selling (kg)	-	52	64	65	60	50
Total production (kg)	28	110	126	122	119	100

FSRD Site: Amnura, Chapai Nawabganj

Table 3.24.5 provides data on pond area, fry number and weight, final total amount and number of fish, and survival rate. During 2019-20, 2020-21 and 2021-22, 8 ponds were chosen for carp fish polyculture. The ponds were 5 decimals in size and 1.50 meters in depth. The average survival rate of carp fishes here was 82 percent, according to the findings.

Information on average performance of individual carp species can be found in Table 3.24.6. Average weight of silver carp was 946 g after 180 days from stocking whereas maximum body weight increase (%) was found from Mrigal (598%). Table 3.24.7 indicates the yield and economic analysis. Average fish production was 95 kg per pond with net returns of Tk. 7772. Among the total production farmers consumed about 57%, sold 33% and distributed about 10% to their neighbor's, relatives and well-wishers from the produced fish (Table 3.24.8). The marginal farmers were benefitted by carp polyculture system and they showed further interest for farming of carp polyculture.

Table 3.24.5. Performance of fish farming (carp polyculture) at FSRD site, Amnura, Chapai Nawabganj during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year I	5.0 and 1.50	17.50 kg and 150 nos.	117.00	755	93 kg and 123 no.	82
Year II	5.0 and 1.50	17.00 kg and 155 nos.	112.00	748	90 kg and 121 no.	78
Year III	5.0 and 1.50	18.00 kg and 160 nos.	113.00	760	103 kg and 136 no.	85
Average	5.0 and 1.50	17.50 kg and 155 nos.	114.00	754	95 kg and 127 no.	82

Table 3.24.6. Average performance of individual carp species under polyculture system at FSRD site, Amnura, Chapai Nawabganj during 2019 to 2022

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase % over initial
Silver carp	16	160	37.0	946	491
Ruhi	13.5	95	30.0	650	584
Mrigal	14.2	96	32.0	670	598
Average	14.5	117	33.0	755	545

Table 3.24.7 Fish production, and income before and after Intervention at FSRD site, Amnura, Chapai Nawabganj during 2019 to 2022

Description	Production Before intervention (kg)		Production after Intervention (kg)				
			Production kg pond^{-1}				Average production kg ha^{-1}
	pond^{-1}	ha^{-1}	Year I	Year II	Year III	Average	
Total production (kg)	20	988	93	90	103	95	4693
Gross return (Tk.)	2400	118560	11160	11700	13390	12083	596917
Total cost (Tk.)	1000	49400	4125	4240	4570	4312	212996
Gross margin (Tk.)	1400	69160	7035	7460	8820	7772	383921

Table 3.24.8 Utilization pattern of fishes before and after Intervention at FSRD site, Amnura, Chapai Nawabganj during 2019 to 2022

Description	Before Intervention (kg Pond^{-1})	After Intervention (kg pond^{-1})				
		Year I	Year II	Year III	Average	Average (%)
Consumption (kg)	16	50	55	58	54	57
Distribution (kg)	4	9	12	10	10	10
Selling (kg)	-	34	23	35	31	33
Total production (kg)	20	93	90	103	95	100

FSRD Site: Chanduria, Rajshahi

Carp fish polyculture technology was implemented on 6 seasonal ponds at the FSRD site. The average size of ponds were 6 decimal and depth of water was 1.5 m. After 7 days of pond preparation, fingerlings were acclimatized in pond water and released in the pond. The average initial weight of fry (89 g), final average weight (795 g), total amount and number of fry (100 kg and 123) and survival rate (84.6 %) are shown in Table 3.24.9. Average body weight increased by 917 % over initial body weight (Table 3.24.10) after 180 days from stocking. The findings revealed that average yield of fish after intervention was 100 kg per pond with an average gross margin of Tk. 9775 per pond (Table 3.24.11). Among the average total production they consumed, distributed to relatives, and sell their products in local market. It was observed that, farmers sold most of the fish (65%), consumed about 28% and distributed about 7% to their neighbors, relatives and well-wishers of the produced fish (Table 3.24.12). The farmers benefitted by carp polyculture system, and they showed their interest in farming of carp polyculture.

Table 3.24.9. Performance of carp polyculture fish farming at FSRD site, Chanduria, Rajshahi during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year I	6 and 1.5	14 kg and 164 nos.	87	980	125 kg and 128 no.	78
Year II	6 and 1.5	15 kg and 171 nos.	90	830	120 kg and 145 no.	84.8
Year III	6 and 1.5	10 kg and 114 nos.	89	575	55 kg and 96 no.	84
Average	6 and 1.5	13 kg and 150 nos.	89	795	100 kg and 123 no.	84.6

Table 3.24.10 Average performance of individual carp species under polyculture system at FSRD site, Chanduria, Rajshahi during 2019 to 2022

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase % over initial
Silver carp	16	110	38	1030	836
Catla	13	100	29	875	775
Ruhi	12.8	85	33	812.5	856
Mrigal	14	70	34	807.5	1054
Grass carp	13	80	30	1000	1150
Average	13.8	89	33	905	917

Table 3.24.11 Fish production and income before and after Intervention at FSRD site, Chanduria, Rajshahi during 2019 to 2022

Description	Production Before intervention (kg)		Production after Intervention (kg)				
			Production kg pond^{-1}				Average production kg ha^{-1}
	pond^{-1}	ha^{-1}	Year I	Year II	Year III (3 Months)	Average	
Total production (kg)	60	2470	125	120	55	100	4117
Gross return (Tk.)	10500	432250	21875	19200	10450	17175	707037
Total cost (Tk.)	4150	170842	10500	8500	3200	7400	304633
Gross margin (Tk.)	6350	261408	11375	10700	7250	9775	402404

Table 3.24.12 Utilization pattern of fishes before and after Intervention at FSRD site, Chanduria, Rajshahi during 2019 to 2022

Description	Before Intervention (kg Pond^{-1})	After Intervention (kg pond^{-1})			
		Year I	Year II	Year III	Average
Consumption (kg)	16	35	32	17	28
Distribution (kg)	4	9	8	4	7
Selling (kg)	40	81	80	34	65
Total production (kg)	60	125	120	55	100

FSRD Site: Jiaroki, Kushtia

Six seasonal ponds were chosen for carp polyculture program at the FSRD site. The ponds ranged in size from 21 decimal in length to 1.52 m in depth. Fingerlings were released into the pond after 7 days of pond preparation and acclimatization with pond water. Table 3.24.13 shows the average initial weight of fry (73 g), ultimate weight (845 g), total amount and number of fry (200 kg and 236), and survival rate (77 percent). Information on average performance of individual carp species can be found in Table 11.24.14. Average weight of silver carp and rajputi was 1000 g after 180 days from stocking whereas maximum body weight increase (%) was found from silver carp (900%). The average fish yield after intervention was 200 kg per pond with an average gross margin of Tk. 12809 per pond (Table 3.24.15). Farmers sold the majority of the fish they produced (62 percent), consumed approximately 27 percent, and dispersed around 11 percent to their neighbors, family, and well-wishers (Table 3.24.16). Farmers benefited from the carp polyculture method, and they expressed interest in carp polyculture system.

Table 3.24.13. Performance of carp polyculture fish farming at FSRD site, Jiarokhi, Kushtia during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year I	21 and 3.50	20.00 kg and 286 nos.	70.00	750	161 kg and 215 no.	75
Year II	21 and 3.50	22.50 kg and 306 nos.	73.50	885	209 kg and 236 no.	77
Year III	21 and 3.50	24.50 kg and 325 nos.	75.50	900	231 kg and 257 no.	79
Average	21 and 3.50	22.33 kg and 306 nos.	73.00	845	200 kg and 236 no.	77

Table 3.24.14 Average performance of individual carp species under polyculture system at FSRD site, Jiarokhi, Kushtia during 2019 to 2022

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase % over initial
Silver carp	13.2	100	39.8	1000	900
Catla	10	110	30	750	582
Ruhi	10	120	31	800	567
Mrigal	12	110	31.6	900	718
Rajputi	12.5	120	27	1000	733
Average	11.54	112	32	890	700

Table 3.24.15 Fish production and income before and after Intervention at FSRD site, Jiarokhi, Kushtia during 2019 to 2022

Description	Production Before intervention (kg)		Production after Intervention (kg)				
			Production kg pond^{-1}				Average production kg ha^{-1}
	pond^{-1}	ha^{-1}	Year I	Year II	Year III	Average	
Total production (kg)	30	353	161	209	231	200	2354
Gross return (Tk.)	2700	31770	28980	37620	41580	36000	423720
Total cost (Tk.)	1000	11770	6500	7200	7900	7200	84744
Gross margin (Tk.)	1700	20000	22480	30420	33680	28800	338976

Table 3.24.16 Utilization pattern of fishes before and after Intervention at FSRD site, Jiarokhi, Kushtia during 2019 to 2022

Description	Before Intervention (kg Pond^{-1})	After Intervention (kg pond^{-1})				
		Year I	Year II	Year III	Average	Average %
Consumption (kg)	10	50	52	60	54	27
Distribution (kg)	5	20	21	24	22	11
Selling (kg)	15	91	136	147	125	62
Total production (kg)	30	161	209	231	200	100

FSRD Site: Kamalbazar, Sylhet

At the FSRD sites, a program of carp polyculture in seasonal ponds was implemented with the goals of increasing farmer income and alleviating rural people's protein deficiency. Under this program, 8 selected farmers from two villages received fish fries/fingerlings. The growth of fish was measured every 15 days with periodic checks. Weeds and wild fish were removed from the pond for fish cultivation, and the pond was limed at a rate of 1 kg/decimal, as well as prepared for stocking with organic manure (cow dung) at a rate of 3 kg/decimal.

Average size of the ponds was 20 decimals with 1.5 m depth. The result revealed that average survival rate was 79%. Average yield and number of fish was 347 kg/pond and 395 per pond respectively (Table 3.24.17). Performance of individual carp species can be found in Table 3.24.18. Maximum average weight (1020) and body weight increase (%) (1033%) after 180 days were found from silver carp. Total production, consumed, distribution, selling and economic analysis are shown in Table 3.24.19. It was observed that in Kamalbazar, Sylhet total production was 347 kg pond^{-1} with the gross margin of 22880 Tk. pond^{-1}. Farmers sold most of the fish (46%) among total production (Table 3.24.20). The farmers were benefitted by carp polyculture system, and they showed interest for farming of carp polyculture.

Table 3.24.17 Performance of carp polyculture fish farming at FSRD site, Kamalbazar, Sylhet, during 2019 to 2022

Year	Average area and depth of pond (dec. and m)	Amount and number of fingerlings	Avg. weight of fingerlings (g)	Average weight of fish at harvest period (g)	Total amount and number of fishes at harvest period	Survival rate (%)
Year I	20 dec &1.5m	40.5 kg (479)	84.6	877	340 kg (388)	81
Year II	20 dec &1.5m	44 kg (568)	78.2	890	390 kg (438)	77
Year III	20 dec &1.5m	38 kg (472)	81	830	310 kg (373)	79
Average	20 dec &1.5m	41 kg (506)	82	866	347 kg (395)	79

Table 3.24.18. Average performance of individual carp species under polyculture system at FSRD site, Kamalbazar, Sylhet, during 2019 to 2022.

Spices	Initial size (cm)	Initial wt. (g)	Size after 180 days (cm)	Weight after 180 days (g)	Body wt. increase % over initial
Silver carp	13	90	31.8	1020	1033
Catla	10	85	24	815	859
Mrigal	12	70	27	760	986
Average	12	82	27	865	959

Table 3.24.19. Fish Production and income before and after intervention at FSRD site, Kamalbazar, Sylhet, during 2019 to 2022.

Description	Production Before intervention (kg)		Production after intervention (kg)				
			Production kgpond^{-1}				Average production kgha^{-1}
	Pond^{-1}	ha^{-1}	Year I	Year II	Year III	Average	
Total production (kg)	275	3396	340	390	310	347	4285
Gross return (Tk.)	30250	373560	37400	42900	34100	38133	470943
Total cost (Tk.)	12100	149424	14960	17160	13640	15253	188375
Gross margin (Tk.)	18150	224136	22440	25740	20460	22880	282568

Table 3.24.20. Utilization pattern of fishes before and after intervention at FSRD site, Kamalbazar, Sylhet, during 2019 to 2022.

Description	Before intervention (kgPond^{-1})	After intervention (kgpond^{-1})				
		Year I	Year II	Year III	Average	Average (%)
Consumption (kg)	110	130	120	170	140	40
Distribution (kg)	35	30	50	60	47	14
Selling (kg)	130	180	220	80	160	46
Total Production (kg)	275	340	390	310	347	100

E. Off-Farm Activities

Besides of agricultural production, some farm families' especially the women were engaged with weaving *Katha*, sewing cloths with machine, bee keeping and making different handicrafts with jute rope during their leisure periods. Some farmer had autoriksha, two-wheel tractor and rented them with custom hiring basis. Sometimes, one farmer also sale his labor as a cook.

3.25 Maximization of farmers' income through Off-farm activities at different FSRD sites during the years of 2019 to 2022

FSRD site: Basantapur, Rajshahi

Off-farm activities, in addition to agricultural activities, are an effective way to boost farm total revenue. Initially, one family makes dresses on a custom-hire basis. Four households are initially hauling the manual van. Following the intervention, we educated the recipients on the importance of converting the vans to be powered. As a result, they converted them, and their income increased. The average gross margin improved by 85 percent following intervention, with an average gross margin of Tk. 35362. (Table 3.25.1). It would be beneficial to boost total farm revenue if all households could engage in certain off-farm activity.

Table 3.25.1 Average economics of off-farm activities at FSRD site, Basantapur, Rajshahi during 2019 to 2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
Sewing cloth	7800	2120	5680	11893	3000	8893	57
Van pulling	38500	6000	32500	80400	19875	60525	86
Average	23150	4060	19090	46146	11438	34709	82

MLT site: Amnura, Chapainawabganj

At the Amnura, Chapainawabganj site, almost every household engaged in off-farm enterprises such as 2-wheel tractor driving, mechanical katha sewing, grocery shop, livestock business, kumra bora, and so on. The average two income categories are included in this research. The gross margin improved by 108 percent following intervention, with a gross margin of Tk. 26000. (Table 3.25.2).

Table 3.25.2 Average eeconomics of off-farm activities at FSRD site, Amnura, ChapaiNawabgonj during 2019 to 2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
2WT operator	30000	15000	15000	55000	22500	32500	117
Sewing Katha mechanically	15000	5000	10000	32500	8575	23925	139
Average	22500	10000	12500	43750	15538	28213	126

FSRD site: Chanduria, Rajshahi

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Initially one household was started handicrafts making and finally most of the households were practiced handicrafts besides of other off-farm activities.It was found that after intervention the average gross margin increased by 95%, with the average gross margin of Tk. 5252 (Table 3.25.3). So, if all households could introduce some off-farm activities, it would be helpful to increase total farm income.

Table 3.25.3 Economics of off-farm activities at FSRD Site, Chanduria, Rajshahi, 2019 to 2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
Sewing machine	3500	800	2700	6050	1650	4400	63
Handicrafts-Bag (Jute rope)	4600	1200	3400	9405	2310	7095	109
Handicrafts-Mat (Jute rope)	2500	500	2000	4950	990	3960	98
Average	3533	833	2700	6802	1650	5252	95

FSRD Site: Jiarokhi, Kushtia

Off-farm activities such as sewing clothing and manufacturing Kantha were practiced by three households. Off-farm activities were found to generate good cash revenue, which helped resource-poor farmers make ends meet to some extent. Following the intervention, the net profit from off-farm activities was Tk. 15000 farm-1 (Table 3.25.4). As a result, if all households could engage in some off-farm activities, it would be beneficial to raise their total farm revenue, which would help to improve the rural household's livelihood.

Table 3.25.4 Economics of off-farm activities at FSRD Site, Jiarokhi, Kushtia during 2019 to 2022

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
Khata making	12000	3000	9000	54000	18000	36000	300
Sewing	0	0	0	12000	3000	9000	100
Average	4000	1000	3000	22000	7000	15000	400

FSRD Site: Kamalbazer, Sylhet

Off-farm activities such as Kantha manufacturing and honey production utilizing a honey box were done by four households. It was discovered that after the intervention of kantha (Table 3.25.5) as well as farmers employing this product for their personal purpose, a gross margin of

Tk. 6000 was obtained. Honey production had only recently begun following intervention, and growers intended to profit in the future.

Table 3.25.5 Economics of Off-farm activities at FSRD site Kamalbazar, Sylhet, during 2019 to 2022

Types of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin (GM) increase (%)
	GR	TVC	GM	GR	TVC	GM	
Kantha making	1500	400	1100	9000	3000	6000	445
Bee keeping	-	-	-	8000	4500	3500	-
Average	1500	400	1100	8500	3750	4750	332

F. Income Enhancement

FSRD site: Basantapur, Rajshahi

Farmers' resources (land, labor, capital, etc.) have been used optimally by integrating year-round vegetable production, HYV seeds, improved cropping patterns, and production technologies, de-worming, vaccination program, and Carp polyculture. As a result, farmer's income has increased, which may lead to improved livelihood. Before the project's intervention, the average per farm gross return and gross margin were Tk. 763525 and Tk. 443197, respectively, whereas after the project's intervention, they were Tk. 445450 and Tk. 263265. (Table 3.26.1).

Table 3.26.1 Technologies used and return from different component of farming systems at FSRD Site, Basantapur, Rajshahi during 2019 to 2022.

Name of component	Cost & return before intervention (Tk.)			Cost and return after intervention (Tk.) (avg.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	4580	825	3855	25753	3472	22282	18427	378
Field crop	385540	162450	225090	562630	228175	334455	109365	49
Livestock	28820	15800	13020	113849	72200	41649	28629	219
Fisheries	3360	1150	2210	15147	5045	10102	7892	357
Off-farm	23150	4060	19090	46146	11438	34709	15619	81
Total	445450	184285	263265	763525	320330	443197	179932	68

MLT site: Amnura, Chapainawabganj

Farmers' resources (land, labor, capital, etc.) have been utilised efficiently thanks to the integration of year-round vegetable production, HYV seeds, improved cropping patterns and production technology, de-worming, vaccination program, and Carp polyculture. The average per farm gross margin was Tk. 197925 prior to the project's intervention, but it increased to Tk. 373011 after the project's activities were implemented (Table 3.26.2). In comparison to prior intervention, the average increase in gross margin was 88 percent.

Table 11.26.2 Technologies used and return from different component of farming systems at FSRD site, Amnura, ChapaiNawabgonj during 2019 to 2022

Name of component	Cost & return before intervention (Tk.)			Cost and return after intervention (Tk.) (avg.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	4280	875	3405	24141	3995	20145	16740	492
Field crop	283520	115250	168270	434035	177327	256708	88438	53
Livestock	27850	15500	12350	115333	55160	60173	47823	387
Fisheries	2400	1000	1400	12083	4312	7772	6372	455
Off-farm	22500	10000	12500	43750	15538	28213	15713	126
Total	340550	142625	197925	629342	256332	373011	175086	88

FSRD Site: Chanduria, Rajshahi

The results of integrated farming using a holistic approach showed a significant increase in total farm productivity and profitability. Farmers' income has increased as a result of the enhanced technology and resources available to them, which may lead to improved livelihood. During three consecutive years, the highest return was obtained from the field crop, followed by livestock. Year-round vegetables and fruits on the farmhouse, on the other hand, had a significantly larger economic return. In terms of return on investment (percentage increase) over prior status, the homestead sector had the greatest growth (301 percent), followed by cattle (242 percent) (Table 3.26.3). Overall gross margin was increased by 58% per family per year.

Table 3.26.3 Technologies used and feedback from different component of farming systems at FSRD Site, Chanduria, Rajshahi during 2019 to 2022

Name of component	Cost & return before intervention (Tk.)			Cost and return after intervention (Tk.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	8244	3978	4244	19367	2325.33	17042	12798	301
Field crop	164940	81508.8	120624	270075	104849	165229	44605	37
Livestock	55960	48100	7860	82087	55207	26880	19020	242
Fisheries	10500	4150	6350	17175	7400	9775	3425	54
Off-farm	3533	833	2700	6802	1650	5252	2552	95
Total	256006	126051	129955	406922	201859	205163	75208	58

FSRD Site: Jiarokhi, Kushtia

Farmers' resources (land, labor, and capital) have been used optimally by integrating year-round vegetable production, improved cropping patterns and production technologies, de-worming, vaccination program, and carp polyculture. As a result, farmer's income has increased, which may lead to improved livelihood. The agriculture sector was shown to have the highest return. Fisheries had the second greatest gross margin rise, followed by Housing. The livestock component, as well as off-farm activities, played a significant role in increasing farm income (Table 3.26.4).

Table 3.26.4 Technologies used and return from different component of farming systems at FSRD Site, Jiarokhi, Kushtia during 2019 to 2022

Name of component	Cost & return before intervention (Tk.)			Cost and return after intervention (Tk.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	2040	1000	1040	13440	8000	5440	4400	423
Nearby Homestead	0	0	0	3000	1000	2000	2000	100
Field crop	408300	158215	250085	471970	162262	309708	59623	24
Livestock	60000	47125	12875	82600	55000	27600	14725	114
Fisheries	2700	1000	1700	36000	7200	28800	27100	1594
Off-farm	12000	3000	9000	66000	21000	45000	36000	300
Total	485040	210340	274700	673010	254462	418548	143848	52

FSRD Site: Kamalbazer, Sylhet

By integration of year-round vegetables production, HYV seeds, improved cropping patterns and production technologies, de-worming, vaccination program, carp polyculture, the resources (land, labour, capital, etc.) of the farmers have used optimally and therefore farmer's income have been increased markedly. It was observed that maximum return recorded from the homestead area which was 2421% increased after intervention of technologies. The second highest gross margin increased from off-farm activities that was 332% followed by livestock (50%). The average increment of gross margin after intervention was 26 % compared to before intervention (Table 3.26.5).

Table 3.26.5 Technologies used and return from different component of farming system at FSRD site, Kamalbazar, Sylhet, during 2019 to 2022.

Name of component	Cost & return before intervention (Tk.)			Cost & return After intervention (Tk.)			Gross margin increased after intervention	
	Gross return	Total variable cost	Gross margin	Gross return	Total variable cost	Gross margin	Amount (Tk.)	%
Homestead	420	150	270	10642	3833	6808	6538	2421
Nearby Homestead	6720	1500	5220	35493	9567	25927	20707	397
Field crop	762620	1487364	1920326	4135415	1754894	2380521	460195	24
Livestock	58400	35246	23498	88160	52896	35264	11766	50
Fisheries	30250	12100	18150	38133	15253	22880	4730	26
Off-farm	1500	400	1100	8500	3750	4750	3650	332
Total	859910	1536760	1968564	4316343	1840193	2476150	507586	26

G. Integration Among Different Components

3.27 Feasibility study on integration among different household components at different FSRD sites during the years of 2019 to 2022

Integration is carried out to recycle resources as efficiently as possible (Fig 1). Livestock droppings and feed waste can be put directly into the pond to provide feed for fish and zooplankton, ensuring environmentally friendly integration. Livestock excrement can be used to nourish grass or other plant growth, which can then be utilized as fish food. The fishponds can be utilized to irrigate vegetables, and the wastes and byproducts can be used to feed livestock. However, most manure lost up to half of its nitrogen content before it was converted to nitrate and used as fertilizer by plants. The quantity also became inadequate as the population increased, so chemical fertilizers and artificial feeds had to be purchased, eroding the small profits of the small farmers.

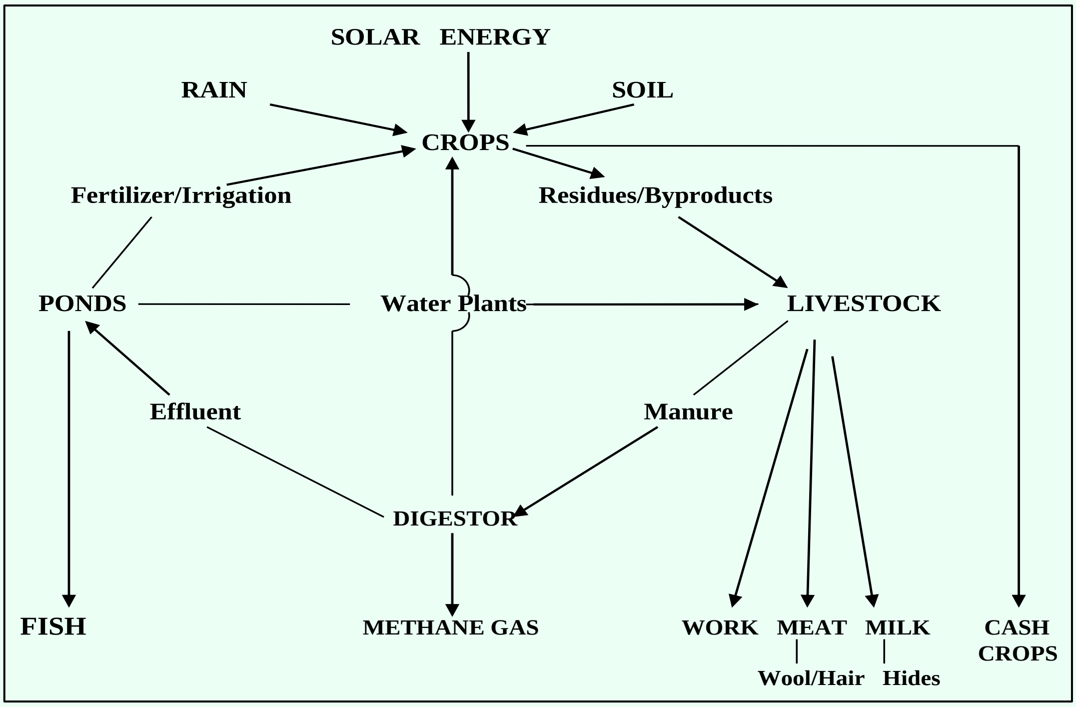

Fig. 1: Flow diagram of Integrated Farming

H. Livelihood Improvement (sustainability)

The term "means of securing the essentials of life (food, water, shelter, and clothes)" refers to a person's "means of securing the fundamental necessities of existence." A person's livelihood is described as a set of actions that are necessary for daily life and are carried out throughout one's life. Securing water, food, medication, shelter, and clothing are examples of such activities. A person's livelihood is determined by their ability to obtain the aforementioned necessities in order to meet their own and their family's basic needs. Improvement of livelihoods is a complicated system.Increasing the ability to earn enough money, the security of nutritious and secure food, medical treatment, education, assets, and an acceptable living leading to social standing may all contribute to improved livelihood (Table 3.27.1). However, the characteristics that were considered for the long-term viability of livelihood improvement at various FSRD sites are listed below.

Table 3.27.1 Livelihood improvement parameters (sustainability) have been made after intervention of the project activities at different FSRD sites during the years of 2019 to 2022.

Sl. No.	Area of consideration	Impact created	Indicator to assess the sustainability
1	Income enhancement	Gross margin increased by 68-88%	– Production of vegetables and fruits in homestead area was increased considering time and space properly – Production was done in integrated way (crop, livestock, fisheries, agroforestry) to minimize production cost and maximize yield – Used STB or FRG for balanced fertilization of crops (Cereals, Oilseeds, Vegetables etc.) – Used of modern varieties – Innovative technologies and mechanization – Used fallow land under cultivation – Increased farmers production skill due to training

2	Family nutrition	Improved satisfactorily	– Vegetable intake from homestead source increased 400-700% – Fruit intake from homestead source increased 100-200% – Fish and poultry meat and egg production and intake increased remarkably – Changed in consumption habit towards vegetables and fruit – Reduced no. of attack and frequency of diseases
3	Soil health	Maintenance/ Increased	– Used of organic matter (FYM) – Decreased the use of insecticides/chemicals due to use of organic matter and IPM technology
4	Resource use pattern	Increased	– Used homestead (100%) – Introduction of homestead vegetables production model for respective site using 8 to 10 production niches. – Every inch of land was used with time and space
5	Technical knowledge	Increased sharply	– Young girls and boys are engaged for implementation of new technologies – Training, field days, LSP activities, fortnightly meeting with field staffs and farming group and exchange of views with different type of peoples.
6	Adaptation innovation	Increase of 60-70%	– New crops, varieties are used and BARI Masur-8 and BARI Sarisha-17 deiminated rapidly in the project period. – Used of recommended fertilizers – Used of different preservation and curative measures of food and seeds – LSP activities
7	Employment	Increased	– Used of unutilized family labor – Women participation in Agricultural activities (Homestead vegetables, livestock, duck and poultry rearing, compost making) the new technology and created employment. – LSP development
8	Micro-environment	Improved	– Household wastes being used for composting and their used in crops – Used of IPM/bio-pesticides saved environment from pollution. – New plantation and increased vegetables contribute to favorable environment
9	Housing	Improved	– New house and repairing of house help in improve living
10	Social status	Improved	– Increased access of better living standard to people – Improved mental strength due to higher income, development of skill on technologies and public conduct.
11	Education	Improved	– Women empowerment especially increased income made them to educate their children for a better future.
12	Women participation	Increased	– Homestead vegetables cultivation – Tree plantation and nursing – Composting – Seed preservation - Homestead mini nursery – Cow, Poultry and Duck rearing – All these ensured women empowerment

Farmer's opinion

The resource poor farmers are interested to adopt those technologies which can provide additional production and quick return in terms of cash income. They are mostly vulnerable to their decision and shift of other activities. Due to adoption of integrated farming, they are hopeful to maintain their family with farm income. The increased productivity, gross margin and nutrition supplementation from the homesteads source made them confidant for livelihood improvement.

Impact

- Farmers gathered knowledge about component basis innovative technologies due to which they grow their awareness about integrated farming systems activities for better maintenance of their life.
- Women were specially participated in homestead-based activities like vegetable production, taking care of fruit trees, poultry rearing, cattle rearing and composting because they were rained up about the relevant technologies.
- In the recent days school girls and children are included in the homestead activities especially vegetable gardening and poultry rearing.
- Farmers were motivated to implement integrated holistic approach because they got cash income from different enterprises.

Limitations of the study

- Scarcity of residual soil moisture particularly in Barind area.
- Homestead activities hampered sometimes due to laborious work and shortage of manpower
- Lack of strong multidisciplinary scientific team to implement the program
- Lack of skillness of site level staffs and the farm family members for optimum production and accurate data collection
- Quality of inputs need to be ensured

Conclusion

An integrated farming system is an eco-friendly approach in which waste of one enterprise becomes the input of another thus making efficient use of resources. From the study it was revealed that the components of farming system like home gardening, cropping system, dairying, poultry, fishery, etc. are interrelated. The waste of dairying like dung, urine, refuse etc. is used for preparation of FYM, which is an input in cropping systems. The straw obtained from the crops is used as fodder for cattle are used for different field operations for growing crops. Thus, different enterprises of farming systems are highly interrelated. The vital indicator for livelihood improvement is increasing income compared to existing condition, which was successfully obtained from the program. So, the proper utilization of farmer's resources can help them in this area. However, integrated farming system is a very promising technology for livelihood improvements of farmers but it needs multidisciplinary well experienced strong scientific team for more successful integration of technologies.

CLIMATE RESILIENT FARMING SYSTEMS RESEARCH AND DEVELOPMENT FOR THE COASTAL ECOSYSTEM

1. Introduction

Bangladesh is the third most vulnerable country in terms of population exposed to sea level rise. Coastal areas of Bangladesh are also a hub of hydro meteorological disasters including cyclones, tidal surges, floods, drought, soil salinity, saline water intrusion, waterlogging, and land subsidence. This has a direct bearing on livelihoods as agriculture provides employment for over 60 percent of the population in Bangladesh and it is a key economic activity for the 40 million inhabitants in the coastal zone. The agricultural system is heavily dependent on environmental factors such as the timing, intensity and distribution of the monsoon, soil salinity and the availability of freshwater for irrigation. Anticipated climate change effects suggest that total rainfall in the coastal area is unlikely to decrease. Moreover, higher temperatures, changes in monsoon timing and predictability, sea-level rise and land subsidence driven by natural and human activities will make farming less secure as a livelihood unless there is improved farm management. In this context, it has become an urgent need to demonstrate modern agricultural technologies through "Integrated farming or Mixed Crop-Livestock System Approach" rather than seasonal or crop specific approach to that particular soil and micro-climatic conditions especially at Coastal areas. The subsistence farms in coastal areas are highly diversified with complex relationships among the various sub-system and the enterprises within a subsystem. While there are different production alternatives, farmers have a limited set of resources. A holistic approach to technology generation and packaging is essential to achieve this result through maximizing the complementary interactions among the different farming enterprises/ production system and the biophysical and socio-economic environment. So the program was designed to develop integrated farming technologies to maximize farm productivity and efficient use of resources, to modify/fine tune on-station technologies generated by OFRD, BARI, Patuakhali of coastal ecosystems and to integrate component technologies (crops, livestock, fisheries, agro- forestry and homestead gardening, etc.) for improving farm practices, establish linkage with different stakeholders.

Approaches and Methodologies

The program was conducted at Farming System Research and Development site (FSRD) located at Jamla, Dumki, Patuakhali during 2021-22. According to the objective resource poor farmers viz. marginal, small and medium having major components of farming and sizable homestead under single ownership were targeted and twelve farm households from each site covering four farmers from each category were selected. The detail information regarding livelihoods pattern of each household especially total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year were documented. Based on the potentials, suitable technological options were addressed and accordingly farmers' selected suitable technologies were adjusted with their need for livelihood improvement.

Results and Discussions

A. Crop component

Year-round vegetables production in homestead

The activity was conducted at the FSRD site Jamla, Dumki, Patuakhali during 2021-22. BARI developed `Lebukhali model' (Table 1) was modified on the basis of farmers choice and ecology of the region to use in Jamla, FSRD site for homestead year-round vegetable production. In modified Ledukhali model only f0ur nieces were used instead of previous seven. Fence, Shady place and Marshy Land nieces were removed as they were not available in the homestead. Nearby fallow space incorporated in the model that was used as sorjan system of vegetable production. Cropping pattern in open sunny place was also modified presented in Table 2. Seeds of different vegetables were distributed among six farmers of 3 categories i.e. medium, small and marginal.

For implementing Modified Lebukhali model, five beds were prepared by each farmer. Intercultural operation and management practices were done by the farmers following recommended practices.

Table 1. Lebukhali model includes seven production units as follows:

Niche/space		Year round homestead vegetable pattern		
		Rabi	*Kharif I*	*Kharif II*
Open sunny space	Bed-1	Red amaranth + Radish	Brinjal	Brinjal
	Bed-2	Red amaranth + Nolkhol	Okra	Indian spinach
	Bed-3	Coriander leaf + cabbage	Stem amaranth	Kangkong
	Bed-4	Red amaranth + Brinjal	Kangkong	Kangkong
	Bed-5	Red amaranth + Tomato	Indian spinach	Indian spinach
Trellis		Cucumber, Bitter gourd	Ribbed gourd	-
Non-fruit trees		-	Sponge gourd/Yam	Sponge gourd/Yam
Pond/ditch slope		Bottle gourd	Bitter gourd	-

Table 2. "Modified Lebukhali Model" includes Four production units as follows:

Niche/space		Year round homestead vegetable pattern		
		Rabi	Kharif I	Kharif II
Open sunny space	Bed-1	Tomato + Spinach	Indian Spinach	
	Bed-2	Brinjal + Red Amaranth	Kangkong	
	Bed-3	Nolkhol + Coriander leaf	Stem Amaranth	Okra
	Bed-4	Cauliflower + Spinach	Okra	Red Amaranth
	Bed-5	Radish + Red Amaranth	Stem Amaranth	Red Amaranth
Trellis		-	-	Ribbed gourd /Snake gourd
Non-fruit trees		-	Sponge gourd/Yam	Sponge gourd/Yam
Pond/ditch slope		Bottle gourd/Sweet gourd	Bitter gourd	

Vegetable and fruit production increased 55% for Marginal, 185% for small and 125% for medium farmers over before intervention of modified Lebukhali model at FSRD site, Jamla, Dumki, Patuakhali (Table 3&4). Homestead vegetable production as well as consumption, distribution and selling increased after intervention. Consumption, distribution and selling of vegetables increased about 41%, 0%, 53% for marginal farmer, 121%, 37%, 205% for small farmer and 100%, 40%, 136% for medium farmer respectively over before intervention in FSRD site Jamla, Duki, Patuakhali (Table-5).

Table 3. Round the year vegetables and fruits production from different nichesunder Farming System Research homestead during July 21-June 2022

Farm Categories	Spaces	Before intervention		After intervention (2021-22)		Avg. Incr. %
		Prod^n (kg)	Income (Tk.)	Prod^n (Kg)	Income (Tk.)	Income (%)
Marginal	Open sunny place	10	200	55	1100	450
	Trellis	15	300	22	440	47
	Non-fruit trees	12	240	15	300	25
	Pond/ditch slope	35	700	40	800	14
	Total (Veg)	**72**	**1440**	**132**	**2640**	83
	Fruit	18	720	20	800	11
	Total (Veg+Fruit)	**90**	**2160**	**152**	**3440**	59
Small	Open sunny place	20	400	65	1300	225
	Trellis	26	520	30	600	15
	Non-fruit trees	16	320	16	320	0
	Pond/ditch slope	42	840	48	960	14
	Total (Veg)	**132**	**2640**	**159**	**3180**	20
	Fruit	22	880	30	1200	36
	Total (Veg+Fruit)	**154**	**3520**	**189**	**4380**	24
	Open sunny place	16	320	75	1500	369

Farm Categories	Spaces	Before intervention		After intervention (2021-22)		Avg. Incr. %
		Prod^n (kg)	Income (Tk.)	Prod^n (Kg)	Income (Tk.)	Income (%)
Medium	Trellis	22	440	35	700	59
	Non-fruit trees	14	280	18	360	29
	Pond/ditch slope	45	900	56	1120	24
	Total (Veg)	**162**	**3240**	**184**	**3680**	14
	Fruit	20	800	35	1400	75
	Total (Veg+Fruit)	**182**	**4040**	**219**	**5040**	25

Table 4. Round the year vegetables and fruits production and utilization pattern before and after Intervention during July 21- June 2022

Farmers category	Description	Before Intervention		After Intervention	
		Veg. (kg)	Fruits (kg)	Veg. (kg)	Fruits (kg)
Marginal	Consumption	25	6	35	8
	Distribution	0	0	0	0
	Selling	47	12	97	12
	Total prod^n	**72**	**18**	**132**	**20**
	GR (Tk.)	1440	720	2640	800
	VC (Tk.)	375	0	600	200
	NR(Tk.)	**1065**	**720**	**2040**	**600**
Small	Consumption	45	7	65	12
	Distribution	12	0	0	6
	Selling	75	15	94	12
	Total prod^n	**132**	**22**	**159**	**30**
	GR (Tk.)	2640	880	3180	1200
	VC (Tk.)	500	200	800	350
	NR(Tk.)	2140	680	2380	850
Medium	Consumption	62	15	90	20
	Distribution	15	5	0	5
	Selling	83	0	94	10
	Total prod^n	**162**	**20**	**184**	**35**
	GR (Tk.)	3240	800	3680	1400
	VC (Tk.)	500	250	900	400
	NR(Tk.)	2740	550	2780	1000

Vegetables avg. price=20 Tk/kg, Fruits avg. price=40 Tk/kg.

Table 5. Increment of consumption, distribution and selling of different categories of farmer during July 21- June 2022

Farmers category	Disposal event	Vegetable			Fruit		
		Before Intervention	After intervention	Avr. increment (%)	Before Intervention	After intervention	Avr. increment (%)
Marginal	Consumption	25	35	40	6	8	33
	Distribution	0	0	0	0	0	0
	Selling	37	97	162	12	12	1
	Total prod^n	**62**	**132**	**112**	**18**	**20**	**11**
Small	Consumption	45	65	44	7	12	71
	Distribution	12	0	0	0	6	100
	Selling	75	94	25	15	12	-20
	Total prod^n	**132**	**159**	**20**	**22**	**30**	**36**
Medium	Consumption	62	90	45	15	20	33
	Distribution	15	0	0	5	5	0
	Selling	83	94	13	0	10	100
	Total prod^n	**162**	**184**	**15**	**20**	**35**	**75**

Intervention of modern varieties of field crops

Participatory variety selection trials on Aman Rice: Generally, co-operative farmers cultivated local T. Aman in Kharif II season. They prefer local rice varieties having tall seedling and bolder grain. So, to select T. Aman modern varieties like local a Participatory variety selection trial on Aman Rice was conducted with the co-operative farmers. According to their choice three modern rice varieties i.e. BR-23 and BARI dhan-52 were supplied during Kharif-2 of 2021. The highest yield (4.06 t ha^{-1}) was found from BRRI dhan52 whereas farmers preferred BR23 as water level in the field was high during the growing season.

Table 6. Average Yield of different T. Aman rice varieties at selected farmers of FSRD site, Jamla, Patuakhali during Kharif II season of 2021-22

Varieties	Mean Yield (t ha^{-1})	Avr. local rice yield (t ha^{-1})
BR23	3.85	3.17
BRRI dhan52	4.06	

Intervention of Rabi crop varieties: Scope of Rabi field crop cultivation is very limited due to late harvest of Aman rice. Moreover remaining excessive moisture in field delay land preparation for Rabi crops by this time sowing period of maximum Rabi crops passed away. So a very few corps could be cultivated in Rabi. The crops that could be sown after Mid-January should be selected to cultivate.Chilli, Mung, Sunflower, Groundnut are such crops and their yield performance also satisfactory. Relaying of Grasspea is common in the region but most of years these two crops damaged by unusual rainfall during Rabi season. Moreover their yield performance is also poor.

Table 7. Average yield and economic analysis of different *Rabi* crops in production program trials during 2021-22

Crops	Varieties	Mean Yield (t ha^{-1})		Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
		Trial field	Farmer's field			
Sunflower	BARI Surjamukhi-2	1.76	1.72 (Hysun)	114400	75500	38900
Mungbean	BARI Mung-6	1.78	1.25	106800	45000	61800
Chilli	BARI Morich-1	1.90	0.95 (local)	285000	95600	189400
Groundnut	BARI Chinabadam-8	2.80	1.46 (Dhaka-1)	168000	80000	88000
Aus rice	BRRI dhan-48	3.56	-	71200	45650	25550

Price (Tk./Kg): Chilli =150, Mungbean =60, Sunflower =65, G.Nut=60 and Aus =20

Saplings distributions: Each farmer received five types of fruit saplings and the average number of samplings per farmer was 23. The survival rate of dragon , lemon and malta was 80% whereas the survival rate of mango and guava was 90%.

Table 8**.** Name of the varieties of supplied saplings among the co-operative farmers at FSRD sites, Patuakhali

Varieties of the saplings		No. of Saplings/fermer	Survival rate (%)
Mango	BARI Mango-4	05	90
Dragon fruit	BARI Dragon-1	04	80
Guava	BARI Peyara-2	05	90
Malta	BARI Malta-1	05	80
Lemon	Local	03	80

Fruit trees of homestead were fertilized twice in a year. Pesticide and fungicides were sprayed in mango trees in 06co-operative farmers and 05 another farmers of the side. The fruit trees were irrigated in drip system throughout the dry period. Fruit production was highest in case of medium category of farm due to abundance of different fruit species along with space for fruit trees in the homestead. On the other hand fruit production, consumption and distribution was found lowest in marginal category of farm due to less diversity of fruit trees. Moreover, selling of fruit is comparatively higher in all cases due to good market price and demand of fruit throughout the year.

Table 9. Per farm fruit Production and utilization pattern at FSRD site, Patuakhali, 2021-22

Fruit	Production	Consumption (kg)	Distribution (kg)	Sold (kg)	Gross return (Tk.)
Mango	15 Kg	10 kg	05 kg	-	750
Guava	18 Kg	06 kg	04 kg	08 kg	540
Velvet apple	8 Kg	03 kg	-	05 kg	480
Jack fruit	04 nos	03 nos	01 nos		360
Coconut	20 pair	05 pair	02 pair	13 pair	800
					3230

B. Livestock Component

For improvement of cattle health and control diseases and mortality rate proper vaccination is a key program. Farmers' would be economically benefitted through de-worming of cattle because improvement of its health. Proper vaccination against major diseases reduces the mortality rate of cattle. In the vaccinated group Anthrax Vaccine and FMD vaccine were injected as per recommended schedule. Poultry rearing are common practices in the site. Poultry disease is the main problem faced by the farmers for poultry rearing. Only proper vaccination can reduce the mortality rate of poultry. To reduce mortality rate this program was conducted at the site. The supplied and their own poultries were vaccinated during 2021-22. The BCRDV, RDV and Fowl pox vaccine for Chick and the Duck plague vaccine for ducks were used as per recommended schedule.

Improvement of cattle health by de-worming and vaccination

De-worming and vaccination program was carried out at the FSRD sites, Jamla, Dumki, Patuakhali throughout the project period. Thirty cattle including 03 milking cows owned by the cooperative farmers were selected for de-worming and vaccination (Table 10). Second dose of de-worming was given 35-40 days interval as per body weight of the cattle recommended by concerned personnel of ULO, Dumki, Patuakhali. However, the information regarding de-worming cattle and performance are presented in Table 7b. It was observed that de-worming is an easy process to adopt with minimum cost. It was also observed that among the vaccinated cattale no anthax disease was found and incidence of foot and mouth disease was only 01% that is 88% lower than before of vaccination (Table-11).

Table 10. Livestock covered by de-worming and vaccination program at FSRD site Jamla, Dumki, Patuakhali

Livestock Type	De-worming	Vaccination
Cattle	20	Anthrax (20), Foot and Mouth (20)

Table 11. Effect of cattle vaccination at FSRD site, Jamla, Dumki, Patuakhali

Diseases	Before vaccination (%)	After vaccination (%)
Anthrax	08	0
Foot and Mouth	10	01

Calf rearing

Five co-operativefarmers were engaged in calf rearing. They bought calf from local market and brought up them in their yard with locally available fodder and residue of homestead.

Table 12. Income from beef fattening during 2021-22

Name of Farmers	Total calf	Rearing cost	Income (Tk.)	Net Income (Tk.)
Abdul Mannan Khan	03	35400	97600	62200
Anwar HossainMrida	03	42000	95300	53300
ManikHawlader	02	16500	42000	25500
Paresh Chandra	02	26300	81600	55300
KabirHossain	01	10500	34700	24200
Avr. income				220500

Vaccination program on poultry production

This program was conducted at FSRD site, Jamla, Dumki, Patuakhali during 2021-22. The vaccination of poultry program has created a great awareness to the co-operative farmers and neighborhood farm families the site**.** It revealed that, mortality rate can be minimized significantly through vaccination **and it goes down belo**w 5% most of the cases in the sites which can be considered as negligible comparing to the condition before the vaccination program**.** After vaccination of poultry, all of the diseases frequency reduced drastically and mortality rate came below 8% (Table 13) and this type of program is mostly impacted on concern farmer and so far they would follow to vaccinate the poultry in routinely.

Table 13. Number of birds vaccinated and mortality rate before and after vaccination at FSRD site, Jamla, Dumki, Patuakhali in coastal ecosystem during 2021-22

Name of poultry	Name of vaccine	No. of bird vaccinated	Mortality before Vaccination (%)*	Mortality after Vaccination (%)*
Chicken	BCRDV	60	45	10
	RDV	800	70	6
	FOWL POX	110	55	4
Duck	Duck plague	100	70	5

Poultry rearing

Almost every participatory household family in the site keep small flocks of indigenous domestic fowl and ducks under a backyard management system although indigenous poultry are poor producers of eggs and meat. There has no systematic breeding program and close inbreeding occurs among indigenous stocks. Moreover, to meet the increasing demand of meat new and non-traditional poultry were distributed among the farmers of FSRD site Jamla, Dumki, Patuakhali. Systematic rearing system such as feed management, housing management, egg hatching mud pot and vaccination program for chickens and ducks were done according to plan of activities in the site for enhanced meat and egg production. The average initial body weight of sonali chicks was 60-75g during distribution. Final body weight was 1.24 kg. Average total return per farmer was Tk 6900 and gross margin per farmer were Tk. 3800 (Table.14)

Table 14. Average performances of Sonali chicken for meet purpose at farmers' level after 6 months of rearing at FSRD site Jamla, Dumki, Patuakhali during 2021-22

SL. No.	**Description of Item**	2021-22
01.	Number of farmers	06
02.	No of birds supplied per farmers	10
03.	Initial body wt/bird (g)	65
04.	Procurement price/bird (Tk.)	25
05.	No of chicken survive/farmer	8
06.	Weight gained/bird (Kg) after 6 month	1.24
07.	**Egg Production (Number)**	120
08.	Consumption	30
09.	Sale	50
10.	Distribution	0
11.	Hatch	35

SL. No.	Description of Item	2021-22
12.	Damage	05
13.	Total income from chick rearing (Tk.)	6900
14.	Total variable cost (Tk)	3100
15.	Gross margin (Tk)	3800

Small scale pigeon rearing in farmer's household

Pigeons rearing are a traditional practice in rural household of coastal region. It is a low cost income generation event of rural people. Squabs soup is very delicious and use as a tonic to gain energy escaping weakness in ill period. Pigeon is a very good source of protein and rapid income generation as it is very prolific breeder and its meat is very tender and loved by all. So pigeons were supplied to cooperative farmers of FSRD site, Jamla, Dumki, Patuakhali to increase family income through squab production and to increase nutritional supply to family members.

Methodology: The activity was undertaken at the FSRD site Jamla, Dumki, Patuakhaliduring 2021. Twenty four pairs of adult pigeon were distributed to six farmers (Two pairs to each farmer) during July 2021. Local breeds of pigeons were collected from the local market. The routine works of vaccination was followed regularly and natural feeds were fed. Egg, squab production and body weight gain was monitored regularly. Technical supports (feeding and watering management, vaccination etc) and advice were also given to the farmers. Necessary treatments were also provided as per requirement.

Key findings: Average per farm squab production was 08 pair during February to June 2022. In four month squab production was 08 pair per farm of which 03 pair was stocked. Per farm squab consumption was 02 pair and sold 03 pair during 04 months. Squab stocking as well as selling increased their income. Consumption of squab also increased their nutrition. Pigeon rearing provides additional income of Tk 3000 per farm by squab stocking and selling.

Table 15: Average per farm Income from in house pigeon rearing during 2021-22

Initial stock (pair)	Present stock (pair)	Squab consumption (pair)	Squab distribution (pair)	Squab sell (pair)	Value of present stock (Tk.)	Income from selling (Tk.)
02	05	02	0	03	3000/-	600

*One pair squab price = 200/-

Key words: Pigeon, squab, nutrition, income, production

C. Fisheries Sector

In case of mono culture of mono-sex Tilapia, the growth conditions were satisfied which was harvested in November, 2021. The highest production of Tilapias (289 kg / pond) was obtained from pond 4 which size was bigger than the other ponds as well as highest gross margin (35764 TK.) and BCR (3.20) was obtained from the same pond.

Table 16. Yield and economic analysis of monosex tilapia during 2021-22 at FSRD Site, Jamla, Dumki

Pond	Total Yield (kg/Pond)	Total Cost (Tk. /Pond)	Gross Return (Tk. /Pond)	Gross Margin (Tk. /Pond)	BCR
1	29.5	1876	5310	3434	2.83
2	31.5	1876	5670	3794	3.02
3	289	16256	52020	35764	3.20
4	178	10273	32020	21747	3.00

Table 17. Disposalpattern of produced monosex tilapia culture among four farmers during 2021-22 at FSRD Site, Jamla, Dumki, Patuakhali

Pond	Total Yield (kg/Pond)	Consumption (Kg)	Distribution (Kg)	Sell (Kg)
Pond 1	29.5	5	5	19.5
Pond 2	31.5	7	3	21.5
Pond 3	289	12	10	267
Pond 4	178	12	8	158

Most of the farmers sold their monosex tilapia rather than consumption and selling was highest (267 kg) in pond no. 3 and 158 kg in Pond no. 4. Most of the farmers consume a good amount of fish and sell rest of their production whereas distribution was also higher as compared to Patuakhali.

IMPROVEMENT OF FARM PRODUCTIVITY THROUGH INTERVENTION OF IMPROVED AGRICULTURAL TECHNOLOGIES IN CHAR LAND ECO-SYSTEM

N. SULTANA AND M.S. ISLAM

Abstract

Char is a deposit of mud mostly sand as islands within the river, face the flash flood along with other natural disasters due to climate change. The modern agricultural technologies are not properly disseminated in the char land due to scattered, isolated and disconnected transport network. Char areas of Bangladesh are also a hub of hydro meteorological disasters like unpredictable flash flood, seasonal drought, soil erosion and so on. To keep the above issues in the mind, the project activities were identified and prioritized to maximize the farm productivity and farmers benefits with efficient use of famer's existing resources. The activities of the project were initiated from early February 2018 at the FSRD Site, Charkharicha, Mymensingh and FSRD Site, Charpara, Sonatala, Bogura.

Farming system research and development program is an integrated farming approach for sustainable resource management approach to maximize farm productivity, farm resource use efficiency, employment opportunity, farmers' income and nutrition as well as livelihood of the resource poor farm households of char land ecosystem.With rapid increasing population and declining agricultural land, food and nutrition security of resource poor farm households through integrated farming are gaining priority.The integrated farming activities are carried out in Char land ecosystem of Mymensingh and Bogurafrom the year of 2018-19.The research areas were i*)* Homestead production system ii*)* Crops and cropping system iii*)* Poultry and livestock production system, iv*)*Fisheries production system and v*)* Off-farm activities.All components of integrated farming such as vegetables, fruits, cereal crops, livestock, fish and off-farm activities were brought under improved technological intervention and accordingly income wasgenerated from these components.In Charlandecosystem of Mymensingh and Boguraoverall results of homestead production program revealed that intake of vegetables was markedly increased (av163%)by all families included in this system.Average intake of fruits per year was also increased (av 195%) after intervention of the technology.Existing fruit tree management and new plantation has created a good impact on farm households. In Charlandecosystem of Mymensingh and Bogurafarmers obtained higher yield and economic return from their alternative or improved cropping pattern with improve variety (s) better management approaches.Two improved cropping pattern viz. Mustard-Boro-T.aman and Potato-Boro-T.aman trials were conducted in FSRD site, Char Kharicha and Char Anondipur, Mymensingh and one improved cropping pattern Mustard-Boro-T.aus-T.aman trials were conducted in FSRD Site, Sonatola, Bogura. Newly released high yielding crop varieties were also introduced through on farm validation program where farmers obtained higher crop yields and gross margin.Due to deworming and vaccination program body weight and milk was increased of cattle over pre intervention. Mortality ofpoultry reduced *(64-88%)* after vaccination. Among the seasonal fish culture mono sex tilapia culture gave higher gross margin *(a*vTk. 10363/pond*)* at farmers' level. Women participation in agricultural activities increased to a great extent that showed some positive effect on gender equity within the family. The daily nutritional requirements of the family members were supplemented considerably due to increased consumption of vegetables and fruits from the homestead gardening and also from fish, chicken and livestock production. Active participation of the farmers' and integration of their available resources in planned way has created a positive impact on improving livelihood of resource poor farm household. Finally, it can be concluded that interventions made in different components exerted a visible positive impact in improving farmers' socio-economic condition and livelihood of the both char land ecosystem as well.

Introduction

The subsistence farms of Bangladesh are highly diversified with complex relationships among the various sub-system and the enterprises within a subsystem. While there are different production alternatives, farmers have a limited set of resources. These resources may be utilized in such a manner that maximize farm productivity, farmers benefit and resource use efficiency in an environmentally sound and sustainable way. A holistic approach to technology generation and packaging is essential to achieve this result through maximizing the complementary interactions among the different farming enterprises/ production system and the biophysical and socio-economic environment. BARI is conducting research on different discipline through its different centres and divisions. Crop research centre and divisions are generating a good number of technologies including new cultivars/different management techniques/machines etc. for the farmers of Bangladesh. However, before transferring those to extension agencies/ NGOs and farmers they need on-farm verification/test of fine-tuning to fit into the farmers existing socio-agro-economic environments. Moreover, through on-farm trial valuable farmers' feedback is obtained to modify technology or to develop new technology. BARI has given this noble responsibility to OFRD to test those developed on–station technologies directly to the farmer's field. Proper utilization of these resources with improved technologies can ensure higher production and income generation. Bangladesh Agricultural Research Institute has developed a number of technologies which can be used for increasing production and income of the farmer. Some technologies developed by NARS institute on farming system were verified for dissemination of the technology. Department of Agricultural Extension, OFRD, BARI and many NGOs are trying to disseminate these technologies among the farmers. Under this program, year round vegetables and creeper production in homestead, plantation and management of existing trees, livestock and fisheries activities and pilot production of different cropping patterns were undertaken for livelihood improvement of the farmers. In this regard an integrated effort was made for livelihood improvement of the resource poor farm households with the following objectives-

i) To generate integrated farming technologies to maximize the farm productivity with judicious use of farm resources for charland

ii) To optimizethe homestead land use for the availability of vegetables and fruits round the year

iii) To maximize the farm productivity and efficient utilization of char land areas

iv) To create awareness about modern agriculture technology among the participating farmers

v) To integrate component technologies (crops, livestock, fisheries, agro-forestry and homestead gardening, etc.) for improving farm productivity

v) To establish linkage with different stakeholders

Methodology

Integrated Farming combines the best of modern tools and technologies with traditional practices according to a given site and situation. In char land ecosystem, Farming System Research and Development were executed in Mymensingh and Bogurawith the view to improving of crop production and nutrition, generation of income and livelihood improvement by the integration of farmer's resources.However, for the implementation of the integrated Farming System Research and Development in char land, the following methods were considered-

Location of the Project Site

Site selection has been done on the basis of climatic, edaphic, social, vegetation and economic conditions of the regions. Two villages were selected for each FSRD site i.e. Char Kharicha and char Anondipur, Mymensingh and from Bogura village Boyra and Shyampurwere selected. In Mymensingh, two selected villages has a distance of fifteen km from the sadarupazila headquarter and is located Latitude: N24^{0}49' and longitude: E 90^{0}23' (AEZ-9).In Bogura, two villages are located at N 24^{0}95' latitude and E 89^{0}52'longitude and latitude N 24^{0}95'and 89^{0}54' E longitude (AEZ-4).

Figure 1. Location of FSRD site Char Kharicha, Mymensingh (24^{0}49' N latitude and longitude: 90^{0}23' E longitude; AEZ-9)

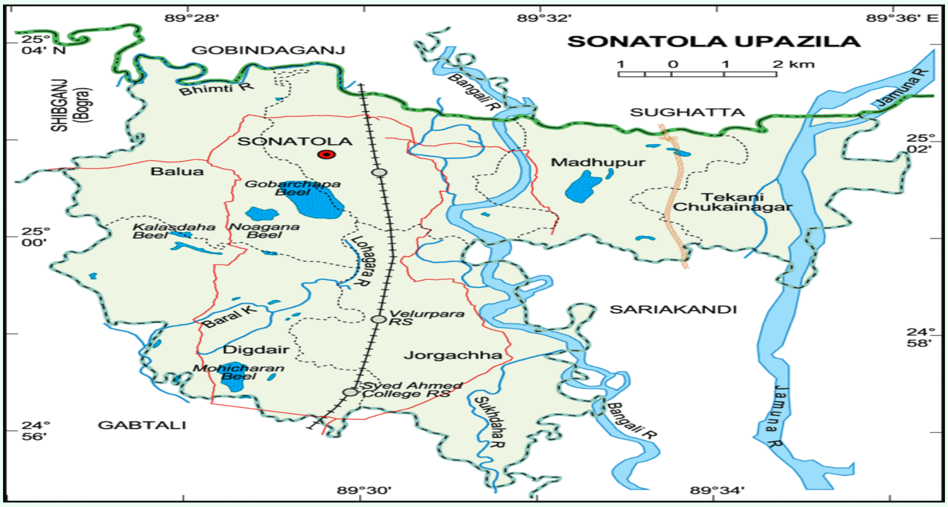

Figure 2. Location of FSRD site Char Kharicha, Mymensingh (24^{0}95' N latitude and 89^{0}52'E longitude and 24^{0}95'N latitude and 89^{0}54' E longitude; AEZ-4)

Table 1. Category-wise selected farmers information of FSRD site Char Kharicha, Mymensingh

Categories	No. of Farmer	Total farm size (ha)	Av. family size (no.)	Av. cultivated land (ha)	Av. homestead area (ha)	Av. pond area (ha)
Marginal	4	0.17	5.0	0.11	0.04	0.03
Small	4	0.95	4.75	0.78	0.08	0.04
Medium	4	2.12	7.5	1.60	0.25	0.04

Specific Methodology

The integrated farming system research activities in char land were initiated at FSRD site Char Kharicha under sadarupazila of Mymensingh district while in Bogura it was started in Charpara under Sonatalaupazila during 2018-2019 to 2020-2021. Before initiating the program, several steps were followed such as i) identification of proven/recommended technologies, ii) selection of farmer cooperator ,iii) accounting of pre-intervention status, iv) analysis of existing system and selection of technologies for intervention, v) implementation and performance evaluation. On the basis of farmer's traditional practices, their needs and choices, several alternatives of technologies such as crops, livestock, fisheries and other components were incorporated with active participation of the farmers. According to the aim of the program resource poor farmers-landless, marginal and small having major components of farming and sizable homestead under single ownership were targeted and twelve farm households covering from two to three villages were selected. Before going to implement the project activities, a baseline survey of individual households was carried out. Farmers were addressed suitable technology and best ones were selected by them with their need based for livelihood improvement. On-Farm Research Division (OFRD) team facilitated the cooperators for technological support for maximizing the productivity and identified five potential area of intervention.

Training program was arranged to buildup farmers capacity and to develop awareness regarding nutrition and crop production.An individual household survey (Benchmark survey) was carried out before starting the project activities. The detail information regarding livelihoods pattern were documented. Total resources inventory, liabilities, technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year was accounted by detail households' case study with intensive visit and cross examinations for authentication of the data before intervention. Based on the potentials suitable technological options were addressed to the farmers and accordingly farmers selected suitable technologies adjusting with their need for livelihood improvement. Year round vegetable production followed by respective location-wise model in each homestead, fruit tree management and new plantation, crops and cropping system improvement through improve cropping pattern development and promising variety piloting, vaccination of poultry and livestock, rearing of Turkey, poultry, pigeon and calf, green fodder production, fish culture and some off-farm activities were identified as their major potential area.

During the implementation period of project activities, site working group meeting, PRA, base line survey, field visit was done and field staffs were organized. On-Farm Research Division (OFRD) team facilitated the cooperators for technological intervention to maximize the productivity of the components. However, season-wise (Rabi= October-March, Kharif I= April-June &Kharif II= July-September) data on production, farm level utilization with disposal pattern, possible integration among the components, economic return focusing income and expenditure and other socio-economic information was collected and tabulated accordingly.

A. HOMESTEAD PRODUCTION SYSTEM

a) Year-round vegetable production

The fallow and un-utilized homestead areas were brought into vegetables and fruit production considering time and space. *Narekeli* model and *Goyespur* model were imposed to produce vegetables and fruits round the year at the FSRD site, Mymensingh and Bogura, respectively during the year of 2018-2020 (Table 1 and Table 2). In each FSRD site, two village were considered to conduct the activities of the project and 12 cooperator farmers were selected on the basis of their available resources and potentials for homestead farming under small farm category. A total of eight production units were considered in *Narekeli* Model while nine units were used in *Goyeshpur*Model**.** In both models,five beds were considered in sunny places where vegetables were cultivated round the year and the unit plot size 5m×1m was maintained. Each farm families consist of average 5 members. The recommended seed rate, plant spacing, fertilizer dozes and sowing dates were followed for all crops accordingly in all niches. Vegetables from different beds and niches were harvested according to their maturity and the recorded data were converted in to average. The selected farmers were provided training and suggestion by the FSRD team on year round vegetable and quick growing fruits production. Vegetables from different beds and niches were harvested according to their maturity and the recorded data were converted in to average. The produce values were calculated with the local market price for all crops.

Table 1. *Narekeli*model having eight production units practiced at FSRD site, Mymensingh

Space			Rabi	Kharif-1	Kharif-2
			October-March	April-June	July-September
1	Open sunny space	Bed-1	Tomato *Red amaranth +Red amaranth (BARI Lalshak-1)	Indian spinach (BARI Puishak-1)	Stem amaranth (BARI Data-1)
		Bed-2	Lalshak+cabbage *Radish (BARI Mula-1) +Spinach (BARI Palongshak-1)	Kangkong *Pat shak (Deshitosha)	Kangkong *Indian spinach (BARI Puishak-1)
		Bed-3	Coriander+onion *Carrot (New Kuroda-35)	Okra *Kangkong (BARI Gimakalmi-1)	
		Bed-4	Spinach+Garlic (BARI Rashun-1)	Chilli *Latirajkachu (BARI Panikachu-1)	
		Bed-5	Carrot + Bitter gourd *Onion (BARI Piaj-1)	*Stem amaranth (BARI Data-1)	*Red amaranth (BARI Lalshak-1)
2	Roof top		Country bean (BARI Sheem-1)	*Sweet gourd (Local cultivar)	-
3	Trellis				
		Trelly-1	Bottle gourd (Hybrid)	*White gourd (BARI Chalkumra-1)	Yard long bean (Local cultivar)
		Trelly-2	Country bean (BARI Sheem-1)	*Bitter gourd (Hybrid)	*Snake gourd (BARI Chichinga-1)
		Trelly-3	Country bean (BARI Sheem-1)	*Sweet gourd (BARI Mistikumra-1)	White gourd (BARI Chalkumra-1)
4	Fence		Bitter gourd (Hybrid)	*Sponge gourd (BARI Dhundol-1)	
5	Marshy land		Latirajkachu (BARI Panikachu-1)		
6	Shady Place		Turmeric, Ginger, *Moulovikachu (Locally collected)		
7	House Boundary		Papaya /Drumstick *Chewing type sugarcane (Local cultivar)	Papaya /Drumstick *Chewing type sugarcane (Local cultivar)	Papaya /Drumstick *Chewing type sugarcane (Local cultivar)
8	Unused tree				
		Creper-1	Potato yam (Local gachalu)	Potato yam (Local gachalu)	Potato yam (Local gachalu)
		Creper-2	*Country bean (BARI Sheem-1)	*Sponge gourd (BARI Dhundol-1)	*Sponge gourd (BARI Dhundol-1)

*Newly introduced crop in home garden. Text in the parenthesis is the variety name of respective crop.

Table 2. *Goyeshpur* model having nine production units practiced at FSRD site, Bogura

Niches		Rabi	Kharif-1	Kharif-2
		October- March	April-June	July-September
1. Open sunny space	Bed-1	Radish (BARI Mula-2)	Stem Amaranth (BARI Danta-1)	Indian spinach (BARI Puishak-1)
	Bed-2	Cabbage/Lalshak (BARI Patakopi-1)	Brinjal/*Corriander (BARI Bt Begun-4)	Indian Spinach (BARI Puishak-1)
	Bed-3	Tomato (BARI Tomato-16/17)	Okra/Gimakolmi (BARI Dherosh-1)	Okra (BARI Dherosh-1)
	Bed-4	*Onion/lalshak onion (BARI Peyaj-1/4)	Red Amaranth (BARI Lalshak-1)	Gimakolmi (BARI Gimakolmi-1)
	Bed 5	*Garlic (BARI Rosun-1/2)	Sweet Gourd *Pat shak (Local)	Red Amaranth (BARI Lalshak-1)
2. Roof top		Bottle gourd/sweet gourd (BARI Chalkumra-1)	Sweet Gourd/ Ash gourd (BARI Chalkumra-1)	Bottle Gourd/ Ash gourd (BARI Chalkumra-1)
3. Trellis		Bottle gourd (BARI Lau-4/local)	Sweet Gourd/ Ash gourd (BARI Mistikumra-1)	Sweet Gourd/ Ash gourd (BARI Mistikumra-1)
4. Shady Place		Turmeric/Ginger/ Olkachu (Local)	Turmeric/Ginger/ Olkachu (Local)	Turmeric/Ginger Olkachu (Local)
5. Marshy Land		PaniKachu (Local)	Panikachu (Local)	Panikachu (Local)
6. Unproductive Tree		Country bean (BARI Sheem-1/2)	Bottle gourd (BARI Lau-4/local)	Potato yam (Local)
7. Fence		Yard long bean (Local)/Country bean	Bitter gourd (BARI Korola-1)/Country bean	Sponge gourd/Ridge gourd (Local)
8. Backyard		Banana (Local), Guava (BARI Peyara-2)	Banana, Mango (BARI Aam-3/4), Jackfruit, Drumstick	Banana, Lemon, Moringa (Local)
9. House Boundary		*Dragon fruit (BARI Dragon Phol-1), Papaya/lemon (Local)	*Dragon fruit (BARI Dragon Phol -1), Papaya/lemon (Local)	*Dragon fruit (BARI Dragon Phol -1), Papaya/lemon (Local)

*Newly introduced crop in home garden. Text in the parenthesis is the variety name of respective crop.

b) Fruits production

Fruits have key role to provide necessary nutrient to boost up the immunity of human beings and thus several activities was done to produce fruits round the year in the homestead under this project tenure in both sites. The available and unutilized niches of the homestead area have been brought into fruit production with the recommendation of the program. The fallow and underutilized homestead areas were utilized scientifically considering the time and space. Improved management practices such as fertilization, irrigation, pest control and pruning was suggested to some of quick growing fruits (Papaya, Lemon, Ber, Banana etc.) along with some existing fruit trees (Mango, Jackfruit, Coconut, Olive, *Indian dellenia*, Wood apple etc.) for higher yield and quality fruit production.

B.CROPS AND CROPPING SYSTEM

a) Improvement or development of cropping pattern

This component was implemented by developing cropping pattern and development of crop production by introducing new technologies or varieties. To increase cropping intensity the existing cropping pattern was improved by inclusion of other one or two crops in char land ecosystem. All field operations and management practices were closely monitored and data were recorded accordingly. However, in FSRD site, Mymensingh three crops based two cropping patterns viz. Mustard - Boro -T.Aman rice and Potato-Boro - T.Aman were studied against the existing cropping pattern Boro - Fallow- T.Aman rice to improve the existing cropping pattern, increase cropping intensity, higher yield and economic return.The experiment was laid out in RCB design with six dispersed replications in both the years. Unit plot size was 400 m^2. All agronomic activities including sowing/transplanting and harvesting dates, seed rate, plant spacing, fertilizer management, etc. are mentioned in Table 4. Recommended fertilizer packages (FRG, 2012) following the application methods were used for all the crops. Irrigation, pest managements and other intercultural operations were done as and when necessary. Crop cut was done from an area of 3m^2 at three spots from each plot for yield samples in all cases. The data on yield and economics of all the crops were taken plot wise and stated in Table 3.

On the other hand, a four crop based cropping pattern, Mustard -Boro -T. Aus -T. Aman against Mustard -Boro-T. Aman rice cropping pattern and Wheat - Jute -T. Aman against Boro -Fallow-T. Aman were developedat FSRD site, Char Shyampur, Bogura during to improve the existing cropping pattern, increase cropping intensity, higher yield and economic return.

Table 3. Activities for improvement or development of cropping pattern at FSRD site Char Kharicha, Mymensingh, under char land ecosystem

Observation	**Improved cropping pattern**			**Existing cropping pattern**		
Cropping Pattern-I						
Crop	Mustard	Boro	T. Aman	Boro	Fallow	T. Aman
Varity	BARI Sarisha-14	BRRI dhan28	BRRI dhan56	BRRI dhan29		BRRI dhan49
Date of sowing/ Transplanting	12-14 Nov	05-07 Feb,	08-12Aug	12-18 Jan		09-13 Aug
Seed rate ((kg ha^{-1})	7.5	40	40	50		50
Spacing	Broadcast	20×15	20×15	20×15		20×15
Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	115-34-40-24-2-1	135-20-60-18-4	80-22-35-1	115-19-60-17-2		70-16-30-0-0
Date of harvesting	25-30 Jan	6 June	18-31 Oct	15 June		12-16 Nov
Field duration (days)	74-77	119-121	72-80	148-154		95
Turn around time (days)	14-25	7-10	36	61-63		-
Cropping Pattern-II						
Crop	Potato	Boro	T. Aman	Boro	Fallow	T. Aman
Varity	BARI Alu-25	BRRI dhan28	BRRI dhan56	BRRI dhan29		BRRI dhan49
Date of sowing/ Transplanting	14-18 Nov	05-07 Feb	08-12Aug	12-18 Jan		09-13 Aug
Seed rate (kg ha^{-1})	1600	40	40	50		50
Spacing	60×25	20×15	20×15	20×15		20×15
Fertilizer dose (N-P-K-S-Zn-B, kgha^{-1})	120-50-110-24-4-2	135-20-60-18-4	80-22-35-1	115-19-60-17-2		70-16-30-0-0
Date of harvesting	25-30 Jan	6 June	28-31 Oct	15 June		12-16 Nov
Field duration (days)	72-73	122-124	80-81	144-148		95
Turn around time (days)	10-17	8-11	69	61-65		53-57

The experiment was laid out in RCB design with six dispersed replications in both the years. Unit plot size was 600 m^2. All agronomic activities including sowing/transplanting and harvesting dates, seed rate, plant spacing, fertilizer management, etc. are mentioned in Table 4. Recommended fertilizer packages (FRG, 2012) following the application methods were used for all the crops. Irrigation, pest managements and other intercultural operations were done as and when necessary. Crop cut was done from an area of 3m^2 at three spots from each plot for yield samples in all cases. The data on yield and economics of all the crops were taken plot wise and stated in Table 4.

Table 4. Management practices followed in improved and existing pattern cropping at FSRD site, Bogura

Observation	**Improved cropping pattern**				**Existing cropping pattern**		
Cropping pattern-I							
Crop	Mustard	Boro	T.aus	T. aman	Mustard	Boro	T. aman
Varity	BARI Sarisha- 14	BRRI Dhan-28	BRRI Dhan-48	BRRI dhan 52	Tori-7	BRRI Dhan-28	Swarna
Date of sowing/ Transplanting	Oct 26	Jan 20	May 13-10	Aug 04-4	Oct 20	Jan 20	July 25-29
Seed rate (kg ha^{-1})	6	40	40	40	8	40	40
Spacing	Broadcast	15-20	15-20	15-20	Broadcast	15-20	15-20
Fertilizer dose (N-P-K-S-Zn-B kg ha-1)	120-70-50-30-3-1	138-21-82-20-4-0	65-11-41-0-0	90-12-53-12-0-0	95-50-40-0-0	125-18-70-15-2-0	102-20-60-16-0-0
Date of harvesting (range)	Jan 10	May 08	Aug 01	Nov 06-16	Jan 10	April 25	Nov 12-15

Observation	**Improved cropping pattern**			**Existing cropping pattern**		
Cropping pattern-II						
Crop	Wheat	Jute	T. Aman	Boro	Fallow	T. Aman
Variety	BARI Gom-30	O-9897	BRRI dhan75	BRRI Dhan28	-	Swarna
Date of sowing/ Transplanting	Nov 20	April 10	Aug 5	Jan 14	-	July 21
Seed rate (kg ha^{-1})	18	7	40	40	-	40
Spacing	Broadcast	15×20	15×20	15×20	-	15×20
Fertilizer dose (N-P-K-S-Zn-B kg ha^{-1})	115-32-45-22-0-1.5	104-12.5-38-15-0-0	90-12-53-12-0-0	138-21-82-20-4-0	-	102-20-60-16-0-0
Date of harvesting	March 28	July 27	Nov 10	April 22	-	Nov 6

b) Production program

Bangladesh Agricultural Research Institute has developed different crop varieties to popularize those one among the farmers of that area and thus improved the existing cropping system of that area. Agronomic activities imposed in crop production program are mentioned in Table 5 and Table 6.However, the details of crop management are given in result part.

Table 5. Management practices, variety, number of farmers, area covered by different crops at FSRD site, Mymensingh during 2018 to 2021

Name of crops	**Variety**	**Farmers (no)**	**Area (ha)**	**Date of sowing**	**Date of harvesting**
Okra	BARI Derosh-2	5	0.40	15-20 Mar. 2018	20 Apr-15 June2018
Bottle gourd	BARI Lau-3	6	0.53	7-10 Sep. 2018	20 Nov-30 Dec 2018
Snake gourd	BARI Chichinga-1	7	0.40	10-15 Apr. 2018	2-30 June 2018
Stem amaranth	BARI Danta-1	10	1.05	10-12 Apr. 2018	20-30 May 2018
Potato	BARI Alu-25	6	0.61	10-15 Nov. 2018	25-30 Jane 2019
Mustard	BARI Sarisha-14	8	1.01	10-15 Nov. 2018	25-30 Jane 2019

Table 6. Management practices, variety, number of farmers, area covered by different crops at FSRD site, Bogura during 2018 to 2021

Name of crops	Variety	Farmers (no)	Area (ha)	Date of sowing	Date of harvesting
Potato	BARI Alu-25 and BARI Alu-36	7	0.53	6-18 Nov, 2019	6 -13 February, 2020
Mustard	BARI Sarisha-14	12	0.40	3-12 Nov, 2019	25 Jan-10 Feb, 2020
Sweet potato	BARI Mistialu-8	2	1.05	10-15 Nov, 2019	10-15 Feb, 2020
Potato	BARI Alu-36, BARI Alu-41, BARI Alu-53 and BARI Alu-78	12	1	10-20 Nov, 2020	-
Mustard	BARI Sarisha-14 andBARI Sarisha-17	40	8	1-15 Nov, 2020	-
Sweet potato	BARI Mistialu-8	2	0.13	15-16 Nov, 2020	-

C. LIVESTOCK COMPONENT

Livestock is an integral part of a farm family and an important component of FSRD program which is executed by cattle rearing, poultry and duck rearing, vaccination of poultry and livestock etc. A total of 9 and 5 different types of activities under livestock's component were conducted at FSRD sites of Mymensingh and Bogura, respectively during 2018-2020 and detail methodology of different activities are given bellow.

Deworming & vaccination: The profitability of livestock mostly depends on animal health and is thus farmers would be economically benefitted through deworming of cattle and as well as vaccination against some major diseases. For this purpose, a number of feces sample of cattle were selected by the symptomatic parasitic infection and then investigated the parasites through feces sample analysis. After confirmation of parasitic infestation, the test animal was de-wormed by broad spectrum anthelmintics i.e. Trilev-vet. Livamisole for round worm and Triclabendazole were provided for liver fluke as per recommendation of the body weight. After deworming, Vitamin A, D and E containing injections were also being injected in cattle. Proper vaccination against four major diseases may reduce the mortality rate of cattle. For this purpose a short FGD was conducted to identify the disease severity and mortality after vaccination.Inthe vaccinated group Anthrax vaccine, Foot and mouth disease (FMD) vaccine were injected as per recommended schedule.

Poultry rearing: It is one of the vital parts of livestock and a common practice in rural Bangladesh. Poultry disease is the main problem for poultry rearing and it causes a great loss due to mortality rate and only proper vaccination can reduce the mortality rate of poultry. The success of poultry rearing and effectiveness of poultry vaccine a program was conducted at the farmers field. A good number of poultry birds were vaccinated during the project period. In the vaccinated group BCRDV, RDV, Fowl pox and Fowl cholera vaccine were used as per recommended schedule. Suggestions were made to the facilitator as and when necessary to solve the specific problem by regular contacting.

Duck rearing: The counterpart of livestock component is duck rearing and thus provided khaki Campbell breed to respective farmers. The concern farm family made a small house for duck with local technique from bamboo and corrugated tin (7ft × 6ft) near their own living house. Each farmer was given 8 ducks of 4 months old in FSRD site, Mymensingh. The ratio of male and female was 1:7. Twenty kilogram of initial feed, one feeder and one drinker were supplied to initiate the experiment. Ducks were offered commercial feed and sufficient clean drinking water with dextrose saline twice a day. Rice husk with sand used as litter materials and changed twice in every week. During the day time the ducks are kept in the backyard pond and at night in their small house.

Turkey rearing: It is a new farming activity in Bangladesh. Farmers are rearing turkey as an ornamental bird with a limited extent without having prior experience. Mainly interested farmers started turkey farming by importing day-old chicks from neighboring country, India. Its popularity is increasing gradually because of gamey flavor of meat with lower fat content. Farmers are raising turkey in free range, semi-intensive and intensive system, respectively. Farmers used commercial, homemade and both homemade and commercial feed, respectively for feeding their turkey. Farmers had encountered diseases like New Castle disease, Fowl pox, Fowl cholera and Mycoplasmosis by using vaccine. Twenty days old total 25 poults were supplied among the four farmers of FSRD site, Mymensingh during October 2018 in winter season.

Beef fattening: Beef fattening program was carried out at FSRD site Bogura during Feb 2020 to December 2020. At first 8 cattle were selected for fattening based on their age, size and shape. On an average each animal was 2 years old with squire shaped and defects. After selection, animals went under deworming treatment as per suggestion of Department of Livestock. Thereafter, the cattle were fed with urea molasses straw, green grass, granular feed, @ 2-3, 5-6, 1 kg and water @10-15 L as per 100 kg body weight. The composition of urea molasses straw was dry straw 82%, 22% molasses, urea 3% and water 70%. To make 1 kg granular feed, 250g wheat bran, 150g rice bran, 200g mustard oilcake, 150g boiled broken rice grain, 200 milled pulses husk, 20g salt, 25g dcp and 0.05g vitamins were mixed. The animals were vaccinated against FMD and Anthrax. The animals were reared in confined condition. Water was given just after supply of granular feed. Vitamin-B was supplied as regular basis with the increased body weight. Initially the animals were fed with 2kg sliced straw, 6 kg green grass and 1.5kg granular feed. Molasses mixed water at the ratio of 20:1 was provided to the animals.

D. FISHERIES COMPONENT

Proper management is the key factor for getting profitability of fish culture in pond under homestead area. The program of carp polyculture in seasonal pond of FSRD site was undertaken with the view to increase concern farmer income and to boost up the protein deficiency. Before conducting the fish culture in pond, following activities were done chronologically. For fish cultivation, weeds and wild fishes were removed from the pond and Lime was given at the rate of 1 kg per decimal as well as prepared for stocking with organic manure (cowdung) at the rate of 3 kg per decimal. Fingerlings stocking density is mostly depending on fingerlings size, species, pond depth, feed availability etc. However, in poly culture system, Catla, Rui, Mrigal, Common and Mirror carp may form 10–15%, 15–20%, 10–15% and 15–20% respectively maintaining 20-30 fingerlings decimal^{-1}Fish feed partially collected and supplied by the co-operative farmers whereas Lime and fingerlings were supported from the program. Periodic checking and suggestion were given by the office personnel of the respective FSRD site.

E. OFF-FARM ACTIVITY

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income and consequently could contributed to livelihood improvement of household. Different off-farm activities at FSRD sites of Mymensingh and Bogura during the year of 2018-2021.

Initially in Mymensingh, one household was started handicrafts making for commercial practice and finally most of the households showed their interest in practicing handicrafts besides of other off-farm activities. In some farm families' especially the women were engaged with sewing cloths with machine, making different handicrafts during their leisure periods. Nine farmers had shallow machine and provide irrigation water commercially.Two farmer was engaged with small electric shop and tea stall and it opened at his off-time. Four farmers have power tiller and sometimes they sale labor.

On the other hand, two women of selected farm households were engaged with weaving Katha, sewing cloths with machine, making different handicrafts during their leisure periods at FSRD site, Bogura. Besides, two farmers had shallow machine and provided irrigation water commercially. Two farmers worked as fishermen and caught fishes from Bangaliriver.

Results and Discussions

A. HOMESTEAD PRODUCTION SYSTEM

Location: FSRD Site, Mymensingh

1. Year-round vegetables and fruits production and its disposal pattern

Vegetables production:

After intervention of *Narkeli* model along with proven and improved technologies in the homestead, the results of vegetables production are presented in Table 7. In open sunny space, the average vegetable production of both villages of Mymensingh was maximum (54.5-388.5 kg homestead^{-1}) in Kharip-II season followed by Kharif-I (51-311 kg homestead-1). In Rabi season, the vegetables production was somehow found to be smaller (87.0 kg homestead^{-1}) than in Kharip-I and Kharip-II season might be due to crop variety for vegetable production when production was mostly affected by leafy vegetables. Vegetable production in homestead was 259.50, 996.50 and 336 (partial) kg homestaed^{-1} year^{-1} during Feb.2018-Jan.2019, Feb.2019-Jan.2020 and Feb.2020-Jan.2020 and thus average production was 530.7 kg homestaed^{-1} year^{-1} that was 742% higher compared to 63 kg homestaed^{-1} year^{-1} (as per base line). However, the remarkable increment (742.3 kg homestaed^{-1} year^{-1}) was obtained in vegetable production of char land ecosystem of Mymensingh might be enhanced by using improved technologies and judicious time management and so far the enhancement of labor utilization pattern.

Utilization of vegetable:

The disposal pattern of different vegetable produced in the homestead area was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetable varied with two locations of Mymensingh and amount of total vegetable production (Table 9). After intervention, the average vegetable intake per farm family was 106.67 kg homestaed^{-1} year^{-1}. Distribution of vegetable was recorded as 14.0 kg and selling of vegetable per year was 410.0 kg. Increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their relationship. After intervention of program, encourage the farmer to consume more vegetables as it's an earning source of cash income from more selling of vegetable. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Income from vegetables cultivation: After intervention of the program, the gross return from vegetables per farm was recorded as Tk. 7960 with variable cost of Tk. 2266 from which Tk. 5693 could be benefitted as cash income per family per year (Table 8).

Fruits production:

The available and unutilized niches of the homestead area have been brought into fruit production with the recommendation of the program. The fallow and underutilized homestead areas were utilized scientifically considering the time and space. Improved management practices such as fertilization, irrigation, pest control and pruning was suggested to some of quick growing fruits (Papaya, Lemon, Ber, Banana etc) along with some existing fruit trees (Mango, Jackfruit, Coconut, Olive, *Indian dellenia*, Wood apple etc.) for higher yield and quality fruit production in FSRD site, Mymensingh. It was observed that after intervention of improved technology, the fruit production was increased significantly. Higher amount of fruit was found to be produced at homestead area after implementation of the program (Table 7). However, the produced highest amount of fruits were observed in *Kharip-I* and it was (1000 kg per homestead) during the whole three consecutive year which was followed by *Kharip-II* (110 kg homestead^{-1}) and *Rabi* (100 kg homestead^{-1}). Minimum fruits production was observed in *Rabi* season and it is actually due to less availability of winter fruits species and variety in Bangladesh aspects, which might be a research prone area for scientist of Bangladesh to emphasis in developing winter fruits varieties. The fruit production trend was 135, 585 and 490 (partial) kg homestaed^{-1} year^{-1} during Feb. 2018 - Jan. 2019, Feb. 2019 - Jan. 2020 and Feb. 2020 - Jan. 2020 and however average production was 403.30 kg homestaed^{-1} year^{-1} that was 102% higher compare to 200 kg homestaed^{-1} year^{-1} (as per base line).Using of improved technologies including judicious fertilizer management in fruit trees might be increased the fruit yield tremendously.

Table 7. Year round vegetables and fruits production from different niches of homestead at FSRD site, Mymensingh during Feb. 2018 to Dec. 2020

Niches	Season Wise Vegetables Production (kg)									Total Production (kg)		
	Rabi (Oct. - March)			Kharif-1 (April-June)			Kharif-2 (July-Sept.)					
Open sunny space	Yr I	Yr II	Yr III	Yr I	Yr II	Yr III	Yr I	Yr II	Yr III	Yr I	Yr II	Yr III
Bed-1	10	25.5	9	13	70	10	9.5	85.5	10	32.5	181	29
Bed-2	18	7.0	-	7	80	12	10.5	99	12	35.5	186	24
Bed-3	20	17.0	-	10	86	13	11.0	103	13	41	206	26
Bed-4	4	14.0	-	7	35	8	12.0	54	11	23	103	19
Bed-5	6	23.5	-	14	40	15	11.5	47	12	31.5	110.5	27
Total	**58**	**87**	**9**	**51**	**311**	**58**	**54.5**	**388.5**	**58**	**163.5**	**786.5**	**125**
Trellis	-	12	25	-	12	35	4	13	20	4	37	80
Shady Place	-	5	5	-	10	20	8	10	25	8	25	50
Tree support	-	30	-	20	25	10	15	20	15	35	75	25
Fence	-	8	5	15	20	15	20	25	12	35	53	32
House Boundary	-	5	5	6	5	7	8	10	12	14	20	24
Total (vegetable)	**58**	**147**	**49**	**92**	**383**	**145**	**109.5**	**466.5**	**142**	**259.5**	**996.5**	**336**
Fruits	10	40	50	100	500	400	25	45	40	135	585	490
Total (vegetables +fruit)	**68**	**187**	**99**	**192**	**883**	**545**	**134.5**	**511.5**	**182**	**394.5**	**1581.5**	**826**

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

Utilization of fruits: The disposal pattern of different fruits produced under homestead area was recorded timely. The fruits intake per farm family per year was 140 kg after the program intervention, whereas it was only 100 kg before intervention, and it was observed that after intervention 40% increment was shown mainly due to increment of total production and motivation (Table 9). After implementation of the program, the distribution and selling tendency of fruits was increased and it was recorded as 26.67 kg and 236.67 kg, respectively per year. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested to sell for getting some cash money.

Income from fruits cultivation: In fruit sector, after program intervention, gross return per homestead was recorded as Tk. 6050 with the variable cost of Tk. 1566 per year, which was only Tk. 4484 of gross margin per year (Table 9).

Table 8. Year round vegetables and fruits production from different niches of homestead during Feb. 2018 to Dec. 2020 (Comparative data)

Niches	Before intervention		After intervention									
			YearI		Year II		Year III		Average of three years		Av. increment over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (%)	Income (%)
Open sunny place	0	0	163.5	2452.5	786.5	11797.5	125	1875	358.3	5375	100	100
Trellis	20	300	4	60	37	555	80	1200	40.3	605	101.7	101.7
Shady place	10	150	8	120	25	375	50	750	27.7	415	176.7	176.7
Tree support	10	150	35	525	75	1125	25	375	45	675	350.0	350.0

Niches	Before intervention		After intervention									
			YearI		Year II		Year III		Average of three years		Av. increment over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (%)	Income (%)
Fence	8	120	35	525	53	795	32	480	40	600	400.0	400.0
House boundary	15	225	14	210	20	300	24	360	19.3	290	28.9	28.9
Total	**63**	**945**	**259.5**	**3892.5**	**996.5**	**14947.5**	**336**	**5040**	**530.7**	**7960**	**742.3**	**742.3**
Fruit(other places)	200	3000	135	2025	585	8775	490	7350	403.3	6050	101.7	101.7
Total	**326**	**4890**	**394.5**	**5917.5**	**1581**	**23722.5**	**826**	**12390**	**934.0**	**14010**	**186.5**	**186.5**

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020, Market price (Tk. kg^{-1}) =15

Table9. Year-round vegetables and fruits production and its utilization pattern at before and after intervention during Feb 2018 - Dec. 2020

Description	Before Intervention		After Intervention							
	Vegetable (kg)	Fruits (kg)	Vegetables production (kg)				Fruits production (kg)			
			Year I	Year II	Year III	Ave.	Year I	Year II	Year III	Ave.
Consumption	10.00	100	50.00	200.00	70.00	106.67	70.0	200.0	150.0	140.00
Distribution	3.00	20	9.50	16.5	16.00	14.00	5.00	35.00	40.00	26.67
Selling	50.00	80	200	780.00	250.00	410.00	60.0	350.0	300.0	236.67
Total production	63.00	200	259.5	996.50	336.00	530.67	135	585.0	490.0	403.33
Gross return (Tk.)	945.00	3000	3892.5	14947.5	5040.0	7960.0	2025	8775.	7350.	6050.0
Variable cost (Tk.)	500.00	500	800.00	4000.00	2000.0	2266.67	700	2000.	2000.	1566.67
Net return (Tk.)	445.00	2500	3092.5	10947.5	3040.0	5693.33	1325	6775.	5350.	4483.33

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

5. Plantation and Management

A number of different fruits sapling were supplied to the cooperator farmers in view of increasing nutrient intake from fruits sector by the households of Mymensingh FSRD site during the year of 2018 - 2020. Under this program different types of fruit saplings e.g. Mango, Litchi, Guava, Lemon, Coconut, chewing type Sugarcane, Dragon fruit and Lotkon were supplied among cooperator and their neighbor farmers. The supplied total number of sapling and their survival rate of different fruits are shown in Table 15. Survival rate of different fruit saplings ranged from 34 -100 percent. The reason behind the mortality of the sample goes to lack of carefulness on watering in case of drought, support and fence (Table 10).

Table 10. Distribution of fruit saplings at FSRD site, Mymensingh during Feb. 2018 to Dec. 2020

Sl no	Types of fruits sapling	Variety	Number of fruits sapling				
			Year I	Year II	Year III	Total	Mortality (%)
01	Mango	BARI Aam-3	60	30	40	130	21
02	Litchi	BARI Litchi-1	40	-	-	40	15
03	Lemon	BARI Lemon-2	30	30	-	60	20
04	Guava	BARI Peyara-2	30	-	-	30	25
05	Dragon fruit	BARI Dragon Phol-1	25	-	-	25	0
06	Coconut	local	-	30	-	30	0
07	Sugarcane	BSRI Akh-42/local	-	30	-	30	66
08	Lotkon	Local	-	-	40	40	0

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

Location: FSRD Site, Bogura

1. Year round vegetables and fruits production and its disposal pattern

Vegetables production:

After intervention of the proven and improved technologies in the homestead vegetable production trend are presented in the Table 11. In open sunny space, the average vegetable production of Bogura was maximum in *Rabi* season (52 - 87 kg $homestead^{-1}year^{-1}$) followed by

Kharif-II (47-64 kg homestead^{-1} year^{-1}). In *Kharif-I* season the vegetables production was somehow found to be lower (47 - 51 kg homestead^{-1} year^{-1}). Higher vegetables production in *Rabi* season might be due to variety of vegetables produced. By using all niches total vegetable production was 388.23, 483.40 and 55.04 kg homestead^{-1} year^{-1} during Feb. 2018 - Jan. 2019, Feb. 2019 - Jan. 2020 & Feb. 2020 - Dec. 2020 and thus average production was 475.56 kg homestead^{-1} year^{-1} which was much higher than that of 117.39 kg homestead^{-1} year^{-1} at before intervention of model and the remarkable average increment of vegetable production (305.11%) was observed at Bogura (Table 11) and it might be enhanced by using improved technologies and judicious time management and so far the enhancement of labor utilization pattern.

Utilization of vegetables

The disposal pattern of homestead production was recorded regularly through the help of the co-operator farmers. The results indicated that disposal pattern of vegetable varied with two char areas of Bogura (Table 13). The average vegetable intake per farm family was 277.32 kg after the program intervention during the three-consecutive year. After program intervention the distribution of vegetable was recorded as 67.87 kg and selling of vegetable per year was 130.36 kg in both sites of FSRD site of Bogura. Increased production of vegetable encouraged the farm families to distribute relatively more vegetable to their relatives and neighbor, which might be helpful to increase their relationship. After intervention of program, encourage the farmer to consume more vegetables as it's an earning source of cash income from more selling of vegetable. The better utilization of homestead area with optimum management by effective farm family labor can be achieved for optimum vegetable production and subsequent intake, distribution and sell.

Income from vegetables cultivation:

After intervention of the program, the gross return from vegetables per farm was recorded as Tk. 6003 with the gross margin of Tk. 2110 from which Tk. 3893 could be benefitted as cash income per family per year (Table 13).

Fruits production:

After intervention of improved technology, the fruit production was increased significantly (Table 17 & Table11). Considering whole project tenure, the highest amount of fruits (141 kg homestead^{-1}) produced in *Kharip-I* followed by *Kharip-II* (104 kg homestead^{-1}) and *Rabi* (43 kg homestead^{-1}). Minimum fruits production was observed in *Rabi* season might be due to less availability of winter fruits species and variety in Bangladesh aspects, which might be a research prone area for scientist of Bangladesh to emphasis in developing winter fruits varieties. After intervention of proven technology related to fruit tree management, fruit production was 43, 90 and 156 kg homestead^{-1} year^{-1} during Feb. 2018 - Jan. 2019, Feb. 2019 - Jan. 2020 & Feb. 2020 - Dec. 2020 and thus average production was 96 kg homestead^{-1} year^{-1} which was much higher than that of 31 kg homestead^{-1} year^{-1} at before intervention of model and the remarkable average increment of vegetable production (209.68%) was observed at Bogura (Table 12& Table13). Using of improved technologies including judicious fertilizer management in fruits has increased the fruit yield tremendously year after year.

Utilization of fruits:

The disposal pattern of different fruits produced under homestead area was recorded timely. The fruits intake per farm family per year was 63.93 kg after the program intervention, whereas it was only 15.5 kg before intervention and it was observed that after intervention 312.45% increment was shown mainly due to increment of total production and motivation (Table 12). After implementation of the program, the distribution and selling tendency of fruits was increased and it was recorded as 11.63 kg and 20.43 kg, respectively per year. Increased production of fruits encouraged the farm families to distribute towards their relatives and neighbor, but the farmers were more interested to sell for getting some cash money.

Income from fruits cultivation:

After program intervention, gross return per farm was recorded as Tk. 3550 with the gross margin of Tk. 2873 per year, which was only Tk. 930 and Tk. 680, respectively per year before intervention. The increment of gross margin was 322.5% (Table 12).

Table 11. Year round vegetables and fruits production from different niches of homestead at FSRD site, Bogura during Feb. 2018 to Dec. 2020

Niches		Season Wise Vegetables Production (kg)									Total Production (kg)		
		Rabi (Oct. - March)			Kharif-1 (April-June)			Kharif-2 (July-Sept.)					
		Year I	Year II	Year III	Year I	Year II	Year III	YearI	Year II	Year III	YearI	Year II	Year III
Open sunny space	Bed-1	12	21.5	25.5	11.96	11	13	15	9.5	12.3	38.96	42.00	50.80
	Bed-2	16	5	7	6.44	8	7	12	10.5	13.9	34.44	23.50	27.90
	Bed-3	12	15	17	9.20	7	10	9	11	11.7	30.20	33.00	38.70
	Bed-4	7	12	14	6.44	9	7	7	12	12.7	20.44	33.00	33.70
	Bed-5	5	19	23.5	12.88	12	14	4	11.5	13.4	21.88	42.50	50.90
Sub-total		**52.00**	**72.50**	**87.00**	**46.92**	**47.00**	**51.00**	**47.00**	**54.50**	**64.00**	**145.92**	**174.00**	**202.00**
Roof top		77	80	82	11.04	9	12	18	26	12.2	106.04	115.00	106.20
Trellis		55	51	62.5	11.59	10.5	12.6	14	36	31	80.59	97.50	106.10
Shady Place		0	4	6	2.76	4	3	0	4	39	2.76	12.00	48.00
Marshy land		0	2	0	8.28	7	9	0	5	4	8.28	14.00	13.00
Unproductive Tree		0	3.5	5.5	9.66	11.3	10.5	6	4	6	15.66	18.80	22.00
Fence		9	5	3	3.68	5	4	7	6	3.1	19.68	16.00	10.10
Backyard		0	3.1	2.54	4.10	4	5	0	4	8.6	4.10	11.10	16.14
House Boundary		0	13	15	5.20	6	5	0	6	11.5	5.20	25.00	31.50
Total (vegetables)		**193**	**234.1**	**263.54**	**103.23**	**103.8**	**112.1**	**92**	**145.5**	**179.4**	**388.23**	**483.40**	**555.04**
Fruits		9	15	19	20	45	76	13	30	61	42	90	156
Total (fruit)		43			141			104					

* Year I=Feb.2018-Jan.2019, Year II=Feb.2019-Jan.2020& Year III=Feb.2020-Dec.2020

Table 12. Year round vegetables and fruits production from different niches of homestead during Feb. 2018 to Dec. 2020 (Comparative data)

Niches	Before intervention		After intervention									
			Year I		Year II		Year III		Average		Avg. increment over before intervention	
	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (Tk.)	Production (kg)	Income (%)
Open sunny place	0	0	145.92	1459.2	174.00	2088	202.00	3030	173.97	2192	100	100
Roof top	55	550	106.04	1060.4	115	1380	106.20	1593	106.04	1344	98.33	144.45
Trellis	42	420	80.592	805.92	97.5	1170	106.10	1592	75.36	1189	125.55	183.13
Shady place	1	10	2.76	27.6	12	144	48.00	720	9.25	297	1992.0	2872.0
Marshy land	3	30	8.28	82.8	14	168	13.00	195	14.76	149	292.00	395.33
Unproductive Tree	2.5	25	15.66	156.6	18.8	225.6	22.00	330	14.85	237	652.80	849.60
Fence	0	0	19.68	196.8	16	192	10.10	152	17.27	180	100	100
Backyard	6.89	68.9	4.1	41	11.1	133.2	16.14	242	15.57	139	51.62	101.40
House Boundary	7	70	5.2	52	25	300	31.50	473	5.2	275	193.81	292.62
Sub-Total	**117.39**	**1174**	**388.23**	**3882**	**483.40**	**5800**	**555.04**	**8325**	**475.56**	**6003**	**305.11**	**411.32**
Fruit (other places)	31.0	930	42	1260	90	3150	156	6240	96	3550	209.68	281.72
Total	**148.39**	**2104**	**430.23**	**5142**	**573.4**	**8950**	**711.04**	**14565**	**571.56**	**9553**	**285.17**	**354.03**

* Year I=Feb.2018-Jan.2019, Year II=Feb.2019-Jan.2020& Year III=Feb.2020-Dec.2020

Table 13. Year round vegetables and fruits production and its utilization pattern at before and after intervention during Feb. 2018 - Dec. 2020

Description	Before Intervention		After Intervention							
	Vegetable (kg)	Fruits (kg)	Vegetables production (kg)				Fruits production (kg)			
			Year I	Year II	Year III	Ave.	Year I	Year II	Year III	Ave.
Consumption	60.06	15.5	270.23	279.42	282.32	277.32	37.0	60.3	94.5	63.93
Distribution	24.18	4.0	42.5	67.33	93.79	67.87	5.0	9.9	20	11.63
Selling	33.16	11.5	75.5	136.65	178.93	130.36	0	19.8	41.5	20.43
Total production	117.4	31	388.23	483.4	555.04	475.56	42	90	156	96.00
Gross return (Tk.)	1174	930	3882	5801	8326	6003.0	1260	3150	6240	3550.00
Variable cost (Tk.)	650	250	1320	2180	2830	2110.0	350	450	1250	683.33
Net return (Tk.)	524	680	2562	3621	5496	3893.0	910	2720	4990	2873.33

* Year I=Feb.2018-Jan.2019, Year II=Feb.2019-Jan.2020& Year III=Feb.2020-Dec.2020

Plantation of saplings and Management of fruit trees

Fruit trees are the essential elements of a homestead. Though there are some common fruit tree species (Mango, Jackfruit) usually exist around the homestead area but they lack fruit diversity. In order to extend the harvesting period of fruit or make the fruits available throughout year in the homesteads different fruit tree species need to be accommodated there along with management of the existing plants. With the view of increasing fruits production as well as diversity OFRD, Bogura provided different fruit saplings with the financial support of the project for plantation in the farmers homestead areas. Besides new plantation, existing fruit tress was brought under management like irrigation, fertilization, training and pruning, spray against insects and diseases. A total of 473 saplings of different quality fruits varieties were supplied to homestead e. g. Mango, Litchi, Dragon fruit, Dwarf Coconut and quick growing Guava, Papaya, Lemon was distributed among the farmers. Among the supplied saplings, 1% mango and 1% litchi became died due to transportation shock. As a result of new plantation coupled with management of fruit plants, the production increased remarkably in the subsequent years. Details of fruits saplings distribution presented in the Table 14.

Table 14. Distribution of fruit saplings at FSRD site, Bogura during Feb. 2019 to Dec. 2020

Sl. No.	Types of the fruit saplings	Variety	Sapling number		Total (No.)	Mortality (%)
			Year II	Year III		
1	Mango	BARI Aam-4	35	250	285	1
2	Litchi	China-3	10	12	22	1
3	Dwarf Coconut	-	6	12	18	0
4	Guava	BARI Peyara-2	12	60	72	0
5	Lemon	Seed less	20	12	32	0
6	Dragon fruit	BARI Dragon Phol-1	8	36	44	0
Total distributed			91	382	473	

* Year II=Feb.2019-Jan.2020 & Year III=Feb.2020-Dec.2020

Family labor utilization pattern

Homestead production systems create an income generation for woman which is an opportunity for employment and empowerment. It has been observed that woman had a good involvement in intercultural operations, harvesting and a remarkable engagement in cooking. Eighty per cent women are employed in cooking and 15% of their female children are also engaged in cooking (Table 15).Most of the hard job such are land preparation are done by male farmer. Children were also helping the men and women adult workers in the production systems especially in non hard working areas. From the data after intervention of homestead it has been observed that family labour as women and children can utilize their labour properly and women are coming forward and participated in more income generation.

Table 15. Family labor utilization pattern for homestead vegetable production at FSRD site, Mymensingh during February 2018 to December 2020

Working area	Men (%)				Women (%)				Children (%)			
	Year I	Year II	Year III	Av.	Year I	Year II	Year III	Av.	Year I	Year II	Year III	Av.
Land preparation	70	80	90	80	15	20	10	15	5	5	5	5
Seed/seedling	70	80	90	80	15	20	10	15	5	5	5	5
Sowing/planting	65	75	85	75	15	25	20	20	5	5	5	5
Intercultural operations	60	70	50	60	40	30	35	35	10	0	5	5
Harvesting	35	45	40	40	40	50	60	50	5	10	15	10
Marketing	80	100	90	90	0	0	0	0	5	15	10	10
Cooking	0	0	0	0	70	90	95	85	20	15	10	15

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

Family labor utilization pattern

Homestead is a unique place where family members involve and share their labour with better understanding among the family members. They usually shared and paid their labour according to the suitability of their own time management to run their farm smoothly in order to improve their daily livelihood. It's a never-ending journey to reach the destination where they would like to find themselves as a whole. They utilize their family labour in different daily activities throughout the year. The details of family labour utilization presented in the Table 16. It was observed that men paid their labour mostly on hardworking activities like land preparation, sowing or planting of crops, different intercultural operations, harvesting as well as marketing of produced goods. On an average about 56.43% labour of a farm family came from male (Men) part. Though female were mostly involved in cooking, but they also met their shoulder with their male counterpart to work on different activities as stated above. Averagely, 43.57% female labour was involved to do the different jobs in their own farm. Children of the farm family was also involved as a helping hand to support the family in their leisure period. On an average, 9.43% labour came from children to help the family for land preparation to marketing as well as cooking. From the data after intervention of homestead it has been observed that family labour as women and children can utilize their labour properly and women are coming forward and participated in more income generation.

Table 16. Family labor utilization pattern for homestead activities at FSRD site, Bogura during 2018-2020

Working area	Men (%)				Women (%)				Children (%)			
	Year I	Year II	Year III	**Av.**	Year I	Year II	Year III	**Av.**	Year I	Year II	Year III	**Av.**
Land preparation	70	65	60	**65**	30	35	40	**35**	6	8	10	**8**
Seed/seedling	60	50	55	**55**	40	50	45	**45**	5	10	15	**10**
Sowing/planting	65	55	60	**60**	35	45	40	**40**	5	6	7	**6**
Intercultural operations	80	60	70	**70**	20	40	30	**30**	8	6	10	**8**
Harvesting	70	50	60	**60**	30	50	40	**40**	5	5	8	**6**
Marketing	90	80	85	**85**	10	20	15	**15**	8	10	12	**10**
Cooking	0	0	0	**0**	100	100	100	**100**	18	16	20	**18**
Average	62.14	51.43	55.71	**56.43**	37.86	48.57	44.29	**43.57**	7.86	8.71	11.71	**9.43**

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

B. CROPS AND CROPPING SYSTEM

Location: FSRD site, Mymensingh

The crops and cropping systems in char land were performed with a view to develop improved cropping pattern as well as to increase crop productivity by introducing new technology or variety. Following crops and cropping systems were practiced in the FSRD site of Mymensingh during 2018-2020.

I. Improvement of existing cropping pattern

For the improvement of cropping pattern, two cropping patterns were developed in Char land of Mymensingh. All the field operations and management practices were closely monitored and data were recorded and are presented accordingly.

Cropping pattern 1: The results of tested pattern against existing pattern presented in Table 22. In the improved pattern BARI Sarisha-14 gave higher seed yield (1640 and 1750 kg ha^{-1}) over the average national yield of Mustard (1079 kg ha^{-1}) at the FSRD site, Char Anondipur, Mymensingh during 2018-19 and 2019-2020. Moreover, the crop duration of modern mustard variety BARI Sarisha-14 was expected and did not hamper on Boro rice cultivation. In improved pattern Boro rice gave the highest yield (5.05 and 6.5 t ha^{-1}) over the existing pattern (4.5 and 5.8 t ha-1) during the two consecutive years might be due to intercultural practices such as application of balanced fertilizer, appropriate seedling rate and age, better management practice and also due to inclusion of modern variety. Mustard yield increased 100% as it was cultivated in the fallow land and T.aman rice yield slightly decreased in improved pattern might be due to varietal performance (Table 17). Considering average of two years. REY in improved cropping pattern was 13.58 tha^{-1} against 9.06 in existing pattern that contributed higher gross margin (Tk. 111691 ha^{-1}).

able 17. Yield and economic return of improved and existing cropping pattern at the FSRD site, Mymensingh during 2018-19 and 2019-20

Observation	Improved cropping pattern (Mustard – Boro – T.aman)			Existing cropping pattern (Boro – Fallow – T.aman)		
Crop	T. Aman	Mustard	Boro	T. Aman	Fallow	Boro
Year-I: 2018-19						
Seed/grain yield (t ha^{-1})	4.12	1.64	5.05	4.32	-	4.5
Straw yield (t ha^{-1})	3.5	3.5	4.5	3.5	-	4.5
REY (t ha^{-1})	13.58			8.82		
Gross return (Tk ha^{-1})	69420	74020	85300	72620	-	76500
Total variable cost (Tk ha^{-1})	43858	35750	65000	41580	-	64550
Gross margin (Tk ha^{-1})	25562	38270	20300	31040	-	11950
Whole pattern Gross margin (Tk. ha^{-1})	84132			42990		
MBCR	2.06			-		
Year-II: 2019-20						
Seed /grain yield (t ha^{-1})	3.5	1.75	6.5	3.5	-	5.8
Straw yield (t ha^{-1})	4.0	3.0	4.5	4.0	-	4.0
Whole pattern REY (t ha^{-1})	13.58			9.3		
Gross return (Tk ha^{-1})	67000	81750	147000	67000	-	131600
Total variable cost (Tk ha^{-1})	45000	46500	65000	45000	-	65000
Gross margin (Tk ha^{-1})	22000	35250	82000	22000	-	66600
Whole pattern Gross margin (Tk. ha^{-1})	139250			88600		
MBCR	1.11			-		
Average						
REY	13.58			9.06		
Gross Margin (Whole pattern)	111691			86045		
MBCR	1.59			-		

REY: Rice equivalent yield, Unit price (Tk. kg^{-1}): Mustard=43 & 45, Mustard by-product=1, Boro rice=16 & 22, Rice straw=1, Aman rice=16 & 18, Rice straw=1

Cropping pattern 2: The results of the tested pattern against existing pattern presented in Table 18. In the improved pattern BARI Alu-25 gave the higher yield (26.90 and 20.00 t ha^{-1}) over the average national yield of potato (18.00 t ha^{-1}) at the FSRD site, Char Anondipur, Mymensingh during the two consecutive year 2018-19 and 2019-2020. Moreover, the crop duration of modern potato variety BARI Alu-25 was expected and did not hamper on Boro rice cultivation. In improved pattern Boro rice gave the highest yield (5.20 and 6.0 t ha^{-1}) over the existing pattern

(5.0 and 5.5 t ha-1) during the two consecutive years might be due to intercultural practices such as application of balanced fertilizer, appropriate seedling rate and age, better management practice and also due to inclusion of modern variety.Potao yield increased 100% as it was cultivated in the fallow land and T.aman rice yield slightly decreased in improved pattern might be due to varietal performance. Considering average of two years. REY in improved cropping pattern was 35.68 tha-1 against 9.20 in existing pattern that contributed higher gross margin (Tk. 414236 ha-1). Considering average of two years, REY in improved cropping pattern was 35.68 tha-1 against 9.20 in existing pattern that contributed higher gross margin (Tk. 414236 ha-1).

Table 18. Yield and economic return of improved and existing cropping pattern at the FSRD site, Mymensingh during 2018-2019

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	T. Aman	Potato	Boro	T. Aman	Fallow	Boro
Year-I: 2018-19						
Seed /grain yield (t ha-1)	4.15	26.90	5.20	4.30	-	5.0
Straw yield (t ha-1)	3.8	33.63	4.5	3.3	-	4.0
REY (t ha-1)	42.98			9.3		
Gross return (Tk ha-1)	78500	538000	87700	80700	-	84000
Total variable cost (Tk ha-1)	43898	142840	60750	41680	-	70000
Gross margin (Tk ha-1)	34602	395160	26950	39020	-	14000
Whole pattern Gross margin (Tk. ha-1)	456712			53020		
MBCR	3.97			-		
Year-II: 2019-20						
Seed /grain Yield (t ha-1)	4.20	20.0	6.0	3.5	-	5.5
Straw yield (t ha-1)	3.4	-	5.2	4.0	-	5.0
REY (t ha-1)		18.18				
Whole pattern REY (t ha-1)	28.38			9		
Gross return (Tk ha-1)	87400	400000	137200	74000	-	126000
Total variable cost (Tk ha-1)	45000	142840	65000	45000	-	65000
Gross margin (Tk ha-1)	42400	257160	72200	29000	-	61000
Whole pattern Gross margin (Tk. ha-1)	371760			90000		
MBCR	2.97			-		
Average						
REY	35.68			9.20		
Gross Margin (Whole pattern)	414236			71510		
MBCR	3.47			-		

REY: Rice equivalent yield, Unit price (Tk. kg-1): Potato=20, Boro rice=16 & 22, Rice straw=1, *Aman* rice=18 & 20, Rice straw=1

II. Production program

Results: After intervention of the program the variety and technology of BARI have been disseminated in the concern farmer's field and it was observed that the yield and income were generated enormously. However, the yield, cost and return of different crops have been shown in Table 19.

Okra: The BARI released variety BARI Dherosh-2 was conducted in the farmers field with recommended dose of input supplied and observation was done routinely. The data was collected after every harvest and converted the yield with market price and performance was observed. The average fruit yield of okra was 19.58 t ha-1 during the three consecutive years. The gross return was calculated and it was obtained Tk. 264900 ha-1, total variable cost and gross margin were Tk. 57145 and Tk. 207755 ha-1, respectively. The benefit cost ratio was (BCR) 4.74 which indicated that this technology is economically profitable.

Bottle gourd: TheBARI Lau-3 was disseminated in the farmers' field and the average fruit yield of bottle gourd during the three years of cultivation was 28.90 t ha-1. The gross return, total variable cost and gross margin were Tk. 324850, Tk. 115000 and Tk. 209850 ha-1, respectively.

The benefit cost ratio was 2.72 which marked a profitable technology as well as variety has been cultivated in the farmers' field.

Snake gourd: During the first two consecutive years the snake gourd was cultivated according to the technology and variety in the concern farmers' field. The inputs from the OFRD, BARI, Mymensingh was supplied to the field and collected data showed that the average fruit yield of snake gourd was 20.35 t ha^{-1}. The gross return, total variable cost and gross margin were converted in to the market price and it was observed that the GR was one an average Tk. 271725, the TVC was Tk. 91725 and the GM was Tk. 180000 ha^{-1}, respectively. The BCR (2.96) showed a profitable technique in cultivating of snake gourd in farmer's field.

Stem amaranth: The BARI released variety BARI Data-1 was cultivated in the farmers' field to show the performance of the variety. It is quick growing vegetable and the average yield of two consecutive years was 33.75 t ha^{-1}. The gross return was so hike Tk. 287500 ha^{-1}, the total variable cost was lower than that of any other crops and it was Tk. 52790 $ha^{-1}$and gross margin were Tk. 267500, Tk. 52790 and Tk. 234710 ha^{-1}, respectively. So far, the BCR was 5.44 which indicated that this technology is economically advantageous.

Bitter gourd: The BARI Corolla-2 was supplied to the concern farmers field to show the performance of the variety among the farmers and the average yield of bitter gourd was obtained 19.96 t ha^{-1} which indicated a promising variety in that locality. The calculated gross return, the total variable cost and the gross margin were tabulated and it was observed that the GR was Tk. 291900, the TVC was Tk. 137500 and the GM was Tk. 213050 ha^{-1}, respectively. The obtained BCR 2.54 showed a promising variety that could be disseminated among the concern farmers in the farming system research site.

Potato: The BARI Alu-25 made a good awareness among the farmer in the farming system research and development site. The BARI released variety is taken over the place of local cultivar which was usually cultivated over there. The all input was supplied from the project support and crop was grown up. However, the average tuber yield of potato was 26.97 t ha^{-1}. The calculated gross return, the total variable cost and the gross margin were calculated and it was Tk. 303400, Tk. 119434 and Tk. 183966 ha^{-1}, respectively. The BCR was 2.54 which further indicated that the high yielding BARI released variety of potato cultivation is economically profitable in the farmers' field.

Mustard: TheBARI Sarisha-14 is a promising variety of mustard all over the country is cultivating. However, in the concern project site the variety gave a good performance and it was 1.66 t ha^{-1} which is better seed yield than that of national average (1.079 t ha^{-1}). After calculating the gross return, it was obtained Tk.72825 ha^{-1}, total variable cost was Tk. 32913 ha^{-1} and the calculated gross margin was Tk. 40278 ha^{-1}, respectively. The benefit cost ratio was 2.28 indicated a better technology in the farmer's field.

Papaya: A production technology was followed in the project are of FSRD site, Mymensingh where hybrid variety was followed. Other than variety all other technical support were supplied and a promising good result were observed in the year 2020. However, the yield was obtained as 35.00 t ha^{-1} and the calculated gross return was Tk. 525000 ha^{-1}, the total variable cost was Tk. 192750 ha^{-1} and gross margin was Tk. 332250 ha^{-1}, respectively. The benefit cost ratio 2.72 indicated an accepted cultivation technology in the farmers' field.

Brinjal: A locally collected brinjal variety was followed here in the farmers' field and the production technique was disseminated over there in. All the input was supplied from OFRD, BARI, Mymensingh and the obtained yield was 28.00 t ha^{-1} in the year, 2020. The calculated gross return was Tk. 560000 ha^{-1}, the total variable cost was Tk. 120000 ha^{-1} and gross margin was Tk. 440000 ha^{-1}, respectively. The benefit cost ratio 3.66 indicated an accepted cultivation technology in the farmers' field.

Farmers' opinion: Farmers are very much impressed having the higher yield of BARI Sarisha-14 and was happy to be easily fitted to Mustard-*Boro*-T. a*man* cropping pattern without hampering the *Boro* cultivation. Farmers reacted over the variety very positively and satisfaction with for its high yield. A good number of seed has been stored by the farmers for growing in the next year. High yielding potato variety (BARI developed variety) create an awareness among the farmer for higher yield and hike market price in early marketing but lack of storage facility and fluctuation of market price of tuber as of the main constraints for extension of the technology. All the BARI released varieties and technologies make a good impact on the farmers as of the crops higher yield and economic return, quality and sometimes attractive shape and color. They would follow the technology and grow the crops variety in the coming year and some of them stored a smart amount of seeds for the next year cultivation.

Table 19. Performance of different crops under production program at FSRD site, Mymensingh during 2018-20

Crop	Variety	Yield (t ha^{-1})				GR (Tk ha^{-1})	TVC (Tk ha^{-1})	GM (Tk ha^{-1})	BCR
		Year-I	Year-II	Year-III	Avg.				
Okra	BARI Derosh-2	19.15	-	20.00	19.58	264900	57145	207755	4.74
Bottle gourd leaf	BARI Lau-3	35.85	25.85	25.00	28.90	324850	115000	209850	2.72
Snake gourd	BARI Chichinga-1	22.35	18.35	-	20.35	271725	91725	180000	2.96
Data	BARI Danta-1	36.75	30.75	-	33.75	287500	52790	234710	5.44
Bitter gourd	BARI Corolla-2	19.46	20.46	-	19.96	291900	137500	213050	2.54
Potato	BARI Alu-25	28.30	26.30	26.30	26.97	303400	119434	183966	2.54
Mustard	BARI Sarisha-14	1.58	1.75	1.64	1.66	72825	32913	40278	2.28
Papaya		-	-	35.00	35.00	525000	192750	332250	2.72
Brinjal		-	-	28.00	28.00	560000	120000	440000	3.66

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

Location: FSRD site, Bogura

I. Improvement of existing cropping pattern

According to the suitability of the land a four-crop based Mustard – Boro - T. aus -T. Aman and a three crop-based Wheat-Jute-T. Aman patterns were developed against Mustard – Boro - T. Aman rice and Boro-Fallow-T. Aman rice respectively. Transformation of three crop-based pattern to four crops and two crops based to three by changing suitable verities of selected crops could contributed to higher system productivity as well as economic return.

Cropping pattern 1: Yield and economic performance of the tested pattern against existing pattern is presented in Table 20. In the improved pattern BARI Sarisha-14 gave higher seed yield (1.46 and 1.51tha^{-1} in 20118-19 and 2019-20 respectively) over the local Tori-7 (0.95 and 0.96 tha^{-1} in 20118-19 and 2019-20 respectively) at the FSRD site, Char Shyampur, Bogura during 2018-19 and 2019-2020. Moreover, the crop duration of modern mustard variety BARI Sarisha-14 was expected and did not hamper on Boro rice cultivation. In improved pattern. T. Aus rice planted in alternate pattern contributed to 3.52-3.96 tha^{-1} grain in the respective years. Higher rice equivalent yield was recorded as 15.33 tha^{-1} in 2018-19 and 16.93 tha^{-1} in 2019-20 season from improved pattern and lower (10.71 and 11.44 tha^{-1} in 2018-19 and 2019-20 respectively) from existing pattern. Higher rice equivalent yield contributed to the higher gross margin (Tk.141660 ha^{-1} in 2018-19 and Tk.169630 ha^{-1} in 2019-20) in improved pattern and lower (Tk.92370 ha^{-1} in 2018-19 and Tk.111900 ha^{-1} in 2019-20) in the existing pattern. MBCR was recorded as 2.04 and 2.10 for the respective years. Considering average of two years. REY in improved cropping pattern was 16.23 tha^{-1} against 11.08 in existing pattern that contributed higher gross margin (Tk. 155645 ha^{-1}).

Cropping pattern 2: Yield and economic performance of the tested pattern against existing pattern is presented in Table 21. In the improved pattern BARI Gom-30 gave satisfactory grain yield (3.76 tha^{-1}) and Jute contributed to the fibre yield of 2.43 tha^{-1} at the FSRD site, Char Shyampur, Bogura during 2019-2020. Higher rice equivalent yield was recorded as 15.35 tha^{-1} in improved pattern and lower (10.20 tha^{-1}) in the existing pattern. Higher rice equivalent yield

(15.35 tha-1) contributed to the higher gross margin (Tk.188680 ha^{-1}) in improved pattern and lower (Tk.106630 ha^{-1}) in the existing pattern. MBCR was calculated as 4.92 from the improved pattern.

Table 20. Yield and cost and return analysis of four crop based cropping pattern against existing cropping pattern at the FSRD site, Bogura during 2018-20

Observation	Improved cropping pattern (Mustard - Boro -T. aus- T.aman)				Existing cropping pattern (Mustard-Boro - T.aman)		
Crop	Mustard	Boro	T. Aus	T. Aman	Mustard	Boro	T. Aman
Year-I: 2018-19							
Seed/grain yield (t ha^{-1})	1.46	4.18	3.58	3.52	0.95	3.98	3.9
Straw yield (t ha^{-1})	1.68	5.1	3.75	3.68	1.1	4.59	4.2
REY (t ha^{-1})	15.53				10.71		
Gross return (Tk ha^{-1})	60080	93800	79100	77760	39100	88780	86400
Total variable cost (Tk ha^{-1})	29390	52480	42560	44650	24380	50980	46550
Gross margin (Tk ha^{-1})	30690	41320	36540	33110	14720	37800	42850
Whole pattern Gross margin (Tk. ha^{-1})	141660				92370		
MBCR	2.04				-		
Year-II: 2019-20							
Seed /grain yield (t ha^{-1})	1.51	4.63	3.78	3.96	0.96	4.24	4.2
Straw yield (t ha^{-1})	1.85	5.25	4.56	4.72	1.23	4.96	5.23
Rice equivalent yield (t ha^{-1})	16.93				11.44		
Gross return (Tk ha^{-1})	62250	103100	84720	88640	39630	94720	94460
Total variable cost (Tk ha^{-1})	29390	52480	42560	44650	24380	50980	41550
Gross margin (Tk ha^{-1})	32860	50620	42160	43990	15250	43740	52910
Whole pattern Gross margin (Tk. ha^{-1})	169630				111900		
MBCR	2.10				-		
Average							
REY	16.23				11.08		
Gross Margin (Whole pattern)	155645				102135		
MBCR	2.07				-		

Price; Mustard: 40 Tk/kg, Mustard stover: 1.0 Tk/kg and Rice: 20 Tk/kg, Rice straw: 2.0 Tk/kg,

Table 21. Yield and economic return of three crop based cropping pattern against existing cropping pattern at FSRD site, Bogura during 2018-20.

Observation	**Alternate cropping pattern**			**Existing cropping pattern**		
Crop	Wheat	Jute	T.Aman	Boro	Fallow	T. Aman
Seed /grain Yield (tha^{-1})	3.76	2.43	4.12	4.81	-	4.35
Straw/stover yield (tha^{-1})	3.12	5.16	4.72	5.06	-	5.42
Rice equivalent yield (t ha^{-1})	15.35			10.20		
Gross return (Tk ha^{-1})	78320	136980	91840	106320	0	97840
Total variable cost (Tk ha^{-1})	34860	38950	44650	50980	0	46550
Gross margin (Tk ha^{-1})	43460	98030	47190	55340	0	51290
Whole pattern Gross margin (Tk. ha^{-1})	188680			97530		
MBCR	4.92			-		

Price; Wheat: 20 Tk/kg, Jute fibre: 50 Tk/kg, Rice: 20 Tk/kg, Rice straw: 2.0 Tk/kg, Wheat stover: 1.0 Tk/kg, stick: 3 Tk./kg

II. Production program

FSRD site, Bogura: Production programs with BARI developed different crops were conducted under farmer's field condition at FSRD site, Bogura to observe their yield performance as well as popularize crop varieties among the farmers. BARI Alu-25 and BARI Alu-36 for potato, BARI Sarisha-14 for mustard, BARI Mistialu-8 for sweet potato, BARI Gom-27 and BARI Gom-33 for wheat, BHM-9 and BHM-16 for maize were selected production program under farmers field condition in char land areas. Quality seeds, tubers, vines were provided on behalf of OFRD, Bogura. In addition to this, fertilizers and pesticides as well as pheromone trap for fall army worm of maize were given to the fares to ensure better crop stand. Farmers were advised to follow modern cultivation practices for better yield. Data regarding yield and economic return are given in Table 22.

Table 22. Management practices, variety, number of farmers, area covered by different crops at FSRD site, Bogura during 2019-2020

Name of crops	Variety	Farmers (no)	Area (ha)	Date of sowing	Date of harvesting
Year-II: 2019-20					
Potato	BARI Alu-25 and BARI Alu-36	7	0.53	6-18 Nov, 2019	6 -13 February, 2020
Mustard	BARI Sarisha-14	12	0.40	3-12 Nov, 2019	25 Jan-10 Feb, 2020
Sweet potato	BARI Mistialu-8	2	1.05	10-15 Nov, 2019	10-15 Feb, 2020
Wheat	BARI Gom-30 & BARI Gom-33	8	0.32	14-25 Nov, 2019	28 Feb-8 Mar, 2020
Maize	BHM-9 & BHM-16	4	0.61	15-22 Nov, 2019	20-27 Apr, 2020
Year III: 2020-21					
Potato	BARI Alu-36, BARI Alu-41, BARI Alu-53 and BARI Alu-78	12	1	10-20 Nov, 2020	-
Mustard	BARI Sarisha-14, 17	40	8	1-15 Nov, 2020	-
Sweet potato	BARI Mistialu-8	2	0.13	15-16 Nov, 2020	-
Wheat	BARI Gom-33	6		15-24 Nov, 2020	-
Maize	BHM-16	1	0.12	28 Nov, 2020	-

* Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020, BHM= BARI Hybrid Maize

C. LIVESTOCK SYSTEM

For improvement of cattle health and to control diseases and keeping mortality rate in minimal, proper vaccination is a key program. Farmers' would be economically benefitted through deworming of cattle because of its health improvement. Proper vaccination against four major diseases reduces the mortality rate of cattle. In the vaccinated group Anthrax Vaccine, FMD vaccine, BQ vaccine and HS vaccine were injected as per recommended schedule. Poultry rearing are common practices of rural Bangladesh. Poultry disease is the main problem faced by the farmers for poultry rearing. Only proper vaccination can reduce the mortality rate of poultry. To reduce mortality rate and investigating effectiveness of poultry vaccine at farmers' level this program was conducted at the farmer's households. In the vaccinated group BCRDV, RDV, Fowl pox and Fowl cholera, Duck plague vaccine were used as per recommended schedule. Both FSRD sites of Char land eco-system has undertaken different types of activities for improvement and increased income of concern farm family and the results of those activities are given bellow as site wise.

Location: FSRD site, Mymensingh

I. Deworming of cattle

After deworming the milking rate per day and body weight of cattle gaining observed promisingly. However, the information regarding deworming cattle and performance are presented in Table 23. It was observed that deworming is an easy process to adopt with minimum cost. Eight cattle were dewormed and eight were kept controlled (un-dewormed) of milchcows during the program in FSRD site. While the number of dewormed livestock was as 110. It was found that, before deworming the frequencey of disease incidence was higher whereas the average body weight, disease incidence, lactation yield and the lactation period increased over the controlled cows.The gaining body weight of dewormed milch cow was observed as 40 g/day/cow whose average lactation yield was increased up to 0.4 L/day over the controlled.

Table 23. Average body weight gain, milk production and lactation period after deworming at FSRD site,Mymensingh during 2018-2020

Treatment	Animal (no)		Av Body wt gain/day/animal (g)		Av Lactation yield (litre/day)		Av. Lactation period (day)	
	Year-I	Year-II	Year-I	Year-II	Year-I	Year-II	Year-I	Year-II
Controlled Cattle	05	08	90	90	1.65	1.6	215	215
Dewormed Cattle	05	08	135	130	2.05	2.0	222	222

* Year-I: 2018-19, Year-II: 2019-2020

II. Vaccination of cattle

A total of 110 cattle in FSRD site, Mymensingh were vaccinate dunder this program and vaccinatoin were done on antharax and FMD of cattle. Frequency of diseases of disease incidence of livestock was listed out from the cooperative farmers. It was observed that, after vaccination the mortality rate by foot and mouth disease (FMD) was drastically reduced and it was shown nil (0%) whereas before conduction of the program it showed 10-15% of mortality (Table 24). The contact farmer can easily be adopted this technology of vaccination as it is minimum cost effective and it can be done as per routine work. The cooperator farmers were very much interested about the vaccination program and admitted that it was a good way to reduce mortality rate. Vaccination of cattle, make improvement of health of livestock and handsome cash return to the target farmers**.** That's why the cooperator farmers were interested and adopted this technology as per routine wise after finishing the experimental period.

Table 24. Mortality rate (%) of cattle at before vaccination and after vaccination against major diseases at FSRD site, Mymensingh during 2018- April, 2021

Year of vaccination	Name of the vaccine	No. of cattle Vaccinated	Percentage of mortality (%)	
			Before intervention	After intervention
Feb 2018- Jan. 2019	Anthrax & FMD	110	10	0
Feb 2019- Jan.2020	Anthrax & FMD	110	15	0
Total		220	15	0

III. Vaccination of poultry

The vaccination of poultry program has created a great awareness to the cooperator farmer and neighborhood of farm families at the concerning FSRD sites. Four types of vaccines as BCRDV, RDV, Fowl Pox, Fowl Cholera were vaccinated in the program (Table 25). It revealed that, mortality rate can be minimized significantly through vaccination and it goes down below 5% most of the cases which can be considered as negligible comparing to the condition before the vaccination program. By the application of RDV and Fowl Cholera vaccine have reduced the mortality rate 86% BCRDV and Fowl pox vaccine could reduce the mortality rate at about 88%. After vaccination of poultry, all of the diseases frequency reduced drastically and mortality rate ranged from 2-5% (Table 25) and this type of program is mostly impacted on concern farmer and so far they would follow to vaccinate the poultry in routinely.

Table 25. Mortality rate (%) of chicken at before vaccination and after vaccination against major diseases at FSRD site, Mymensingh during Feb. 2018-April, 2021

Year of vaccination	Name of the vaccine	No. of chicken Vaccinated	Percentage of mortality (%)	
			Before intervention	After intervention
Feb 2018-Jan. 2019	BCRDV	200	21	3
	RDV	190	25	4
	Fowl Pox	180	25	5
	Fowl Cholera	170	22	3
Feb 2019-Jan.2020	BCRDV	150	18	2
	RDV	140	20	3
	Fowl Pox	130	25	4
	Fowl Cholera	160	21	3

IV. Turkey rearing in the farmers' household

Average performances of turkey breed at farmers' level up to 5 months of rearing have been shown in Table 26. Twenty days old total 25 turkey birds were distributed among the four farmers of FSRD site, Mymensingh during October 2018 in winter season. Among the birds, 52% were died due to lack of selection of chicks, healthcare, brooding, feeding, housing etc. and inadequate technical information and support and coldness. But the performance of alive birds was very good. They gained average body weight after five months is 4.50 kg/bird. Although the rapid growth rate and benefit within very short tenure, having some problems for turkey rearing. The farmer faces the problem for technical support and building facilities. There still having the unavailability of manufactured feed and feeding standard, housing and turkey production technology. Low egg yield and unsatisfactory egg fertility and hatchability is also limiting factor for turkey rearing. However, it is a new bird for quick profit as it adapted in climate of Bangladesh. Low disease prevalence, low feeding cost, high market price, alternate source of income and protein makes a good opportunity for household farmer for turkey rearing.Farmers are interested in rearing turkey as it collected 50% feed staff from green vegetables and field grasses that reduces total cost of production and makes it profitable business.

Table 26. Performance of Turkey rearing after 5 months of distribution at FSRD site, Mymensingh during Feb. 2018-April, 2021

Name of Farmer	Bird supplied (no)	Chicken survives (no)	Initial body wt (g/poult)	Body wt after 5 months (kg/bird)
1. Md. Reju Miah	9	5	250-300	4.50
2. Md. Sayan Uddin	7	3	250-300	4.00
3. Md. Mirash Uddin	5	3	250-300	4.50
4. Md. Abadul Miah	4	1	250-300	5.00
Total	25	12	-	4.50

V. Duck rearing in the farmer's household

Although, some ducks were died might be due to duck plague a unique disease for duck but after 5 months of rearing the average body weight of each duck was achieved around 1.6 kg. The survival rate was promising and it was observed that around 79% ducks were able to lay eggs after attaining at the age of 6 months and it continued whole the year. After intervention of improved feeding, technological support and vaccination the laid eggs per duck was increased and it was on an average 112 eggs per month of laying (Table 27). It was observed that among the farm family, one farmer (Farmer 1) obtained the highest survival rate (88%) and so far laid eggs (120) and consumption rate might be due to the carefulness of rearing ducks. One important thing clearly observed that after rearing ducks the consumption rate of eggs per farm family has been increased on an average 47% (Table 27) which ensure the nutritional balance of the concerned farmers. The obtaining extra cash income from the duck rearing possesses the livelihood improvement of the contract farm family.

During the tenure of February to December, 2020, four Khaki Campbell ducks were supplied to each of ten farmers and their survival rate was promising and it was almost 100%. After two months of rearing, it was observed that average body weight gained around 1.57 kg and some of the ducks are being laid to eggs and the average egg laid per month was observed as 47. After intervention of the program the awareness of consumption of egg in farm family has been increased and, on an average, it was observed 49% (Table 32) which ensure the nutritional balance that means the improvement of livelihood. During the last two months on an average per month Tk. 474 to be earned by a family that they expense for their improvement of livelihood. On the other hand, some farm family expresses their good satisfaction on fulfill the aesthetic need and as well as bear the expenditure of their child education.

VI. *Sonali* chicken rearing at farmer's level for egg and meat purpose

One of the important sector of livestock production in Bangladesh is poultry for providing eggs and meat. The rural people is rearing the indigenous poultry for eggs and meat and some cases of some additional income but the performance of local hens is genetically poor. From our survey report it was shown that the percentage of egg production of local hens was only 12%. In this context, Sonali breed has much productive and adaptive capacity in village conditions. Keeping these views, the study was under taken during the last February to date on 2020 (Table 28). Production of eggs and meat is still in pipeline but body weight gained 0.90 Kg per bird after one month of rearing.

Table 27. Performance of Duck rearing after 6 months of distribution at FSRD site, Mymensingh during Feb, 2018-April, 2021

Name of farmers	Ducks supplied (no)	Duck survived (no)	Body wt after 6 months (kg)	Egg laid month^{-1} (no)	Egg consumption month^{-1} (no)		Monthly income (Tk)
					Before	After	
Year-II: February 2018 -January 2020							
Md. Abdul Momin	8	7	1.7	120	20	30	1200
Md. Abdul Kadir	8	6	1.6	110	15	28	1100
Md. AbulHashem	8	6	1.5	106	13	25	1060
Year-II: Feb 2020 –April, 2021							
Md. Abdul Momin	4	4	1.8	50	20	40	500
Md. Abdul Kadir	4	4	1.6	45	30	45	450
Md. Azizulislam	4	4	1.5	65	40	60	650
Md. Sekandar Ali	4	4	1.6	50	20	30	500
Md. EmdadulHaque	4	4	1.7	60	20	30	600
Md. Fazlur Rahman	4	4	1.6	70	20	25	700
Md. Mostafa Mia	5	4	1.5	29	40	60	290
Md. Kamrul Islam	4	4	1.4	35	25	35	350
Md. Sain Uddin	4	4	1.6	30	15	20	300
Md. Mirash Uddin	4	4	1.4	40	15	20	400

Market price of egg: 40 Tk per 4 pieces

Table 28. Performance of *Sonali chicken* at household level up to 2 months of rearing at FSRD site, Mymensingh during Feb.2020 – April, 2021

Description of Item	Observation
Number of farmers	11
No of birds supplied (per farmer)	6
Date of supplied period	10th Nov. 2020
Initial body wt/bird (kg)	0.75
Procurement price/bird (Tk.)	127
No of chicken survive	100%
Date of delivery egg	Not yet
Egg Production (Number)	-
Consumption	-
Sale	-
Distribution	-
Total number of Egg	-
Performance of Bird	
Weight gained/bird (Kg) after one month	0.90
Consumption	-
Sale	-
Distribution	-
Total number	-
Total income from bird (Tk.)	-
Total variable cost (Tk)	-
Total return/farmer in Tk. (Market value of Egg + Meat)	-
Gross margin (Tk)	-

VII. Artificial insemination on cattle

One farmer was suggested to artificial insemination and supplied brahmi AI to two of the cattle and it has been waiting for calf birth. The cattle were inseminated on June 20th, 2020 and the feed for caring the cattle were also supplied by the supervision of OFRD, BARI, Mymensingh. During the last six months the body weight increased as 60 kg (Table 29).

Table 29. Performance of artificial insemination after attaining 6 months of growing at FSRD site, Mymensingh during Feb. 2020 – Dec. 2020

Name of farmers	Cattle (no)	Initial body wt (kg)	Body wt after 6 months (kg)	Body wt increased (kg)
Md. Momin Mia	2	115	175	60

VIII. Goat rearing in the farmers' household for increase income of farmers

One of the important sub sector of livestock component is goat rearing in household to generation of income. For this purpose, four farmers were supplied goat during the period of February to December, 2020. However, their details are as follows in the Table 30and production is in pipeline.

Table 30. Performance of goat rearing at household level at FSRD site, Mymensingh during Feb. 2018 –April, 2021

Description of Item	**Observation**
Number of farmers	4
No of goat supplied per farmers	1
Date of supplied	30th Nov, 2020
Age of goat during distribution	1 year 1 month
Initial body wt/goat (kg)	10
Procurement price/goat (Tk.)	3000
No of goat survive (%)	100
Weight gained/goat (kg) after 1 month	About 0.7 – 0.9

Location: FSRD site, Bogura

I. Vaccination of cattle

The results generated under vaccination of cattle are represented in Table 36. A total of 670 cattle in FSRD site, Bogurawere vaccinated against Anthrax and FMD, 200 goat and 120 sheep were vaccinated with PPR vaccine. Frequency of diseases of disease incidence of livestock was listed out from the cooperative farmers. It was observed that, after vaccination the mortality rate by foot and mouth disease (FMD) was drastically reduced and it was shown nil (0%) whereas before conduction of the program it ranged from 2-15% (Table 31). The contact farmer can easily be adopted this technology of vaccination as it is minimum cost effective and it can be done as per routine work. The cooperator farmers were very much interested about the vaccination program and admitted that it was a good way to reduce mortality rate. Vaccination of cattle make improvement of health of livestock and handsome cash return to the target farmers. That's why the cooperator farmers were interested and adopted this technology as per routine wise after finishing the experimental period.

II. Vaccination of poultry

This program was conducted at FSRD site, Bogura during 2018-2020. The vaccination of poultry program has created a great awareness to the cooperator farmer and neighborhood of farm families at the concerning FSRD sites. Four types of vaccines as BCRDV, RDV, Fowl Pox, Fowl Cholera, Duck plague were vaccinated in the program (Table 32). It revealed that, mortality rate can be minimized significantly through vaccination and it goes down below 6% most of the cases which can be considered as negligible comparing to the condition before the vaccination program. By the application of vaccine, average mortality went down from 22.40% at pre intervention to 5.47% at post intervention condition. After vaccination of poultry, all of the diseases frequency reduced drastically, and mortality rate is about 6% (Table 32) and this type of program is mostly impacted on concern farmer and so far, they would follow to vaccinate the poultry in routinely.

Table 31. Mortality rate (%) of livestock at before vaccination and after vaccination against major diseases at FSRD site, Bogura during Feb. 2018 –April, 2021

Year of vaccination	Name of the vaccine	No. of livestock Vaccinated			Percentage of mortality (%)	
		Cattle	Goat	Sheep	Before intervention	After intervention
Year I	Anthrax & FMD	400	-	-	15	0
Year II	Anthrax & FMD, PPR	50	50	40	3	0
Year III	Anthrax & FMD, PPR	220	150	80	2	0
	Total	**670**	**200**	**120**		

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

Table 32. Mortality rate (%) of poultry birds at before vaccination and after vaccination against major diseases at FSRD site, Bogura during Feb. 2018 – April, 2021

Year of vaccination	Name of the vaccine	No.of poultry birdsVaccinated				Percentage of mortality (%)	
		Chicken	Duck	Pigeon	Turkey	Before intervention	After intervention
Year I	BCRDV	460	-	-	-	28	4
	RDV	329	-	-	-	21	6
	Fowl Pox	270	-	-	-	19	5
	Fowl Cholera	180	-	-	-	17	6
	Duck plague	-	200			30	5
Year III	BCRDV	150	-	-	-	28	3
	RDV	120	-	-	-	21	5
	Fowl Pox	120	-	-	-	19	6
	Fowl Cholera	130	-	-	-	17	4
	Duck plague	-	105			30	5
Year III	BCRDV	140	-	-	-	17	7
	RDV	250	-	-	-	16	4
	Fowl Pox	130	-	-	-	25	6
	Fowl Cholera	150	-	-	-	13	6
	Duck plague	-	200			35	10
Total		**2429**	**505**	**Average**		**22.40**	**5.47**

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

III. Duck rearing

Eleven farmers were given duck in Bogura and provided with Khaki Campbell breed locally rearing duck bought from a local market. Averagely 3 ducks were died in each family might be due to duck plague a unique disease for duck but after 5 months of rearing the average body weight of each duck was achieved around 1.12 kg in 120 days and 2.2 kg in 180 days (Table 33a and Table 33b). The survival rate was promising, and it was observed that around 78% ducks were able to lay eggs after attaining at the age of 6 months and it continued whole the year. After intervention of improved feeding, technological support and vaccination the laid eggs per duck was increased and it was on an average 150 eggs per month of laying (Table 33a). One important thing clearly observed that after rearing ducks the consumption rate of eggs per farm family has been increased from 27 no/month at pre intervention to 98 no/month at post intervention period with an average increment of 262.93% (Table 33a) which ensure the nutritional balance of the concerned farmers. The obtaining extra cash income from the duck rearing possesses the livelihood improvement of the contract farm family. The monthly income obtained from egg per household was calculated as Tk. 480 (Table 33c). Initially 250g weighed ducklings were supplied to the farmers that gained 2.2 kg weight each after six months rearing with 780% increased body weight along with 337.5% higher market value (Table 33c). Utilization pattern of eggs was presented in the Table 33b. About 62% eggs produced in the farm family was consumed by themselves. 6% eggs were distributed to the relatives and finally 32% was sold in the market to get cash income for meeting other household needs.

Table 33a. Performance of *Khaki Campbell* rearing at FSRD Site, Bogura during Feb. 2019 - April, 2021

Name of farmers	Ducks supplied (no)	Duck survived (no)	Egg laid month^{-1} (no)	Egg consumption month^{-1} (no)	
				Before	After
1. Md. Miju	15	12	159	25	92
2. Md. Abdul Kalam	15	13	156	23	98
3. Md. Anarul Islam	15	14	210	30	103
4. Md. Saidur Rahman	15	12	173	27	95
5. Md. Sukur Ali	15	10	113	23	96
6. Md. Helal	15	13	156	29	104
7. Helal Mia	15	12	126	27	96
8. Md. Alaul	15	11	144	26	95
9. Md. Ainul Islam	15	10	98	31	102
10. Md. Jenarul Islam	15	14	148	23	90
11. Md. Bitul Sarkar	15	13	168	33	107
Average	**15**	**12**	**150**	**27**	**98**

Table 33b. Individual weight gain by *Khaki Campbell* rearing at FSRD Site, Bogura during Feb. 2019-April, 2021

Breed	Initial body wt at 60 days old (g)	120 days old (kg)	180 days old (g)	Body wt increase over Initial (%)	Market value increment (%)
Khaki camble	250	1.12	2.2	780	337.5

Initial price: 80 Tk/duckling, Present value: 350 Tk/duck,

Table 33c. Utilization pattern of eggs hatched by *Khaki Campbell*at FSRD site Bogura during 2019-2020

No of egg produced	Consumption (%)	Distribution (%)	Sale (%)	Income from sale (Tk)
150	62%	6%	32%	480

Market price of egg: 40 Tk per 4 pieces

IV. Sheep and Goat rearing

Initially 8 farmers provided with sheep till June 2020. Two sheep became dead due to feeding on insecticide sprayed fodder. After the month of June 2020, again six goats were distributed among the rest six farmers including two who had lost their sheep. The animals were vaccinated and provided with feed. Previously given four adult ewes have given birth to new offspring. One sheep gave 3 kids and the other three gave 6 (each gave 2) offspring. Gross value, rearing cost and gross margin of individual farmer was Tk. 6333, 2000 and 4333 per year, respectively (Table 33).

Table 33. Performance of sheep/goat rearing at household level at FSRD site, Bogura during Feb. 2018 – April, 2021

Description of Item	Year I	Year II	Year III
Number of farmers	1	7	6
No of sheep/goat supplied per farmers	1	1	1
Date of supplied	25 July 2018	25 Sep 2019	16 July, 2020
Age of goat during distribution	8 Month -1 Yr	6 Month-1.2 Yr	1 year 1 month
Initial body wt/goat (kg)	5-7	4.5-6	5-7
Procurement price/goat (Tk.)	3000-3500	3500-4000	3800-4200
No of goat survive (%)	100	80	100
Weight gained/goat (kg) after 6 month	9.6	8-11	7-8
Total number of kids born (Feb.2018-Dec. 2020) per farmer	-	4	5 (2 dead)
Gross value (Tk.)/ farmer	6333		
Rearing cost (Tk)/farmer	2000		
Gross margin (Tk.)/farmer	4333		

* Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

V. Beef fattening

Beef fattening program was carried out at FSRD site, Bogura during February 2020 to December 2020. Details about beef fattening presented in the Table 35. A total of 10 cattle from six farmers household were selected for fattening. The initial body weight of the selected animal was ranged from 38 kg to 92 kg with an average weight of 56.67 kg. The cattle were provided with supplied food as prescribed by Department of Livestock Office, Bogura. Besides this, farmers also feed their cattle with their farm produced crop stubble, grass. After 160 days of rearing, cattle weight increased remarkably ranged from 55 kg to 140 kg with an average increased body weight 85.67 kg. The average increment of body weight was 50.17%. Initially the mean value of each cattle was Tk. 51833 which was increased to Tk. 67166 with an average increased value of 29.58%.

Table 35. Performance of beef fattening at household level at FSRD site, Bogura during Feb. 2018 – Dec. 2020

Farmer	No. of breed	Initial body wt. (kg)	Body wt. after 160 days (kg)	Wt. increased over Initial (%)	Initial value (Tk)	Present value (Tk)	Increment (%)
Farmers 1	2	92	135	47	78000	103000	32
Farmers 2	1	45	60	33	40000	49000	23
Farmers 3	2	85	140	65	75000	102000	36
Farmers 4	1	40	55	38	37000	48000	30
Farmers 5	1	38	60	58	41000	50000	22
Farmers 6	1	40	64	60	40000	51000	23
Average		**56.67**	**85.67**	**50.17**	**51833**	**67166**	**29.58**

D. Fisheries Component

Fisheries sub-system has a unique role to improve livelihood and play a vital role in integration of different component of FSRD program. Fish culture in seasonal pond is an income generation and meeting up protein deficiency to rural people also an aesthetic hobby for some people.

Location: FSRD site, Mymensingh

I. Maximization of farmers' income through the technique of mixed polyculture of carp at lowcost management

Survival rate: There were four seasonal ponds selected for poly culture of carp fishes in FSRD site, Mymensingh during 2018-2019. In carp polyculturesilver carp , Rui, Catla, Mrigel and grass carp fingerlings were released in the pond. Number of ponds, average pond area (dec.) and depth (m), total amount (kg) and weight of fry, total amount and number of fishes and survival rate etc. has been presented in Table 36a. The results revealed that, in poly culture of carp fishes the average survival rate of various fishes was 75.20% in FSRD site, Mymensingh.

Yield and economic return: Yield and economic analysis of fish culture before and after intervention have been presented in Table 36b. It was observed that, before intervention 3507 kg per ha fish was found with the gross margin Tk.187563 ha^{-1} whereas after intervention 6020 kg ha^{-1} fish was found with the gross margin Tk. 360767 ha^{-1}. The BCR was 3.02 in before intervention and it was 3.98 after intervention.

Utilization pattern: Among the total production farmers consumed, distributed to relatives and sold their products in local market. It was observed that, farmers sold most of the portion (average 433 kg), consumed about average 40 kg and distributed average15 kg through their neighbors, relatives and well-wishers of the produced fish (Table 36c). The farmers were benefitted by carp polyculture system and they showed further interest for farming of carp polyculture.

Table 36a. Performance of fish under carppolyculture in seasonal pond at FSRD site, Mymensingh during 2018-2019

No of pond	Area & depth of pond (dec& m)	Amount and number of fry	Total amount & number of fish	Survival rate (%)
04	20 dec 1.45 m	9.25 kg and 1375	488 kg and 1020	75.20

Table 36b. Production and economic return at pre and post intervention of carppolyculture technique at FSRD site, Mymensingh during 2018-2019

Before intervention				BCR	After intervention				BCR
Production (kg ha^{-1})	Total income (Tk)	TVC (Tk)	Benefit (Tk ha^{-1})		Production (kg ha^{-1})	Total income (Tk)	TVC (Tk)	Benefit (Tk ha^{-1})	
3507	280560	92997	187563	3.02	6020	481600	120833	360767	3.98

Table 36c. Utilization pattern of harvested fish under carppolyculture at FSRD site, Mymensingh during 2018-2019

Total yield (kg/Pond)	Consumption (kg)	Distribution (kg)	Sale (kg)
488	40	15	433

II. Maximization of farmers' income through the culture of mono sex tilapia at low cost management

Three seasonal ponds were selected for fish culture with mono sex tilapia in FSRD site, Mymensingh during 2019-2020. The ponds were average 20 decimal sized with a 1.45 m depth. Information on ponds area, fry amount and weight, final total amount and number of fish, survival rate has been shown in Table 37a. The results revealed that, mono sex tilapia fish culture 85% of fry could be survived and gave achievable weight at harvest. The yieldand gross margin of fish varied from pond to pond due to its size. The BCR found from mono sex tilapia was 3.73 (Table 37b). Among the total production farmers usually used to sell all the fishes although they consumed and distributed some of it to their relatives (Table 37c). It was observed that, farmers sold most of the portion (79%), consumed about 16% and distributed about 3% among their neighbors, relatives and well-wishers. The farmers showed their interest in cultivating mono sex tilapia for its quick growing and more beneficent.

Table 37a. Performance of monosex tilapia in seasonal pond at FSRD site, Mymensingh during 2019-2020

No of pond	Area and depth of pond (dec& m)	Amount and number of fry	Av weight of fry (gm)	Final average weight of fish (g)	Total amount & no of fish	Survival rate (%)
3	26 dec& 1.56 m	23 kg & 473	50	278	118 kg & 417	85

Table 37b. Production and economic return of monosex tilapia at FSRD site, Mymensingh during 2019-2020

Before intervention				BCR	After intervention				BCR
Production (kg ha^{-1})	Total income (Tk)	TVC (Tk)	Benefit (Tk ha^{-1})		Production (kg ha^{-1})	Total income (Tk)	TVC (Tk)	Benefit (Tk ha^{-1})	
2507	200560	49800	150750	3.02	3268	262400	55500	206900	3.73

Table 37c. Utilization pattern of harvested tilapia fish at FSRD site, Mymensingh, 2019-2020

Av yield (kg/pond)	Consumption (kg)	Distribution (kg)	Selling (kg)
118	20	4	94

Location-II: FSRD site, Bogura

I. Maximization of farmers' income through carp polyculture technique at low cost management

There were twelve ponds selected for carp polyculture production in seasonal ponds. The ponds were averagely 12 decimals sized with av. 3.6 m depth and the survival rate of carp fishes were 75-85% (Table 38a). Yield cost and return analysis are shown in Table 43b. Around 250% yield was increased after the intervention improved technology of carp polyculture as compared to the previous condition. The average yield of fish after the intervention was obtained 52 kg in 2018 to 102 kg in 2019 per pond with the average gross margin Tk. 7180 per pond and the benefit increased to 257.21% from each pond. At pre intervention stage, farmers paid a little or no interest on modern pond management technique. Even, they did not have knowledge about standard carp polyculture management.

Table 38a. Performance of fish under carppolyculture in seasonal ponds at FSRD site, Bogura during 2019-2020

Fish Breed	Initial size (cm)	Initial wt. (g)	Size after 90 days (cm)	Weight after 90 days (g)	Size after 180 days (cm)	Weight after 180 days (g)	Survival rate (%)
Silver carp	5	15	16	150	32	500	80
Catla	4	12	13	120	25	450	70
Ruhi	4	12	13	120	25	450	75
Grass carp	6	15	15	170	35	550	75
Rajputi	3	8	9	100	15	300	85

Table 38b. Production and economic return of fish under carppolyculture in seasonal ponds at FSRD site, Bogura during 2019-2020

Fish component	Before Intervention	After Intervention				Increased (%)
		Year I	Year II	Year III	*Average	
Production (kg/pond)	22	52	102	Not harvested	77	250
Total income (Tk/pond)	2640	6240	12240		9240	250
Required cost (kg/pond)	630	1060	3060		2060	226.98
Gross margin (Tk/pond)	2010	5130	9180		7180	257.21

*Average of two years. Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-April, 2021

Table 38c. Utilization pattern of harvested fish under carppolyculture in seasonal ponds at FSRD site, Boguraduring 2019-2020

Fish component	Before Intervention	After Intervention				Increased (%)
		Year I	Year II	Year III	*Average	
Production (kg/pond)	22	52	102	Not harvested	77	250
Consumption (Kg)	16.80	32.48	67.20		49.84	196.67
Distribution (Kg)	5.20	6.40	9.30		7.85	50.96
Sale (Kg)	0	13.12	25.50		19.31	100

* Average of two years. Year I= Feb.2018-Jan.2019, Year II= Feb.2019-Jan.2020 & Year III= Feb.2020-Dec.2020

E. OFF FARM ACTIVITIES

Location: FSRD site, Mymensingh

Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Initially one household was started handicrafts making for commercial practice and finally most of the households showed their interest in practicing handicrafts besides of other off-farm activities. In Mymensingh, besides agricultural production, some farm families' especially the women were engaged with sewing cloths with machine, making different handicrafts during their leisure periods. Nine farmers had shallow machine and provide irrigation water commercially.Two farmer was engaged with small electric shop and tea stall and it opened at his off-time. Four farmers have power tiller and sometimes they sale labor. However, it was found that after intervention the gross margin increased 144.76%, with the gross margin of Tk. 4200 (Table 39). So, if all households could introduce some off-farm activities, it would be helpful to increase total farm income.

Table 39. Economic return of off-farm activities at FSRD site, Mymensingh during 2019-20

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin (GM) increased (%)
	GR	TVC	GM	GR	TVC	GM	
Sewing machine	3000	1500	1500	8500	3200	2500	66.66
Irrigation provider	6000	2500	3500	9000	3500	5500	57.14
Electric shop	7000	3000	4000	8000	3000	5000	25.00
Tea stall	6000	4000	2000	8000	4000	3000	50.00
Selling labor	4000	-	4000	5000	-	5000	25.00
Average	**5200**	**2750**	**3000**	**7700**	**3425**	**4200**	**44.76**

Location: FSRD site, Bogura

From the results for 2019-20, it was observed that after intervention the average gross margin increased 29.44%, with the av. gross margin of Tk. 7766.67 (Table 40a). So, if all households could introduce some off-farm activities, it would be helpful to increase total farm income. Other than agricultural activities, which called off-farm activities is also a good opportunity for increasing farm total income. Initially, one household was started handicrafts making for commercial practice, and finally, most of the households showed their interest in practicing handicrafts besides other off-farm activities. For 2020, It was found that after the intervention the average gross margin increased to 132.46%, with the av. gross margin of Tk. 6500 that was Tk. 3000 at before intervention (Table 40b). So, if all households could introduce some off-farm activities, it would be helpful to increase total farm income.

Table 40a. Economic returnof off-farm activities at FSRD site, Bogura during Feb. - Dec. 2019

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross margin (GM) increased (%)
	Gross return	Required cost	Gross margin	Gross return	Required cost	Gross margin	
Sewing machine	5000	1500	3500	8500	3200	5300	51.43
Irrigation provider	7000	3500	3500	9000	3500	4500	28.57
Fishing	15000	4000	11000	18000	4500	13500	22.73
Average	**9000**	**3000**	**6000**	**11833.33**	**3733.33**	**7766.67**	**29.44**

Table 40b. Economic returnof off-farm activities at FSRD site, Bogura during Feb. - Dec. 2020

Type of activities	Before intervention (Tk.)			After intervention (Tk.)			Gross Margin (GM) increased (%)
	Gross return	Required cost	Gross margin	Gross return	Required cost	Gross margin	
Sewing machine	2500.00	750.00	1750.00	7500.00	2000.00	5500.00	214.28
Irrigation provider	3500.00	1750.00	1750.00	5500.00	2200.00	3300.00	88.57
Fishing	7500.00	2000.00	5500.00	15000.00	4300.00	10700.00	94.54
Average	**4500**	**1500**	**3000**	**9333**	**2833**	**6500**	**132.46**

F. COST AND RETURN FROM DIFFERENT COMPONENT OF AN INTEGRATED FARM

Cost and return related comparative data of an integrated farm has been given in Table 46 and Table 47 for FSRD site, Mymensingh and Bogura, respectively. Holistic approach in a farm under integrated way may bring higher income than the previous condition. Selection of suitable cultivars, following modern cultivation techniques, rearing of farm animal, feeding them in a proper way, timely vaccination of farm animals and bird, practicing carp poly culture techniques may enhance farm productivity as well as income in an integrated manner which ultimately contributed to livelihood development of the target beneficiary. Data presented in the Table 41, revealed that, the total income of a farm family at FSRD site, Mymensingh was increased from Tk.64182 (Before intervention) to Tk. 114498 (after intervention). Total net income was increased by 80.44%. On the contrary, at FSRD site Bogura, the total income of a farm family was increased from Tk.60688 (Before intervention) to Tk. 109127 (after intervention) in the Table 42. Total net income was increased by 82.68%.

Table 41. Economic return from different sub-systems for integration of farming system at FSRD site, Mymensingh during 2018 –April, 2021

Components	Before Intervention (Tk.)			After Intervention (Tk.)			Increased (%)
	Total Income	Cost	Net income	Total Income	Cost	Net income	
Homestead vegetables	945	500	445	7960	2266	5693	1179.32
Homestead fruits	3000	500	2500	6050	1566	4483	79.32
Field crop (1 bigha)	50017	170	32961	65498	22770	42728	29.63
Livestock	2380	700	1680	15050	4470	10580	529.76
Fisheries	2640	630	2010	12240	3060	9180	356.72
Off-farm	5200	2750	3000	7700	3425	4200	44.67
Total	**64182**	**22136**	**42596**	**114498**	**37557**	**76864**	**80.44**

Table 42. Economic return from different sub-systems for integration of farming system at FSRD site, Bogura during 2018 –April, 2021

Components	Before Intervention (Tk.)			After Intervention (Tk.)			Increased (%)
	Total Income	Cost	Net income	Total Income	Cost	Net income	
Homestead vegetables	1174	650	524	8326	2830	5496	948.85
Homestead fruits	930	250	680	4680	1250	3430	404.41
Field crop (1 bigha)	4907	18056	31015	61498	22770	38727	24.86
Livestock	2680	600	2080	13050	4570	8480	307.69
Fisheries	2640	630	2010	12240	3060	9180	356.72
Off-farm	4500	1500	3000	9333	2833	6500	116.66
Total	**60995**	**21686**	**39309**	**109127**	**37313**	**71813**	**82.68**

Farmers' opinion

The farmers from FSRD sites responded positively specially for homestead garden as it is a source of fresh vegetables and even it is a source of cash income during raining season or crisis moment. The resources poor farmers are interested in adopt those technologies which can provide additional production and quick return in terms of cash income. They are mostly vulnerable to their decision and shift to other activities. Due to adoption of integrated faming, they are hopeful to maintain their family with farm income.

Problems/Constraints

1. Tedious, laborious and continuous work, needing skills in production techniques of different components.
2. Lack of strong multidisciplinary scientific team to implement the program
3. Lack in easy analytical tool to interpret data comfortably. (Needs a computer programming on Analysis of results)
4. Skill of site level staff and the farm family members were not as effective as required for optimum production and accurate information.
5. Initially higher investment is required which is a major problem.

Conclusion

An integrated farming system is a recyclable approach in which waste of one enterprise becomes the input of another thus making efficient use of resources. From the study it was exposed that the components of integrated farming like home gardening, cropping system, dairying, poultry, fishery, etc. are interrelated. The waste of dairy like dung, urine, refuse etc. is used for preparation of FYM, which is an input in cropping systems. The straw obtained from the crops is used as fodder for cattle and used for different field operations for growing crops. Thus, different enterprises of farming systems are highly interconnected. The vital indicator for livelihood improvement is increasing income compared to existing situation, which was effectively obtained from the program. So, the proper utilization of farmers' resources can help them in this area. However, integrated farming is a very talented technology for livelihood improvements of farmers, but it needs multidisciplinary skilled strong scientific team for more successful integration of technologies. Furthermore, it is needed to establish the technology for sustaining the integrated farming system research program in all farming system research and development sites.

Project V:

Socioeconomic Studies

CASE STUDY OF FARM MACHINERY IN CHAR AREAS OF MYMENSINGH DISTRICT

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Abstract

The study aimed at exploring farmers' perception towards farm mechanization and finding out its relationships with the selected characteristics of the farmers. Problems faced by the farmers in farm mechanization and their corresponding solutions were also explored. Data were collected by using a pre-tested interview schedule at Sadar upazila of Mymensingh district from randomly selected 60 respondents by using simple random sampling method during February to March 2022. Farmers' attitude towards farm mechanization was the focus issue of the study and was measured by Likert scale. The observed score of farmers' attitudes towards farm mechanization ranged from 13 to 59 with the mean score of 33.33. Among the farmers, 40.0 percent belonged to neutral attitude category while 31.66 percent belonged to unfavorable and 28.33 percent to the favorable attitude category. Two out of eight selected characteristics of the farmers viz, educational qualification and extension media contact had significant positive relationships and annual income had negative significant relationship with their attitude towards farm mechanization. Rests of the characteristics had no significant relationship with the focus issue. Based on Problem Facing Indices (PFIs) the top ranked problem in relation to farm mechanization is initial investment and maintenance cost is high (PFI 143) and the top ranked solution suggested by the farmers in relation to farm mechanization is government subsidy in heavy farm machineries. Different agricultural development organizations should recognize the existing problems of farm mechanization and step forward for solving these problems.

Introduction

Farm mechanization in Bangladesh is demanding issue by the farmers due to high production cost of traditional technology which is labour intensive. Every year about 0.20 million people is added to the population of Bangladesh whereas, agricultural land is decreased around @1% per year. To meet up the food requirement of the increase's population from the decreased agricultural land, agricultural productivity and cropping intensity need to be increased. Crop productivity and yield can be increased through the use of modern agricultural practices. Timely preparation of land, sowing by seeder in lines, weeding, application of fertilizer and irrigation is very important for sustain crop yield and reduction of cost. This can be done by adopting appropriate mechanization. Scarcity of agricultural labour becomes serious during peak harvesting season of paddy. Delayed harvesting again causes loss of grain during harvesting. These problems can be solved by adopting appropriate farm mechanization. Farm mechanization reduces the crop production cost, reduces the drudgery of the farmers and increases cropping intensity as well as higher production.

Farming systems through farm mechanization and production intensification offer a range of productivity, socio-economic and environmental benefits to producers, food value chain sector and society in general. Mechanization enables farm family members not only to increase farm productivity via production intensification in some cases expansion, but also to seek off-farm employment opportunities (Houmy *et al*., 2013). In Bangladesh, mechanization is more likely to decrease labor demand when it enables more land to be cultivated because of potential production cost savings and reduction in drudgery by substituting manual labor and traditional tools with efficient machineries (Mottaleb *et al*., 2016). However, mechanization is just one component in the agricultural intensification process and mechanization should not actually initiate intensification where it is not already driven by population pressure and market demand (FAO, 2011, 2016). In summary, agricultural mechanization needs to be simultaneously: environmentally compatible, economically viable, affordable, adapted to local conditions, in view of current developments in weather patterns, and climatic condition. In practice, it involves the wide-scale application of conservation agriculture practices (FAO, 2016).

Emphasizing on above discussed necessity, farmers' attitude towards farm mechanization is very important for its adoption. The Government of Bangladesh is giving much emphasis for agricultural development of the country through farm mechanization in recent time (Fuad & Flora, 2019). Department of Agricultural Extension (DAE) encourages and supports planning and implementation of all agricultural extension activities emphasizing farm mechanization at the grass-root level (DAE, 2016). For appropriate farm mechanization the farmers need enough supervising, demonstration programs and training for farm mechanization. Different characteristics of the farmers might influence this phenomenon, which might be needed to be investigated for clear representation of their attitude towards farm mechanization. Farmers' problems regarding farm mechanization and their suggested solutions also might help to this comprehensiveness of understanding. Therefore, the present study was undertaken with the following specific objectives;

- To know the farmers' perception about existing farm machinery.
- To identify the factors affecting farmers attitude towards farm mechanization and
- To identify the problems and prospects of farm mechanization.

Methodology

The study was conducted in Mymensingh district. The Sadar upazila of Mymensingh district was selected purposively. Two unions of the upazila namely Bidyagonj and Boror char were selected randomly. Face-to-face interview method was used for data collection. A pre-tested interview schedule was used during the interview for data collection. A total of 60 farmers were randomly selected for interview. Farm machinery those are commonly used like power tiller, threshing machine, spray machine etc. in char areas was considered in this study.

Farmers' attitude towards farm mechanization was the focus issue of the study. This variable was measured by using Likert scale (Likert, 1932). Twelve statements (6 positive and 6 negative) on various aspects of farm mechanization were asked to the farmers. The positive and negative statements were arranged randomly in the schedule in order to avoid acquiescence response bias i.e., the common tendency to agree with all statements/questions asked. A neutral midpoint, balanced questions, and the appropriate amount of positive and negative scale points ensure the bias does not compromise the data and represent the real picture of attitude of the farmers. There were five options to response a statement, namely 'strongly agree', 'agree', 'undecided', 'disagree' and 'strongly disagree' with a corresponding score of 5, 4, 3, 2, and 1, respectively for the positive statements and the scoring was reversed for the negative statements. A respondent was asked to indicate his or her attitude regarding a statement by selecting the appropriate option. The attitude score of a respondent was computed by summing the scores for his/her responses to all the statements. Hence, scores of a respondent could range from 12 to 60; while 12 indicating highly unfavorable attitude and 60 highly favorable attitudes towards farm mechanization. In addition, eight characteristics of the farmers were selected to describe the profile of the farmers were: age, educational qualification, household size, earning members, farming experience, farm size, annual income and extension media contact. The selected characteristics were considered to have relationship with the farmers' attitude towards farm mechanization.

Farmers faced many problems in farm mechanization. To determine the problems, the researcher made discussion with the farmers of the study area during pre-testing of the questionnaire. Eight problems were identified. Each farmer was asked to indicate his or her option regarding each problem. Farmers had option to indicate each problem as 'high', 'medium', 'low' or 'not at all'. To get score of each problem four options 'high', 'medium', 'low' or 'not at all' were assigned by score of 3, 2, l and 0, respectively. For getting total score of the eight problems of the farmers, each problem along with rank order was computed by using the following formula:

Problem Facing Index (PFI) = $P_h \times 3 + P_m \times 2 + P_l \times 1 + P_n \times 0$

Where, Ph = Number of respondents with 'high' response
Pm = Number of respondents with 'medium' response
PI = Number of respondents with 'low' response
Pn = Number of respondents with 'not at all' response

The problem facing score could range from 0 to180 (3×60), where 0 indicates not faced the problem at that entire specific problem and 180 indicates the highest extent of problem faced for that specific problem.

The suggestions offered by the respondents to their problems faced in farm mechanization were ranked by content analysis through counting citations and ranked order of the suggestions was also constructed based on the citations.

Data collection was done from February to April 2022. The collected data were coded, edited, summarized, tabulated and analyzed to fulfill the objectives of the study. In order to find out the relationship between the selected characteristics of the farmers and their attitude, Karl Pearson's Product Moment Correlations Co-efficient (r) was computed.

Results and Discussion

Farm machineries used by respondent in the study area

In the study area, farmers use power tiller, threshing machine, spray machine, weeder, combine harvester and local hand tools. BARI developed farm machineries are not available in the char areas. Farmers in the study area claimed that they need developed and modern farm machineries. List of farm machineries shown in Table 1.

Table 1: List of farm machineries used by farmers

Name of the farm machinery	Percentage of the respondent	Own	Rented
Power tiller	100	17	83
Threshing machine	90	11	89
Spray machine	100	100	-
Weeder	43	100	-
Combine harvester	7	-	100
Local hand tools	100	100	-

Source: Field survey, 2022

Farmers' attitude towards existing farm mechanization

The observed overall score of attitudes towards farm mechanization ranged from 13 to 59 with the possible range of 12 to 60. The mean score of farmers' attitudes towards farm mechanization is 33.33 (Table 2). Based on the possible range of farmers' attitude towards farm mechanization, respondents were classified into three categories namely 'unfavorable' (up to 28), 'neutral' (29-44) and 'favorable' (above 44). It was found that among the respondents' 40 percent belonged to neutral attitude category while 31.66 percent had unfavorable attitude and 28.33 percent had favorable attitude towards farm mechanization. The findings implied that most of the respondents were clustered around the neutral attitude towards farm mechanization category. This indicates that attitude towards farm mechanization is not at satisfactory level. It is required to bring the favorable attitude of the farmers towards farm mechanization because 28.33 percent of the farmers had favorable attitude towards farm mechanization. This can be done by supporting farmers with their demand led farm mechanization related information by different agricultural extension organizations (Table 2).

Table 2: Distribution of different categories of farmers based on their attitude towards farm mechanization score (N = 60)

Range		Categories	Frequency	Percentage	Mean
Possible	Observed				
12-60	13-59	Unfavorable (Up to 28)	19	31.66	33.33
		Neutral (29-44)	24	40.00	
		Favorable (Above 44)	17	28.33	
		Total	60	100	

Source: Field survey, 2022

Demography of the farmers: The findings of the selected characteristics are presented in Table 3. The respondents were classified in suitable categories for describing their selected characteristics as per the standard of the discipline.

Age of the farmers was found to vary from 22 to 60 years with a mean of 39.88 years. It was found that 61.67 percent of the farmers fell in the middle-aged category, while 30.00 percent of the farmers fell in the young-aged category, and 8.33 percent in the old-aged category. Findings also indicated that an overwhelming majority of the farmers were middle and young aged. Exposure to formal education is very important for shaping-up the behavior of an individual (La Belle, 1982). The educational scores of the farmers ranged from 0.5 to 10 years, the mean is 3.46. Results indicated that 56.67 percent of the farmers can sign their name only, 31.67 percent had secondary, and 11.67 percent of the farmers had primary level of education. Literacy rate in Bangladesh is 73.2 percent (BBS, 2019). But in the study area, the literacy rate is 43.34 percent which is much lower than the national average. The household size of the respondents ranged from 3 to 9 persons with a mean of 5.80. Findings indicate that majority of the farmers (53.33 percent) have medium sized household. On the other hand, 31.67 percent had small household and 10.8 percent had large household. The findings indicate that about over-whelming majority of the respondents had medium to small sized household. The number of earning member of the household of the respondents ranged from 2 to 7 persons, the mean is 3.98. It was also found that 60.00 percent of the respondents had moderate number of earning members while 26.67 percent had large, and 13.33 percent had low number of earning member. It was also found that 86.67 percent of the respondents had moderate to high number of earning members in their family. Earning member expresses how many family members are earning and higher earning member of the household indicates that more earning of the household medium to large number of earning members might influence high earning of the family and high earning might help in adopting farm mechanization at high rate.

Table 3: Distribution of the farmers based on their selected characteristics

Characteristics	Scoring method	Categories	No. of respondent	Percentage	Mean
Age	No. of year	Young (≤ 35)	18	30.00	39.88
		Middle (36-55)	37	61.67	
		Old (> 55)	5	8.33	
Educational qualification	Year of schooling	Can sign name only (0.5)	34	56.67	3.46
		Primary (1-5)	7	11.67	
		Secondary (6-10)	19	31.67	
Household size	No. of members	Small (1-4)	19	31.67	5.80
		Medium (5-6)	32	53.33	
		Large (>6)	9	15.00	
Earning member	No. of members	Low (up to 2)	8	13.33	3.98
		Medium (3-4)	36	60.00	
		Large (>4)	16	26.67	
Farming experience	Years	Fair (1-10)	20	33.33	14.35
		Good (11-20)	31	51.67	
		High (>20)	9	15.00	
Farm size	Hectare	Marginal (0.02-0.20)	18	30.00	0.44
		Small (0.21-1.0)	38	63.33	
		Medium (1.01-3.0)	3	5.00	
		Large (above 3)	1	1.67	
Annual income	('000' Tk)	Low (≤ 100.00)	7	11.67	155.40
		Medium (100.01-200.00)	48	80.00	
		High (>200.00)	5	8.33	
Extension media contact	Score	Low (1 to 11)	8	13.33	16.36
		Medium (12-22)	41	68.33	
		High (23-31)	11	18.33	

Source: Field survey, 2022

Findings of Table 2 also indicate that farming experience of the respondents ranged from 1 to 30 years. The mean farming experience is 14.35 years. It was found that the majority of the respondents had good farming experience (51.67 percent), while 33.33 percent had fair farming experience and 15.00 percent had high farming experience. Farm size of the respondents ranged from 0.21 to 4.08 hectare. The mean of farm size is 0.44 hectare. Following the classification provided by Department of Agricultural Extension (DAE, 2016) it was found that the majority of the respondents have small farm size (63.33 percent) followed by 30.00 percent are marginal farmer, 5.00 percent operate medium farm and 1.67 percent operate large farm. This means that majority of the sample farmers were marginal to small farmers. Results of Table 2 show that the highest proportion (80.00 percent) of the respondents has medium income, while 11.67 percent have low, and another 8.33 percent have high annual income. Thus, majority of the respondents (88.33) belong to medium to high income category. The extension media contact scores of the respondents ranged from 6 to 31 with a mean score of 16.36. It was found that most of the respondent (68.33 percent) had medium extension media contact as compared to 18.3 percent had high contact and 13.33 percent had low contact of extension media. The findings of the study reveal that an overwhelming majority of the respondents (86.66 percent) had medium to high extension media contact.

Relationships between farmers' attitude towards farm mechanization and their characteristics

Karl Pearson's Product Moment Correlation co-efficient (r) was used to determine the relationships between the selected characteristics and farmers' attitude towards farm mechanization. A summary of the correlation analysis is presented in Table 4.

Out of eight selected characteristics of the farmer two characteristics, educational qualification and extension media contact showed positive significant relationship with their attitude towards farm mechanization. In contrast, annual income of the farmers showed negative significant relationship with their attitude towards farm mechanization. Rests of the characteristics such as age, household size, earning members, farming experience and farm size of the farmers had no significant relationship with their attitude towards farm mechanization.

Education might broaden the horizon of outlook of an individual as well improve the cognitive content. Again, extension media contact provides non-formal education to the farmer which also strengthens their capacity of outlook and analytics as well. All these might contribute to form favorable attitude of the farmers towards farm mechanization. However, farmers having high income might not be interested to invest more for sole use of their machineries at their own field. But the farmers having low or moderate income might hire farm machineries or might invest more to buy farm machineries for not only the sole use in their own field but also to earn money by lending the machineries. All these might explain the negative correlation between farmers' attitude towards farm mechanization and annual income.

Table 4: Correlation coefficients of the selected characteristics of the farmers and their attitude towards farm mechanization

Focus issue	Selected characteristics	Computed values
Attitude towards farm mechanization	Age	0.004
	Education qualification	0.237*
	Household size	0.025
	Earning members	-0.016
	Farming experience	0.007
	Farm size	0.080
	Annual income	-0.265*
	Extension media contact	0.383**

**Correlation is significant at the 0.05 level; * Correlation is significant at the 0.01 level

Problems faced by the farmers in farm mechanization

Frequency distribution of the farmers according to their problems faced in each of the eight problems related to farm mechanization has been showed in the Table 5 along with Problem Facing Index (PFI) and their rank order.

Problem Facing Index (PFI) for each of the problems ranged from 41 to 143 with a possible range of 0 to 180. Results of Table 4 show that based on PFIs the first ranked problem is 'machinery use is not profitable' (PFI 143). This might be due to the fact that the initial investment and maintenance cost is high for the farm machineries. The second ranked problem is 'low quality of machinery' (PFI 128). Quality of farm machinery is very much important for brining positive attitude and adoption of farm mechanization by the farmers as the initial cost of the machineries is very high. Without satisfaction regarding the quality of the machinery, the development of favorable attitude of the farmers towards farm mechanization will not be possible. The third ranked problem is 'repair and maintenance cost are high' (PFI 122). The local workshops for maintenance of the farm machineries are not well established in rural areas. Farmers need to bring their farm machineries in Upazila headquarter for repair and maintenance. This is time consuming and cumbersome work for them. The least three problems faced by the farmers in farm mechanization are: 'working quality is not good' (PFI 97) 'need to go to upazila or zila to buy spare parts' (PFI 91), and 'Spare parts are not available' (PFI 41).

Table 5: Rank order of problems faced by the farmers in farm mechanization

Problems	Not at all (0)	Low (1)	Medium (2)	High (3)	PFI	Rank
Initial investment and maintenance cost is high	2	4	23	31	143	1st
Low quality of machinery	0	9	34	17	128	2nd
Repair and maintenance cost are high	0	11	36	13	122	3rd
Lack of modern and heavy machineries	0	11	42	7	116	4th
Spare parts are not available	31	18	10	1	41	8th
Lack of credit facilities	2	5	43	0	91	7th
Need to go to upazila or zila to buy spare parts	1	28	24	7	97	6th
High price of machinery to afford	1	14	39	6	110	5th

PFI: Problem Facing Index

Suggested solutions of the problems

The ranked order of the suggested solutions given by the farmers in relation to their problems in farm mechanization is given in Table 6.

Table 6: Ranked order of the solutions suggested by the farmers in relation to problems in farm mechanization

Suggested solutions	No. of respondent	Rank
Government should provide subsidy in modern farm machineries	54	1
The terms and conditions for getting subsidized farm machineries should be soft and easy	41	2
Subsidies on fuel of the farm machineries need to be ensured and monitored strictly	34	3
Necessary credit support should be provided as and when necessary, as easy terms to buy farm machineries	29	4
Market price of the farm machineries should be monitored regularly by the concerned government authority	23	5

Table 6 indicates that the top three solutions farmers demanded in relation to the problems they faced in farm mechanization are: government subsidy in modern farm machineries followed by softened and easy terms and conditions for getting subsidized farm machineries and assurance of subsidized fuel for operating farm machineries with strict monitoring system. These suggestions indicate farmers are concerned about monetary and administrative burdens regarding farm mechanization, which are needed to be softened. The lowest ranked solutions they demanded are necessary credit support should be provided as and when necessary, as easy terms to buy farm machineries and market price of the farm machineries should be monitored regularly by the concerned government authority. Agricultural financial institutes are needed to be more softened to provide credit for farm mechanization and the markets of farm machineries should be regularly watched for price stabilization by DAE.

Conclusion

The majority of the farmers had neutral attitude towards farm mechanization. So, for bringing favorable attitude of the farmers it could be concluded that different agricultural extension organizations should provide necessary support (like motivational tour, field day, campaign etc.) and subsidy to farm machineries. In addition, user friendly farm machineries are also needed to be developed so that farmers can use them easily which might help to form favorable attitude of the farmers. The issues are needed to be considered for development of user-friendly farm machineries are land size, soil type, availability of repairing facility or service center, resale value etc. There is positive relationship between educational qualification and farmers' attitude towards farm mechanization. In addition, findings indicate that more than half of the respondents have no institutional education. So, it could be concluded that more non-formal education like mass-education needs in the study area. The training experience of the farmers is not satisfactory in the study area. Thus, arrangement of proper training for the farmers by different agricultural development organizations is needed to be arranged on updated farm machineries to bring more favorable attitude towards farm mechanization. The overwhelming majority of the respondents had low to medium extension contact, but the variable is positively related with attitude towards farm mechanization, extension efforts are needed to be strengthened in the study area. Farmers having high annual income are needed to be strategically dealt (like field tour, presentation of operational efficiency etc. for their motivation) for bringing their favorable attitude towards farm mechanization. In addition, Department of Agricultural Extension and other agricultural development organizations should realize the existing problems of the farmers in relation to farm mechanization and necessary steps should be taken to minimize those problems like, government subsidy in modern farm machineries followed by softened and easy terms and conditions for getting subsidized farm machineries and assurance of subsidized fuel for operating farm machineries with strict monitoring system.

SOCIOECONOMIC STUDY OF FLOATING AGRICULTURE IN KISHOREGANJ DISTRICT

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Abstract

The floating bed agriculture is popular practice in haor and southern Bangladesh. BARI is improving its management technology. The aim of this study was to calculate the cost benefit analysis and economic viability of vegetables production on the floating bed in Kishoreganj district of Bangladesh. The study area was selected purposively, and 30 households (HHs) were surveyed through purposive sampling technique from a population of 45 households. From the results of those primary data, it was found that majority of the farmers were relatively younger and middle aged and were in a position to put more physical effort for floating garden in the studied area. Agriculture is the main occupation of 90% of the farmers who are involved in floating farming. On an average, gross return of the demo farmer was calculated at Tk. 30690 per year for three bed which was 67% higher than non-demo farmers' of Tk.18390 and total cost was estimated at Tk. 17180 and Tk. 11010 in demo and non-demo farmers, respectively. Gross margin was estimated at Tk. 13510 in demo farmers which was 83% higher than non-demo farmers. Benefit cost ratio was 7% higher in demo farmers than non-demo farmers due to use modern variety and improved management.

Introduction

The Haors having a unique hydro-ecological characteristic is a large bowl-shaped floodplain depression located in the northeastern region of Bangladesh covering about 1.99 million hectares of area and accommodating about 19.37 million people. The Haor basin is an internationally important wetland ecosystem covering 43% of the northeastern region of Bangladesh, which is mostly situated in Kishoreganj, Sunamganj, Habiganj, Moulvibazar Sylhet, B. Baria and Netrakona districts. This Haor basin is a remote and difficult area that is flooded every year during monsoon. Over 80% of the rain falls during the monsoon season from June to October. Since some parts of Bangladesh remain flooded for a prolonged period of the year, agriculture is the hardest hit (MoEF, 2011; Walsham, 2010), which has a serious impact on the lives of the farming population. The farming communities of the long-term water logging areas who are completely dependent upon the land-based agriculture affected seriously for water logging conditions. In such a flooded and long water logging condition, the farmers of some parts of Bangladesh have been tackling this situation and sustaining their lives by utilizing self-innovated “floating agriculture”. In some parts of Bangladesh, most affected by flood and where water remains for a prolonged period of time, farmers are using their submerged lands for crop production by adopting scientific methods which are similar to hydroponic agriculture practices, i.e. floating agriculture, whereby plants can be grown on the water in a bio-land or floating bed of water hyacinth, algae or other plant residues.

This practice has traditional roots in practices dating back to the country’s forbearers. According to their needs, people in different parts of Bangladesh have adopted, modified and named this practice differently (*baira*, *boor*, *dhap*, *gathua*, *gatoni*, *geto*, *kandi* and *vasoman chash* and floating agriculture).

Actually, this practice is most successful in the coastal areas that are adjacent to the sea-bank areas, which remain submerged for long periods, especially in the monsoon season, as well as the wetland Haor Areas (MoA, GoB). The floating agriculture is a crop production practice in soilless floating beds prepared with locally available materials like water hyacinth mainly and other aquatic weeds. Locally this technique is known as “Dhap Agriculture” and it practiced from many years in the flood prone and water logging areas of Barisal, Gopalganj and Pirojpur districts (Haq et al, 2002; Islam and atkin, 2007; Irfanullah, 2009; and Irfanullah, 2011). Moreover, very little chemical input is needed for crop production, low labor costs, and good market price of the crops is accepted as a means of cleaner production. There was no socio-economic study conducted earlier on floating agriculture therefore, the present study was undertaken to provide information through fulfillment the objectives set for the study.

Methodology

Sampling Technique, Sample Size and Data Source

Some areas of Kishoreganj district are the only source of floating agriculture. Kishoreganj sadar, Karimganj and Nikli upazila of Kishoreganj district are famous for floating vegetables production. This study purposively selected Kishoregtanj sadar, Karimganj and Nikli Upazilas as study area only because of highest number farmers of this area were practicing floating agriculture in Kishoreganj. Only three villages namely Kashorarchar in Kishoreganj sadar, Pathanpara in Karimganj and Guroi in Nikli Upazila produced floating bed vegetabkles and sample were selected from these villages. A population of 45 households were identified from the local floating farmers as sampling frame and all units of the population were planned for data collection. Data were collected from the members of the households who were directly involved in floating vegetables production. Out of 45 households, only 30 were found at their home at the time of interview.

Data Collection Technique

All the data accumulated for the present study was considered as primary source because of face-to-face interview with the help of interview schedule. The respondents were briefed about the objectives of the study before conducting the actual interview. All the interviews were conducted in Bengali and the interviews were recorded with the consent of the respondents during April-May 2022. Besides, the researcher took field notes, made observations as well as photos of the areas. It was explained to the floating vegetables growers that the study was purely academic. Interviews were normally conducted at the respondent's house at their leisure period.

Analytical Technique

In order to find out the cost and return from the floating vegetables production, the research included the financial analysis considering the timing of benefit and cost throughout the rotation period of vegetables production for three beds. The collected data were first edited and tabulated for analysis to fulfill the objectives of the study. Descriptive statistics such as average and percentage were used in this study. The profitability was estimated using gross margin, net return and benefit cost ratio analysis.

Socioeconomic characteristics

Socioeconomic profile of the respondent farmers is required to have an idea about the present farm activities, possible development opportunities and potentials for more efficient farming. Therefore, information regarding respondents age, education, occupation, family size, farm size, land use pattern, training and experience in cultivation were recorded for the study.

Age: Age of the farmers plays an important role in the crop production and better management of the farming activities. The age of the floating farming was examined by classifying the three groups: 20-40, 41-60 and 61-82 years (Table 1). On an average majority of the farmers belonged to the age group 20-40 (51%) which was 50% in Kishoreganj sadar, 52% in Karimganj and 51% in Nikli upazilla of Kishoreganj district. This information imply that majority of the farmers were relatively younger and middle aged and were in a position to put more physical effort for floating garden. Farmers belonging to this age group were supposed to have enormous vigor and risk bearing ability. A noticeable portion of the farmers (41%) were 41 to 61 years old, whereas only 8% farmers were 62 to 82 years old (Table 1).

Education: Literacy may be defined as the ability of an individual to read and write or formal education received up to certain standard. Education helps individual to become conscious of their environment and develop rational insight into many matters of life. Farmers education is expected to be an important issue in increasing the production of farming output. Education is likely to influence the farmers to adopt the modern technology ad it makes them more capable to manage scares resources efficiently so that they can earn more profit. On the basis of education level, the literacy status of the respondent farmers has been categorized into three groups. The categories are (1) no formal education (2) primary and (3) secondary. Information on the education levels of the respondents is presented in Table 1. It is observed that, most of the farmers (71%) received formal education of which 46% have primary level of education and 25 have secondary level of education in the study area, respectively (Table 1).

Table-1. Percentage distribution of respondents by their socioeconomic characteristics

Particulars	% Farmers responded			
	Kishoreganj sadar	Karimganj	Nikli	All
1. Age				
20-40 years	50	52	51	51
41-61 years	41	40	42	41
62-82 years	9	8	7	8
2. Level of education				
No formal education	24	30	33	29
Primary (Class I-V)	50	44	44	46
Secondary (Class VI-SSC)	26	26	23	25
3. Occupation				
Main occupation				
Agriculture	86	96	94	92
Petty business	14	4	6	8

Particulars	% Farmers responded			
	Kishoreganj sadar	Karimganj	Nikli	All
Service		-		
Others		-		
Subsidiary occupation				
No profession	72	78	75	75
Agriculture	12	3	6	7
Others	16	19	19	18
4. Household size				
2-4	40	44	30	38
5-7	51	48	57	52
8-10	9	8	13	10
11-13				
5. Farm size (%)				
Small (0.19-0.99 ha)	70	70	76	72
Medium (1.00-3.03 ha)	22	20	18	20
Large (above 3.03 ha)	8	10	6	8
6. Experience in farming				
1-10 years	45	48	42	45
11-20 years	30	29	34	31
21-30 years	17	16	15	16
31-40 years	8	7	9	8
7. Floating farming experience (no. of yrs.)	3	3	3	3
Training received				
Agriculture farming	72	65	63	67
Floating farming	80	74	71	75
8. Extension contact				
Strong	48	53	40	47
As usual	33	31	26	30
No contact	19	16	34	23

Source: Field survey, 2022

Occupation: Main occupation of a farmer generally reflects his commitment in that particular field and demonstrates his economic standing in the society. Majority of the sample farmers (92%) reported that agriculture as their main occupation followed by petty business as their subsidiary occupation (8%) (Table 1). A greater part of the farmers (75%) had no subsidiary occupation. Only 7% farmer had agriculture and 18% farmers had other profession as their subsidiary occupation.

Household size: The family size was also investigated in the study. Household size included the number of adult males, adult female and children of the respondent households. The household size was categorized by three categories such as number of members 2-4 persons, 5-7 persons and 8-10 persons (Table 1). Among all surveyed farmers, most of the respondents (52%) in the study areas had family size within the number of 5 to 7 persons followed by 2-4 persons (38%). Only 10% of farmers had large family size with member of 8-10 persons (Table 1).

Farm size: In the study areas, farm size was categorized as small, medium and large farm (Table 1). Among all farmers, 72% farmers of the study areas were fall under the category of small farmers whereas 20% floating vegetables growers had medium size farm. Only 8% chickpea growers' farm size was large (Table 1).

Experience in floating and normal farming: Farming experience is an important factor to ensure farm technical efficiency. Technical inefficiency of the production is significantly related to farming experience of the farmers. About 45% farmers had 1 to 10 years' agriculture farming experience. A noticeable portion (31%) of the farmers had 11 to 20 years' experience in agriculture farming, 16% farmers had 21 to 30 years' experience and another 8% farmers had 31 to 40 years' experience (Table 1). It was found that all of the sampled farmers belonged to 3 years of floating farming experience only to cultivate floating vegetables in the study areas.

Training: Farmers' training on different aspects of agriculture plays an important role in crop production. About 75% floating farmers received training on floating agriculture, especially in vegetables cultivation. About 67% farmers received training on different crops of different aspects of agriculture. It was reported that most of the trained farmers benefited by the training.

Extension contacts: Majority of the farmers (47%) had strong extension contact with extension personnel. About 30% of the respondents expressed that they were connected with extension workers only 1-2 times in a cropping season which is only contemporary. A good number of people (23%) had no contact with extension services (Table 1).

Construction of floating beds

The basic construction of the floating bed requires bamboo poles, a boat, water hyacinths and a simple tool to cut the weeds. The bed is then built up of layers of aquatic weeds, mainly water hyacinths *(Eichhornia crassipes)* but also other kinds of water weeds like water lettuce *(Pistia stratiotes)*, duckweed *(Najas graminea)*, *Salvinia* spp. and *Potamogeton alpinus*. In perennial wetlands and permanently waterlogged areas it is possible to cultivate on these floating beds the whole year round. In seasonally waterlogged areas, the beds are used during the wet season and left to decompose on the agricultural land, once the water withdraws. The floating beds are primarily constructed where water hyacinths are available. The beds can be prepared in any depth of water, and they can be moved by dragging them behind a boat.

In Kishoreganj, the villagers construct floating beds using the masses of water hyacinths and other aquatic weeds that grow naturally and profusely in the river, surrounding wetlands, canals and ditches. Construction starts at the beginning of the monsoon (June-July) with the collection of water hyacinths and other aquatic weeds, and it continues up to late autumn. To start the construction, farmers put a long bamboo pole (as long as they want the final bed to be), on a collected mass of fully matured water hyacinths. To build one bed, water hyacinths growing in an area roughly five times larger than the bed itself are required. Mature water hyacinths are preferred because they decompose slower than immature water hyacinths. The first layer of water hyacinths acts as the base of the floating bed and maintains the stability, buoyancy and thickness of the bed. A single man then stands on the bamboo pole lying over the mass of water hyacinths and starts to pull the water hyacinths together from both sides of the bamboo. In this process, he proceeds towards the end of the bamboo and compacts the accumulated hyacinths under his feet. This process is continued until the desired height (3.5 feet) and length of the bed (30 feet) is obtained. When the construction of the bed is complete, the bamboo is removed. After 7 - 10 days a second round of water hyacinths are dumped on the bed and then the bed is left to decompose before being planted. The top of the floating bed needs 15 - 20 days to decompose before sowing seed or planting seedlings. Sometimes farmers use semi-decomposed aquatic plants such as water lettuce, duckweed and immature water hyacinths on the top of the bed to speed up the decomposition, thereby making nutrients available for seedlings and reducing evaporation from the bed. To improve conditions for the young seedlings further, the seeds are sometimes placed inside a ball made of compost, manure and aquatic creepers (locally called tema), before being planted on the floating bed. In this way, a smooth germination and sufficient nutrients are ensured for the initial establishment. However, the newly constructed floating bed can also be cultivated from the first day – if compost is available and is spread thickly on the bed before planting.

There are no fixed rules about the size and shape of the floating beds, but generally the villagers construct beds that are that are 30 feet in length, 4.5 feet in width and about 3 feet in height above the water level for better management of the crop.

Table 2. Cost of floating bed preparation with macha for vegetables production by demo farmer

Items	Quantity	Unit cost	Total cost
Bamboo	3	200	600
Net (feet)	40	10	400
Roop (Kg)	1.5	140	210
Seed or seedling purchase			1200
Fertilizer and pest management			200
Crop harvesting and maintenance	2	300	600
Labor	3	350	1050
Total cost for floating bed			4260
Bamboo for macha preparation	15	200	3000
Labour for macha preparation	4	350	1400
3 beds with macha (4260x3)			17180

Source: Field survey, 2022

Table 3. Cost of floating bed preparation with macha for vegetables production by non-demo farmer

Items	Quantity	Unit cost	Total cost
Bamboo	2	200	400
Net (feet)	40	10	400
Roop (Kg)	0.5	140	70
Seed or seedling purchase	-	-	1000
Fertilizer and pest management	-	-	100
crop harvesting and maintenance	1	300	300
Labor	1	300	300
			2570
Bamboo for macha preparation	12	200	2400
Labour for macha preparation	3	300	900
3 bed with macha (2570x3) +3300			11010

Source: Field survey, 2022

Table 4. Production and return of different vegetables on floating bed under demo farmer

Items	Production (Kg. /bed)	3 bed/year	Price (Tk./kg)	Total return
Red Amaranth	46	1380	10	13800
Bottle gourd	150	450 (3 times)	12	5400
Sweet gourd	145	435 (3 times)	10	4350
Bitter gourd	62	186 (3 times)	20	3720
Cucumber	76	228 (3 times)	15	3420
Total return				30690

Source: Field survey, 2022

Table 5. Production and return of different vegetables on floating bed under non-demo farmer

Items	Production (kg/bed)	3 Bed/year	Price (Tk./kg)	Total return
Red Amaranth	31	930 (10 times)	10	9300
Bottle gourd	75	225 (3 times)	12	2700
Sweet gourd	69	207 (3 times)	10	2070
Cucumber	96	288 (3 times)	15	4320
Total return				18390

Source: Field survey, 2022

Table 6. Comparative cost and return of floating vegetables under demo and non-demo farmer (3 bed)

Items	Demo farmer	Non-demo farmer	% Over non-demo farmers
Total return	30690	18390	67
Total cost	17180	11010	56
Gross margin	12640	7380	83
BCR	1.74	1.67	7

Source: Field survey, 2022

On an average, gross return of the demo farmer was calculated at Tk. 29820 per year for three bed which was more than 67% higher than non-demo farmers' of Tk.18390 (Table 6) and total cost was estimated at Tk. 17180 and Tk. 11010 in demo and non-demo farmers, respectively (Table 2 and Table 3). The production cost of the demo farmer was 56% higher than non-demo farmers' due to more stronger floating bed and used more bamboo and other inputs (Table 6). The net return was estimated at Tk. 12640 at demo farmer which was 83% more than the non-demo farmers (Table 6). Benefit cost ratio of demo farmer was 7% higher than the non-demo farmers which calculated at 1.74 in demo farmers and 1.67 in non-demo farmers, respectively.

From the study of Pavel et al. (2014), it was noted that in a period of 0.26 year depending on bed size NPR varied from BDT 6146 to BDT 127 followed by highest revenue of TK 9275 and lowest revenue of BDT 1050 with an average BCR of 2.68. BCR of 3.17-3.9 found from seedling production in the research of Irfanullah et al. (2005) at Nanikhir village of Gopalgonj district which was about four times higher than floating vegetable cultivation. The study of Hoque et al. (2016) revealed that BCR ranged from 1.27 to 3.44 with an average 1.75. They also reported that traditional Aman rice give only 2-2.5 t ha^{-1} yield where BCR is 1.20 whereby introducing floating agriculture gives a BCR of 1.5. Finding of the above discussion indicates that BCR declining over time. Increasing livelihood expenditure and input cost of floating seedling agriculture over time may be responsible to the reduced BCR.

Floating bed cultivation has proved to be a successful means of agricultural crop production in wetland areas of India, Burma (Myanmar) and Bangladesh (Irfanullah, 2013). Bangladesh is a low-lying country. The wetland areas of Bangladesh face more flooding/water logging for a longer duration than other countries (Pavel, et al., 2013). Floating gardening is a form of hydroponics. In the floodplains of southern Bangladesh, floating gardening is an age-old agricultural practice (Haq, et al., 2002; Islam and atkin, 2007;). Locally available aquatic plants are used to build a platform on which vegetables are cultivated and seedlings are raised during flooding. Later on, the platform residue is used as organic fertilizer for winter cropping. There are many social, economic and ecological benefits associated with this technique the year round (IUCN Bangladesh, 2009; Irfanullah et al. 2011).

Maintenance of floating bed

- Farmers use boats or rafts to look after their floating bed
- Weeding to be done as required
- The bed should be adequately fenced or covered by net to protect against duck and rodents
- Crops which are infected by pests and diseases should be uprooted, insects like Aphids, Leaf hoppers, White flies etc. can harm crops. Leaf spot, mosaic etc. are major diseases that affect floating vegetables bed crops. Organic pests and disease control measures should be adopted. No chemical pesticide should be used.

Disadvantages of floating practices

- Accessibility to markets is difficult from waterlogged areas
- Labour is not willing to work in floating bed, so they want more wages

Conclusion

The uptake of this technology may be limited in wetlands with limited supply of fast-growing organic material like water hyacinth. Awareness rising of the local communities is needed in areas where floating agriculture is not a traditional practice. Farmers in the study areas interested to produce vegetables and other crops in floating bed. They were also getting benefit from the floating bed agriculture.

PROFITABILITY AND VARIETAL ADOPTION OF CHICKPEA IN SOME SELECTED AREAS OF BANGLADESH

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Abstract

Chickpea is an important pulse crop widely grown in Bangladesh. BARI has developed many improved chickpea varieties and disseminated to the farmers' fields. The up-to-date information regarding adoption and financial profitability of this crop are unknown to the researchers and policymakers. Therefore, the study was conducted in Rajshahi district to determine the adoption status and profitability of BARI chickpea production and to examine the factors affecting the yield of BARI chickpea during 2020-2021. The study revealed that 58% farmers cultivated BARI chickpea varieties in the study area. The average level of adoption of BARI Chickpea-1, BARI Chickpea-2, BARI Chickpea-3 and BARI Chickpea-5 were 25%, 3%, 5% and 25%, respectively at farm level. The cultivation of chickpea was profitable to the farmers since the per hectare total cost, gross return and gross margin of chickpea cultivation were Tk 71830, Tk 87128 and Tk 53688, respectively. Unavailability of latest BARI chickpea seed, lack of technical know-how, lack of training, and diseases (root rot) were the main constraints to BARI chickpea cultivation at farm level.

Key words: Adoption, Profitability, Chickpea, Bangladesh.

Introduction

Pulses are important legume crops in Bangladesh because of their importance in food, feed and cropping systems. It contains about twice as much protein as cereals. It also contains amino acid lysine which is generally deficit in food grains (Elias et al., 1986). Pulses have played an important role in sustaining the productivity of soils in Bangladesh for centuries. They are generally grown without fertilizer since they can meet their nitrogen requirement by symbiotic fixation of atmospheric nitrogen in the soil (Senanayake et al., 1987; Zapata et al., 1987; Fried and Middleboe, 1977). The per capita consumption of pulse in Bangladesh is only 17 g/day, which is much lower than FAO recommendation of 45 g/day.

The area, production and yield of chickpea in Bangladesh were 18433 ha, 12000 tonnes (t) and 0.65 t/ha, respectively in 2000-01 (BBS, 2017). After 21 years, the area, production and yield of chickpea were 5216 ha, 5009 tonnes (t) and 0.96 t/ha, respectively in 2021-22 (BBS, 2022). Thus, it is noted that area and production of Chickpea decreased 71.70 and 58.26 percent, respectively, while its yield is increased by 47.69 percent. The area and production of chickpea is declining year after year (Table 1).

It is observed in Table 1 that the annual growth rates of chickpea area and production decreased significantly in all periods, while the rate of yield increased in all periods due to introduce new and HYV of chickpea. Similar trend was found by Matin et. al. (2014). In Pakistan, growth rate trend showed a lower rate of decline for the chickpea areas, but a higher rate of increase in yield during 1964-95 (Khan et al., 1988).

Table 1. Area, production, yield of Chickpea and annual growth rates Chickpea in Bangladesh during 2000–2021.

Year	Area (ha)	Production (t)	Yield (t/ha)
2000-01	18433	12000	0.65
2001-02	17512	11000	0.63
2002-03	17051	11000	0.65
2003-04	15668	10000	0.64
2004-05	14747	10000	0.68
2005-06	14286	10000	0.70
2006-07	14286	10000	0.70
2007-08	10646	7168	0.67
2008-09	9312	6551	0.70
2009-10	8226	5744	0.70
2010-11	9354	6605	0.71
2011-12	8965	7326	0.82
2012-13	8318	6755	0.81
2013-14	7842	5947	0.76
2014-15	8050	6672	0.83
2015-16	6924	6382	0.92
2016-17	6735	6237	0.93
2017-18	5724	4964	0.87
2018-19	5480	5347	0.98
2019-20	5275	4942	0.94
2020-21	5216	5009	0.96
Growth rate:			
2000-2010	-8.70***	-7.52***	1.18***
2010-2021	-6.46***	-3.72***	2.74***
2000-2021	-6.65***	-4.36***	2.29***

Note: Growth rates were calculated by fitting exponential function/a semi-log model ($LnY_1 = Ln\ a + b_t$).
*** indicates significant at 1% level of probability.

Source: Various issues of BBS, 2017, 2000, and 2022.

Chickpea is cultivated in different parts of the country. But it is extensively cultivated in Barind areas of Rajshahi region under north-western parts of Bangladesh. The yield of local chickpea variety in Bangladesh is very poor. BARI has developed a good number popular variety of chickpea which is growing in the farmers' fields. But the adoption status and the economic performance of this crop are unknown to the researchers and policymakers. Because a limited study was done in this line. The rate of adoption and sustainability of any crop depends largely on its economic profitability. Economic viability is one of the important criteria for assessing the suitability of a new crop technology. Therefore, this study is expected to provide valuable information and may be useful to the researchers of BARI as well as the policy makers of both GO and NGO for formulating appropriate policy for widespread cultivation of chickpea in Bangladesh. With this view in mind, the study was undertaken to the following objectives.

i. To know the area covered and adoption status of BARI Chola varieties at farm level;
ii. To estimate the profitability of the BARI Chola;
iii. To examine the factors affecting the yield of chickpea; and
iv. To find out the constraints to BARI chickpea cultivation and varieties adoption in farmers' level.

Materials and Methods

***Sampling design*:** A multi-stages sampling procedure was followed to select study areas and sample households. At first, three chickpea growing districts namely Rajshahi, Chapainowabgonj and Jhenaidah were purposively selected for the study according to higher hectarage of chickpea. Secondly, one upazila from each district was purposively selected and one block from each upazila was also selected randomly for household survey. Finally, a list of chickpea growers was constructed for each block and then a total of 120 samples taking 40 samples from each block list were randomly selected for data collection.

Data collection procedure: Data for the present study were collected by interviewing sample chickpea growers using a pre-tested interview schedule during the period from March to May 2022. Secondary data were also collected from Directorate of Agricultural Extension to supplement the study and different issues of BBS.

Analytical techniques: The collected data were analyzed by tabular and statistical methods. The profitability of chickpea cultivation was examined on the basis of gross margin, net return and rate of return over cost. BARI chickpea varieties cultivated by farmers were classified into four categories for determining the adoption level of technologies in terms of agronomic practices, time of operation, and input use. The categories were developed based on the mean index of the farmers with respect to each technology. A higher index indicates a higher level of adoption, while a lower index indicates a lower level of adoption of a technology. Technology adoption level was categorized for mean index > 100 as overuse; (70-100) as high; (50-69) as medium and <50 as low (Miah and Alam, 2008). Adoption index was determined by the following formula.

$$Adoption\ index = \frac{Farmers'practice}{Recommendation} \times 100$$

Cobb-Douglas production function was used to estimate the contribution of factors influencing the productivity of chickpea. The functional form of the Cobb-Douglas model is given below:

$$Y = AX_1^{b1} X_2^{b2} ....X_n^{bn} e^{ui}$$

The production function was converted to logarithmic form so that it could be solved by least square method i.e,

$$\text{Log } Y = \text{Log } a + b_1 \log X_1 + ... + b_n \log_n + U_i$$

The empirical production function was as follows:

$$\text{Ln}Y = a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + U_i$$

Where,

Y = Yield (kg ha^{-1})
X_1 = Human labour (man-days ha^{-1})
X_2 = Mechanical power cost (Tk ha^{-1})
X_3 = Seed (kg ha^{-1})
X_4 = Urea (kg ha^{-1})
X_5 = TSP (kg ha^{-1})
X_6 = MoP (kg ha^{-1})
X_7= Gypsum (kg ha^{-1})
X_8 = Pesticides (Tk ha^{-1})
a = Intercept
$b_1, b_2, ... b_n$ = Coefficients of the respective variables to be estimated.
Ui = Error term

Results and Discussion

Farm size of the sample farmers

The average age of the farmer was 49 years. The educational status of farmers was 62, 28 and 10 percent for primary, secondary and higher secondary levels, respectively. The farm size of the sample farmers was 1.06 ha in the study areas. The average chickpea cultivated area was found to be 0.38 ha (Table 2).

Table 2. Socio-economic profile of chickpea farmers in the study area

Particulars	Rajshahi
Age of farmers (year)	49
Educational level (%)	
Primary	62
Secondary	28
Higher secondary	10
Farm size (ha)	1.06
Chickpea cultivated area (ha)	0.38

Source: Field Survey, 2022.

Variety adoption

About 42% farmers cultivated local variety of chickpea and it was followed by BARI Chola-1 (25%), BARI Chola-5 (25%), BARI Chola-4 (5%) and BARI Chola-3 (3%) (Table-3).

Table 3. Adoption scenario of chickpea varieties

Study area	BARI Chola-1 (%)	BARI Chola-3 (%)	BARI Chola-4 (%)	BARI Chola-5 (%)	Local (%)	Total (%)
Rajshahi	25	3	5	25	42	100

Source: Field Survey, 2022

Input use pattern of **BARI chickpea cultivation**

Human labour was measured in terms of man-day, which usually consisted of 8 hours. It was employed for land preparation, fertilizing, weeding, pesticiding, harvesting, threshing, cleaning and drying. The total number of human labour used for chickpea cultivation was 54 man-days/ha in which 32 and 22 mandays were for hired and family supplied, respectively (Table 4). They used chickpea seeds at the rate of 52 kg/ha. The application of urea, TSP, DAP, MoP, gypsum, zinc and boron per hectare were 19 kg, 09 kg, 59 kg, 34 kg, 11 kg, 0.37 kg and 2.02 kg, respectively in the study area.

Table 4. Input use pattern and cost of chickpea production at farm level

Cost Items	Rajshahi	
	Quantity (mandays or kg/ha	Amount (Tk/ha)
Hired labour	32	12112
Mechanical power cost	-	10858
Seed	52	5508
Urea	19	309
TSP	09	192
DAP	59	982
MoP	34	510
Gypsum	11	113
Zinc	0.37	75
Boron	2.02	265
Pesticides		2515
Intt. on operating capital	-	376
Total variable cost	**-**	**33816**
Land use cost	-	29939
Family labour	22	8075
Total cost	**-**	**71830**

Source: Field Survey, 2022.

Yield, Return and Profitability level of chickpea cultivation

The cost of cultivation was calculated on the basis of total variable cost and total cost. The average cost of chickpea production was estimated at Tk 71830/ha and Tk 33816/ha, respectively on the basis of total cost and total variable cost (Table 4). It is evident from Table 5 that the average grain yield of chickpea varieties was 1435 kg/ha in study area. On an average, gross return was found to be Tk 87128/ha. The average gross margin of chickpea was estimated at Tk 53688/ha and net return of chickpea was calculated Tk 15298/ha in the study area. Benefit cost ratio was found to be 1.22 on total cost basis in study area.

Table 5. Productivity and profitability of chickpea production at farm level

Items	Rajshahi
Yield (kg/ha)	1435
Gross return (Tk/ha)	87128
Total variable cost (Tk/ha)	33816
Total cost (Tk/ha)	71830
Gross margin (Tk/ha)	53688
Net return (Tk/ha)	15298
Benefit cost ratio (undiscounted)	1.22

Source: Field Survey, 2022.

Constraints to BARI chickpea production at farm level

The farmers in the study areas encountered some constraints to BARI chickpea production. The first ranked constraint was unavailability of latest BARI chickpea varieties seed in study area. It followed by unknown about latest BARI chickpea varieties, lack of technical know-how, and lack of training, attack of diseases (root rot), high price of pesticides, slightly low price, and less taste compared to local variety chickpea (Table 6).

Table 6. Constraint to BARI chickpea production at farm level

Constraints	Rank value
	Rajshahi
1. Unavailability of latest BARI chickpea varieties seed	1
2. Unknown about latest BARI chickpea varieties	2
3. Lack of technical know-how	3
4. Lack of training	4
5. Attack of diseases	5
6. High price of pesticides	6
7. Lower price and less taste compared to local chickpea variety	7

Source: Field Survey, 2022

Facilities needed for increasing BARI chickpea production

Chickpea farmers in the study areas encountered some constraints to BARI chickpea production. They used improved seeds of different chickpea verities which were developed by BARI and disseminated for farm level use for some years back. In the meantime, eleven improved chickpea varieties have already been released for farmers' use. But these latest varieties are not available to them. Therefore, all the respondent farmers demanded for making those latest chickpea varieties available to their nearest local seed market (Table 7). Technical know-how about the improved production technology is very much important for efficient use of inputs and receiving higher yield. Most respondent chickpea farmers did not get expected yield due to apply traditional knowledge in producing chickpea. Therefore, they need hand-on training on chickpea production. Biotic stress is another important constraint to chickpea cultivation for which they can't harvest good yield. They opined that some of their used varieties were susceptible to disease. Hence, most of the respondent farmers suggested developing disease resistant variety for them.

Table 7. Facilities demanded by farmers regarding BARI chickpea cultivation.

Type of facility	Percent of responses
1. Availability of latest BARI chickpea varieties seed	100
2. Providing training about chickpea production	100
3. Development of disease resistant chickpea variety	96

Source: Field Survey, 2022.

Conclusion and Recommendations

Based on the findings of the study, it may be concluded that the highly adopted variety was BARI Chickpea-5. About 42% farmers cultivated local variety. BARI has developed some new varieties which are better in all respects to them. So, popularization of BARI Chickpea-5 and BARI Chickpea-9 is needed, and farmers should be motivated accordingly.

Majority of the farmers did not get desired yield due to ignore the recommended use of inputs. So, formal and hand-on training and demonstration on modern method of producing BARI chickpea should be imparted to the farmers. The gross margin and net return of BARI chickpea cultivation were positive and encouraging to the farmers. This message should be circulated among the growers through various media. Chickpea farmers could not receive higher benefit from chickpea cultivation due to various constraints. These constraints were unavailability of latest BARI chickpea variety seed, unknown about latest BARI chickpea varieties, lack of technical know-how, lack of training and attack of diseases. Therefore, necessary steps should be taken to make disease resistant BARI chickpea seed available to the farmers. Nonetheless, chickpea farmers should also be provided hand-on training on package technology of chickpea cultivation.

Project VI:

Transfer of Technology

- **Bt Brinjal Trial**
- **Pilot Production Program**
- **Seed Production**

A. Bt Brinjal Trial

ON-FARM TRIAL OF BARI RELEASED BT BRINJAL VARIETIES IN BANGLADESH

Abstract

The field trial was conducted at 40 farmers field of 04 districts in Bangladesh such as Bogura, Khulna, Kishoreganj, and Narsingdi during 2021-2022 to observe the performance of transgenic BARI Bt brinjal varieties at the farmers' field. Tested three wBARI Bt brinjal varieties performed better against non Bt counterparts, reduced brinjal shoot and fruit borer (BSFB) infestation produced maximum healthy fruit and offered higher gross margin in all locations. These varieties showed maximum 0-0.41% shoot, 0-0.58% fruit infestation by number, 00.75% fruit infestation by weight and 27.40-40.48 t ha^{-1} yield against 20.15-38.00% shoot,26.50-59.25% fruit by number, 11.16-57.30% fruit infestation by weight and 10.35-6.28 t ha^{-1} yield in non-Bt counterparts. Among the 4 districts, field trial under3 districts totally free from BSFB infestation.

Introduction

Brinjal (*Solanum melongena*) is one of the most important and popular vegetables in Bangladesh that grown widely round the year. The crop is damaged severely by the notorious insect called brinjal shoot and fruit borer (BSFB) and the damage ranges from 30-70% depending upon the locality and edaphic conditions. To address this problem, farmers in major brinjal growing areas in the country spray chemical insecticides every alternate day and ranges from 60-180 times per growing season. The practice is unacceptable and unhealthy to consumers, farmers, and the environment. Bt-brinjal is a transgenic brinjal developed by inserting a crystal protein gene (*Cry1Ac*) from the soil bacterium, *Bacillus thuringiensis* into various brinjal cultivars and these plants are found to be resistance against BSFB. Bangladesh is the first country in the world to approve the commercial cultivation of four Bt-brinjal varieties *viz*. BARI Bt begun-1, BARI Bt begun-2, BARI Bt begun-3 and BARI Bt begun-4 on October 30, 2013 by Bangladesh Agricultural Research Institute (BARI). Previous experiments conducted at different stations of BARI indicate that Bt varieties reduce the BSFB infestation, number of insecticide applications and improve yield. The present study was undertaken to evaluate the performance of the varieties under the farmers' field condition and to popularize the varieties among the farmers to promote their adoption in different areas of Bangladesh.

Materials and Methods

The trial was conducted in 40 farmers' field of 04 districts such as Bogura, Khulna, Kishoreganj, and Norsingdi during 2021-22 to observe the performance of four Bt-brinjal varieties *viz*. BARI Bt begun-1, BARI Bt begun-3 and BARI Bt begun-4. Unit plot area was 16.50-33 decimal with the spacing of 100 cm × 80 cm. The crop was sowing at 10 October, 2021-12 January, 2022 and its harvested date was 27 February-20 May, 2022. Two rows of non Bt counterpart of respective Bt varieties were planted as the border crops (refuse). Stable bleaching powder was applied 20 days before transplanting @ 21 kg ha^{-1} for preventive measure against bacterial wilt. The fertilizers were used @ 138-40-100-18-1.7-3.6 kg ha^{-1} NPKSBZn and Cowdung 10 tha^{-1}. One-third MP and rest fertilizers except urea were applied during final land preparation. Remaining two-third MP was divided into three split and applied at 20 DAP, at flowering and fruiting stage. Urea was applied in four equal installments at 20 DAP, at flowering, fruiting and continuous fruiting stage. Plant protection measures for other pest were taken in some severely infested plots; Furadan applied @ 33 kg ha^{-1} during transplanting, Imidaclorpid, Difenthuron, Azadiractin, Pagasus etc. were sprayed to control sucking pests as and when necessary. Similarly, Bavistin @ 2ml L^{-1} water was sprayed in 2-3 times to control Fusarium wilt and Tilt @ 0.5ml L^{-1} was sprayed in 1-2 times to control Phomopsis blight infested plots. Epilachna beetle was controlled by destroying egg mass and larva, pupa & adult by hand picking. Other intercultural operations were done as and when necessary. Ten plants were selected randomly from each plot to record plant height, individual fruit weight, length & breadth of fruit, number of total & infested fruit plant^{-1}. Yield data was calculated based on total plots. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Table 1. Varieties used in different locations with transplanting and harvesting date, 2021-22

Location	No. of trial	Varieties	Sowing time	Harvesting time
Bogura	25	BARI Bt begun-1, BARI Bt begun-4 with non Bt counterparts	27 Oct- 17 Nov 2021	20 Feb-30 April 2022
Kishoreganj	03	BARI Bt begun-4 with non Bt counterparts	21-23 November 2021	07 Feb-20 March 2022
Khulna (Koyra)	07	BARI Bt begun-4 with non Bt counterparts	10 Oct.- 12 Jan 2021	20 December to 20 May 2022
Norsingdi	05	BARI Bt begun-3 with non Bt counterparts	25-30 Nov, 2021	Jan to April 2022
	40	BARI Bt begun-2 and BARI Bt begun-3, BARI Bt begun-4 with non Bt counterparts	10 October 2020 - 27 January, 2021	02 February -19 June 2021

* Non Bt counterparts of the varieties were also planted as border crops

Results and Discussion

Performance of BARI Bt Begun-1: BARI Bt Begun-1 was cultivated in Bogura district. The yield of BARI Bt Begun-1 was 28.50 ton per hectare. BSFB infestation in shoot 0.00 percent and in the fruit (by no.) 0.00 percent as well as infestation (by wt.) 0.00 percent in BARI Bt Begun-1. The non-Bt counterpart of the variety BARI Begun-4 (Kazla) was infected by BSFB both in shoot and fruit and infestation observed 20.15 percent shoot and 54.75 percent fruit (by no.) along with 53.20 percent (by wt.) was infected by BSFB. The average marketable yield of non-bt-brinjal was recorded as 12.40 ton per hectare (Table 2).

Performance of BARI Bt Begun-3: BARI Bt Begun-3 was cultivated in Norsingdi district. The yield of BARI Bt Begun-3 was 27.40 ton per hectare. BSFB infestation in shoot 0.00 percent and in the fruit (by no.) 0.00 percent as well as infestation (by wt.) 0.00 percent in BARI Bt Begun-3. The non-Bt counterpart of the variety BARI Begun-4 (Kazla) was infected by BSFB both in shoot and fruit and infestation observed 38.00 percent shoot and 26.70 percent fruit (by no.) along with 20.24 percent (by wt.) was infected by BSFB. The average marketable yield of non-bt-brinjal was recorded as 26.28 ton per hectare (Table 3).

Performance of BARI Bt Begun-4: BARI Bt Begun-4 was cultivated in Bogura, Kishoreganj and Khulna districts. The yield of BARI Bt Begun-4 range from 31.06-40.84 ton per hectare. BSFB infestation in shoot 0.00-0.41 percent and in the fruit (by no.) 0.00-0.58 percent as well as infestation (by wt.) 0.00-0.75 percent in BARI Bt Begun-4. The non-Bt counterpart of the variety BARI Begun-4 (Kazla) was infected by BSFB both in shoot and fruit and infestation observed 22.00-26.24 percent shoot and 26.50-59.25 percent fruit (by no.) along with 11.16-57.30 percent (by wt.) was infected by BSFB. The average marketable yield of non-bt-brinjal was recorded as 10.35-22.45 ton per hectare (Table 4).

Non target Pest incidence: Different sucking pests (Jassid, Whitefly, Thrips, Aphid, Flea beetle, Red mite, Epilacna beetle etc.) and diseases (*Fusarium* wilt, *Phomopsis* blight, Bacterial wilt, Little leaf etc.) were observed in some locations (Table 5). These pests and diseases were controlled by appropriate management approaches.

Farmers' Opinion

- As the fruits of Bt-brinjal varieties are almost free from BSFB infestation, no sorting is required.

- Production cost becomes lower in Bt varieties since no application of insecticides against BSFB is required. Higher gross margin obtained due to BSFB free fresh healthy fruits.
- Many farmers who have visited Bt-brinjal plots demanded seeds for cultivation.
- BSFB free smooth and good-looking fruit created an excellent feelings and curiosity among the farmers.

Table 2. Performance of BARI Bt Begun-1 over location during 2021-22

Location	BSFB infestation (%)						Fruit yield (t ha^{-1})	
	Shoot		Fruit (by no.)		Fruit (by wt.)			
	Bt	Non-bt	Bt	Non-bt	Bt	Non-bt	Bt	Non-bt
Bogura	0.00	20.15	0.00	54.75	0.00	53.20	28.50	12.40

Table 3. Performance of BARI Bt Begun-3 over location during 2021-22

Location	BSFB infestation (%)						Fruit yield (t ha^{-1})	
	Shoot		Fruit (by no.)		Fruit (by wt.)			
	Bt	Non-Bt	Bt	Non-bt	Bt	Non-bt	Bt	Non-bt
Norsingdi	0.00	38.00	0.00	26.70	0.00	20.24	27.40	26.28

Table 4. Performance of BARI Bt Begun-4 over location during 2021-22

Location	BSFB infestation (%)						Fruit yield (t ha^{-1})	
	Shoot		Fruit (by no.)		Fruit (by wt.)			
	Bt	Non-Bt	Bt	Non-Bt	Bt	Non-Bt	Bt	Non-Bt
Bogura	0.00	23.50	0.00	59.25	0.00	57.30	34.75	10.35
Kishoreganj	0.00	22.00	0.00	26.50	0.00	11.16	31.06	18.65
Khulna	0-0.41	26.24	0-0.58	33.71	0-0.75	22.27	40.84	22.35
Range	0-0.41	22.00-26.24	0.00-0.58	26.50-59.25	0.00-0.75	11.16-57.30	31.06-40.84	10.35-22.45
Mean								

Table 5. Major disease and insect infestation observed in Bt Brinjal field during 2021-22

Treatment	Major diseases	Insect infestation	Insecticide sprayed	Fungicide sprayed	No of spray	
BARI Bt Begun-4	Wilt, Little leaf (18-24%), Phomopsis blight	Flee beetle, white fly, thrips, red mite	Pegasus, Imitaf	Provex	Insecticide	Fungicide
BARI Begun-6 (Non Bt)					2	1

Conclusion

BARI Bt begun varieties performed better over their non Bt counterparts in respect of BSFB infestation and yield in all locations of the country. Among the 14 districts, field trial under 13 districts totally free from BSFB infestation. Maximum gross margin was obtained from BARI Bt begun varieties over non Bt counterparts. This technology is highly effective against the target insect pest, Brinjal shoot and fruit borer. But sporadic infestation of other non-target sucking pests, like white fly, thrips, jassid, aphid, flea beetle, red mite, Epilacna beetle etc. and diseases (bacterial wilt, *fusarium* wilt, phomopsis blight, little leaf etc.) was observed in some locations. For large scale demonstration, more awareness should be developed for the cooperative farmers about the Bt technology and management of the non-target insect-mite pests & diseases.

B. Production Programs

PILOT PRODUCTION OF WHEAT VARIETIES IN DIFFERENT LOCATIONS OF BANGLADESH

Pilot production program of Wheat were executed with the variety of BARI Gom-28, BARI Gom-30, BARI Gom-33 and BWMRI-3 during the *Rabi* season of 2021-22 at farmers' field condition of different locations (Table 1). The seeds were treated with Provex @ 3g kg^{-1} seed. Seeds were sown @ 120 kg ha^{-1} maintaining line at 20 cm. The lands were fertilized as recommended dose i.e.,110-22-60-15-4-1, N-P-K-S-Zn-B kg ha^{-1}. Two-third of N and all of the other nutrients were applied as basal during final land preparation and one- third of N was top-dressed after first irrigation i.e., 20-day after sowing (DAS). Irrigations were done twice at 20 DAS and 45 DAS. Affinity, a weedicide was sprayed after 5 days of 1st irrigation to control the broadleaf weed.

Results: Among the varieties, BARI Gom-33 produced the maximum grain yield (3.90 t ha^{-1}) at Satkhira followed by BARI Gom-33 (3.84 t ha^{-1}) in Faridpur. The lowest grain yield (2.59 t ha^{-1}) was obtained from the variety BARI Gom-33 in Khulna.

Farmers' opinion: Farmers of different locations are satisfying to grow BARI developed wheat varieties because of their higher yield as well as resistance to disease and unfavorable climate. Farmers of Satkhira and Bagerhat are interested to grow BARI Gom-30 and BARI Gom-33 due to bolder size seed and attractive seed color.

Table 1. Crop management and yield performance of Wheat during the *Rabi* season of 2021-22

Location	Variety	No. of farmer	Area (ha)	Date of sowing	Date of harvesting	Grain yield (t ha-1)
Faridpur	BARI Gom-33	20	0.06	28 Nov.-3 Dec. 2021	25-30 Mar. 2022	3.84
	BWMRI-3	11	0.06			3.80
	BARI Gom-28	20	0.06			3.74
Rangpur	*BARI Gom 30*	11	3.60	21-28 Nov. 2021	29 Mar. 2022 - 5 Apr. 2022	4.30
Khulna	BARI Gom-33	11	2.88	18 Nov. to 28 Dec. 2021	19 Feb. to 28 Mar. 2022	2.59
Satkhira	BARI Gom-30	14	3.20	20 Dec. 2021	10 Apr. 2022	3.90
	BARI Gom-33	8	3.73	04 Dec. 2021	28 Mar. 2022	3.25
Bagerhat		8	3.73	29-29 Nov. 2021	29 Mar. to 03 Apr. 2022	3.00
Total (Farmer and area)		103	17.32	Average yield		3.55

PILOT PRODUCTION OF HYBRID MAIZE VARIETIES IN DIFFERENT LOCATIONS OF BANGLADESH

Production program of BARI Hybrid Maize varieties was piloted at the farmers' field in Khulna district during the *Rabi* season of 2021-22. BARI Hybrid Maize-16 was used in this pilot production platform. The total area under this program was 6 ha and 18 farmers have participated. The seeds were sown on 28 December to 17 January to 30 January 2022 in the farmers' field. Cowdung and plant nutrients (N, P, K, S, Zn and B) were applied in the form of Urea, TSP, Muriate of potash, gypsum, Zinc sulphate, and Boric acid at the rate of 5 t ha^{-1}, 250, 55, 110, 40, 5 and 1.5 kg ha^{-1}, respectively. The one-third of urea and all other fertilizers and manure were applied during final land preparation. The rest amount of urea was applied in two equal splits at knee-high stage (40-45 DAS -1st top dress) and before flowering (2nd top dress). Irrigation was done two times during the crop period. Weeding was done 2 times to maintain the proper hygienic condition of the crop. The crop was harvested from 9 -13 May 2022.

Results: Maize varieties (BARI Hybrid Maize-16) gave the highest grain yield (9.23 t ha^{-1}) in Khulna.

Farmers' opinion: Farmers preferred BHM-16 due to shorter in height. Seeds of BARI Hybrid Maize should be available in the local market during the production period.

Table 1. Yield of BARI Hybrid Maize during the *Rabi* season of 2021-22

Location	Variety	No. of farmers	Area (ha)	Date of sowing	Date of harvesting	Grain yield (t ha^{-1})
Khulna	BARI Hybrid Maize- 16	18	6.00	28 Dec. 2021 to 17 Jan. 2022	23 Apr. To 10 May 2022	9.23

PILOT PRODUCTION OF BARLEY VARIETIES IN DIFFERENT CHAR LAND AREAS

The production program with BARI released Barley varieties, viz. BARI Barley-6, BARI Barley-7 and BARI Barley-9 were executed in the Charland of Gaibandha, and Khulna during the year of 2021-22. Seeds were sown during 1-12 Dec 2021. The crop was fertilized with N, P, K, S, Zn, and B @ 80-30-50-10-3-1 kg ha^{-1} in the form of urea, TSP, MoP, gypsum, zinc sulfate monohydrate, and boric acid, respectively. Two third of N and the full amount of P, K, S, Zn, and B was applied as basal during final land preparation. The remaining one-third of N was applied at 23 days after sowing (DAS) as a top dress followed by irrigation. The crop was irrigated twice. The crop was harvested on 16-18 March 2022. Data on seed yield was recorded from an area of 40 m^2 from the whole plot avoiding borderline from each side of the unit plot at the time of harvesting. The collected data were averaged and converted into ton per hectare and presented in Table 1.

Results: Results revealed that grain yield of Barley varieties were ranged from 1.95 to 2.47 t ha^{-1} where the maximum yield was obtained from BARI Barley-9 at Khulna (2.47 t ha^{-1}) followed by BARI Barley-7 in Gaibandha (2.11 t ha^{-1}). The lowest grain yield was obtained from BARI Barley-6 in Gaibandha (1.95 t ha^{-1}). The overall yield performance of all studied varieties BARI Barley-6 was found suitable to grow in charland conditions as they are tolerant to drought conditions. The highest gross margin was obtained from BARI Barley-9 (Tk. 50150 ha^{-1}) in Khulna due to higher market price with supplementary local demands.

Farmer's opinion: Farmers in the char lands showed their interest in cultivating BARI released Barley varieties, BARI Barley-6 and 7 for its higher yield potentials in charland condition than the locally grown barley cultivar and ensured marketing. The barley variety BARI Barley-9 are higher yield potential, less to disease and insect infestation. To keep the continuation of barley cultivation trial farmers stored their seed from the trial plots.

Table 1. Yield and economic return of BARI Barley varieties in different Charlands during the year of 2020-21.

Locations	Variety	No. of farmers	Area (ha.)	Average grain yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Gaibandha	BARI Barley-6	2	0.30	1.95	68250	28500	39750
	BARI Barley-7	2	0.30	2.11	73850	28500	45350
Khulna	BARI Barley-9	3	0.12	2.47	86450	36300	50150
Total (Farmer no and Area)		8	1.73	-	-	-	-
Average (Grain yield, GR, TVC and GM)				2.4	94133	42720	51413

Price range (Tk kg^{-1}): 35.00 of Barley

PILOT PRODUCTION OF BARI RELEASED FOXTAIL MILLET VARIETY IN THE CHAR LAND AREAS

A total of 150 trials were conducted at char land Saghata of Gaibandha with BARI released drought and heat tolerant foxtail millet variety, BARI Kaon-2 and BARI Kaon-3. A total 400 Kg of seeds (300 kg of BARI Kaon-2 and 100 kg of BARI Kaon-3) were distributed among 150 farmers to cultivate 40 ha of char lands. Planting started on 05 January 2022 and continued up to 25 January 2022. Soil test basis (STB) fertilizer doses were applied, and standard intercultural management practices were followed in the trial plots. Harvesting of the 150 trial plots started on 20 April 2022 and continued up to 30 April 2022. Yield (t ha^{-1}) of BARI Kaon-2 at char lands ranged from 1.99 to 2.31 t ha^{-1} with an average value of 2.15 t $ha^{-1.}$ The cost and return analysis are presented in Table 1. It was observed that the highest gross margin was found in BARI Kaon-2. Gross return was associated with the production of root yield. Higher root production facilitated the higher gross return. However, the average return and gross margin were Tk. 85900 ha^{-1} and Tk. 48400 ha^{-1}, respectively, and the average foxtail millet cultivation cost was Tk.37500 ha^{-1}.

Farmer's reaction

BARI Kaon-2 and BARI Kaon-3 cultivation in the char areas of Gaibandha district day by expanding due to its higher yield potential than local cultivar, good price, and ensuring market. BARI Kaon-2 maturation takes place 10 to 15 days earlier along with synchronous maturitthan the local cultivar which helped in a uniform harvest of the crop and saves the crops from the early flash flood.

Table 1. Yield and economic performance of foxtail millet at different char land under OFRD, BARI, Gaibandha and Rangpur in 2021-22

Variety	No. of farmers	Total Area (Ha.)	Sowing date	Harvesting date	Average grain yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
BARI Kaon-2	100	40	05-25 Jan. 2022	20-30 April 2022	2.31	92200	37500	54700
BARI Kaon-3	50	10	05-25 Jan. 2022	20-30 April 2022	1.99	79600	37500	42100
Average					2.15	85900	37500	48400

Market price (Tk kg-1): 40

PILOT PRODUCTION OF BARI RELEASED PROSO-MILLET VARIETIES IN THE CHAR LAND AREAS

A total of 13 (Thirteen) farmer trials were conducted at char area Saghata of Gaibandha with the BARI released Proso-millet variety (BARI Cheena-1). Seeds were sown on 15-20 December 2021. Fertilizers were applied as per FRG, 2018 and standard intercultural management practices were followed in the trial plots. Harvesting of the 6 trial plots started on 20 March 2022 and continued up to 30 March 2022. No disease infection and insect infestation were not observed in the trial plots. The yield of BARI Cheena-1 ranged from 2.99 to 3.39 t. ha^{-1} with an average of (3.29 t. ha^{-1}). The cost and return analysis showed that gross return and gross margin were Tk. 110550. ha^{-1} and Tk. 148,050 ha^{-1} from BARI Cheena-1, respectively where the average cultivation cost was Tk. 37500 ha^{-1} (Table 1).

Farmer's reaction

- Farmers in the char areas showed their interest in cultivating BARI released BARI Cheena-1 for their higher yield, well adapted in char areas, and ensured marketing for bird feed.
- Seed hub at the farmers' needs need to be established largescale scale production.
    - Need to improve value chain for sustainable Proso-millet production in char area.

Table 1. Yield and economic performance of BARI Cheena-1 variety at different char land under OFRD, BARI, Gaibandha and Rangpur in 2021-22

Variety	No. of farmers	Total Area (ha.)	Sowing date	Harvesting date	Average grain yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
BARI Cheena-1	13	2.00	15-20 Dec 2021	20-30 Mar 2022	3.29	148050	37500	110550

Market price (Tk kg^{-1}): 45

PRODUCTION PROGRAM OF BARI OAT-1 IN FARIDPUR

A production program of BARI Oat-1 was conducted at the FSRD site of Faridpur during the *Rabi* season of 2021-22 to observe the performance and to popularize BARI Oat-1 among the local farmers. The program was conducted in about 02 decimal of land. Only one farmer was selected. Different crop management practices like date of sowing, intercultural operations, date of harvest etc. are stated in Table 1. Seeds were sown @ 70 kgha^{-1} in maintaining spacing 25 cm line to line with continuous sowing on 20 December 2021. The crop was fertilized with 80-30-30-30-10-3-1.0 kg of N-P-K-S-Zn & B ha^{-1}in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. All of P, S, Zn and B, and half of N was applied as basal during final land preparation. Remaining N was applied in two equal splits at 25 DAS and 50 DAS under moist soil condition and mixed thoroughly with the soil. Weeding was done once at 22 DAS. The crop was harvested at 13 April, 2022 (114 DAS). The yield was recorded by crop cut from a total of 6m^2 area having three spots (2 m^2 in each) of the plot and converted to yield ha^{-1}. The yield is presented in Table 1. The yield of BARI Oat-1 was 2.07 t ha^{-1}. The seed yield of BARI Oat-1 was somehow higher due to dense population and proper management.

Farmers' opinion: Farmers happy to observe the first-time oat crop and getting higher yield from BARI Oat-1. No pest infestation was observed. Next cropping season, they will cultivate BARI Oat-1 variety. But they are worried for marketing.

Conclusion: Yield is higher and low production cost then other cereals. But processing not easy and selling problem.

Table 1. Yield of BARI Oat-1 at at the FSRD site, Faridpur during 2021-22

Variety	Farmers (no.)	Area (dec.)	Date of sowing	Date of harvest	Grain yield (t ha^{-1})
BARI Oat-1	01	02	20 Dec, 2021	13 April, 2022 (114 DAS)	2.07

PILOT PRODUCTION OF MUSTARD VARIETIES IN DIFFERENT LOCATIONS ACROSS THE COUNTRY

The pilot production programs were carried out at 21 locations (Pabna, Mymensingh, Manikganj, Tangail, Faridpur, Sylhet, Sherpur, Cumilla, Bhola, Kishoreganj, Kushtia, Gaibandha, Barind, Rajshai, Gopalganj, Khulna, Satkhira, Bagerhat, Noakhali, Shyampur Rajshahi, Rangpur) of Bangladesh during the *Rabi* season of 2021-22 (Table 1). BARI Sarisha-14, BARI Sarisha-15, BARI Sarisha-17 and BARI Sarisha-18 were used in different locations in the pilot production program. Quality seeds of the different BARI released Mustard varieties were distributed. The seeds were broadcasted @ 8.0 kg ha^{-1}. Half of N and all other fertilizers were applied during final land preparation. The rest of N was top-dressed at 33 days after sowing (DAS) followed by irrigation. For controlling the *Alternaria* leaf spot, Rovral was spraying twice at the rate of 0.2 percent at 10 days interval from 45 DAS. For controlling aphid Malathion and Rison were sprayed @ 0.3 percent. At the maturity stage, data on yield was collected accordingly.

Results: Location wise variety, number of farmers involved, area covered, and seed yield is presented in Table 1. All the varieties of Mustard in different locations gave better seed yield than that of the national average (650 kg ha^{-1}). However, among the short duration tested Mustard varieties (BARI Sarisha-14) the maximum seed yield (2.22 t ha^{-1}) was found in Sherpur. On the other hand, short-duration variety BARI Sarisha-14 performed well over the locations and yielded ranged from 1.44 to 2.17 t ha^{-1}. However, another short-duration variety BARI Sarisha-17 also performed better all over the locations and yield ranged from 1.31- 1.81 t ha^{-1}. BARI Sharisha-18 gave the maximum seed yield 1.82 t ha^{-1} in Shyampur, Rajshahi though the variety took more duration for its maturity.

Farmers' opinion: Farmers are interested to cultivate BARI Sarisha-14 and BARI Sarisha-17, the reason being impressed to have the higher yield of BARI Sarisha-14 and 17 within a shorter period (average of 85 days) and these variety can easily be fitted in the Mustard-*Boro*-T. *Aman* cropping pattern without hampering the *Boro* cultivation. Farmers in the Shyampur Rajshahi, Sherpur, Jashre, Khulna, Satkhira, Bagerhat and Faridpur location impressed on seed yield BARI Sarisha-18, and it took more days to attain maturity which can be fitted in Mustard- Jute- T. *Aman* cropping pattern.

Table 1. Performance of Mustard varieties in different locations during the year of 2021-22.

Location	Variety	No. of farmer	Area (ha)	Date of sowing	Date of harvesting	Seed yield (t ha^{-1})
Pabna	BARI Sarisha -14	15	3.5	15 Nov- 4 Dec 2021	10-15 Feb 2022	1.56
	BARI Sarisha-17	110	26.50	20 Nov– 6 Dec 2021	21 Feb. -5 Mar 2022	1.81
	BARI Sarisha-18	8	2.5	15-20 Nov 2021	5-10 Mar 2022	1.76
Mymensingh	BARI Sarisha-14	42	11.45	06-25 Nov 2021	27 Jan - 3 Feb, 2022	1.45
Manikganj	BARI Sarisha-14	102	29.20	26 Oct - 6 Nov 2021	3-8 Feb 2022	1.44
	BARI Sarisha-17	42	14.67	1-5 Nov 2021	6 -10 Feb 2022	1.31
Tangail	BARI Sarisha-14	83	24.00	7-19 Nov 2021	24 -30 Jan 2022	1.54
Faridpur	BARI Sarisha-18	39	6.00	8-25 Nov 2021	16 Feb - 15 Mar 2022	1.62
Sylhet	BARI Sarisha-14	10	1.0	15-20 Nov. 2021	15- 20 Feb 2022	1.64
	BARI Sarisha-17	10	1.0			1.68
Sherpur	BARI Sarisha-14	35	3.15	4-5 Nov. 2020	23-25 Jan. 2022	2.17
	BARI Sarisha-18	12	0.40	15-18 Nov. 2021	18-20 Feb 2022	2.22
Cumilla	BARI Sarisha-14	12	2.44	12 Nov -1 Dec 2021	15 Jan.-22 Feb 2022	1.56
	BARI Sarisha-17	23	6.26	30 Nov _24 Dec 2021	20 jan – 27 Feb 2022	1.68
Bhola	BARI Sarisha-14	10	1.25	14 Nov to 20 Dec 2021	20-22 Mar 2022	1.49
Kishoreganj	BARI Sarisha-14	42	6.07	25-30 Oct 2021	17-27 Jan 2022	1.56
	BARI Sarisha-17	60	12.14			1.64
Kushtia	BARI Sarisha-14	17	2.00	10 -20 Nov 2021	5- 10 Feb 2022	1.59
	BARI Sarisha-18	26	3.00	12-22 Nov 2021	27 Feb – 14 Mar 2022	1.68
Jashore	BARI Sarisha-18			28 -30 Nov 2021	20 -23 Mar 2022	1.75
Gaibandha	BARI Sarisha-14	90	15	25-30 Oct 2021	10-20 Jan 2022	1.63
	BARI Sarisha-17	15	2	28-30 Oct 2021	3-6 Feb 2022	1.88
Barind, Rajshai	BARI Sarisha-11	2	0.13	31 Oct 2021	18 Feb 2022	1.50
	BARI Sarisha-14	2	0.13	01 Nov 2021	30 Jan 2022	1.60
	BARI Sarisha-15	4	0.13	01 Nov 2021	30 Jan.2022	1.56
	BARI Sarisha-17	2	0.13	01 Nov 2021	04 Feb 2022	1.70
	BARI Sarisha-18	2	0.13	04 Nov2021	16 Feb 2022	1.80
Gopalganj	BARI Sarisha-18	15	3.0	1 – 3 Dec 2021	03 -05 Mar 2022	1.87
Khulna	BARI Sarisha-14	20	12.14	15-29 Nov. 2021	4-16 Feb. 2022	1.63
	BARI Sarisha-17	6	1.33	15-25 Nov. 2021	10-20 Feb. 2022	1.66
	BARI Sarisha-18	28	68.33	15Nov-30 Dec. 2021	24 Feb -16 Mar. 2022	1.63
	BARI Sarisha-19	2	0.26	20-30 Nov 2021	15-24 Feb 2022	2.43
Satkhira	BARI Sarisha-14	110	22.67	10-12 Nov. 2021	30-1 Feb. 2022	1.46
	BARI Sarisha-17	76	20.00	10-15 Nov. 2021	01-02 Feb. 2022	1.58
	BARI Sarisha-18	17	5.33	15-28 Nov. 2020	05-20 Mar.2022	1.76
Bagerhat	BARI Sarisha-17	2	1.00	25Nov-24 Dec 2021	27-29 Feb. 2022	1.50
	BARI Sarisha-18	27	32.40	25Nov-24 Dec. 2021	12-26 Mar. 2022	1.79

Location	Variety	No. of farmer	Area (ha)	Date of sowing	Date of harvesting	Seed yield (t ha^{-1})
Noakhali	BARI Sorisha-17			18-24 dec 2021	15- 17 Mar 2022	0.80
Shyampur, Rajshahi	BARI Sarisha-14	20	3.00	25-30 Nov. 2021	18 Feb.- 12 Mar. 2022	1.41
	BARI Sarisha-18	25	1.00			1.82
Rangpur	BARI Sarisha-14	14	5.2	09-20 Nov 2021	01-20 Feb 2022	1.55
Total		**1177**	**350**	Average yield		**1.65**

PILOT PRODUCTION OF GROUNDNUT VARIETIES IN DIFFERENT AREAS

The production program of BARI Groundnut varieties was conducted in the Charland of Tangail, Sylhet, Gaibandha and Bhola district. The production program was demonstrated in 58 farmer's field in 7.68 ha of land. The quality seed of the BARI released Groundnut was collected from the Oil Seed Research Centre of BARI, Gazipur. The pilot production field was fertilized with N-P-K-S-Zn-B-cow dung @ 12-17-45-32-2-1.8-5000 kg ha^{-1} in the form of urea, triple superphosphate, muriate of potash and gypsum, Zinc sulphate, Boric acid, respectively. Half of the urea and all TSP, MoP, Gypsum, Zinc sulphate, and Boron were applied during final land preparation. The remaining half of urea was applied at 45 DAS during the flowering stage of the crop. Seeds of Groundnut were sown in line maintaining 30cm x 15cm spacing. The seed rate was 100 kg ha^{-1} with a shell. The seeds were sown on 14 November 2021 to 22 January 2022. The plot was weeded twice and one light irrigation was given in the field. Other plant protection measures were taken as and when required. Nitro @ 2 ml L^{-1} was sprayed to control insects. The crop was harvested from 26 April to 11 June 2022. Data on yield (in large plot area) was recorded and presented. The crop was infested with leaf-eating insects and Nirto @ 2 ml L^{-1} was sprayed to control insects. Leaf rust disease was controlled spraying with Contaf @ 2ml L^{-1} water. No other disease or pest incidence was observed in the experimental plots.

Results: The yield of BARI released Chinabadam varieties were ranged from 1.93 to 2.16 t ha^{-1} where the maximum yield (2.14 t ha^{-1}) was obtained from BARI Chinabadam-9 in Bhola. The variety BARI Chinabadam-8 was giving lowest yield (1.93 t ha^{-1}) in Sylhet (Table 1).

Farmers' opinion: The farmers opined that the seed size of BARI Groundnut varieties (BARI Chinabadam-8 and BARI Chinsbsdam-9 is bigger than farmers' variety (Dhaka-1).

Table 1: Performance of Groundnut yield during the *Rabi* season of 2021-22.

Locations	Treatments	No. of Farmers	Area (ha)	Seed yield (t ha^{-1})
Tangail	BARI Chinabadam-8	16	1.79	2.21
Sylhet	BARI Chinabadam-8	12	1.65	1.93
Gaibandha	BARI Chinabadam-8	20	2.10	2.16
Bhola	BARI Chinabadam-9	10	2.14	2.23
Total (No. of farmers and Area)		58	7.68	8.53

PILOT PRODUCTION OF SESAME IN DIFFERENT LOCATIONS

The production program of BARI Sesame variety was conducted in Cumilla and Rajshahi district during the *Kharif-I* season of 2021 in the farmers' field under rainfed condition. BARI Til-4 was demonstrated in ten (5) farmer's field in 3.73 ha of land. The quality Sesame seed was collected from Oilseed Research Centre of BARI, Gazipur. The experimental block was fertilized with N-P-K-S-Zn-B-cowdung @ 55-30-25-20-2-1.70 kg ha^{-1} in the form of urea, triple super phosphate, muriate of potash and gypsum, zinc sulphate, boric acid, respectively. Half of urea and all TSP, MoP, Gypsum, Zinc, and Boron was applied during final land preparation. The remaining half of urea was top-dressed at 30 days after sowing (DAS) during the flowering stage of the crop. Seeds of BARI Til-4 were sown as broadcast @ 5.5 kg ha^{-1} on 20 April 2020. The crop was sprayed with Darsban @ 2 ml L^{-1}water to control cutworm and other leaf feeder insects to support the normal growth of the plant. Plant protection measures were taken as and when required. The crop was harvested from 05 to 15 July 2021. Data on yield was recorded and converted into t. ha^{-1}.

Results: The maximum seed yield of BARI Til-4 was found 1.45 t ha^{-1} in Cumilla. The lowest seed yield 1.22 t ha^{-1} also found from the same variety in Rajshahi

Farmers' opinion: The farmers opined that the seed yield of BARI Til-4 is much higher than the local variety The color of the seed in BARI Til-4 is reddish-brown. But the market price of black colored seed is higher than the reddish seed of BARI Til-4. Due to higher seed yield farmers were interested to cultivate BARI Til-4 in the next season.

Table 1: No. of farmer, area covered, date of sowing, harvesting, and yield of BARI Til-4 at Charland Manikganj and Faridpur during *Kharif-I* season of 2021.

Location	Variety	No. of farmer	Area (ha)	Date of sowing	Date of harvesting	Grain yield (t ha^{-1})
Cumilla	BARI Til-3	2	0.73	20-23 April, 2021	05 to 10 July, 2021	1.25
	BARI Til-4	3	0.57	20 -25April, 2021	05 to 15 July, 2021	1.45
Rajshahi	BARI Til-4	16	5.0	20 -25 Mar, 2021	20 May-25 June 2021	1.22

PILOT PRODUCTION OF SOYBEAN VARIETIES IN DIFFERENT LOCATIONS AT FARMERS FIELD

The production program was conducted in the farmer's field in Bhola and Noakhali during the *Rabi* season of 2021-22. BARI Soybean-6 was used as planting materials. The crop was fertilized with 25, 35, 55, and 18 kg ha^{-1}of N, P, K, and S, respectively. All fertilizers except urea were applied during final land preparation as a basal dose. All fertilizers except urea were applied during final land preparation as basal dose. Seeds were sown @ 60 kg ha^{-1}on 09-11 October 2021 through broadcast method. Different intercultural operations and plant protection measures were taken as and when necessary to raise healthy crops. Harvesting was done from 26 December 2021 to 5 January 2022. Data were collected on an individual plant basis from ten (10) randomly selected plants of each plot in such a way that the border effect was avoided for high precision.

Results: Yield of soybean varieties across locations were ranged from 1.76 to 2.00 t ha^{-1}, where the maximum seed yield 2.00 t ha^{-1} was obtained from BARI Soybean-5 in Noakhali.

Farmer's opinion: BARI Soybean-5 is highly accepted by the farmers as it offers higher yield as well as economic return during late kharif season.

Table 1. Yield, cost, and return analysis of BARI Soybean during *Rabi* season of 2021-22

Location	Variety	No. of farmer	Area (ha)	Seed yield (t ha^{-1})
Bhola	BARI Soybean-5	7	1.40	1.83
	BARI Soybean-6	4	3.36	1.76
Noakhali	BARI Soybean-5	6	1.50	2.00

PILOT PRODUCTION OF SUNFLOWER VARIETIES IN DIFFERENT LOCATIONS AT FARMERS FIELD

The pilot production program was implemented in Cumilla, Kishoreganj, Faridpur, Bhola, Sylhet, Gaibandha, Khulna and Bagerhat district during the *Rabi* season of 2021-22 to display the performance of sunflower varieties under farmer's field condition. BARI developed Sunflower variety BARI Surjamukhi-2 and BARI Surjamukhi-3 was used in this program. The trial plot was plowed by the tiller with four passes then followed by laddering. Chemical fertilizer was applied @ 100-30-60-20-1.5 kg ha^{-1} N, P, K, S, and B in the form of Urea, TSP, Mop, Gypsum, Boric acid in the field. Half of Urea and full doses of all other fertilizers were applied during final land preparation. The rest amount of Urea was top-dressed at 25 and 45 days after sowing. Seeds were sown on 28 November -16 December 2021 with a spacing of 50 cm × 25 cm, respectively. The seeds were treated with Provax-200 at the rate of 2.5 mg Kg^{-1} of seeds. To control caterpillar (*Admair* and *Cortan Plus*) Nitro 505 EC at the rate of 2ml $L^{-1}$was sprayed twice at the flowering and grain filling stage. For controlling blight and root rot diseases of sunflower Autostin 72 Wp and Rovral -50 WP (@ 1 mg L^{-1} of water) was sprayed after diseases appeared. The crops were harvested 5-25 March 2022. Data on yield was recorded and presented as t ha^{-1}.

Results: The seed yield of BARI Surjamukhi-2 and BARI Surjamukhi-3 were ranged from 1.20 to 2.15 t ha^{-1}. The seed yield was higher in BARI Surjamukhi -3 than BARI Surjamukhi -2. The overall yield performance of Sunflower varieties across locations was comparatively low in Bagerhat considering the potential yield of sunflower. The probable causes for its low yield may be due to unfilled grain of the sunflower, severe bird attacks, unknown management practices, root and stem rot diseases, difficulties in threshing and human theft as a new crop in that area

Farmer's opinion:

1. Farmers were very much impressed on sunflowers as a new crop in their traditional cropping pattern Rabi- Fallow-T. *Aman*.
2. They were satisfied to see the yield performance of BARI Surjumukhi-2 and BARI Surjumukhi-3 at the farm level. But, some kind of problem to sell their seed because the market channel of Surjumukhi was not established yet.
3. Farmers preferred BARI Surjomukhi-3 due to its short height, uniform big- head.

Table 1. Seed yield and yield contributing characters of BARI Surjomukhi varieties at a different location during the *Rabi* season of 2021-22.

Locations	Varieties/lines	Farmers No.	Land area (ha.)	Seed yield (t ha^{-1})
Cumilla	BARI Surjomukhi-3	6	0.12	2.15
Kishoreganj	BARI Surjomukhi-3	6	0.20	1.57
Faridpur	BARI Surjomukhi-3	6	1.25	1.82
Bhola	BARI Surjomukhi-3	3	0.40	1.79
Cumilla	BARI Surjomukhi-3	4	0.25	2.15
Kushtia	BARI Surjomukhi-3	6	0.45	2.07
Sylhet	BARI Surjomukhi-2	6	0.20	1.93
	BARI Surjomukhi-3	6	0.20	2.10
Gaibandha	BARI Surjomukhi-2	10	1.0	1.90
	Bari Surjomukhi-3	10	0.6	1.75
Khulna	BARI Surjamukhi-3	10	0.75	1.79
Bagerhat	BARI Surjamukhi-3	9	0.75	1.20
Total (Farmer no. and Land area)		82	6.17	-
Average (Seed yield)				1.85

PILOT PRODUCTION OF LENTIL VARIETIES

The production program was implemented in Noakhali, Bogura, Faridpur, Gaibandha, Kushtia, Satkhira and Bagerhat district during the *Rabi* season of 2021-2022. Quality seeds of BARI Masur-7 and 8 with inorganic fertilizers and pesticides were supplied to the farmers. Fertilizers were applied @ 20.73-17- 17.5-9.42-1.02 kg ha^{-1} NPKS and B, respectively. All fertilizers were applied as basal during final land preparation. Irrigation was done at one time at 33 DAS. One wedding was done in the Lentil field. The crop was sprayed by Provex-200 and Rovral for controlling footrot and Stemphylium blight diseases, respectively. The crop was sprayed by Tafgor @ 2ml L^{-1} to control aphid at 74 DAS.

Results: The **y**ield of Lentil varieties across locations were ranged from 1.08 to 2.04 t ha^{-1} where the maximum seed yield (2.10 t ha^{-1}) was obtained from BARI Masur-8 in Gaibandha followed by seed yield (2.10 t ha^{-1}) in Bogura. The lowest seed yield was 1.08 t ha^{-1} obtained from BARI Masur-8 in Bagherhat.

Farmers' opinion

Lentil growers were satisfied to get the higher seed yield from BARI Masur-8 as the variety resistant to *Stemphylium* blight and it offers a higher yield and more net return than local Lentil cultivar.

Table 1. Number of farmers involved, area covered, and seed yield of Lentil variety in different locations during the year of 2021-22.

Location	Variety	No. of farmer	Area (ha)	Date of sowing	Date of harvesting	Seed yield (t ha^{-1})
Noakhali	BARI Masur-8	3	1.15	27 to 30 Dec. 2021	26 Mar. to 4 Apr. 2022	1.16
Bogura	BARI Masur-8	25	1.76	21 Nov. to 25 Dec. 2021	8-30 March 2022	2.04
Faridpur	BARI Masur-8	21	3.47	11 Nov. to 02 Dec. 2021	17-25 March 2022	1.70
Gaibandha	BARI Masur-8	35	6.60	5-10 Nov. 2021	10-25 March 2022	2.10
Kushtia	BARI Masur-7	2	0.40	20 November, 2021	7-15 March, 2022	1.50
	BARI Masur-8	7	1.75	15-25 November, 2021	15-25 March, 2022	1.74
Pabna	BARI Masur-8	5	0.50	15-17 December, 2021	18-23 March, 2022	1.69
Khulna	BARI Masur-8	10	5.87	12 Nov. to 25 Dec. 2021	01-17 Mar. 2022	1.71
Satkhira	BARI Masur-8	4	1.47	28-30 Nov. 2021	15-16 Mar. 2022	1.82
Bagerhat	BARI Masur-8	17	4.40	16 Nov. to 24 Dec. 2021	12-66 Mar. 2022	1.08
Total (Farmer no. and area) and Average Seed yield (t ha^{-1})		129	27.27			1.65

PILOT PRODUCTION OF CHICKPEA VARIETIES IN DIFFERENT AREAS OF FARMERS FIELD

The production program of Chickpea was piloted at the Faridpur during the *Rabi* 2021-22 to popularize BARI Chola-9 and BARI Chola-10 among the farmers. Seeds were sown from 15 November-5 December 2021 irrespective of farmers. Fertilizers were applied @ 32-28-24-18-2-1.5 kg ha^{-1} as the source of N, P, K, S, Zn, and B were applied in the form of urea, triple superphosphate (TSP), muriate of potash (MoP), gypsum, Zinc sulphate monohydrate, and boric acid, respectively in the field. All the fertilizers were applied during final land preparation. One-time irrigation was provided immediately after sowing. Insecticide (Volium Flexi) was sprayed twice starting from flower initiation at an interval of 15-16 days (66-69 and 82-84 DAS). The crop was harvested at 122 DAS. The yield was recorded by crop cut from a total of 6m^2 area having three spots (2 m^2 in each) of the plot and converted to yield ha^{-1}. The yield performance are presented in Table 1.

Results: The highest yield was obtained 1.95 t ha^{-1} in BARI Chola-5. The yield of BARI Chola-10 was 1.96 t ha^{-1}.

Farmer's opinion: Farmers showed interest in BARI Chola-10 for its higher yield, bold seed size. Pest attack was lower in BARI released variety than local variety. They will cultivate BARI Chola-10 variety in the next year.

Table 1. Yield, cost and return analysis of BARI Chickpea during the *Rabi* season of 2021-22.

Locations	Variety	No. of farmers	Area (ha)	Seed yield(t ha^{-1})
Faridpur	BARI Chola-10	3	0.80	1.96
	BARI Chola-5	4	0.40	1.98

PILOT PRODUCTION OF MUNGBEAN IN DIFFERENT LOCATIONS AT FARMERS FIELD

A production program was piloted with BARI Mug-6 at the Rajshahi and Bhola Crop was sown 1-8 March 2021 and harvested 28 April to 20 May 2021 during the *Kharif I*, 2021. Fertilizer dose (kg ha^{-1}) was followed $N_{24}P_{32}K_{24}S_{18}Zn_2B_1$ kg ha^{-1}. All fertilizer was applied as basal during final land preparation. One irrigation (30 March 2021, 29 DAS) and one hand weeding (29 DAS) were done. The collected data were averaged and converted into ton per hectare were presented in Table 1.

Results: The maximum seed yield was 1.49 t ha^{-1} obtained from BARI Mung-6 in Bhola and followed by seed yield 1.40 t ha^{-1} from BARI Mung-8 in the same location. The lowest seed yield was found 1.49 t ha^{-1} from BARI Mung-6 in Rajshahi.

Farmer’s opinion: Farmers of Bhola were happy for getting higher yield from BARI Mung-6 but demand one-time harvested variety that may reduce labor cost.

Table 1. Yield and cost return analysis of BARI Mungbean-6 during the Kharif-I season of 2021.

Location	Variety	No of farmer	Area (ha)	Seed yield (t ha^{-1})
Rajshahi	BARI Mung-6	57	17.5	1.41
Bhola	BARI Mung-6	10	0.50	1.49
	BARI Mung-8	12	0.65	1.40

PILOT PRODUCTION OF BLACKGRAM IN DIFFERENT LOCATIONS OF CHARLAND AREAS

The pilot production program was executed in the farmer’s field of Manikganj, Bogura, Faridpur and Kushtia. BARI Mash-3 was used in the production program. The seeds of BARI Mash-3 were sown from 28 to 31 August 2021. The land was fertilized with NPKSZnB at the rate of 20.74-18-20-9-1.5-1.7 kg ha^{-1}, respectively. There was enough rainfall during the growing season. Weeding, control of pests, and other intercultural operations were done as and when required. The crop was harvested from 19 to 28 November 2021. At harvest, the yield data was recorded and converted into yield per hectare.

Results: The yield of the BARI Mash-3 was ranged from 1.20 to 1.49 t ha^{-1} where the maximum seed yield (1.49 t ha^{-1}) was obtained in Bogura followed by Faridpur (1.43 t ha^{-1}). The lowest seed yield (1.20 t ha^{-1}) was attained in Kushtia.

Pest incidence: Hairy caterpillar was observed in some plots. Grasshopper was also observed in some plots. The pests were controlled spraying with Karate @ 2 ml $L^{-1}$and Nitro @ 2 ml L^{-1} water in the field.

Farmers' opinion: Previously farmers of the area used to cultivate local variety. They were happy to see the new variety and interested to grow BARI Mash-3 for its higher yield.

Table 1. Yield, cost, and return analysis of BARI Blackgram during the *Kharif*-2 season of 2019-20

Locations	Variety	Farmers involved	Area (ha)	Seed yield (t ha^{-1})
Manikganj	BARI Mash-3	3	0.40	1.21
Bogura	BARI Mash-3	23	2.71	1.49
Faridpur	BARI Mash-3	4	2.48	1.39
	BARI Mash-4	4	0.20	1.29
Kushtia	BARI Mash-3	15	5.00	1.20
Average		49	10.79	1.31

PILOT PRODUCTION OF BARI RELEASED GRASSPEA VARIETIES IN DIFFERENT LOCATIONS AT FARMERS FIELD

The production program of Grass pea was piloted at Gaibandha, Rangpur, Bogura, Khulna, Satkhira, and Bagerhat district during the *Rabi* season of 2021-22 in the farmers' field. BARI Kheshari-2, and BARI Kheshari-3 were validated in the farmer's field. The trial plots were fertilized with total fertilizers during final land preparation @ 21-18-20-10-2-1 of N-P-K-S-Zn-B were applied as urea, triple superphosphate, and muriate of potash, gypsum, zinc sulfate, and boric acid, respectively. All the fertilizers were applied in the land during final land preparation. Seeds were sown as broadcast @ 55 kg ha^{-1}in different farmers' fields from 6 to 15 November 2021. Indofil M-45 @ 2 g $L^{-1}$and water was sprayed to control downy mildew disease. Root rot disease was controlled using Nativo @ 2g L^{-1} of water. Nitro @ 2ml L^{-1} water was sprayed to control pod borer insects. Irrigation was given once at 30 days after sowing. Other plant protection measures were taken as and when required. The crop was harvested from 24 March to 3 April 2022. Data on yield were recorded plot-wise and converted into ton per hectare.

Results: Yield among the grasspea varieties were ranged from 1.39 to 1.63 where the maximum yield (1.63 t ha^{-1}) was obtained from BARI Kheshari-2 in Satkhira followed by seed yield 1.57 t ha^{-1} in Bagerhat. The lowest yield 1.24 t ha^{-1} was obtained from BARI Kheshari-2 in Bagerhat.

Disease and Insect reaction: Downy mildew disease was observed in all the studied varieties at the vegetative growth stage. Indofil M-45 @ 2 g L^{-1} water was sprayed to control downy mildew disease. Nativo @ 2g L^{-1} water was sprayed to control root rot disease. Aphid infestation was observed in the plot and it was controlled spraying several times with Nitro (Chloropyriphos + Cypermethrin) @ 2 ml L^{-1} water.

Farmers' opinion: Farmers are very much interested to cultivate BARI Kheshari-2 and BARI Kheshari-3 for the higher bearing of the pod as well as higher seed yield.

Table 1. No. of the farmer, area, yield, cost and return analysis of BARI Grasspea varieties during the *Rabi* season of 2021-22.

Locations	Variety	Farmers involved	Area covered (ha)	Seed yield (t ha^{-1})
Gaibandha	BARI Kheshari-3	30	3.60	1.47
Rangpur	BARI Kheshari-3	8	2.86	1.43
Bogura	BARI Kheshari-3	12	3.03	1.39
Khulna	BARI Kheshari-2	5	2.14	**1.38**
	BARI Kheshari-3	5	5.96	**1.49**
Satkhira	BARI Kheshari-2	15	19.20	**1.44**
	BARI Kheshari-3	20	20.93	**1.63**
Bagerhat	BARI Kheshari-2	12	8.80	**1.24**
	BARI Kheshari-3	11	8.93	**1.57**
Total		118	75.45	**-**
Average		-	-	1.44

PILOT PRODUCTION OF GARDEN PEA IN DIFFERENT LOCATIONS AT FARMERS FIELD

The production program of Field pea was conducted at Tangail and Bagerhat district during the *Rabi* season of 2021-22 in the farmers' field. The experimental plots were fertilized with total fertilizers during final land preparation @ 20-18-20-9-1-1.5 kg ha^{-1} of N-P-K-S-Zn-B applied as urea, triple super phosphate and muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Seeds were sown as broadcast @ 80 kg ha^{-1} on 13 November 2021. No irrigation was required as the land contained enough soil moisture. Other plant protection measures were taken as and when required. Green pods were harvested from 02-26 February 2022. Data on yield were recorded and converted into ton per hectare.

Results: Yield of BARI Motorshuti-3 is shown in Table 1. The maximum green pod yield 2.56 t ha^{-1} was found BARI Motor-3 in Bagerhat.

Disease and Insect reaction: Nativo @ 2g L^{-1} water was sprayed to control root disease. No other disease and insect infestation were observed in the field.

Farmers' opinion: Farmers opined that Field pea is a new crop in the farmers' field in Tangail and Bagerhat. Farmer is interested to cultivate BARI Motor-3 for its higher yield.

Table 1: Yield of Field pea during the *Rabi* season of 2021-22

Location	Variety	Farmers no.	Area (ha)	Yield (t/ha)
Tangail	BARI Motor-3	05	1.67	1.80
Bagerhat	BARI Motor-3	01	0.13	2.56

PILOT PRODUCTION OF ONION VARIETIES IN CHAR LAND AREAS

A production program of BARI Piaz-1, BARI Piaz-4, BARI Piaz-5 and BARI Piaz-6 was conducted under farmer's field condition at the Faridpur, Sherpur, Rangpur, Narsingdi, Mymensing, Jamalpur, Manikganj, Gaibandh, Bhola, Bogura, Khulna, Satkhira and Kushtia during the *Rabi season of* 2021-22 to observe the performance of BARI Piaz-1, BARI Piaz-4, BARI Piaz-5 and BARI Piaz-6 against local popular cultivar. Seedling was transplanted on 11 Dec to 25 Jan 2021 for winter variety. The crop was fertilized with 140-60-60-30-3-1.5 kg of N-P-K-S-Zn and B ha^{-1} in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. All of P, S, Zn and B, and half of N and K will be applied as basal during final land preparation. Remaining N and K will be applied in two equal splits at 27-33 DAT and 47-56 DAT under moist soil condition and mixed thoroughly with the soil. Pesticides named Roval, Ridomil, Amister top, Confidor, karate were sprayed. Onion varieties were harvested at 73-90 DAT. Data on yield and economic returns were recorded and presented in Table 1.

Results: The maximum bulb yield was found 28.00 t ha^{-1} from BARI Piaz-5 in Sherpur and followed by BARI Piaz-4 (22.06 t ha^{-1}) in Faridpur. The lowest bulb yield was found 8.08 t ha^{-1} from BARI Piaz-1 in Satkhira.

Farmers' opinion: Farmers opined confidently to the BARI Piaz-4 (winter Onion) for its higher bulb yield

Table 1. Yield, of onion at different locations during the *Rabi* season of 2021-22.

Location	Variety	Farmers (no.)	Area (ha)	Bulb yield (t ha^{-1})
Faridpur	BARI Piaz-4	6	0.51	22.06
	Local (Lal Teer king)	1	0.40	18.98
Sherpur	BARI Piaz-5	6	0.25	28.00
Rangpur	BARI Piaz-4	12	0.25	14.10
Narsingdi	BARI Peaj-4	5	0.36	18.36
Mymensingh	BARI Peaj-1	6	0.08	14.90
	BARI Peaj-4	10	0.17	15.20
	BARI Peaj-5	10	0.50	18.20
Manikganj	BARI Piaj-4	2	0.26	20.14
Gaibandha	BARI Piaj-1	100	20.00	12.65
	BARI Piaj-4	20	2.00	17.40
	BARI Piaj-6	30	4.00	16.50
Bhola	BARI Piaz-4	3	0.27	16.28
	BARI Piaz-6	2	0.13	14.13
Bogura	BARI Piaz-4	32	1.75	16.58
	BARI Piaz-6	9	0.47	16.74
Khulna	BARI Piaz-4	1	0.13	12.54
Satkhira	BARI Piaz-1	3	0.53	8.08
	BARI Piaz-4	4	0.53	12.50
Kushtia	BARI Piaz-4	2	0.75	20.25
Total		264	33.34	-
Avg. Bulb yield (t ha^{-1})		-	-	16.67

PRODUCTION OF BLACK CUMIN AT FARMERS FIELD IN DIFFERENT LOCATIONS

The production program was conducted at the area of Tangail, Bhola, Faridpur, and Satkhira during the *Rabi* season of 2021-2022 to popularize and disseminate BARI Kalojira-1 among the farmers and also to increase the income through increasing yield. BARI Kalozira-1 was cultivated among the 23 farmers covering 5.10 hectares of land. The crop was fertilized with 60-20-40 kg NPK ha$^{-1.}$ Half of Urea and full amount of TSP and MoP were applied at the time of final land preparation. Remaining urea was top dressed at 45 days after sowing (DAS) before flowering stage. The seeds were sown on 11-26 November, 2021 in broadcast with seed rate of 7 kg ha^{-1}. Intercultural operation, pests and other crop management practices were done properly for normal growth of the crop. The crop was harvested on 12 March to 26 April, 2022. Yield was recorded by crop cut of 20 m^2 randomly in different spot from each plot.

Results: The yield of BARI Kalozira-1 was ranged from 0.89 to1.38 t ha^{-1} whereas the local variety was ranged from 0.65 to 0.94 t ha^{-1} with an average of 0.68 t ha^{-1}. BARI Kalozira-1 produced average 46 % higher yield than the local cultivar. The maximum seed yield (1.38 t ha^{-1}) of BARI Kalozira-1 was obtained in Mymensingh. The lowest seed yield 0.76 t ha^{-1} was obtained in Bhola (Table 1).

Farmers' opinion: BARI Kalozira-1 gave higher seed yield than local variety. They also chose BARI Kalozira-1 for its higher seed yield, less disease and pest infestation and attractive seed color and size.

Table 1. Crop management and yield of Black cumin varieties during the *Rabi* season of 2021-2022

Location	Farmers (no.)	Area (ha)	Sowing date	Harvesting date	Seed yield (t ha^{-1})	
					BARI Kalozira-1	Local
Tangail	3	1.0	28-29 Nov.21	28 Mar. 2022	0.89	0.65
Bhola	3	0.5	21-27 Nov.21	20-26 Mar. 2022	0.76	
Faridpur	3	1.25	16-18 Dec. 2021	7-10 Apr. 2022	1.25	0.94
Satkhira	12	1.60	15 Nov. 2021	28 Mar. 2022	1.38	
Total	23	5.10				
Average					1.07	0.795

PILOT PRODUCTION PROGRAM OF GARLIC AT ON-FARM CONDITION

Production program of garlic with BARI Rosun-1 following improved practices were conducted at Bogura during 2021-22 cropping season to increase farmers yield and economic return. Clove sowing of garlic @ 400 kg ha^{-1} was started from 16 November 2021 and continued up to 29 December 2021. Two times weedings were done at 25-20 and 30-40 days after sowing. Two times spay with Tundra and Pegasus @ 2ml/L was made for controlling insects like leaf feeder, thrips. Iprozim 26WP @ 2g/L was applied to prevent purple blotch disease. Harvesting started on 25 March 2022 and continued till 6 April 2022. The Mean yield was found 6.66 t ha^{-1} for BARI Rosun-1 and the mean yield was found 6.68 t ha^{-1} for BARI Rosun-3.

Table 1. Production program of garlic conducted at different locations during 2021-22

Location	Variety	Farmers no.	Area (ha)	Yield (t ha^{-1})
Bogura	BARI Rosun-1	18	0.75	6.66
	BARI Rosun-3	11	0.25	6.68
Total		29	1	
Average				6.67

PRODUCTION PROGRAM OF BARI MORICH-2 IN FARIDPUR

A production program of BARI Morich-2 (*Capsicum annuum* L.) variety was conducted at the FSRD site, Sholakundhu, Sadar, Faridpur during the *kharif I* 2021-22 to popularize BARI Morich-2 among the farmers. A total of 25 decimal land and one farmer was involved in this program. Different crop management practices were stated in Table 1. Chilli seedlings were transplanted maintaining 50 cmX50 cm spacing on 10 April, 2022. Fertilizers were applied @ $N_{130}P_{60}K_{50}$ $S_{15}Zn_{1.5}$ $B_{1.5}$kg ha^{-1}in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. All of P, S, Zn and B and half of N and K was applied as basal during final land preparation. Remaining N& K was applied in three equal splits at 26, 55, and 72 DAT under moist soil condition and mixed thoroughly with the soil. Four times irrigation were provided at pre-transplanting time, 01, 6 and 29 DAT for proper vegetative and pollination. Insecticide (Tafgor)was sprayedon 45, 80 and 100 DAT and mitycide (Oberon) was sprayed on 44 & 54 DAT. The crop was harvested five times during71-138 (20 June to 26 August, 2021) DAT. The fruit yield was recorded from a total of 6m^2 area having three spots (2 m^2 in each) of the plot and converted into yield ha^{-1}. The yield performance were presented in Table 1.

Findings

The green fruit yield of BARI Morich-2 was 6.16 t ha^{-1}. High temperature and heavy rainfall in July (32.84^{o}C and 463.9 mm) and August (32.78^{o}C and 358.9 mm) that affected to pollination. Chilli plants need full sun to produce a good crop, at least six hours of sun a day for fruit set where as in July and August rainfall days were 18 days & 27 days, respectively.

Farmer's opinion

Farmer's chose the variety and preserved seeds for next year's cultivation.

Table 1. Yield performance and management practices of BARI Morich-2 at the FSRD site, Faridpur during 2021-22

Variety	No. of farmer	Area (dec.)	Date of sowing	Date of harvest	Green fruit yield (t ha^{-1})
BARI Morich-2	1	25	10 April, 2022	20 June to 26 August, 2021 (71-138 DAT)	6.16

PILOT PRODUCTION PROGRAMME OF BARI DEVELOPED TURMERIC VARIETIES AT FARMERS' FIELD IN SOUTH-WESTERN PART OF BANGLADESH

Turmeric is a spice made from the roots of the Curcuma longa plant referred as "Queen of Spices". Turmeric is the most essential and important spices crop which shares about 11 % of total spices production (BBS annual estimate 2019-20). The production programme of turmeric variety was piloted at 17 upazillas of Khulna (Dumuria, Batiaghata, Dacope, Phultala, Dighalia, Koyra, Paikgachha, Terokhada, Rupsha, Khulna metro) and Satkhira (Sadar, Tala, Assasuni, Debhata, Kalaroa, Kaliganj and Shyamnagar) during the *Rabi* 2021-22 under "Establishment of Agriculture Research Station, BARI, Gopalganj and eco-friendly agricultural development project in south-western part through strengthening of research" funded project during the *Rabi* season of 2021-22 to evaluate the yield performance of BARI release turmeric varieties. BARI Holud-4 variety was included in the production programme to maintaing a distance of 60 cm x 25 cm. The land was fertilized with N-P-K-S-Zn and @102-25-130-20-0.4 kg ha^{-1} with 5-ton cowdung. All fertilizer were applied as basal during final land preparation. Seed rate used in the land was 2000 kg ha^{-1}. Land was irrigated once to ensure proper joe condition before sowing. Three weeding was done when at necessary. No remarkable disease and insect pest infestation was observed during the crop growing period. Other intercultural operations were done when it was necessary. Data on yield were recorded and converted into ton ha^{-1}.

Result: Results reveal that BARI Holud-4 variety was ranged from 31.00 to 29.00 t ha^{-1} in with an average value of 30 t ha^{-1} where the maximum yield 31.00 t ha^{-1}found in Satkhira. The lowest yield 29.00 t ha^{-1} was found from the variety BARI Holud-4 in Khulna.

Farmer's opinion: Farmers in two locations showed that turmeric variety BARI Holud-4 are higher yield, market price, test and color.

Table 1. Performance of turmeric variety in different locations during the year 2021-2022

Location	variety	No. of Farmers	Area (ha)	Date of sowing	Date of harvesting	Yield (t ha^{-1})
Khulna	BARI Holud-4	1	0.13	21 May 2021	25 Feb. 2022	31.00
Satkhira	BARI Holud-4	2	0.26	20 May 2021	29 Dec. 2021	29.00
Total		3	0.39			30.00

PRODUCTION PROGRAM OF POTATO

The experiment was conducted in the farmers' field of Cox'sbazar, Rajshai, Bhola, Cumilla, Faridpur, Gaibnadha, Gopalganj, Jashore, Khulna, Satkhira, Bagerhat, Kushtia, Manikganj, Mymensingh, Pabna, Sherpur, Tangail, Kishoreganj, Sherpur, and Tangail district of Bangladesh during winter season of 2021-22. Before planting, the seed tubers were soaked in 3% boric acid to control scab disease and sown on 26 November to 10 December, 2021 maintaining the spacing 60cm × 25cm. Manures and fertilizers were applied at the rate of 10 tha^{-1} cowdung along with 160-110-132-13-05-02 kg NPKSZnBha^{-1} in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Half amount of urea and full dose of other fertilizers were applied during final land preparation. The rest amount of urea was applied at 35 days after planting (DAP). Irrigation was done 20DAP and 45DAP, respectively. Ear thing up and weeding were done as and when necessary. The crop was harvested on 5 February to 17 March, 2022.

Results: The tuber yield and other cultural practices of potato production are presented in Table 1. It was observed that the maximum tuber yield (42.50 t ha $^{-1}$) was found from the variety of BARI Alu-81 in Tangail followed by 42.10 t ha $^{-1}$ from the variety BARI Alu-53 in Kushtia. The lowest tuber yield was found 13.35 t ha^{-1} from BARI Alu-13 in Faridpur. Moreover BARI Alu-46, BARI Alu-53, BARI Alu-56, BARI Alu-63, BARI Alu-73, BARI Alu-81 and BARI Alu-88 performed better all over the Bangladesh.

Disease and Pest infestations: There was no notable insect pest incidence was observed in potato varieties but cutworm infestation was found very negligible in early stage of potato plants at all locations. Among the locations, a very few numbers of virus infected plant were observed. The common scab incidence was observed in all the locations.

Farmers' opinion: Farmers are very interested to cultivate potato varieties as they sold potato from the field directly and earn a handsome amount of money from potato selling. They also demanded potato seed at due time in coming season**.** Farmers are happy in growing BARI Alu-46, BARI Alu-53, BARI Alu-56, BARI Alu-63, BARI Alu-73, BARI Alu-81 and BARI Alu-88 due to its higher yield and an extra income generation. They also opined that it can easily be fitted in Potato-*Boro*-*T.aman* rice cropping pattern without hampering the boro cultivation. They are interested in cultivating for the next year if the seeds are available.

Table 1. Agronomic practices of potato production during 2021-22

Locations	Variety	Farmers involved (no)	Area covered (ha)	Tuber yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Cox'sbazar	BARI Alu-13	5	0.13	26.7	320400	172000	148400
	BARI Alu-46	7	0.13	29.72	356640	172000	184640
	BARI Alu-72	8	0.12	33.59	403080	172000	231080
	BARI Alu-73	9	0.11	30.24	362880	172000	190880
Rajshai	BARI Alu-46	10	0.10	24.23	242300	148125	94175
	BARI Alu-53	6	0.12	23.15	231500	148125	83375
	BARI Alu-87	8	0.13	22.55	225500	148125	77375
Bhola	BARI Alu-49	11	0.13	27.59	331080	153220	177860
	BARI Alu-62	6	1.35	30.67	368040	153220	214820
	BARI Alu-72	7	0.40	28.86	346320	153220	193100
Cumilla	BARI Alu-8	12	0.12	30.17	377125	141000	236125
	BARI Alu-13	5	0.12	25.17	314625	141000	173625
	BARI Alu-35	9	0.12	38.51	481375	141000	340375
	BARI Alu-36	12	0.12	37.56	469500	141000	328500
	BARI Alu-46	14	0.12	38.98	487250	141000	346250
	BARI Alu-73	6	0.25	37.1	463750	141000	322750
Faridpur	BARI Alu-13	8	0.35	13.35	273362	151318	121944
	BARI Alu-40	6	0.15	28.87	454702	187818	266884
	BARI Alu-50	5	0.25	28.9	455175	187818	267357
	BARI Alu-73	9	0.52	28.12	442890	187818	255072
Gaibnadha	BARI Alu-35	20	0.60	30.65	306500	135490	171010
	BARI Alu-41	39	1.30	29.70	297000	135490	161510
	BARI Alu-53	38	1.30	31.85	318500	135490	183010
	BARI Alu-63	20	0.60	31.65	316500	135490	181010
	BARI Alu-73	10	0.30	29.63	296250	135490	160760
	BARI Alu-81	10	0.30	31.36	313600	135490	178110
	BARI Alu-88	10	0.30	33.16	331600	135490	196110
Gopalganj	BARI Alu-62	12	0.20	35.00	525000	179225	345775

Locations	Variety	Farmers involved (no)	Area covered (ha)	Tuber yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
	BARI Alu-73	15	0.50	33.28	499200	179225	319975
Jashore	BARI Alu-7	16	0.53	21.25	255000	230000	25000
	BAR Alu-8	13	0.21	22.35	268200	230000	38200
	BARI Alu-13	12	0.24	19.45	233400	230000	3400
	BARI Alu-35	16	0.23	21.55	258500	230000	28500
	BARI Alu-40	14	0.24	20.85	250200	230000	20200
	BARI Alu-41	12	0.21	23.32	279840	230000	49840
Khulna	BARI Alu-72	11	1.40	25.42	381300	169225	212075
	BARI Alu-73	17	22.93	24.09	361350	169225	192125
	BARI Alu-78	6	0.40	25.36	380400	169225	211175
Satkhira	BARI Alu-72	8	1.00	27.03	405450	151041	254409
	BARI Alu-73	7	0.80	26.2	393000	151041	241959
	BARI Alu-78	3	0.20	29.2	438000	151041	286959
Bagerhat	BARI Alu-72	5	0.40	23.52	352800	178940	173860
	BARI Alu-73	9	0.40	24.12	361800	178940	182860
Kushtia	BARI Alu-7	6	1.40	39.64	475680	140227	335453
	BARI Alu-13	3	0.60	30.64	367680	140227	227453
	BARI Alu-53	10	0.21	42.10	505200	140227	364973
	BARI Alu-56	12	0.21	39.10	469200	140227	328973
Manikganj	BARI Alu-37	12	0.21	32.23	483450	216355	267095
	BARI Alu-49	15	0.23	25.60	384000	216355	167645
	BARI Alu-62	6	0.36	27.67	415050	216355	198695
	BARI Alu-73	8	0.21	22.18	332700	216355	116345
Mymensingh	BARI Alu-62	3	0.27	27.55	550900	131300	419600
	BARI Alu-13	3	0.21	27.55	550900	131300	419600
	BARI Alu-40	2	0.22	27.55	550900	131300	419600
	BARI Alu-41	2	0.06	35.50	710000	131300	578700
Pabna	BARI Alu-13	9	0.21	22.60	339000	185300	153700
	BARI Alu-35	12	0.21	19.50	292500	185300	107200
	BARI Alu-40	15	0.21	28.80	432000	185300	246700
	BARI Alu-50	16	0.32	27.00	540000	185300	354700
	BARI Alu-57	12	0.20	24.10	433800	185300	248500
	BARI Alu-62	12	0.16	21.70	325500	185300	140200
	BARI Alu-73	12	0.13	26.35	395250	185300	209950
Sherpur	BARI Alu-8	15	0.15	28.30	424500	163000	261500
	BARI Alu-13	12	0.12	29.78	446625	163000	283625
	BARI Alu-56	12	0.25	36.00	540000	163000	377000
	BARI Alu-62	12	0.52	26.80	402000	163000	239000
	BARI Alu-41	9	0.64	25.41	355740	165800	189940
Tangail	BARI Alu-50	3	0.35	39.00	409500	150608	258892
	BARI Alu-53	1	0.07	33.30	349650	150608	199042
	BARI Alu-62	6	0.75	36.10	361000	150608	210392
	BARI Alu-63	4	0.61	31.83	334215	150608	183607
	BARI Alu-13	3	0.20	27.65	241738	163103	78635
	BARI Alu-37	2	0.18	31.00	310000	175597	134403
	BARI Alu-49	1	0.09	35.00	350000	175597	174403
	BARI Alu-53	5	0.39	31.86	326925	163103	163823
	BARI Alu-57	2	0.31	39.32	393200	175597	217603
	BARI Alu-62	4	0.40	35.86	358600	163103	195498
	BARI Alu-63	2	0.15	32.24	322400	175597	146803
	BARI Alu-81	1	0.25	42.50	425000	175597	249403

Locations	Variety	Farmers involved (no)	Area covered (ha)	Tuber yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Kishoreganj	BARI Alu-46	6	0.25	38.20	534800	165800	369000
	BARI Alu-47	6	.025	39.40	640250	168700	471550
	BARI Alu-53	6	.025	34.18	444340	164800	279540
Sherpur	BARI Alu-7	8	0.25	34.00	510000	170110	339890
	BARI Alu-28	8	0.70	28.08	421200	170110	251090
	BARI Alu-35	8	0.20	35.12	526800	170110	356690
	BARI Alu-36	8	0.40	39.40	591000	170110	420890
	BARI Alu-46	8	0.40	32.78	491700	170110	321590
	BARI Alu-47	8	0.70	41.40	621000	170110	450890
	BARI Alu-50	8	0.30	38.70	580500	170110	410390
	BARI Alu-53	8	0.30	29.67	445050	170110	274940
Tangail	BARI Alu-7	7	1.42	26.36	263600	191932	71668
	BARI Alu-8	7	1.42	27.66	331920	185727	146193
	BARI Alu-28	7	1.42	28.33	339960	191932	148028
	BARI Alu-29	7	1.42	30.00	360000	191932	168068
	BARI Alu-41	8	1.42	32.79	393480	188830	204651
	BARI Alu-46	7	1.42	32.52	341460	191932	149528
	BARI Alu-48	7	1.42	40.00	420000	191932	228068
	BARI Alu-53	7	1.42	27.43	329160	191932	137228
	BARI Alu-63	7	1.42	27.83	333960	191932	142028
	BARI Alu-78	7	1.42	38.00	399000	191932	207068

Market price: Tangail: Tk. 10.50/- 16/- kg (BARI Alu-81, BARI Alu-46, BARI Alu-48, BARI Alu-78) Tk. 12.00/- 20/-kg (BARI Alu-88, BARI Alu-53, BARI Alu-56, BARI Alu-41, BARI Alu-53, BARI Alu-63)

Conclusion: The performance of BARI Alu-46, BARI Alu-53, BARI Alu-56, BARI Alu-63, BARI Alu-73, BARI Alu-81 and BARI Alu-88 is promising on the basis of yield in the selected cultivation area. For large scale production and popularization of this tuber crop initiative could be taken.

PRODUCTION PROGRAM OF BARI Begun-12 AT FARMERS FIELD IN DIFFERENT LOCATIONS

The production program was conducted at Barind, Faridpur, Gopalganj, Mymensingh and Sylhet during the *Rabi* season of 2021-2022 to popularize and disseminate BARI Begun-12 among the farmers and also to increase the income through increasing yield. BARI Begun-12 was cultivated among the 12 farmers covering about 1 hectares of land. The 35-40 days old seedlings were transplanted on 15 October to 20 November, 2021 maintaining the recommended spacing line to line 70cm and plant to plant 70cm. The crop was fertilized with 220-90-125-20-3-1 kg NPKSZNB ha$^{-1.}$ One-third MoP and rest fertilizers except urea was applied during final land preparation. Remaining two-third MoP was divided into three splits and was applied at 32 DAT, at flowering (62 DAT) and fruiting stage (89 DAT). Urea was applied in four equal installments at 32 DAT, at flowering (62 DAT), fruiting (89 DAT) and continuous fruiting stage (109 DAT). Intercultural operation, pests and other crop management practices were done properly for normal growth of the crop. The crop was harvested on 2 January to 15 May, 2022. The yield was calculated in ton per hectare considering the whole plot as harvesting area. Cost and return analysis were performed considering the prevailing market price of eggplant at the harvesting period in the local market.

The results with BARI Begun-12 in different locations of Barind, Faridpur, Gopalganj, Mymensingh and Sylhet districts are presented in Table 1. Among five locations BARI Begun-12 performed better in Mymensingh with the yield of 69.4 t ha^{-1} followed by Gopalganj (49.0 t ha-1). Minimum fruit yield of BARI Begun-12 was recorded from Barind area with the yield of 30.7 t ha^{-1}. The highest gross margin was found from Mymensingh (1937300 Tk. ha^{-1}) and lowest gross margin was found from Barind (336750 Tk. ha^{-1}) due to variation in fruit yield.

Pest and disease incidence: Different sucking pests like Whitefly, Aphid were observed and Imidaclorpid was sprayed @ 0.5 m L^{-1} water to control the insect. Mite was observed from one month of age of plant and Cumulus DS a miticide was sprayed @ 3g L^{-1} water at 3 weeks at 3 to 4 times. Brinjal shoot and fruit borer a devastating insect was observed and Tracer @ 2ml L^{-1} once per week wasapplied to control the pest.

Farmer's opinion: Farmers preferred BARI Begun-12 variety due to its shape, size, softness and higher yield than local variety.

Table 1. Yield and economic performance of BARI Begun-12 at different locations under OFRD, BARI, Barind, Faridpur, Gopalganj and Mymensingh in 2021-22

Location	Farmer's practice variety & yield (t ha^{-1})	Trial plot yield (t ha^{-1})			Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
		Min	Max	Av.			
Barind	25.4	29.8	31.6	30.7	460500	123750	336750
Faridpur	23.8	30.6	33.4	32.0	800000	170800	629200
Gopalganj	35.6	46.2	51.8	49.0	735000	195580	539420
Mymensingh	47.3	67.5	71.3	69.4	2082000	149700	1937300
Sylhet	39.4	44.4	51.6	48.0	864000	260000	604000
Average	34.3	43.7	47.9	45.8	988300	179966	809334

Market price (Tk/kg): 15 in Barind and Gopalganj, 25 in Faridpur, 30 in Mymensingh and 18 in Sylhet.

PRODUCTION PROGRAM OF BARI DEVELOPED COUNTRY BEAN VARIETIES

A production program under OFRD, BARI, Faridpur and Khulna was conducted at the farmer's field during rabi- 2021-22 to demonstrate the performance of BARI Sheem-1, BARI SHeem-6, BARI SHeem-7, BARI Sheem-8 and local and to popularize among the farmers. Ten (10) farmers were selected for this program with a total of 60 decimals of land. The treated seeds with provax (Thiram 37.5% + Carboxin 37.5%) were sown on 9 July to 6 September, 2021.The crop was fertilized with 60-40-30-10-2-0 kg ha^{-1} N-P-K-S-Zn-B, respectively with cow dung @ 4 tha^{-1}. Half of cowdung were applied during final land preparation. The remaining half of cowdung, full amount of P and half of N and K were applied during pit preparation. The rest of N and K were applied as top dress at 24, 64, 103 and 138 days after sowing (DAS). The crop was irrigated two times after top dressing. Weeding was done thrice at 21, 54 and 101 DAS. For controlling disease, one-time Carboxin (17.5%) +Thiram (17.5%) group (Provax 200 WP @ Hossain Enterprise C.C. Limited) on 16 DAS and Propiconazole (Tilt 250 EC @Syngenta Bangladesh Limited) on 27 DAP were sprayed. Eight times Emamectin Benzoate (Guilder @Aama Green Care and Proctin 5WDG @ Sea Trade Fertilizer Limited) during 15-140 DAS, one time Thiamethoxam (Actara 25WG @ Syngenta Bangladesh Limited) with Diafenthiuron (Pegasus @ Syngenta Bangladesh Limited) during 98 DAS, two times Cartap (92%) +Acetamiprid (3%) group (Cartaprid 95 SP @ National AgriCare Import & Export Ltd) during 139 and 165 DAS were applied for controlling aphid, jassid, whitefly type sucking insect. The crop was harvested from 25 October 2021 and ended on 31 January 2022. Yield data were collected after harvest and converted to yield ha^{-1} area. Data on yield and economy were recorded and presented in Table 1.

Results: In Faridpur, **t**he highest fruit yield of BARI Sheem-6 was 15.50 t ha^{-1} which was 4%higher than that of local variety (14.88 kg ha^{-1}). BARI Sheem-6 provided maximum gross margin (383950 Tk. ha^{-1}) than other variety and local variety provided minimum (216850 Tk. ha^{-1}). In Khulna, BARI developed BARI Sheem-7 provided satisfactory yield (12.30 t ha^{-1}) and gross margin (219500 Tk. ha^{-1}).

Farmer's opinion: Farmers were happy with BARI Sheem-6 as it exhibited higher yield and gross margin for highest market price than other varieties. BARI Sheem-1 was also preferred as an early variety.

Disease-pest infestation: Yellow mosaic virus infestation was observed in some plants at later stage. Pod borer insect was also recorded but it was successfully controlled.

Conclusion: The BARI released country bean variety BARI Sheem-6 and BARI Sheem-1 performed better compared to other variety/cultivar due to higher yield and gross margin.

Table 1. Yield and cost& return analysis of BARI country bean varieties and Farmer's variety during 2021-22

Location	Variety	Farmers involved	Area (dec)	Fruit yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
Faridpur	BARI Sheem-1	2	10	14.85	415520	154950	260570
	BARI Sheem-6	2	10	15.50	542150	158200	383950
	BARI Sheem-8	2	10	14.90	372750	155300	217450
	Local	6	30	14.88	372000	155150	216850
Khulna	BARI Sheem-7	2	30	12.30	369000	149500	219500

Input Price (Tk kg^{-1}): Urea-16, TSP-22, MoP-15, Gypsum-10, Zinc Sulphate mono hydrate-220, cowdung-2.50 and seed of country bean-1000; **Output price (Tk kg^{-1}):** Price of output (Tk kg^{-1}): BARI Sheem-1: 28, BARI Sheem-6: 35, BARI Sheem-7: 30, BARI Sheem-8: 25 and Local: 20

PRODUCTION PROGRAM OF BARI DEVELOPED BOTTLE GOURD VARIETY

The demonstration program was carried out in the farmer's field of Barura and Chandina upazilla in Cumilla and Sylhet district during the Rabi season of 2021-22. The soil of the experimental plot was clay loam. Seeds/seedlings were sown/planted on the pits maintaining 2m×2m distance. Two farmers were included in this program. Three varieties were used in the demonstration program such as BARI Lau-4, BARI Lau-5 and Moyna. Seeds of were sown on 04-10 November, 2021. Fertilizers were applied at the rate of 72.6, 34.6, 74, 16, 4.4 and 1.7 kg ha^{-1} of N, P, K, S, Zn and B in the form of Urea, Triple Super Phosphate, Murate of Potash, Gypsum, Zinc sulfate and Boric acid, respectively in the field. No urea, 1/3 MP and full amount of all other fertilizers were applied during final land preparation. Urea and rest amount of 2/3 MP were top dressed four times at 25, 38, 54 and Days after transplanting (DAT). Irrigation was applied according to necessity. Subsequent spraying of Autostin, Redomil gold etc. were used to control diseases. Bio-ferty was sprayed twice to promote growth. Sex pheromone was applied to control fruit fly. The crop was harvested from 15 February to 10 April, 2022. Data were collected and analyzed by using Statistix 10 computer program.

Results: Yield, cost and return analysis of Bottle gourd were presented in Table 1. The average yield of BARI Lau-4, BARI Lau-5 and Moyna were 34.96, 30.25 and 23.68 t ha^{-1} respectively from all location due to contribution of number of fruits $plant^{-1}$, wt. of fruits $plant^{-1}$and yield $m^{-2.}$ As a result, the yield of Moyna was lower than BARI Lau-4 and BARI Lau-5. From the economic analysis, it was found that the higher gross return (Tk. 524850.00 ha^{-1}) and gross margin (Tk. 401350.00 ha^{-1}) was found in BARI Lau-4.

In Sylhet, BARI Lau-4 gave average fruit yield 52 t ha^{-1} with gross margin of Tk. 290300 ha^{-1}.

Farmers' opinion: Farmers were interested to cultivate both the varieties (BARI Lau-4 and BARI Lau-5) for their higher yield. Farmer was very happy with the yield and also expressed that it can be cultivated both seasons.

Table 1: Yield, cost and return analysis of Bottle gourd varieties at different locations under Cumilla region during the rabi season of 2021-22

Location	Variety	Farmers involved	Area covered (Deci.)	Fruit yield (t ha-1)	Gross return (Tk ha-1)	TVC (Tk ha-1)	Gross margin (Tk ha-1)
Cumilla	BARI Lau-4	1	5	35.0	524850	123500	401350
	BARI Lau-5	1	10	30.3	453750	123500	330250
	Moyna	1	5	23.7	355200	124000	231200
Sylhet	BARI Lau-4	1	40	52.0	416000	125700	290300

Market price of bottle gourd @ Tk. 15 kg^{-1} in Cumilla and Tk. 8 kg^{-1} in Sylhet

Conclusion: BARI Lau-4 gave higher yield, had higher market demand and more palatable than BARI Lau-5 and Moyna.

PILOT PRODUCTION PROGRAMME OF BARI DEVELOPED PUMPKIN VARIETIES AT FARMERS' FIELD

The production programme was implemented at Koyra, Khulna, Bagerhat and Gaibandha during summer season of 2021-22 to popularize and dissemination BARI Hybrid Mistikumra-1 and BARI Mitikumra-2 among the farmers. Unit plot size was 7.5m × 1.25m and spacing was maintained 1.5m × 1.5m. The crop was fertilized with N-P-K-S-Zn-Bfertilizers in the form of urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively along with 5 t ha^{-1} Cowdung. Total amount of Cowdung, one third of MoP and all fertilizers except N were applied in pit 7 days prior to seed sowing. Rest K were applied twice at 20 days interval and N were applied in four equal instalments at 15, 35, 55 and 75 days after planting. Intercultural operations like watering and weeding were done as and when required. Folicure @ 1 ml L^{-1} water was applied to control the white fly insect. Control measures were taken against red pumpkin beetle at seedling stage and fruit fly at fruiting stage. Sex pheromone trap was set up in the trail plots to control fruit fly infestation. Data on different plant characters and fruit yield were collected and analyzed statistically.

Result: The yield of BARI Hybrid Mistikumra-1 variety at Koyra was 32.18 tha^{-1}. From the demonstration trail it was observed that the gross return (Tk. 579240 ha^{-1}) and gross margin (Tk. 401040ha^{-1}) was calculated from Mistikumra-1. Besides, from Bagerhat satisfactory yield 25.6 t ha^{-1} and gross margin (282600 Tk. ha^{-1}) was obtained from BARI Mitikumra-2.

The average yield over the locations was 33.15 t ha^{-1} in Gaibandha. The gross margin and the gross return of BARI Hybrid Mistikumra-1 were, Tk. 588,000 ha^{-1} and Tk. 663,000 ha^{-1}, respectively. The average production cost was Tk. 75,000 ha^{-1}.

Pest incidence: There was no remarkable disease or insect found during the growing period.

Farmer's opinion: Farmers are very much impressed to cultivate BARI Hybrid Mistikumra-1 and BARI Mitikumra-2 due to higher yield, market price and test as compared to local variety.

Table 1. Performance of Pumpkin variety in different locations during the year 2021-2022

Location		Variety	No. of farmers	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})
Khulna	Bagerhat	BARI Mitikumra-2	1	25.6	460800	178200	282600
	Koyra	BARI Hybrid Mistikumra-1	1	32.2	579240	178200	401040
Gaibandha		BARI Hybrid Mistikumra-1	15	33.2	663,000	75,000	588,000

Market price (Tk/kg): 18.0 in Bagerhat and Khulna while 20.0 in Gaibandha.

PILOT PRODUCTION PROGRAM OF GARDEN PEA VARIETY

The production program was conducted at Khunua, Sherpur Sadar, Sherpur and at Trishal and Muktagacha MLT site under Mymensingh during rabi season of 2021-2022. The variety BARI Motorsuti-3 was used as planting material in the production program. The seeds were sown @ 100 kg ha^{-1} from 18-22 November, 2021. The crop was fertilized with 48-24-30 kg ha^{-1} NPK. One-third of N and all other fertilizers were applied at final land preparation. Remaining N was top dressed at 20 and 35 DAS. Furadan was applied during final land preparation for controlling soil insect's and companion was sprayed to control foot rot. The crop was harvested from 16-30 January, 2022.

Results: The seed yield and yield attributes of BARI Motorsuti-3 are presented in Table 1. From the Table, it was observed that an average green pod yield (7.26 t ha^{-1}) obtained from BARI Motorsuti-3 in Sherpur. The yield performance of Garden pea variety BARI Motorsuti-3 appeared to be promising in the tested location. The gross return was found Tk. 3,02,400 ha^{-1} and gross margin was Tk. 2,01,700 ha^{-1}.

Green pod yield (8.65 t ha^{-1}) was recorded in BARI Motorsuti-3 from Mymensingh. There was no notable insect pest incidence was observed in BARI Motorsuti-3 production field.

Farmer's opinion: Farmers' are interested to cultivate BARI Motorsuti-3 due to market price is high.

Conclusion: BARI Motorsuti-3 variety might be expanded in Sherpur and Mymensingh region, because it can be easily fitted in Motorsuti-Boro-T.Aman cropping pattern without impede Boro cultivation.

Table 1: Yield, cost and return analysis of BARI Motorsuti-3 variety at different locations during the Rabi season of 2021-22

Location	Farmers involved	Area covered (ha.)	Fruit yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
Sherpur	1	1	7.26	302400	100700	201700
Mymensingh	1	0.1	8.65	302750	122500	180250

Price of BARI Motosuti-3 green pod Tk 40.0 kg^{-1} in Sherpur and 35.0 in Mymensingh, Stover; Tk 2.0 kg^{-1}

PRODUCTION PROGRAM ON OKRA VARIETY IN BAGERHAT

A production program was conducted at MLT site Bagerhat during rabi 2021-2022. The experiment was fertilized with cowdung @14 t ha^{-1}, urea-TSP-MoP @ 150-100-150 kg ha^{-1}. All of organic manure and TSP were applied at basal and urea and MoP were applied in three splits @75, 25, 25 kg ha^{-1} on 30 DAS, 50 DAS and 80 days after sowing (DAS) (FRG, 2012). Seeds were sown at Fakirhat, Bagerhat 10.07.2021 and harvested on 31.08.2021 to 05.10.2021. For crop protection against insects 'Pegasus' was sprayed two-three times in different farmer's field. Irrigations were done according to the visual symptoms of the crop needs from the nearby canal. The experimental plots were kept weed free by hand pulling and with spade. So, finally we analyzed data from two sowing dates. Data on growth and yield components were collected and analyzed.

Results: Yield, cost and return analysis of okra were presented in Table 1. BARI developed BARI Dharosh-2 demonstrated satisfactory yield 15.1 t ha^{-1} and gross margin (111500 Tk. ha^{-1}).

Farmers' opinion: Farmers of Fakirhat, Bagerhat and their neighbors showed their interest to cultivate of BARI Dherosh-2 for its better performance in saline soil.

Conclusion: BARI Dherosh-2 was performed better in terms of yield and economic return in Fakirhat, Bagerhat

Table 1: Yield, Cost and return analysis of okra at Fakirhat, Bagerhat during 2021

Variety	Yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
BADI Dharosh-2	15.1	267800	156300	111500

Market price of okra @ 20 Tk.kg-^{1}

PILOT PRODUCTION OF BARI DEVELOPED RED AMARANTH IN FARMERS' FIELD

The production programme of red amaranth was conducted in the farmers field at MLT sites Fakirhat, Bagerhat, Khulna and Satkhira during *Rabi* season 2021-22 to evaluate of BARI released red amaranth variety. BARI Lalshak-1 was cultivated in 0.25 hectares of land in 4 farmers. The land was fertilized with N-P-k-cowdung @ 120-20-75-5000 kg/ha. Half of urea and full amount of other fertilizer were applied as a basal dose. The remaining amount of urea was applied as top dress. The seeds were sown as broadcast @ 1.5 kg ha^{-1}. Other intercultural operation such as weeding, irrigation and top dressing of urea and plant protection measure were taken as and when required. Data on yield were recorded and converted into ton ha^{-1}. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Result: BARI Lalshak-1 provided 15.0 t ha^{-1} yield in Bagerhat. The gross return (Tk. 150000 ha^{-1}) and gross margin (Tk. 74400 ha^{-1}) was calculated from BARI Lalshak-1.

BARI Lalshak-1 produced satisfactory yield at Satkhira 15.0 t ha^{-1} that was followed by Koyra, Khulna 12.3 t ha^{-1}. The highest gross return (Tk.150000ha^{-1}) and gross margin (Tk. 74400 ha^{-1}) was calculated at Satkhira.

Table 1: Yield, cost and return analysis of BARI Lalshak-1 variety during *Rabi* season, 2021-22

Location	No. of farmers	Area (ha)	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Bagerhat	1	0.06	15.0	150000	75600	74400
Khulna	2	0.13	12.3	122700	75600	47100
Satkhira	1	0.06	15.0	150000	75600	74400

Market price of BARI Lalshak-1 @ 10 Tk. kg^{-1}

Farmer's opinion: Farmers are very much impressed to cultivate BARI Lalshak-1 due to its higher yield, market price, test and its attractive red color as compare to local variety.

PILOT PRODUCTION PROGRAM OF BARI DEVELOPED SPINACH VARIETIES AT FARMERS' FIELD IN SOUTH-WESTERN PART OF BANGLADESH

The production programme was executed at farmer's field at Satkhira during *Rabi* season 2020-21. The aim of this project is to popularize and disseminate BARI Palongshak-1 variety among the farmers and also to increase the income through increasing yield. The soil of the location is generally clay to clay loam. BARI Palongshak-1 variety was included in the production programme. Seeds were sown continuously in line maintaining 30 cm row spacing. The land was fertilized with applied N-P-K-S-Zn-B @ 72.58-30.0-60.0-18.0-1.345-0.64 Kg ha^{-1}, respectively. The total amount of Cowdung, whole amount of TSP and half of Urea and MoP were applied during final land preparation. The rest of MoP and half amount of Urea were top dressed in two equal splits at 20 and 30 days after sowing. One weeding and three irrigations were applied during the experimentation period. Other intercultural operations were done when it was necessary. Data on yield were recorded and converted into t ha^{-1}. The gross economic return was calculated on the basis of prevailing market price of the commodities.

Result: The yield of BARI Palongshak-1 variety presented in Table 1. The yield (32.00 t/ha) was documented from BARI Palongshak-1. From the demonstration trail it was observed that the gross return (Tk. 256000 ha^{-1}) and gross margin (Tk. 174025 ha^{-1}).

Table 1: Yield, cost and return analysis of BARI Palongshak-1during the *Rabi* season of 2021-22

Location	No. of Farmers	Area (ha)	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Satkhira	1	0.13	32.0	256000	81975	174025

Market price of spinach @ 8 Tk. kg^{-1}

Farmer's opinion: Farmers of Satkhira region are highly satisfied to see the yield performance of BARI Palongshak-1.

PRODUCTION PROGRAM OF BARI BITTER GOURD AT MANIKGANJ

The production program of BARI bitter gourd variety was conducted at Sreerampur village under Dhamrai upazila of Dhaka district during Kharif-I season of 2022 in the farmer's field. BARI Korola-1 and BARI Korola-2 were cultivated in two farmer's field in 1.0 bigha of land. The seeds of both the varieties were collected from Horticultural Research Centre of BARI, Gazipur. The seeds were sown directly in pit on 29 March, 2022. The spacing was maintained 1.5 m x 1.0 m. The experimental plots were fertilized during final land preparation @ 80-35-75-18-5-1.8 kg ha^{-1} of N-P-K-S-Zn-B along with 5.0 t ha^{-1} of cowdung. Whole amount of cowdung, one-third of urea, K, TPS, Gypsum, Zinc sulfate and Boron were applied on week before transplanting of seedling. The remaining amount of urea were applied two equal splits at 25 and 40 DAP. Weeding, irrigation, split application of fertilizers, plant protection measures and other intercultural operations were done as and when necessary. Fruits were harvests from 15 May to 25 June, 2022. Data on yield were recorded and converted into ton ha^{-1}.

Results: The fruit yield of BARI Korola-1 and BARI Korola-2 and economic benefit obtained by the farmers is shown in Table 1. Both the BARI developed bitter gourd varieties satisfactory yield and economic return. BARI Korola-1 showed 20% higher yield and 23% higher gross margin over BARI Korola-2.

Table 1: Yield of bitter gourd grown at Sreerampur, Dhamrai, Dhaka during Kharif-I season of 2022.

Variety	Farmers involved	Area covered (Bigha)	Fruit yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
BARI Korola-1	1	3.5	22.6	902000	122260	779740
BARI Korola-2	1	3.5	18.9	754000	122260	631740

Price of bitter gourd @ Tk. 40.00 kg^{-1}

Disease and Insect reaction: The crop was infested by pumpkin beetle and Nitro @ 2 ml L^{-1} water was sprayed. Fruit rot was observed in the field and Autostin @ 2g L^{-1} water was sprayed to control the disease. Thiovit powder @ 5g L^{-1} water was sprayed to control powdery mildew disease.

Farmers' opinion: Farmers were interested to cultivate both the varieties (BARI Korola-1 and BARI Korola-2) for their higher yield but BARI Korola-1 was most popular between the varieties because of higher yield and market demand. They opined that they will cultivate these varieties in the next growing season if seed is available.

Conclusion: Considering the yield and return, BARI developed bitter gourd varieties viz. BARI Korola-1 and BARI Korola-2 are profitable and can be cultivated in large scale in the farmers' field at Dhamrai and Manikganj.

PILOT PRODUCTION PROGRAM OF LENTIL AS RELAY CROP WITH T. AMAN RICE

The production program on lentil (var. BARI Masur-8) was conducted through block approach at farmers' field of Joardah village under FSRD site, Gongarampur, Pabna during the rabi season of 2021-22. Total area of the demonstration plot was about 1.8 hectares where eight farmers were involved. The cooperative farmers were selected after a group discussion organized by OFRD, BARI, Pabna. The seeds of BARI Masur-8 were sown on 18-23 November, 2021 which was 12-14 days before T. aman rice harvesting. Seeds were soaked overnight in fresh water for seed priming. The seed rate of lentil was 35 kg ha^{-1}. The fertilizers were applied @ 37-08-20-13 kg N-P-K-S ha^{-1}. Three to four times fungicides (Rovral 50 WP and Autostin) spraying were done starting at the beginning of flowering and continued at 7-10 days interval to control stem phylum disease. The crop was harvested on 21-22 March, 2022. Data on yield and yield contributing characters were collected, compiled and presented in Table 1.

Results: Performance of lentil as relay crop with T. aman is presented in Table-1. The yield range of lentil was noted 1.13-1.66 t ha$^{-1.}$ However, the average seed yield obtained from BARI Masur-8 was 1.40 t ha^{-1}. This year seed yield was relatively lower as compared to the previous year because adverse climatic condition at the initial growth stage.

Regarding the cost and return analysis, satisfactory gross return (Tk. 107616 ha^{-1}) and gross margin (Tk. 63596 ha^{-1}) was obtained from relay lentil.

Table 1. Performance of BARI Masur-8 as relay crop at FSRD site, Gongarampur during the *rabi* season of 2021-22.

No. of Farmer	Area (ha)	Yield range (t ha^{-1})	Average yield (t ha^{-1})	Stover yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
8	1.8	1.13-1.66	1.40	1.22	107616	44020	63596

Seed: 80.00 Tk..kg^{-1} and Stover: 3.00 Tk. kg^{-1}

Farmer's opinion: Farmers opined that the BARI Masur-8 was high yielder which encourages them to grow as as relay crop with T. aman rice because it is more profitable.

Conclusion: The farmers enriched their skill, knowledge and improved production practices through training and block demonstration to increase pulse production per unit area. The cultivation of BARI Masur-8 as relay through block approach created an excellent impact towards the large-scale adoption of lentil in the farmers' field. Due to technological intervention, there is a chance to improve income and status of the farm family.

PRODUCTION PROGRAMME OF GRASS PEA AS RELAY CROP WITH T. AMAN RICE

The production program was conducted in fifteen farmers field at Tangail and Noakhali district during Rabi season of 2021-2022 to increase crop productivity through fallow land utilization. Grass pea variety BARI Khesari-2, BARI Khesari-3 and local were demonstrated as relaying with T. aman rice through block approach. The seeds of grass pea (var. BARI Khesari-2, BARI Khesari-3 and local) were sown on 05-08 November, 2021 which was 10-15 days prior to T.Aman rice harvest at Tangail. Grass pea was used to address Fallow-T. Aman+ Relay khesari cropping pattern instead of Fallow-T. Aman-Fallow cropping pattern. Seeds were soaked overnight for seed priming. The fertilizers were applied @ 46-8-21-10 kg NPKS ha^{-1}. The seed rate was 70 kg ha^{-1}. No weeding but two times fungicides (Score) were sprayed starting at the beginning of flowering and thereafter 7-8 days interval. The crop was harvested on 15-17 March, 2022. Data on yield was collected and compiled accordingly.

Result: The yield of grass pea is presented in the Table 1. In Tangail, average seed yield of BARI Khesari-3 recorded 1.45 t ha^{-1}. BARI Khesari-3 produced 26 % higher yield over the local variety in Tangail. From the cost and return analysis it was revealed that satisfactory gross return (Tk. 65250 ha^{-1}) and gross margin (Tk. 38060 ha^{-1}) was obtained from grass pea as relay crop with T. Aman rice (Table 1).

In Noakhali, average grain yield was recorded 0.72 t ha^{-1} which offered a gross margin of Tk. 23127 ha^{-1}. Farmers of this area can easily earn this return through relaying grasspea in their rice fields which remain fallow for 7 months. Field crop duration was 116 days in.

Table 1. Yield performance of BARI Khesari-3 at MLT site Bhuapur,Tangail during rabi 2021-22

Location	Variety	Farmers involved	Area (ha)	Seed yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Tangail	BARI Khesari-3	9	2.64	1.45	65750	32550	32700
	Local	3	0.95	1.15	51750	28560	23190
Noakhali	BARI Khesari-2	2	1.0	0.72	39407	16280	23127

Seed (Tk. kg^{-1}) = 45.0 in Tangail and 55.0 in Noakhali

Farmer's opinion: Farmers are interested to relaying grass pea with T.Aman, because it is possible to cultivate with zero tillage and seedlings can survive also in lower level of salinity in presence of adequate soil moisture.

Conclusion: From the above discussion it can be concluded that relay grass pea could be cultivated in relay cropping system with T. aman rice.

PRODUCTION PROGARM OF RELAYING COWPEA WITH T. AMAN RICE AT COASTAL AREA OF COX'SBAZAR

The production program was conducted in three farmers' field at Banglabazar and Khurushkul in Cox'sbazar Sadar during Rabi season of 2021-2022 to increase crop productivity through fallow land utilization. BARI Felon-1 was used to address Fallow-T. Aman + Relay Felon cropping pattern instead of Fallow-T. Aman-Fallow cropping pattern. Average unit plot size was 125 decimal. Felon seeds were broadcast on muddy land of standing T.Aman paddy fields @ 60 kg ha^{-1} during 8-30 November, 2021. Fertilizer was applied at the rate of 30-80-40 (N-P-K kg ha^{-1}) during final land preparation. Weeding and other intercultural operation were done as and when necessary. Zero tillage was followed. The crop was harvested on 22 April-07 May, 2022. Yield and economic data were recorded.

Results: Yield and economic analysis of BARI Felon-1 production were presented in Table 1. Average maximum grain yield was recorded 1.5 t ha^{-1} which offered a gross margin of TK. 54830 ha^{-1} at Banglabazar. On the other hand, the lowest average grain yield 1.3 t ha^{-1} and gross margin TK.44830 ha^{-1} was obtained at Khurushkul. Farmers of this area can easily earn this return through relaying felon in their rice fields which remain fallow for 7 months. Field crop duration was 160 days.

Table 1. Average yield and cost-return analysis of Relay BARI Felon-1 in Cox'sbazar districts during rabi season of 2021-2022

Locations	Number of Farmers	Area coverage (ha)	Yield (t ha^{-1})	Gross return (TK. ha^{-1})	Total Variable cost (TK. ha^{-1})	Gross margin (TK. ha^{-1})
Banglabazar	3	1.5	1.5	75000	20170	54830
Khurushkul			1.3	65000	20170	44830

Price of Grasspea per kg = TK. 50

Farmers' Opinion: Farmers are very much interested to relaying felon with T. Aman rice because it is possible to cultivate with zero tillage and seedlings can survive in presence of adequate soil moisture.

Conclusion: From the above discussion it can be concluded that relay felon could be cultivated in coastal area of Cox'sbazar areas.

PRODUCTION PROGRAM OF BLACKGRAM VARIETIES UNDER ZERO TILLAGE IN FARIDPUR

A production program under "strengthening & increases pulse production project (Madaripur)" was conducted at farmer's field of Dicrir Char, Sadar, Faridpur and Moukuri Char, Mizanpur unuion, Sadar, Rajbari at the MLT site, Rajbari during the Kharif II, 2021to demonstrate the performance of BARI Mash-3 as well as BARI Mash-4 and to popularize among the growers in the locality. Four (04) farmers were selected with a total of615 decimals (18 bigha) for BARI Mas-3 of land. One farmer for BARI Mas-4 with a total of 50 dec. of land. The treated seeds with provax (Thiram 37.5% + Carboxin 37.5%) were sown @ 30-35 kg ha^{-1} by broadcast method without ploughing during mid to third week of September, 2021. All fertilizers were applied @ 20-18-20-10-1.8 N-P-K-S-B kg ha^{-1}during land preparation. BARI Mash-3 were harvested during14-30 December, 2021 (84-100 DAS) irrespective of farmers. Insecticide (Tufgor) was sprayed as per requirement controlling hairy caterpillar. Yield data were collected after harvest from an area of 5 m^2 (sample size was 1 m^2) from the whole plot avoiding border side of each plot and converted to yield ha^{-1} area. Data on yield and economics were recorded and presented in Table 1.

Results: Seed yield of BARI Mash-3 was 1395 kg ha^{-1} which was 55 % higher than that of local variety (900 kg ha^{-1}). But yield (1290 kg ha^{-1}) of BARI Mash-4 was lower due to excessive rainfall occurs after broadcasting of seed so plant population was not up to the mark. BCR of BARI Mash-3 (2.62) was also higher than local (1.96). The amount of preserved seed for next year cultivation was 100 kg for BARI Mash-3 and 40 kg for BARI Mash-4.

Table 1. Yield and cost return analysis of BARI Mash-3, BARI Mash-4 and local variety during 2021

Variety	Seed yield (kg ha^{-1})	Gross return (Tk h^{-1})	Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR	Seed preserved (kg)
BARI Mash-3	1395	97650	37377	60273	2.62	100
BARI Mash-4	1290	90300	35160	55140	2.55	40
Local	900	60750	30925	29825	1.96	30

Input Price (Tk kg^{-1}): Seed of BARI Mash: 100.00
Output price (Tk kg^{-1}): Seed: 70.00 BARI Mash and 67.50 local

Farmers' opinion: Farmers showed interest to cultivate BARI Mash-3 because of higher yield (55%) and bold sized seed. Powdery mildew and YMV infection were lower than local. A good amount of BARI Mash-3 & BARI Mas-4 seed has been stored by the farmers for growing next year.

UPSCALING OF ZERO TILLAGE POTATO WITH MULCH IN COASTAL SALINE AREA OF BANGLADESH

An upscaling program of potato production under zero tillage practice was conducted at two upazilas viz. Koyra and Dacope of Khulna district. There were 47 farmers involved in the trial, covering total 554 decimal land. Among the farmers, 37 of them were from Dacope and 10 from Koyra. Different farmers received different potato varieties as per availability of seed potato (Table 1). Seed potatoes (50-60 g) were sown by pressing with hand into the moist soil after T. Aman harvest. Sowing date ranges from 1st to 3rd week of Decemeber 2021. Before sowing, each plot was fertilized with urea, TSP, MoP and Zypsum at varying rates applied by different farmers.

Immediately after sowing the seed potatoes were covered with compost and/or poultry litter and finally covered with rice straw and/or water hyacinth mulch at 8-15 cm thick. There were notable variations in management practices followed by respective farmers. For example, varying plant population per unit area due to different spacings, amount and thickness of mulches, amount and frequency of fertilizer and irrigation application etc. In addition to these, there were inherent variability of the land, e.g. initial soil moisture, residual nutrient and source of irrigation water.

Results: A significant yield variation was observed among the varieties and farmers field. The range of tuber yield was between 15.2 to 18.7 t ha^{-1} and mean tuber yield was 17.0 t ha^{-1}. It was observed that a number of factors influenced variation in tuber yield, for example, initial soil moisture, residual nutrient, irrigation frequency, quality of irrigation water, different spacings, amount and frequency of fertilizer application, mulch thickness and amount etc. We also observed that tuber yield was higher in those farmers who sown when soil moisture was at field capacity and applied higher amount of compost (5-7 t ha^{-1}).

Table 1. Performance of potato under zero tillage condition in two upazilas of Khulna district during 2021-22

Location	No. of farmer	Land area (dec)	Variety	Sowing date	Harvesting date	Yield (t ha^{-1})
Dacope	42	404	BARI Alu-72,73,78	16 to 29 Dec. 2021	10 to 25 March, 2022	18.7
Koyra	10	130	BARI Alu-72,73	12 to 21 Dec. 2021	11 to 26 March, 2022	15.2
Total	52	554				17.0

Conclusion: A significant yield variation was observed among the varieties and farmers field. The range of tuber yield was between 15.2 to 18.7 t ha^{-1} and mean tuber yield was 17.0 t ha^{-1}. Various factors influenced tuber yield including sowing at field capacity moisture and application of compost at higher dose.

UPSCALING OF ZERO TILLAGE GARLIC IN COASTAL SALINE AREA OF BANGLADESH

An upscaling program of garlic production under zero tillage practice was conducted at three upazilas viz. Koyra, Dacope and Batiaghata of Khulna district. There were 57 farmers involved in the trial, which was in total 141 decimal land. Among the farmers, 8 of them were from Koyra, 44 were from Dacope and 5 from Batiaghata. Popular garlic variety, BARI Roshun-1 was planted by pressing with hand into the moist soil after T. Aman harvest. Sowing date ranges from 2nd to 3rd week of Decemeber 2021. Before sowing, each plot was fertilized with urea, TSP, MoP and Zypsum @ 13, 16, 20 and 7 kg. Immediately after sowing the cloves were covered with rice straw mulch at 8-10 cm thick, the weight of which ranges from 5.69 to 6.94 t ha^{-1}. Some farmers also used rice husk along with rice straw. Two to three light irrigations were applied during growing period. However, there were variations initial moisture, residual fertility, in irrigation water quality and timing of application. The crop was harvested from 10 to 25 April 2022. Crop of Batiaghata could not harvested because of rain damage during January 2022. In fact, all fields were affected by heavy rain.

Results: Field duration of garlic ranges from 95 to 124 days based on different maturity and harvest date. Bulb yield of garlic also varied widely from 0.08 t ha^{-1} to 4.08 t ha^{-1} (Table 1). Variation in yield is due to inundation of most of the fields during heavy rainfall in January.

Table 1. Performance of garlic under zero tillage condition in two upazilas of Khulna district during 2021-22

Location	No. of farmer	Area (Dec.)	Variety	Sowing date	Harvesting date	Yield (t ha^{-1})
Dacope	44	134	BARI Roshun-1	16 to 29 Dec. 2021	8 to 26 April, 2022	1.83
Koyra	8	4	BARI Roshun-1	17 to 30 Dec. 2021	6 to 15 April, 2022	1.66
Total	52	138	2			1.74

Conclusion: Bulb yield of garlic yield under zero tillage practice ranged from 0.08 to 4.08 t ha^{-1}. Heavy rainfall at vegetative stage affected the yield.

PILOT PRODUCTION PROGRAMME OF BARI DEVELOPED WATERMELON VARIETIES AT FARMERS' FIELD

The production programme of watermelon was carried out at the farmer's field under Khulna and Cox'sbazar districts during 2021-22 to popularize and disseminate watermelon varieties among the farmers and also to increase the income through increasing yield. BARI Tormuj-1, BARI Tormuj-2 And Pakijja were selected for production programme. Three varieties such as BARI Tormuj-1, BARI Tormuj-2 And Pakijja were evaluated among the 79 farmers covering 16.35 ha of land for this programme in Khulna while two varieties such as BARI Tormuj-1 and BARI Tormuj-2 were evaluated among the 4 farmers covering 0.4 ha of land. Recommended doses and application methods of manure and fertilizers were applied in the experimental field with N-P-K-S-B-Zn @ 110-312-83-18-1.7-3.6 kg/ha, respectively. The healthy single seedlings of 30 days old were transplanted in the pits. Necessary intercultural operations and irrigation were done during the experimental period to ensure normal growth and development of the plants. Control measures were taken against red pumpkin beetle at seedling stage and fruit fly at fruiting stage. Sex pheromone trap was set up in the trail plots to control fruit fly infestration. Data on yield were recorded and converted into ton ha^{-1}.

Result: In Khulna, newly developed BARI watermelon varieties and pakijja performed better almost in all location. Watermelon yield was outstanding in all locations. Pakijja produced the heighest yield (59.66 t/ha) and other two varieties BARI Tormuj-1was (38.42 t/ha) and BARI Tormuj-2was (35.13 t/ha) produced. From (Table 2) the highest gross return (Tk. 704880 ha^{-1}), gross margin (Tk. 539080 ha^{-1}) and BCR (4.25) was calculated from Pakijja.

In Cox'sbazar, the highest yield (20 t ha^{-1}) and gross margin (142700 Tk. ha^{-1}) was found from BARI Watermelon-1. On the other hand, BARI Watermelon-2 performed 17 t ha^{-1}. It is suitable for growing round the year and its flesh was yellow in color.

Table 1. Performance of watermelon varieties in different locations during the year 2021-2022

Location	Variety	No. of Farmers	Area (Dec)	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Khulna	BARI Tormuj-1	2	25	38.42	461040	157300	303740
	BARI Tormuj-2	2	25	35.13	456690	157300	299390
	Pakijja	75	4038	58.74	704880	165800	539080
Cox'sbazar	BARI Tormuj-1	2	50	20.0	300000	157300	142700
	BARI Tormuj-2	2	50	17.0	272000	157300	114700

BARI Tormuj-1, BARI Tormuj-2 and Pakijja price (Tk. kg^{-1}) = 12, 13 and 12, respectively in Khulna and BARI Tormuj-1 and BARI Tormuj-2 (Tk. kg^{-1}) = 15 and 16 respectively in Cox'sbazar.

Farmers' opinion: Farmers opined that they preferred to grow BARI Tormoj-1 for its high yield potentiality, shape, size and taste.

Conclusion: Considering yield potentiality BARI Tormoj-1 and BARI Tormoj-2 could be suitable to cultivate due to their high productivity.

DEMONSTRATION OF BIO-RATIONAL MANAGEMENT PACKAGE FOR THE MAJOR INSECT PESTS OF CAULIFLOWER

An experiment was conducted at the farmer`s field Nawtata and Harong under MLT site in Chandina under Cumilla district during the Rabi season of 2021-22 to motivate the farmers towards Bio-rational management package against chemical control measure, to minimize production cost, produce safe vegetable and to save the environment. The experimental field belongs to AEZ-19. This study was started from 06 November, 2021 in the farmer's field and continued till 24 February, 2022. The plot size was 221decimals and twelve farmers were involved in the study. Cauliflower seedling (Var. Snow White) was transplanted on 06-18November, 2021 in Bio-rational Pest management plot and 25 November 2021 in farmers practice plots. The cauliflower variety Snow white was transplanted with a spacing of 60 cm x 60 cm. Fertilizers were applied at the rate of 69, 30, 60, 22 and 0.51 kg ha^{-1} of N, P, K, S and B in the form of Urea, Triple Super Phosphate, Murate of Potash, Gypsum and Boric acid, respectively. Half of Urea and MoP and all other fertilizers were applied during final land preparation. The rest amount of Urea and MoP were applied in two equal split at 20 and 35 days after transplanting. 2-3 irrigations were applied during the crop cycle. Weeding was done as and when necessary. The Pheromone mass trapping for *S. litura* + *Helico lure* +SNPV @0.2gL^{-1} of water at 10 days' interval were used against Farmers' practice. The pheromone lure hung through the center of the lid inside the trap in such a way that the lure is 2-3 cm above the water level of trap. Trapping should be started from 2-3 weeks after transplanting and continued till last harvest. A distance of 30 m^2should be maintained between the traps. For controlling different types of pest and diseases farmers were sprayed Nitro, Vertimax, knowin, extramil and Ridomil Gold two to three times @ 1ml and 2.5 g L^{-1} of water at 7-10 days' interval, respectively. SNPV was sprayed one time from insect infestation. The insecticide Nitro 505 EC at the rate 2 gL^{-1} of water was sprayed twice for controlling insects other than fruit flies. Numbers of healthy and infested curds were counted and recorded from total lands when curd was harvested. Treatment wise percent curd infestation was calculated. Number of common cutworm moths were counted and recorded from six randomly installed pheromone traps at 07 days' interval.

Results: Curd infestations as well as prevalence of common cutworm were observed in experimental period. Cauliflower planted during November and harvested within February was infested during the early part with leaf-eating caterpillars. The curd infestation was 5.12% in the bio-rational management plots and 10.81 % in the farmers practice plots. Significant difference was observed between bio- rational management practice and farmers practice in case of all treatments. The highest individual curd weight, number of marketable curd, curd yield t ha^{-1} and variable cost of cultivation were lower in bio-rational pest management plots than the farmers practice plots. Maximum % curd infestation, total variable cost was observed in farmers practice than bio -rational management practice. But the marketable curd %, price $card^{-1}$and Gross return were higher (95.39 %, Tk. 10.8 $card^{-1}$and Tk. 524860 ha^{-1}) in bio-rational pest management plots than in the farmers practice plots (70 %, 8.0 Tk. $card^{-1}$and Tk. 494000.00 ha^{-1}). The number of *Spodoptera* moth and *Helico litura* adults caught per weak per trap were 10.86 and 4.50 respectively. (Table 1). Maximum Gross margin was obtained from bio rational management treated plot than the farmers practice.

Table 1. Effect of bio-rational management on curd infestation and yield of cauliflower at Cumilla during rabi season of 2021-22

Treatments	% Curd infestation	Individual curd weight (Kg)	Yield (t ha^{-1})	Total variable cost (Tk ha^{-1})	Gross return (Tk ha^{-1})	*S.litura* adults $trap^{-1}$ $week^{-1}$	*Helicolitura* adults $trap^{-1}$ $week^{-1}$
Bio-rational management	5.12	2.91	76.36	8400	524860	10.86	4.50
Farmers' practice	10.81	1.80	44.46	15930	494000	-	-

Farm gate price piece: Tk. 20 per Cauliflower, Pheromone trap for *H. armigera*= Tk. 100$trap^{-1}$and *Spodopteralitura* = Tk. 130$trap^{-1}$, SNPV = Tk. 34000/kg

Table 2. Cost and return analysis of bio-rational management and farmers management practices at Cumilla during rabi season of 2021-22

Treatments	No of marketable Curd ha^{-1}	Gross return ($Tkha^{-1}$)	Total variable cost ($Tkha^{-1}$)	Gross margin ($Tkha^{-1}$)
Bio-rational management	26243.00	524860.00	148500.00	376360.00
Farmers' practice	24700.00	494000.00	156030.00	337970.00

Conclusion: It is concluded that, bio-rational management is more effective than farmers practice against cauliflower leaf eating caterpillar. Therefore, further studies to be needed to confirm the results.

DEMONSTRATION OF BIO-RATIONAL MANAGEMENT PACKAGE AGAINST POD BORER INSECT OF TOMATO

This study was started from November, 2021 in the farmers' field of Daulatpur, Daudkandi, Cumilla and continued till April, 2022 to demonstrate the efficacy of bio-rational management package against pod borer insect of tomato. Tomato was transplanted on 05-10 November, 2021 in bio-rational pest management plot and 24 November, 2021 in farmers practice plots. The experimental field belongs to AEZ-19. The total land area was 250 decimals. Ten farmers were included in this demonstration trial. The tomato variety Hero was transplanted with a spacing of 60 cm x 50 cm. The trial was continued up to last week of April, 2022.The Pheromone mass trapping for *S. litura* + *Helico lure* +SNPV @0.2gL^{-1} of water at 10 days' interval were used against Farmers' practice. The pheromone lure hung through the center of the lid inside the trap in such a way that the lure is 2-3 cm above the water level of trap. Trapping should be started from 3-4 weeks after transplanting and continued till last harvest. A distance of 30 m^2 should be maintained between the traps. Farmers practiced plots were placed 200m away from the bio-rational management package plots. No pheromone trap was used in farmers' practice. Spraying of SNPV @ 0.2g L^{-1} of water was started just 35 -40 days after transplanting. The field was fertilized at the rate of 10 t ha^{-1} Cow dung, 210 kg ha^{-1} of N in the form of Urea, 50 kg ha^{-1} of P in the form of TSP and 75 kg ha^{-1} of K in the form of MoP. Half of cow dung, entire amount of TSP and half of MoP were applied during final land preparation. The remaining half of the cow dung was applied during pit preparation. The rest of MoP and entire amount of Urea were top dressed in three equal installments at 17, 33 and 50 days after transplanting. Inter cultural operations were done as and when necessary to maintain hygienic condition of the crop. The number and weight of healthy and borer-infested fruits were counted and recorded during each harvest.

Results: The results of the present study are presented in Table 1 & Table 2.From the table 1, it was observed that bio-rational management package against pod borer insect of tomato (T_1) offered lower fruit infestation (2.53%) and higher percentage of healthy fruit (97.47%), fruit yield (63.18 tha^{-1}) were also obtained from bio-rational management package against farmers practice (9.33%, 90.67% &59.75 tha^{-1}respectively). The number of *Spodoptera* moth and *Helicoverpa* *litura* adults caught per weak per trap were 19.14 and 4.55, respectively in bio rational management practice. Maximum Gross margin (Tk.771700.00 ha^{-1}) was obtained from bio rational management plot than the farmers practice plot.

Farmers opinion: Farmers were very much happy to get bio-rational management package to control the insect pests of tomato by low cost , environment friendly, low labor involvement system. They want the products to be easily available in the market.

Table 1. Effect of bio-rational management package against pod borer insect of tomato during rabi season of 2021-22 at Daulatpur, Daudkandiunder Cumilla district

Treatments	No. of insects Spodo lure $^{-1}$ trap^{-1} week^{-1}	No. of insects Helico lure $^{-1}$ trap^{-1} week^{-1}	Healthy fruits (%)	Infested fruits (%)	Wt. of marketable fruits tha^{-1}	Wt. of unmarketable fruits t ha^{-1}
Bio-rational management	19.14	4.55	97.47	2.53	62.3	0.9
Farmers' practice	-	-	90.67	9.33	54.0	5.8

T_1 = Pheromone mass trapping for fruit flies with cue-lure + attract and kill method, T_2= Farmers practice: Application of synthetic chemical insecticide (Vertimec 1.8 EC, Pegasus, Tundra, Tracer, Ripcord 10EC).

Table 2. Cost and return analysis of tomato under different treatments at Cumilla during rabi season of 2021-22

Treatment	Yield (tha^{-1})	Gross Return (Tk ha-^{1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
Bio-rational management	63.2	947700	185000	771700
Farmers' practice	59.8	896250	219213	677037

For calculating income and benefit the following market prices were used: Farm gate price of tomato = Tk. 15, Pheromone trap for *H. armigera*= Tk. 100trap^{-1}and *Spodoptera litura* = Tk. 130trap^{-1}, SNPV = Tk. 34000 kg^{-1}.

Conclusion: Based on the experimental result, it may be concluded that the treatment Bio-rational management practice may be recommended for maximum fruit yield and less infection of pod borer.

PERFORMANCE OF BARI MANGO VARIETIES IN THE HILLY AREAS OF BANDARBAN

The experiment was conducted at the hill slopes of Tankabati union, Bandarban sadar during 2021-2022. Seven released mango varieties of BARI, namely BARI Aam-1, BARI Aam-2, BARI Aam-3, BARI Aam-4 (Hybrid), and BARI Aam-8 and five other popular commercial mango varieties namely Katimon, Gouramoti, Banana, Himsagar and Govindavog were included in this study. The experiment was laid out in randomized complete block design (RCBD) with six replications. The saplings were planted on 11 July, 2021 with a spacing of 6m × 6m. A single tree of each variety constituted the unit of replication. The trees were fertilized as per schedule described by Hossain (1989).

Ripcord 10 EC @ 1 ml along with Dithane M- 45 @ 2 g per litre of water was sprayed with the help of a hand sprayer at new flush emergence to control mango leaf cutting weevil and anthracnose as per recommendation of Hossain (1989). Manure and fertilizers were applied during pit preparation and post monsoon on 25 June and 20 October 2021. Other intercultural operations, such as weeding and mulching were done as and when necessary. Girth of the trunk was measured at a height of 30 cm from ground level and tree volume was calculated following formula by Castle (1983) with some modifications, such as π/6 X height X (2r) 2 where, 2r = (East – West + North – South canopy spread)/2. Data on vegetative growth viz. plant height, trunk girth and canopy of the tree were recorded after planting and on 18 May, 2022 to observe percent increment in one year. Flowering and yield attributes viz. harvesting, fruit weight, number of fruits per tree, TSS content, edible portion, fruit size, stone size and stone weight will be recorded from third year. All the data will be recorded following mango descriptor recommended by IBPGR (2006). Organoleptic evaluation will also be done and for this, a panel of five members will be selected to determine the pulp colour, sweetness, aroma, texture, juiciness, fibrousness, peeling quality, eye appeal, and general quality of fruits of different genotypes based on the criteria of the score card as follows : a) Pulp colour: 1- light yellow, 2- yellow, 3- bright yellow; b) Sweetness/Taste: 1- insipid, 2- sweet, 3- very sweet; c) Aroma: 1- very slight, 2- pleasant, 3- delightful; d) Texture: 1- firm, 2- medium, 3- soft; e) Juiciness: 1- scantly, 2- much, 3- abundant; f) Fibrousness: 1- abundant, 2- much, 3- scanty; g) Peeling quality: 1- hard, 2- medium, 3- easy, and h) Eye appeal: 1- poor, 2- good, 3- very good (Uddin et al., 1998). Data on insect pest and diseases were also recorded at fruit harvest. The collected data were analyzed statistically and the means were separated by LSD.

Results: BARI Aam-4 showed the highest annual plant height increment (78.3%) over other varieties followed by BARI Aam-1 (61.4%) and lowest increment observed in BARI Aam-11 (Table 1). Most girth increment found at BARI Aam-3 (136%), BARI Aam-1 (123%) and BARI Aam-4 (122%) where lowest was found from Katimon Aam (65.9%) in a year (Table 1). BARI Aam-11 develops canopy more in both direction (140% and 156% respectively) than other varieties and canopy spread was minimum in banana mango variety (44.3% and 64.4% respectively). (Table 1). Overall tree volume rises more in BARI Aam-4 throughout the year (777%) followed by BARI Aam-11 (708%) whereas BARI Aam-10 showed the least increment (90.9%) in first year (Table 1).

Pest incidence: Leaf cutting weevil and anthracnose was very common after new leaf emergence. Ripcord 10 EC @ 1 ml along with Dithane M- 45 @ 2 g per litre of water was sprayed after every new shoot emergence.

Table 1. Annual vegetative growth of different mango varieties in Bandarban during 2021-22

Treatment	Plant height (% increment)	Stem girth (% increment)	Canopy (N-S) (% increment)	Canopy (E-W) (% increment)	Tree volume		
					At planting (m^3)	After one year (m^3)	Annual increment (%)
T_1= BARI Aam-1	61.4	123	68.7	68.2	0.16	0.72	350
T_2= BARI Aam-2	53.1	84.3	90.8	77.0	0.12	0.63	425
T_3= BARI Aam-3	42.9	136	80.5	88.5	0.25	1.11	152
T_4= BARI Aam-4	78.3	122	113	128	0.13	1.14	777
T_5= BARI Aam-8	32.9	90.3	75.2	76.2	0.10	0.30	216
T_6= BARI Aam-10	48.2	83.3	91.6	88.2	0.11	0.21	90.9
T_7= BARI Aam-11	32.6	82.8	140	156	0.13	1.05	708
T_8= Katimon Aam	48.1	65.9	85.2	74.6	0.24	1.15	379
T_9=Gouramoti Aam	33.9	88.4	125	113	0.16	0.79	394
T_{10}= Banana Aam	49.7	85.2	44.3	64.4	0.18	0.61	239
T_{11}= Himsagar Aam	45.1	63.8	39.9	49.9	0.44	1.35	207
T_{12}=GobindavogAam	37.6	85.4	85.6	66.0	0.80	3.43	329

Conclusion: Vegetative data will be collected every year to analyze the growth pattern and flowering and yield data will be collected from the following year.

PRODUCTION PROGRAM OF BARI MANGO VARIETIES IN THE HILLY AREAS OF BANDARBAN REGION

Pilot Production Program of BARI Aam-4 and BARI Am-11 was conducted at Tankabati hill slopes of Bandarban during the rabi season, 2021-2022 to evaluate the performance of these two varieties under farmers' field conditions and to popularize them among the farmers. BARI Aam-

4 was demonstrated in two farmer's field consisting of 1.5 ha and 1 ha of land where BARI Aam-11 was cultivated in another farmer's field consisting of 0.6 ha of land.

The saplings were planted on 11 July, 2021 with a spacing of 6m × 6m. Pits of 1m × 1m × 1m size were dug followed by 5 kg cowdung, 500g Tsp, 250g MoP, 300g Gypsum, 50g $ZnSO_4$ and 50g Boric acid recommended by Fruit division, HRC, BARI, Gazipur. The trees were then fertilized as per schedule described by Hossain (1989). Ripcord 10 EC @ 1 ml along with Dithane M- 45 @ 2 g per litre of water was sprayed with the help of a hand sprayer at new flush emergence to control mango leaf cutting weevil and anthracnose as per recommendation of Hossain (1989).

Results: Percent plant height (78.3%) and stem girth (122%) and annual volume increment (777) was found more in BARI Aam-4 than BARI Aam-11 (32.6%, 82.8% and 708% respectively) (Table 1)

Pest incidence: Leaf cutting weevil and anthracnose was very common after new leaf emergence. Ripcord 10 EC @ 1 ml along with Dithane M- 45 @ 2 g per litre of water was sprayed after every new shoot emergence.

Farmer's Opinion: Farmers of Bandarban region are very much interested for cultivating off season mango varieties so that they can earn maximum benefit. They are optimistic that BARI Aam-4 will ensure more income at late season and off-season production of BARI Aam-11 will generate four times more profit. After one year of planting farmers are happy with the tree growth and they are expected to harvest from the following year.

Table 1. Annual vegetative growth of different mango varieties in Bandarban during 2021-22

Treatment	Plant height (% increment)	Stem girth (% increment)	Canopy (N-S) (% increment)	Canopy (E-W) (% increment)	Annual Volume increment (%)
BARI Aam-4	78.3	122	113	128	777
BARI Aam-11	32.6	82.8	140	156	708

C. Seed Production

SEED PRODUCTION PROGRAM OF LENTIL VARIETIES

A total of 4 trials under seed production program of lentil with BARI Mosur-8 following improved practices was conducted at Ovirampur, Ramchandrapur and Pakuria under the MLT site Shibganj, Bogura during 2021-22 cropping season in order to produce quality seeds at farmers level. Seeds of BARI Mosur-8@ 30 kg ha^{-1} were sown on 17 November and continued till 12 December 2021. Single weeding along with thinning was done at 25 DAS. Three times spay with Pegussus, Karate 55 EC@ 2ml/L was made at 7 days interval as preventive measures for controlling insects like leaf feeder, aphids and borers. Rovral 50WP and Iprozim 26 WP were alternately used @ 2g/L and were sprayed for three times at 7 days to control fungal disease like stemphylium blight. The field was sprayed with 2% urea solution for a single time before flowering. Harvesting was done between 25 to 31 March 2022. Seed yield ranged from 1.84 t ha^{-1} to 2.1 t ha^{-1}. Unit plot yield varied from 92 kg to 247kg depending on plot sizes. A total 72 kg seeds out of 562 kg production were preserved for next year cultivation (Table 2).

Table 2: Performance of BARI Mashur-8 for quality seed production in the 2021-22 cropping season.

Sl. No	Name of the farmer	Date of sowing	Date of harvest	Area coverage (Decimal)	Yield (kg ha^{-1})	Seed produced (kg)	Seed preserved (kg)
1	Md. Badsha Mia	17-11-21	25-03-22	13	2.1	111	20
2	Md. Sadakur Rahman	23-11-21	30-03-22	33	1.85	247	25
3	Sree Satta Ranjan sarker	04-12-21	30-03-22	12	1.9	92	12
4	Sree Palash Chandra	12-12-21	31-03-22	15	1.84	112	15

SEED PRODUCTION PROGRAM OF ONION VARIETIES

A total of 2 trials under seed production program of onion with BARI-Piaz-4 and BARI-Piaz-6 following improved practices was conducted at Bogura and Faridpur during 2021-22 cropping season in order to produce quality seeds at farmers' level. Bulb of BARI Piaz-4 and BARI Piaz-6 @ 2500 kg ha^{-1} were sown on 23-25 Novemver 2021. The crop was fertilized with 160-60-60-30-3-1.5 kg of N-P-K-S-Zn & B ha^{-1} in the form of urea, TSP, MoP, gypsum, zinc sulphate mono hydrate and boric acid, respectively. All of P, S, Zn and B, and half of N and K will be applied as basal during final land preparation. Remaining N and K will be applied in two equal splits at 27 DAT and 58 DAP under moist soil condition and mixed thoroughly with the soil. Weeding was done at 10-15, 25-30 and 40-45 DAS three times. Five times spay with Tundra, Pegasus, Confidor @ 2ml/L was made at 7 days intervals as preventive measures for controlling insects like leaf feeders and thrips. Amistertob, Iprozim 26WP, Rovral 50WP 2g/L was sprayed six times at seven days intervals to control fungal diseases like Leafblight and purple blotch. Harvesting was done between 15-20 April 2022. Seed yield ranged from 378 kg ha^{-1} to 385 kg ha^{-1} in Bogura while yield was 128 kg ha^{-1} in Faridpur. Unit plot yield varied from 5.12 kg to 22.96kg, depending on plot size. A total of 4.5 kg seeds out of 50.46 kg production were preserved for next year's cultivation (Table 1).

Table 1: Performance of BARI Piaz-6 for quality seed production in the 2021-22 cropping season.

Location	Variety	Date of sowing	Date of harvest	Area coverage (Decimal)	Yield (kg ha^{-1})	Seed produced (kg)	Seed preserved (kg)
Bogura	BARI-Piaz-6	23-11-21	20-4-21	15	385	22.38	1.5
	BARI-Piaz-4	25-11-22	15-4-21	15	378	22.96	2
Faridpur	BARI-Piaz-4	19-11-22	15-4-21	10	128	5.12	1

SEED PRODUCTION PROGRAM OF GARLIC VARIETIES

A total of 3 trials under seed production program of garlic with BARI Rosun-1 following improved practices were conducted at Durlavpur under the MLT site Shibganj, Bogura, during 2021-22 cropping season in order to produce quality seeds at farmers' level. Clove of BARI Rosun-1@, 400 kg ha^{-1}, was sown on 15-28 November 2021. Weeding was done twice at 15-20 and 30-40 DAS. Three times spay with alternative use of Confidor, Tundra and Pegasus@ 2ml/L were made at seven days intervals as preventive measures for controlling insects like leaf feeders, thrips and other insects. Rovral 50 WP, Iprozim 26WP, Amistertob, Dithane M45 2g/L was sprayed three times at seven days to control fungal diseases like leaf blight. Harvesting started on 7 April and continued till 12 April 2022. Bulb yield for BARI Rosun-1 ranged from 6.8 to 7 t ha^{-1}. Unit plot yield varied from 413 kg to 559kg, depending on plot size. A total of 90 kg seeds out of 1397 kg production were preserved for next year's cultivation (Table 1).

Table 1: Performance of BARI Rosun-1 for quality seed production in the 2021-22 cropping season.

SL. No.	Name of the farmer	Date of sowing	Date of harvest	Area coverage (Decimal)	Yield (t ha^{-1})	Seed produced (kg)	Seed preserved (kg)
1	Sree Mithunchandra sarker	19-11-21	7-4-21	20	6.9	559	50
2	Sree Uddoychandra sarker	22-11-21	10-4-21	15	7	425	40
3	Sree Shantona Ratti	28-11-21	12-4-21	15	6.8	413	40

SEED PRODUCTION PROGRAM OF BLACKGRAM VARIETIES

A total of 3 trials under seed production program of blackgram with BARI Mash-3 following improved practices was conducted at Bisnapur under the MLT site Shibganj, Bogura, during 2021-22 cropping season in order to produce quality seeds at farmer's level. Seeds of BARI Mash-3@ 30 kg ha^{-1} were sown on 4 and 5 September 2021. Single weeding along with thinning was done at 25 DAS. Three times spay with Karate 55 EC@ 2ml/L was made at 7 days interval as preventive measures for controlling insects like leaf feeder, thrips, hairy caterpillar. Hemoxacil 72WP 2g/L was sprayed three times at 7 days to control fungal disease like leaf spot, stem and leaf rot. Theovit 80WP @ 2g/L was applied to prevent powdery mildew. Harvesting started from 21 November and continued till 24 November 2021. Seed yield ranged from 1.48 t ha^{-1} to 1.52 t ha^{-1}. Unit plot yield varied from 154 kg to 280 kg according to plot size. A total 50 kg seeds out of 546 kg production were preserved for next year's cultivation (Table 1).

Table 1: Performance of BARI Mash-3 for quality seed production in the 2021-22 cropping season.

SL. No.	Name of the farmer	Date of sowing	Date of harvest	Area coverage (Decimal)	Yield (kg ha^{-1})	Seed produced (kg)	Seed preserved (kg)
1	Md. Manik Sarkar	04-09-21	21-11-21	35	1.50	213	25
2	Md. Mahadul Sarkar	04-09-21	22-11-21	30	1.48	180	20
3	Most. Najma Begum	05-09-21	24-11-21	25	1.52	154	15

SEED PRODUCTION PROGRAM OF GARDEN PEA VARIETY

The seed production program was conducted at Khunua, Sherpur Sadar, Sherpur during rabi season of 2021-2022. The variety BARI Motorsuti-3 was used as planting material in this program. The seeds were broadcasted @ 100 kg ha^{-1} in 22 November, 2021 at Khunua village. Fertilizers were applied in the field as per BARI recommended dose. Furadan was applied during final land preparation for controlling soil insect's and companion was sprayed to control foot rot. The crop was harvested from 13 February, 2022.

Results: The seed yield and yield attributes of BARI Motorsuti-3 are presented in Table 1. From the Table, it was observed that an average seed yield (1.15 t ha^{-1}) obtained from BARI Motorsuti-3. The gross return was found Tk. 3,47,700 ha^{-1} and gross margin Tk. 2,42,000 ha^{-1}. The yield performance of Garden pea variety BARI Motorsuti-3 appeared to be promising in the tested location.

Table-1. Performance of BARI Motorsuti-3 for quality seed production during 2021-2022

Area (ha)	Sowing date	Harvesting date	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})
0.3	22.11.2021	13.02.2022	1.15	1.2	347700	105700	242000

Price of BARI Motosuti-3 seed is Tk 300.0 kg^{-1}, Stover; Tk 2.0 kg^{-1}

Farmer's opinion: Farmers' are interested to produce BARI Motorsuti-3 seed due to high price and meet their demand.

Conclusion: BARI Motorsuti-3 seed production might be expanded in Sherpur region to fulfill the need of farmers.

RESEARCH FINDINGS OF DIFFERENT PROJECT ACTIVITIES

- Capacity Building for Conducting Adaptive Trials on Seaweed Cultivation in Coastal Areas
- Research-Extension and Popularization of Vegetables and Spices Cultivation on Floating Bed
- Adaptive trial, development of production technology and community-based pilot production program of summer tomato in Bangladesh
- Adaptation and Scaling up Agroforestry for Livelihood Improvement of farmers in Agricultural Ecosystem of Bangladesh
- Mitigating risk and scaling-out profitable cropping system intensification practices in the salt-affected coastal zones of the Ganges delta
- Nutrient management for diversified cropping in Bangladesh (NUMAN)
- Agrometeorological Information System Development Project (AMISDP)-Component-C (BARI Part)

CAPACITY BUILDING FOR CONDUCTING ADAPTIVE TRIALS ON SEAWEED CULTIVATION IN COASTAL AREAS

PERFORMANCE OF BARI SEAWEED-1 AND BARI SEAWEED-2 IN DIFFERENT MONTHS IN NUNIARCHARA, COX'SBAZAR

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Abstract

Seaweeds are crops of winter season. The best time to cultivate seaweed is from October to March of the year, i.e. six months a year. During these six months six cuts can be made which means that we can harvest seaweeds after one month of each seeding. But each harvest do not produce the same yield because of variation in water quality and wave pressure from month to month during the cultivation season. Monthly production of BARI Seaweed-1 and BARI Seaweed-2 was carried out at Nuniarchara sand-flat, Cox'sbazar during Rabi season 2021-2022. The estimated total fresh yield of BARI Seaweed-1 and BARI Seaweed-2 in open sea of Nuniarchara during October 2021 to March 2022 was 46.32±3.42 (≈4.69±0.63 ton dry) ton and 19.27±2.09 (≈3.09±0.34 ton dry) ton per hectare respectively. Highest yield of BARI Seaweed-1 was obtained in January (15.10±0.88 ton ha^{-1}) and the lowest in February (2.92±0.72 ton ha^{-1}). In case of BARI Seaweed-2, the growing period was from December to March where the highest production was obtained in March (6.55±0.91 ton ha^{-1}) and the lowest in January (2.85±0.33 ton ha^{-1}).

Introduction

Seaweeds are marine macro algae having no defined body structure such as roots, shoots, flowers, seeds etc. The important characteristics of seaweeds are its ability to absorb nutrients from water through their body surface, and can grow on any artificial hard substratum once attached. Bangladesh has a coastline of 710 km that constitutes about 25,000 km^2 coastal areas extending over 76 Upazilas (Sub-districts) with a large inhabitant. Those people depend for their livelihood on fishing, fishery exploitation and other associated activities. From Bangladesh, over 250 species of seaweeds or marine macro-algae (used extensively in many countries as food and industries having pharmaceutical values) grow abundantly in restricted areas like the rocky coast of the St. Martin's Island (SMI) and Inani beach, Cox's Bazar and a few on mangrove trees along the coast and Sundarbans are being reported (Islam 1976, Islam and Aziz 1982, 1987, Aziz *et al.* 2001, 2008a, 2008b, 2015, Islam *et al.* 2002, 2004, 2010). However, people of Bangladesh are not aware of the seaweed potential. Seaweed has plenty of essential nutrients, especially trace elements and bioactive substances. Seaweed protein contains very high quality and all the essential and non-essential amino acids. Seaweed has an abundance of vitamins, including beta-carotene, which is the precursor of vitamin A, the vitamins of the B group, including B12, vitamin C, D, E and K. Seaweed, if systematically cultured and explored, could emerge as a vital agricultural product for coastal people, be consumed as dishes and used in the pharmaceutical and cosmetic industries. Like other countries especially China, Japan, Korea and Indonesia; Bangladesh can boost its economic dimension through exploration of seaweed resources. It has evident that people living in coastal areas of Cox's Bazar collected seaweeds from seashore and sold to the ethnic communities of Cox's Bazar, Bandarban, Khagrachari and Rangamati and some were exported to illegally to Myanmar and China. According to seaweed experts, bulk collection from natural habitat may cause extinction of some important seaweed species. Therefore, sustainable cultivation system can be the only way to ensure proper seaweed supply-chain throughout the year for edible and commercial purpose. BARI has developed modern cultivation system of seaweeds and released two very good varieties namely BARI Seaweed-1 and BARI Seaweed-2. So, this experiment was taken to evaluate the yield performance of these two varieties in different months of winter season at Nuniarchara, Cox'sbazar.

Materials and Methods

After cleaning and sorting, seeds of BARI Seaweed-1 were seeded on synthetic ropes having a length of 15 m and a diameter of 1.0 to1.5 cm. and maintaining a distance of 50 cm between consecutive ropes. The approximate weight of each seed was 1.5 to 2.0g on an average. To protect the ropes from being washed away by sea waves, they were tightly bound with deeply placed bamboo poles at the two distal ends of each rope. Plastic floats were used @ 2 floats per rope to keep the ropes moving upwards during high tides so that seeds could get sufficient sunlight for photosynthesis during day time. But during low tide ropes were laid on the sand flat. Thus, the technique is called "semi-floating method of cultivation". BARI Seaweed-2 is a cold loving seaweed which cannot be grown in open sea during summer and monsoon. Through gametogenesis and sporogenesis, seeds of this seaweed were produced in laboratory during summer. This technique is called muti-step seed production. Spores were attached to synthetic ropes and cultured in controlled environment of the laboratory. Seeds turned into juvenile seedlings within two months. When seedlings became a height of 2 to 3 cm, these were separated from ropes and cultured in aquariums and tanks till winter. When the seedlings got a height of about 10 to 15 cm, they were transplanted to the open sea. One-step seeds were made by cutting the plants in to small pieces and attached into ropes (8 m long). Seeded ropes were placed in a ditch made in the sand-flat of Nuniarchara coast. A distance of 50 cm between ropes and 20 cm between seeds was maintained. After one month of seeding crops were harvested. Samples of each rope were weighed separately and after drying we recorded the dry weight. No additional fertilizer was applied. No pesticides and insecticides were also used. As sea-water contains all the essential nutrient elements required for the growth and development of seaweeds, therefore, no additional fertilizers were applied. Moreover, no pesticides, insecticides etc. was used. Timely removal of *Enteromorpha prolifera*, a green seaweed, which is being considered as a weed, was carried out once a week. Crops were harvested after one month of seeding. Sharp scissors was used for harvesting the crops by making a cut just beneath the rope surface. Each plant was cut separately but the total samples of each rope were weighed collectively by using a digital weight measuring machine. Data of environmental factors of Nuniarchara sand-flat (Salinity, Turbidity, DO, Temperature and pH) were also recorded.

Results and Discussion

Yield of BARI Seaweed-1 gradually increased from October 2021 to January 2022 with gradual increase in salinity and decrease of temperatures and turbidity. Next to January yield was deceased in February and no production was obtained in March. The highest yield was obtained in the month of January in which moderate salinity (28.68±1.58‰), moderate temperature (24.21±0.50ºC), average pH (8.09±0.28) and less turbidity (29.86±5.38 NTU) were prevailed. On the other hand, the lowest yield was found in the month of February estimating at 2.92±0.72 ton/ha fresh weight which was equivalent to 0.47±0.13 ton dry yield. There was no production in March. The estimated total fresh yield of BARI Seaweed-1 following semi-floating cultivation technique was 46.32±3.42 ton which was equivalent to 4.69±0.63 ton dry. Temperature ranging from 22 to 28^{0}C was found optimum for BARI Seaweed-1. Although in March, temperature was 26.98^{0}C when there was no production. Salinity was lowest in October (19.48‰) which gradually increased with the increase in yield up to January (28.68‰) and after then yield was decreased, although the water salinity was increased. This indicates that salinity of water ranged from 19 to 28‰ was optimum for BARI Seaweed-1. Rainfall occurred heavily in October and November and as a result, turbidity values for these months ranked the highest positions. With the decrease in turbidity from October to January, the yield gradually increased and maximum production was recorded in January when water turbidity was 29.86 NTU. Throughout the whole growing season, there was no considerable variation in pH value in different months. However, pH was the lowest in March when there was no production of BARI Seaweed-1. Similar pattern was also found in case of dissolved oxygen parameter.

During this season, the highest yield of BARI Seaweed-2 was obtained in the month of March, which was estimated 6.55±0.91 ton/ha fresh (≈1.05±0.15 ton dry) yield. The lowest yield

(2.85±0.33 fresh yield ha^{-1}) was obtained in December. Yield gradually increased from December to March. The estimated total fresh yield of this variety during this period 19.27±2.09 ton fresh yield (≈3.09±0.34 ton dry) per hectare. The optimum temperature for growing this seaweed in open-sea ranged from 22-27^{0}C which prevailed in December to March of the season. Again, this seaweed prefered high ranges of salinity and highest yields were obtained in February and March when salinity was almost 30‰. Salinity of seawater ranging from 26 to 30‰ was optimum for this seaweed. Turbidty readings show that during the growing season, the water was lowest turbid in February and March and in these two months yields were maximum. No considerable influence of two parameters (pH and DO) could be found on the yield of BARI Seaweed-2. During the whole growing season pH readings were almost simlilar. However, the lowest pH was recorded in March (7.66±0.31) when maximum yield was obtained. Similarity in readings of dissolved oxygen during the whole season indicates that dissolved oxygen level ranging from above 9 to beloe 11 was suitable for this seaweed cultivation. Monthly variation in yield and other attributes are presented in table 1.

Table 1. Monthly variation in yield and other attributes of BARI Seaweed-1 and BARI Seaweed-2 during Rabi season in Nuniarchara, Cox'sbazar

Month	BARI Seaweed-1		BARI Seaweed-2		Temp. (ºC)	Salinity (‰)	Turbidity (NTU)	pH	DO
	f. wt. (ton/ha)	d. wt. (ton/ha)	f. wt. (ton/ha)	d. wt. (ton/ha)					
Oct 2021	7.90 ±0.44	1.23 ±0.10	-	-	28.43 ±0.61	19.48 ±1.81	86.87 ±5.53	8.06 ±0.26	10.5 ±1
Nov 2021	9.10 ±0.71	1.45 ±0.12	-	-	27.88 ±0.64	25.07 ±2.52	82.28 ±2.69	8.02 ±0.18	10.7 ±0.98
Dec 2021	11.30 ±0.67	1.79 ±0.11	2.85 ±0.33	0.46 ±0.05	26.58 ±0.37	26.32 ±2.24	53 ±12.86	7.99 ±0.17	9.90 ±0.74
Jan 2022	15.10 ±0.88	2.42 ±0.14	4.48 ±0.42	0.72 ±0.07	24.21 ±0.50	28.68 ±1.58	29.86 ±5.38	8.09 ±0.28	10.7±0.98
Feb 2022	2.92 ±0.72	0.47 ±0.13	5.39 ±0.43	0.86 ±0.07	22.67 ±0.57	30.32 ±1.06	23.96 ±4.34	7.98 ±0.18	10.1 ±0.55
Mar 2022	-	-	6.55 ±0.91	1.05 ±0.15	26.98 ±0.83	30.23 ±2.18	24.98 ±3.03	7.66 ±0.31	10.6 ±0.89
Total	46.32 ±3.42	7.36 ±0.60	19.27 ±2.09	3.09 ±0.34					

n=5, f. wt. = fresh weight, d. wt. = dry weight

Conclusion

BARI Seaweed-1 was grown from the month of October to March. Highest yield was obtained in January (15.10±0.88 t ha^{-1}) and the lowest in February (2.92±0.72 t ha^{-1}). In case of BARI Seaweed-2, the growing period was from December to March where the highest production was obtained in March (6.55±0.91 t ha^{-1}) and the lowest in January (2.85±0.33 t ha^{-1}). The estimated total fresh yield of BARI Seaweed-1 and BARI Seaweed-2 in open sea of Nuniarchara during October 2021 to March 2022 was 46.32±3.42 (≈4.69±0.63 t dry) ton and 19.27±2.09 (≈3.09±0.34 t dry) ton per hectare respectively.

PERFORMANCE OF BARI SEAWEED-1 AND BARI SEAWEED-2 IN DIFFERENT MONTHS IN REJUKHAL, COX'S BAZAR

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Abstract

Monthly production of BARI Seaweed-1 and BARI Seaweed-2 was carried out at Rejukhal, Ukhiya during Rabi season 2021-2022. BARI Seaweed-1 had the highest fresh yield in January (9.67±0.90 ton ha^{-1}) and the lowest in March (4.14±0.70 ton ha^{-1}). The seaweed was cultivated

using semi-floating method. On the other hand, BARI Seaweed-2 could be grown in two months only. In February the fresh yield was 4.56±0.47 ton ha^{-1} and in March was 3.91±0.58 ton ha^{-1}. Due to unfavorable water conditions and snail infestation this seaweed could not be grown in previous months using semi-floating method. But in February and March it could be cultivated following floating raft technique. The estimated total fresh yield of BARI Seaweed-1 and BARI Seaweed-2 in open sea of Rejukhal during this period was 28.99±3.83 (≈7.36±0.60 ton dry) ton and 8.47±1.05 ton (≈1.36±0.16 ton dry) per hectare respectively.

Introduction

Seaweeds are marine macro algae having no defined body structure such as roots, shoots, flowers, seeds etc. The important characteristics of seaweeds are its ability to absorb nutrients from water through their body surface, and can grow on any artificial hard substratum once attached. Bangladesh has a coastline of 710 km that constitutes about 25,000 km^2 coastal areas extending over 76 Upazilas (Sub-districts) with a large inhabitant. Those people depend for their livelihood on fishing, fishery exploitation and other associated activities. From Bangladesh, over 250 species of seaweeds or marine macro-algae (used extensively in many countries as food and industries having pharmaceutical values) grow abundantly in restricted areas like the rocky coast of the St. Martin's Island (SMI) and Inani beach, Cox's Bazar and a few on mangrove trees along the coast and Sundarbans are being reported (Islam 1976, Islam and Aziz 1982, 1987, Aziz *et al.* 2001, 2008a, 2008b, 2015, Islam *et al.* 2002, 2004, 2010). However, people of Bangladesh are not aware of the seaweed potential. Seaweed has plenty of essential nutrients, especially trace elements and bioactive substances. Seaweed protein contains very high quality and all the essential and non-essential amino acids. Seaweed has an abundance of vitamins, including beta-carotene, which is the precursor of vitamin A, the vitamins of the B group, including B12, vitamin C, D, E and K. Seaweed, if systematically cultured and explored, could emerge as a vital agricultural product for coastal people, be consumed as dishes and used in the pharmaceutical and cosmetic industries. Like other countries especially China, Japan, Korea and Indonesia; Bangladesh can boost its economic dimension through exploration of seaweed resources. Searching of potential areas for seaweed cultivation is essential for the expansion of seaweed farming in our country. Rejukhal has high potentiality to grow seaweeds during winter for its favorable climatic condition. Therefore, this study has been conducted to evaluate the yield performance of BARI Seaweed-1 and BARI-Seaweed-2 in Rejukhal, Ukhiya and to evaluate as well the appropriate months to cultivate seaweed.

Materials and Methods

Seeds of BARI Seaweed-1 were collected from Nuniarchara. After cleaning and sorting, seeds were seeded on synthetic ropes having a length of 15 m and a diameter of 1.0 to1.5 cm. and maintaining a distance of 50 cm between consecutive ropes. The approximate weight of each seed was 1.5 to 2.0g on an average. To protect the ropes from being washed away by sea waves, they were tightly bound with deeply placed bamboo poles at the two distal ends of each rope. Plastic floats were used @ 2 floats per rope to keep the ropes moving upwards during high tides so that seeds could get sufficient sunlight for photosynthesis during day time. But during low tide ropes were laid on the sand flat. Thus, the technique is called "semi-floating method of cultivation". Seeds of BARI Seaweed-2 were also collected from Nuniarchara field. In first two months, this seaweed was tried to grow in semi-floating method, but no production was obtained due to snails' infestation and unfavorable water conditions. When snails' infestation became more destructive, floating raft technology was introduced to produce the seaweed where seeded ropes were tied up in raft made of bamboo and then the raft was placed in water with the help of bamboo pole at relatively deep area so that the ropes could not get touched with mud during low tide. After one month of setting the raft, the crops were harvested and data were recorded. No additional fertilizer was applied. No pesticides and insecticides were also used. As sea-water contains all the essential nutrient elements required for the growth and development of seaweeds, therefore, no additional fertilizers were applied. Moreover, no pesticides, insecticides etc. was used. Timely removal of *Enteromorpha prolifera*, a green seaweed, which is being considered as a weed, was carried out once a week.

Results and Discussion

In early winter i.e. in September, October and November, the salinity of the water remained below 15 ppt due the heavy surface runoff from adjacent hills during monsoon. We got the highest yield of BARI Seaweed-1 in February which was followed by the yield of December and the lowest yield was obtained in March. The estimated fresh yield of BARI Seaweed-1 in one hectare in December, January and March were 8.77 ton, 9.67 ton and 4.14 ton respectively. The total production of this seaweed in this season in Rejukhal was estimated as 28.99±3.83 ton fresh yield (≈7.36±0.60 ton dry) per hectare. Temperature ranging from 24-28^{0}C was found suitable for BARI Seaweed-1. The highest yield was obtained in January when temperature was 25.4^{0}C and the lowest was in March at 27.8^{0}C. The optimum range of water salinity was 19 to 26‰. The water of Rejukhal remained less turbid during the late Rabi season and lowest turbidity (12.99 NTU) was found in January when the yield of BARI Seaweed-1 was maximum. Monthly variations in two important water quality parameters- pH and Dissolved oxygen were minimum. Therefore, it can be revealed that the impact of these two parameters had less influencial effect on the yield of seaweeds during the whole season. The optimum pH and DO ranged 7.5-8.0 and 10-11 respectively.

Snails' feeding on seaweeds cultivated in semi-floating system was observed for the first time in this site which was the reason for less yield of BARI Seaweed-2 this season. The infestation was so alarming that BARI Seaweed-2 could not be grown in December and January in semi-floating method. Therefore, a new technology called floating raft was introduced. Following this method, total yield of *Ulva* in two months was estimated as 8.47±1.05 ton fresh yield (≈1.36±0.16 ton dry) per hectare.

Table 2. Monthly variation in yield of BARI Seaweed-1 and BARI Seaweed-2 in different months in

Rejukhal, Cox'sbazar

Month	BARI Seaweed-1		BARI Seaweed-2		Temp. (ºC)	Salinity (‰)	Turbidity (NTU)	pH	DO
	f. wt. (ton/ha)	d. wt. (ton/ha)	f. wt. (ton/ha)	d. wt. (ton/ha)					
Dec 2021	8.77 ±1.12	1.42 ±0.18	-	-	27.3	19.65 ±1.17	17.55 ±2.54	7.57 ±0.15	10.8
Jan 2022	9.67 ±0.90	1.56 ±0.15	-	-	25.4	21.19 ±0.75	12.99 ±2.50	7.85 ±0.17	10.6
Feb 2022	6.41 ±1.11	1.04 ±0.18	4.56 ±0.47	0.73 ±0.07	24.5	23.04 ±0.79	15.36 ±3.31	8.01 ±0.11	10.75
March 2022	4.14 ±0.70	0.67 ±0.12	3.91 ±0.58	0.63 ±0.09	27.8	25.55 ±0.89	15.54 ±3.61	7.88 ±0.16	10
Total	28.99 ±3.83	4.69 ±0.63	8.47 ±1.05	1.36 ±0.16					

n=5

Conclusion

Rejukhal can be a good cultivation area of BARI Seaweed-1 and BARI Seaweed-2 since water quality of this area remains congenial to growing seaweeds during winter. However, snails' infestation causing yield loss of seaweeds this year has become an issue of concern. Introduction of newly developed floating raft technique of cultivation can be a good alternative to semi-floating method to produce seaweeds in this area. The estimated total fresh yield of BARI Seaweed-1 and BARI Seaweed-2 in open sea of Rejukhal during Rabi season 2021-2022 were 28.99±3.83 (≈7.36±0.60 ton dry) ton and 8.47±1.05 ton (≈1.36±0.16 ton dry) per hectare respectively.

PERFORMANCE OF BARI SEAWEED-1 IN OPEN SEA USING DIFFERENT CULTIVATION METHODS

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Abstract

This experiment was conducted in Rabi season 2021-2022 to find out comparative yield performance of BARI Seaweed-1 in open sea using different cultivation practices at two different locations. The estimated highest fresh yields were observed in newly introduced floating raft method which were 27.20 and 35.17 ton per hectare in Nuniarchara and Rejukhal respectively. Performance in floating method stood next to it. In floating method, estimated fresh yield in Nuniarchara was 13.87 ton per hectare and in Rejukhal was 14.59 ton per hectare. The lowest yield increase was observed in semi-floating method which was estimated at 8.77 and 11.09 ton fresh yield respectively in Nuniarchara and Cox's Bazar. The overall yield performance was better in Rejukhal than in Nuniarchara. However, due to snails' infestation in semi-floating ropes at Rejukhal; comparatively yield was lower in this method than in Nuniarchara.

Introduction

Seaweeds are rich in minerals, vitamins, antioxidants, trace elements, bioactive compounds and have been used as food for centuries in China, Korea and Japan. Seaweeds reduce high blood pressure, cholesterol, and prevent strokes. Phycocolloids (agar, carrageenan and alginate) extracted from cell walls have high industrial and pharmaceutical values. The coastal people will have the opportunity to produce compost and biogas using the seaweeds. In the last two decades seaweed cultivation has doubled and about 94% of all products are derived from the cultured seaweeds. The Philippines started seaweed farming since 1980 and now produce nearly 80% of the world's total *Kappophycus alvarezii* production for carrageenan (Khan & Satam, 2003). About one million Philippines depend on seaweed farming and only 1000 m^2 farm serves as a main source of income of an average family (Cuyugan, 2000). India started seaweed farming in 1980s, established 25 chemical industries fulfilling the demand of Agar and Alginate (Reddy et al., 2006). According to the FAO (2014) statistics, seaweed farming has a value of over US$ 7.5 billion. The farming is possible in open-seawater of about 30‰ salinity along the coast of Chittagong Division at Cox's Bazar to Teknaf and in land-based shrimp and salt production ponds (nursery) in Bangladesh. Seeds for seaweed farming may be produced by 'one-step' (directly using cut pieces and tied with the ropes) and 'multi-step' (inducing millions of spore release by a particular seaweed in laboratories of green houses and allowing spores to grow on ropes and nets) methods (Redmond et al., 2014). Bangladesh have economic values, directly as food (sea-vegetables) and industrial food products of every day uses (Aziz 2015). Red seaweeds are specially valued for their phycocolloid content e.g. agar agar, carrageenan etc. From BARI Seaweed-1, 16 g agar has been produced from 100 g dry seaweed in Seaweed Laboratory of On-Farm Research Division, Cox's Bazar. BARI has developed a technology to grow BARI Seaweed-1 in open sea which is called semi-floating technology. Although floating technique brings higher yield, for better management practice semi-floating method is more convenient. However, this season some problems arisen with this technique. In Rejukhal, it has been observed that when ropes in semi-floating system touched the land during low tide, snails got on the ropes and fed on seaweeds voraciously which causes considerable yield loss. Therefore, a new technology namely floating raft, has been introduced. So, this experiment was taken to find out yield performance of BARI Seaweed-1 in newly introduced method in comparison with other existing methods.

Materials and Methods

Three different cultivation techniques for producing BARI Seaweed-1 in open-sea were tested which were floating method, semi-floating method and floating raft method. Naturally grown healthy seaweed seeds were collected from the sand flat of Nuniarchara. After that seeds were sorted to remove other seaweeds and fouling materials and then cleaned thoroughly with clean sea water several times. For floating and semi-floating methods cleaned seeds were seeded on synthetic ropes having a length of 15 m and a diameter of 1.0 to 1.5 cm. Seeded ropes were placed maintaining a distance of 50 cm between two consecutive ropes. The approximate weight of each seed was 1.5 to 2.0g on an average. To protect the ropes from being washed away by sea waves, they were tightly bound with deeply placed bamboo poles at the two distal ends of each rope. In semi-floating system, plastic floats were used @ 2 floats per rope to keep the ropes moving upwards during high tides so that seeds could get sufficient sunlight for photosynthesis during day time. But during low tide ropes were laid on the sand flat. Whereas, in floating system the ropes were placed in comparatively deep region where the ropes remained submerged always and therefore, no plastic floats were used. In floating raft system, raft was made of using thin bamboo which is locally known as “Muli” and plastic containers. Seeded ropes were fitted inside the raft by attaching two distal poles and the raft was placed in areas where there was always standing water with the help of horizontally placed bamboo as described earlier for floating and semi-floating methods. As sea-water contains all the essential nutrient elements required for the growth and development of seaweeds, therefore, no additional fertilizers were applied. Moreover, no pesticides, insecticides etc. was used. Timely removal of *Enteromorpha prolifera*, which is a weed of seaweeds, was carried out once a week. After one month, crops were harvested. Sharp scissors was used for harvesting the crops by making a cut just beneath the rope surface. Each plant was cut separately but the total samples of each rope were weighed collectively by using a digital weight measuring machine.

Results and Discussion

Methods of seaweed cultivation are greatly varied according to various factors such as cultivation facilities (in the open sea or on the land), productivity and availability of species, dimensional characteristics of an aquatic ecosystem (size and depth) irradiance, temperature conditions, nutrient enrichment, water movement and degree of wave. From the literature it has been evident that *Gracilaria sp.* can be cultured in open sea using different cultivation techniques- coral stone method, concrete block method, single rope floating technique (SRFT), bamboo raft method and tube net method. From previous studies we found that single line semi-floating method is comparatively better to grow BARI Seaweed-1 in open sea than other techniques of cultivation like bottom, off-bottom and floating methods considering cultivation facilities, geographic and dimensional characteristics of our cultivation sites at Nuniarchara and Rejukhal. In this reporting period a problem was arisen with cultivating seaweeds in semi-floating single line method at Rejukhal. It has been observed that when ropes in semi-floating system touched the land during low tide, snails got on the ropes and fed on seaweeds voraciously which causes considerable yield loss. In this study, we therefore incorporated a new technology-“Floating Raft method” to avoid snails’ infestation and attempted to find out comparative yield performance of BARI Seaweed-1 in different cultivation techniques. Among three different techniques of cultivation for BARI Seaweed-1, the highest yield was found in floating raft method in both locations. The highest average fresh yield in floating raft method in Nuniarchara and Rejukhal were 27.200 ton per hectare and 35.171 ton per hectare respectively, which were equivalent to 4.387 ton dry yield and 5.672 ton dry yield per hectare area. The second highest yield was obtained in floating system in both the places. In Nuniarchara, we obtained an estimated 13.869 ton fresh yield which was equivalent to 2.237 ton dry yield per hectare. And in Rejukhal the estimated yield of the seaweed in floating system was 14.591 ton fresh and 2.353 dry yield per hectare. We got the lowest yield per hectare of area in semi-floating system among the three systems in both the locations. However, semi-floating in Nuniarchara (11.088 ton fresh yield/ha≈ 1.788 ton dry yield/ha) had comparatively better yield than in Rejukhal (8.773 ton fresh yield/ha≈ 1.417 ton dry yield/ha). This could be the resultant effect of anthropogenic attack, i.e., small snails in huge number attached to the bunch of seaweed during low tide when the ropes were attached to sand-flat and fed on the bunch by cutting beneath the attachment point. Therefore, bunch loss was occurred and yield was comparatively lower than the yield of other parameters. Snail infestation was the lowest in floating and floating raft system due to not attaching the ropes with sand-flat during low tide. Yield performances were relatively better in Rejukhal than in Nuniarchara.

Table 3. Performance of BARI Seaweed-1 using different cultivation techniques in Nuniarchara

Method	Single rope fresh yield (kg)	Single rope dry yield (kg)	Fresh yield (ton/ha)	Dry yield (t/ha)
Floating	10.400±0.457	1.678±0.074	13.869±0.609	2.237±0.098
Semi-floating	8.316±0.506	1.341±0.081	11.088±0.673	1.788±0.108
Floating raft	2.040±0.161	0.330±0.026	27.200±2.148	4.387±0.346

Table 4. Performance of BARI Seaweed-1 using different cultivation techniques in Rejukhal

Method	Single rope fresh yield (kg)	Single rope dry yield (kg)	Fresh yield (t/ha)	Dry yield (t/ha)
Floating	10.944±0.749	1.765±0.121	14.591±0.999	2.353±0.161
Semi-floating	6.580±0.840	1.061±0.135	8.773±1.120	1.417±0.176
Floating raft	4.748±0.448	0.778±0.088	35.171±3.322	5.672±0.536

Conclusion

In Nuniarchara, estimated fresh yield of BARI Seaweed-1 per hectare in floating raft method was 27.2 ton which was higher than the yield in floating method (13.869 ton) and semi-floating method (11.088 ton). In Rejukhal, estimated fresh yield of BARI Seaweed-1 per hectare in floating raft method was 35.171 ton which was higher than the yield in floating method (14.591 ton) and semi-floating method (8.773 ton). Moreover, in other studies it has been observed that *Ulva lactuca* and *Hypnea boergesenii* have been successfully grown using this technique. Therefore, this technology can be a promising one for commercial production of seaweeds.

PRODUCTION PROGRAM OF *HYPNEA BOERGESENII* IN OPEN-SEA USING FLOATING RAFT TECHNIQUE

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Abstract

Hypnea boergesenii is an indigenous red seaweed species which has high commercial value for its carrageenan content. Due to its fragile body structure, it is very difficult to grow in open sea due to high wave pressure. Floating raft technique is newly introduced seaweed cultivation technology and it has been observed that the yield of BARI Seaweed-1 was relatively higher in this method than other existing methods. Therefore, this study was conducted during Rabi season 2021-22 to find out the feasibility of the technique to grow *Hypnea boergesenii* and estimate the yield in open sea. An estimated 17±3 ton fresh (≈2 ton dry) yield of *Hypnea boergesenii* per hectare per month was obtained in one month of production at Rejukhal.

Introduction

Seaweeds are marine macro algae having no defined body structure such as roots, shoots, flowers, seeds etc. They can take nutrients using their whole body parts called thallus. Seaweeds are rich in minerals, vitamins, antioxidants, trace elements, bioactive compounds and thus they are of great importance in food, beverage, cosmetics and pharmaceutical industries. In many countries of the world, e.g. China, Japan, Korea, Indonesia, seaweeds are being used as food for nutrition and at the same time as export materials to earn foreign currencies. Seaweeds are categorized in three broad sections on the basis of color- red, green and brown. Red and brown seaweeds are mostly used for industrial and pharmaceutical purposes. On the other hand, green seaweeds are suitable for direct consumption. According to seaweed experts green seaweeds could be suitable to culture in Bangladesh. The green seaweeds, such as *Ulva lactuca*, *Ulva linza* and *Caulerpa* *racemosa*, rich in protein, amino acids, vitamins and minerals have multiple uses of fodder, fertilizer, and human food, industrial and pharmaceutical raw materials. They contain compounds that help reduce high blood pressure, cholesterol, and prevent strokes. Seaweeds have effective remedial power against rheumatism, diarrhea and checking growth of tumors. It contains enough calcium, protein, phosphorus and good cholesterol that helps erase diseases in human body. More than one million people are exposed to goiter and related diseases in Bangladesh. Most seaweeds contain more iodine than sea water and are a much better alternative than iodized salt or drugs in regulating the production of thyroid hormone. Besides iodine, seaweed is a perfect source of calcium, phosphorus, iron, sodium, potassium, magnesium, sulphur, copper, zinc, cobalt etc. People of Bangladesh are still not aware of the seaweed potential and its uses. Since we have a long coast line, seaweed cultivation could easily be a new item on our country's limited export basket and would contribute greatly in reducing poverty, persistent unemployment problem and rates of malnutrition. *H. boergesenii* is a red seaweed which is highly rich in an important phycocolloid compound such as carrageenan massively used in food and cosmetic industries. It has evident that due to fragile nature of this seaweed, it could not be grown in open sea using semi-floating technique in Nuniarchara. Therefore, this production program was taken to find out the possibility of growing *Hypnea boergesenii* in open sea in Rejukhal using floating raft technique.

Materials and Methods

In this study, raft floating cultivation method was used for producing *Hypnea boergesenii* in open-sea. Naturally grown healthy *H. boergesenii* seeds were collected from the surface of the coral reef or rock at Inani sea beach on 24th January, 2022. After that seeds were sorted to remove other seaweeds, debris and fouling materials and then cleaned thoroughly with clean sea water for the several times. Later, they were rear for one week in seaweed laboratory under controlled environment for acclimatization to adapt in natural condition. Afterward, only healthy seeds were seeded on synthetic ropes having a length of 4.5 m long and a diameter of 1.0 to 1.5 cm. Seeded ropes were placed maintaining a distance of 30 cm between two consecutive ropes. The approximate weight of each seed was 2.0 g on an average. Floating raft system was made of using four bamboos bind terminal end with ropes resulting a square shape structure and plastic containers. Seeded ropes were fitted inside the raft by attaching two distal poles and the raft was placed in areas where there was always standing water with the help of horizontally placed. The distance between seeds were 20 cm. The date of seeding and harvesting were 01.02.22 and 03.03.22 respectively. As sea-water contains all the essential nutrient elements required for the growth and development of seaweeds, therefore, no additional fertilizers were applied. Moreover, no pesticides, insecticides etc. was used. Regularly dirt's, epiphytes and snails that voraciously eaten seaweed were removed by hand. After thirty days, crops were harvested. Sharp scissors was used for harvesting the crops by making a cut just beneath the rope surface and washed them with clean sea water thoroughly. A digital weight measuring machine was used for their measurement.

Results and Discussion

Methods of seaweed cultivation are greatly varied according to various factors such as cultivation facilities (in the open sea or on the land), productivity and availability of species, dimensional characteristics of an aquatic ecosystem (size and depth) irradiance, temperature conditions, nutrient enrichment, water movement and degree of wave. Along with these factors, cultivation system also varies with the physical conditions or appearance of seaweeds. Seaweeds are of different types depending on their body shape and size. Some are broad-leaf like seaweeds such as *Ulva sp* while some have narrow leah shaped body like *Gracilaria sp.*, *Hypnea sp.* etc. Some are very delicate in nature, some are hard and others are of very fragile body structure. However, their body structure is commonly called thallus or thalloid body. *Hypnea boergesenii* is a red seaweed under the phylum Rhodophyta. It is commonly found in rocky areas of sea attaching with rocks, shells etc. This seaweed has very high medicinal and commercial value as it contains a very important hydrocolloi called carrageenan. In this study we attempted to findout suitable cultivation technique of this important seaweed. In previous studies, it has evident that due to fragile nature this seaweed could not be successfully grown in open sea using semi-floating single line method. Moreover, high wave pressure torn of seaweeds from cultivation ropes. Considering the above issues we attempted to cultivate *Hypnea boergesenii* using Floating Raft technique at Rejukhal where there was less wave pressure. In our study, we found that *Hypnea boergesenii* growing in Floating Raft had been less affected by the motion of water current because of the structure of the raft made by bamboo poles. The estimated average fresh yield of *H. boergesenii* was 17 ton per hectare which was equivalent to 2 ton dry yield per hectare area after 30 days of cultivation. On the other hand, average length of seaweed after 30 days of cultivation was 41 cm.

Table 5. Yield performance of *Hypnea boergesenii* in floating raft method in Rejukhal

Rope	Length of each seaweed (cm)	Fresh weight of each rope (g)	Dry weight of each rope (g)	Fresh weight (ton/h)	Dry weight (ton/h)
1	41	1,800	216	13	2
2	44	2,080	250	15	2
3	47	3,000	420	22	3
4	35	2,440	293	18	2
5	39	2,160	259	16	2
Total	206	11,480	1,438	85	11
Average	41	2,296	288	17	2
Sd.	5	455	79	3	1

n=5

Conclusion

Floating Raft cultivation method has been found suitable for producing *Hypnea boergesenii* in open sea in Rejukhal. The estimated average fresh yield of this seaweed was 17 ton in one month cultivation.

CULTIVATION OF BARI SEAWEED-2 IN OFFSHORE SHED USING ARTIFICIAL LIGHT SOURCE AND NUTRIENT MEDIA

M. S. BHUIYAN, O. F. MASHUK, M. M. RAHMAN, R. A. KANTA, M. SHAHIDUZZAMAN, M. M. ANWAR AND M. F. HOSSAIN

Abstract

BARI Seaweed-2 can be grown in laboratory conditions mimicking its natural atmospheric conditions and nutrient supplementation. This seaweed can be multiplied through multi-step seed production technique in controlled environment. During May to October it cannot be grown in open sea due to unfavorable weather conditions. This study was conducted to find out the cultivation technique of BARI Seaweed-2 in offshore tank using artificial light and nutrient media during February-March 2022. About 235% increase in fresh yield was obtained in culturing the seaweed in food grade plastic tank in offshore shed using artificial light source and replacing half the medium after each three days along with single strength VSE supplementation.

Introduction

Seaweed is a colloquial term for the common name of mostly macroscopic and multicellular marine algae, which do not have root systems or flowers, leaves, stems, fruits and seeds and generally grow and live attached to rock or other hard substrata below the high-water mark or remain drifted in the oceans. Seaweeds regarded as a high profile commercial marine biota for its variety of uses, like raw materials of bio-chemicals (agar, agarose, algin, and carrageenan), dyes, food, feed, enzymes and drugs. Bangladesh is in the transitional zone for the flora and fauna of the Indian subcontinent and Southeast Asia, and is part of the Indo-Burma biodiversity hotspot. It has 710-km-long coastline and a 25,000-sq-km coastal area which support a variety of land use practices. The seacoast of Bangladesh is considered as one of the unreached areas of the world in the field of phycology. This coastal area, with both sandy and muddy beaches, estuaries and mangrove swamps, provides substrates and habitats for the cultivation of various kinds of seaweeds, according to experts. The green seaweeds, such as *Ulva lactuca*, *Ulva linza* and *Caulerpa racemosa*, rich in protein, amino acids, vitamins and minerals have multiple uses of fodder, fertilizer, and human food, industrial and pharmaceutical raw materials. They contain compounds that help reduce high blood pressure, cholesterol, and prevent strokes. Seaweeds have effective remedial power against rheumatism, diarrhea and checking growth of tumors. It contains enough calcium, protein, phosphorus and good cholesterol that helps erase diseases in human body. More than one million people are exposed to goiter and related diseases in Bangladesh. Most seaweeds contain more iodine than sea water and are a much better alternative than iodized salt or drugs in regulating the production of thyroid hormone. Besides iodine, seaweed is a perfect source of calcium, phosphorus, iron, sodium, potassium, magnesium, sulphur, copper, zinc, cobalt etc. People of Bangladesh are still not aware of the seaweed potential and its uses. Since we have a long coast line, seaweed cultivation could easily be a new item on our country's limited export basket and would contribute greatly in reducing poverty, persistent unemployment problem and rates of malnutrition. This study was conducted to find out technique of producing BARI Seaweed-2 in-house in offshore to keep the seeds available to grow in open sea during growing season.

Materials and Methods

BARI Seaweed-2 was cultured in food grade plastic tanks in offshore shed. Artificial light was supplied using solar panel and LED tube lights each having 8 watt capacity. Circulation was made in tanks with circulation machines having a capacity of 12 watt each. Sea water was collected from the sea and stored in containers to settle down the silt and other unwanted materials. Water was filtered through two layered filter cloth and poured into tanks. Healthy fresh seaweed was collected from natural bed and "one-step" seeds were produced by cutting seaweeds into pieces. Seeds were attached in ropes and placed in tanks with the help of plastic PVC pipes and cultured for one month. Water was replaced freshly through siphoning and Von Stoch media was supplemented in accordance with different treatments. After one month, seaweeds were harvested to get the final fresh yield.

Results and Discussion

BARI Seaweed-2 is a green seaweed. It is called sea lettuce and it can be grown in sea during Rabi season. In summer and moonson, it can not be grown in sea because during the summer the water temperature remains very hot and in moonson the salinity of water falls down. Therefore, to maintain the seedstock of this seaweed during offseason and supply seeds in winter has become a great challenge. In this study we attemted to grow BARI Seaweed-2 in food grade plastic tank in offshore shed using artificial light and nutrient media. Seawater contains more than sixty important nutrients which are important for the growth and development of seaweeds. It has evident in literature that in case of growing seaweeds in tanks or other containers different supplemented media is used to enrich the nutrient. Von Stoch Enrichment (VSE) has been proved the most effective nutrient supplement. Moreover, the intensity of changing of media has also impact on the growth and development of seaweeds. In our study we observed that in the month of February about 193% increase in fresh yield was obtained in tank where half culture medium was replaced after each three days and VSE was supplemented after each replacement @ single strength (1ml/L of added fresh sea water). The lowest yield increase (57.14%) was found in tank whose medium was replaced after 21 days of seeding. Considering the results of February, a set of new treatments were taken in March where the highest percentage of yield increase was found in tanks in which medium was replaced in half amount after each three days and VSE was supplemented in single strength with the exchanged media. The highest yield increase percentage was 235%. However, 121% and 107% increase in fresh yield was obtained in tanks where the whole medium was replaced with fresh sea water after each three days and no VSE was supplemented.

Table 6. Cultivation of BARI Seaweed-2 in offshore shed using artificial light and nutrient media

Tank no.	Month	Treatments	Media replacement frequency	Initial fresh wt.(g)	Final fresh wt. (g)	% Increase
Tank-1	February 2022	50% medium replaced +VSE(1S) supplemented	3 days	14	41	192.86%
Tank-2		50% medium replaced +VSE(1S) supplemented	7 days	14	30	114.29%
Tank-3		50% medium replaced +VSE(1S) supplemented	14 days	14	24	71.43%
Tank-4		50% medium replaced +VSE(1S) supplemented	21 days	14	22	57.14%
Tank-1	March 2022	50% medium replaced +VSE(1S) supplemented	3 days	14	47	235.71%
Tank-2		Full medium replaced + no VSE supplemented	3 days	14	29	107.14%
Tank-3		50% medium replaced +VSE(1S) supplemented	3 days	14	45	221.43%
Tank-4		Full medium replaced + no VSE supplemented	3 days	14	31	121.42%

Conclusion

BARI Seaweed-2 can only be grown in sea during winter. As it is a foreign seaweed, it is cultured in laboratory in controlled environments during summer and monsoon and seeds are supplied to farmers in winter. If it can be grown in tank in offshore, farmers can maintain seed stock themselves. With the findings of the present experiment it can be concluded that about 235% increase in fresh yield of BARI Seaweed-2 can be obtained if it is cultured in food grade plastic tank in offshore shed using artificial light source and replacing half the medium after each three days along with single strength VSE supplementation.

CULTIVATION OF BARI SEAWEED-2 IN OPEN SEA IN SYNTHETIC AND COIR NET

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Abstract

Seaweeds can be grown in sea using different techniques or methods which depends on different factors such as cultivation facilities (in the open sea or on the land), productivity and availability of species, dimensional characteristics of an aquatic ecosystem (size and depth) irradiance, temperature conditions, nutrient enrichment, water movement and degree of wave action. This study was conducted during January to March 2022 to evaluate the feasibility of growing BARI Seaweed-2 in nets different types of nets.

Introduction

Seaweeds are marine macro algae having no defined body structure such as roots, shoots, flowers, seeds etc. They can take nutrients using their whole body parts called thallus. Seaweeds are rich in minerals, vitamins, antioxidants, trace elements, bioactive compounds and thus they are of great importance in food, beverage, cosmetics and pharmaceutical industries. In many countries of the world, e.g. China, Japan, Korea, Indonesia, seaweeds are being used as food for nutrition and at the same time as export materials to earn foreign currencies. Seaweeds are categorized in three broad sections on the basis of color- red, green and brown. Red and brown seaweeds are mostly used for industrial and pharmaceutical purposes. On the other hand, green seaweeds are suitable for direct consumption. According to seaweed experts green seaweeds could be suitable to culture in Bangladesh. The green seaweeds, such as *Ulva lactuca*, *Ulva linza* and *Caulerpa racemosa*, rich in protein, amino acids, vitamins and minerals have multiple uses of fodder, fertilizer, and human food, industrial and pharmaceutical raw materials. They contain compounds that help reduce high blood pressure, cholesterol, and prevent strokes. Seaweeds have effective remedial power against rheumatism, diarrhea and checking growth of tumors. It contains enough calcium, protein, phosphorus and good cholesterol that helps erase diseases in human body. More than one million people are exposed to goiter and related diseases in Bangladesh. Most seaweeds contain more iodine than sea water and are a much better alternative than iodized salt or drugs in regulating the production of thyroid hormone. Besides iodine, seaweed is a perfect source of calcium, phosphorus, iron, sodium, potassium, magnesium, sulphur, copper, zinc, cobalt etc. People of Bangladesh are still not aware of the seaweed potential and its uses. Since we have a long coast line, seaweed cultivation could easily be a new item on our country's limited export basket and would contribute greatly in reducing poverty, persistent unemployment problem and rates of malnutrition. The aim of the study was to evaluate the yield performance of BARI Seaweed-2 in nets made of different ropes which will enable to develop this seaweed farming.

Materials and Methods

Two different types of nets i.e. synthetic and coir were used for the production of BARI Seaweed-2 in open sea. Generally, this seaweed prefers comparatively lower temperature. January-March were the best season for their best performance. The nets were placed in deep areas where there was always water remained. The nets were bind with the deeply placed bamboo poles to protect from being washed away by the heavy sea waves. In this system, plastic floats were used @ 4 floats per net to keep the net moving upwards during high tides so that seeds could get sufficient sunlight for photosynthesis during day time. Early grown from Seaweed laboratory *Ulva* seeds were cultured on synthetic and coir nets having a length of (2×2) m^2 and a diameter of 1.0 to 1.5 cm. The approximate average weight of 1.0 g seed were seeded having a distance of 6 inch between the seeds. Since, sea-water contains all the essential nutrient elements required for the growth and development of seaweeds, therefore, no additional fertilizers were applied. In addition, no pesticides, insecticides was used. Timely removal of *Enteromorpha prolifera* which is weed of this seaweed was carried out once a week. After 30 days of cultivation, crops were harvested. Sharp scissors was used for harvesting the crops by making a cut just beneath the rope surface. Each plant was cut separately but the total samples of each rope were weighed collectively by using a digital weight measuring machine.

Results and Discussion

Methods of seaweed cultivation are greatly varied according to various factors such as cultivation facilities (in the open sea or on the land), productivity and availability of species, dimensional characteristics of an aquatic ecosystem (size and depth) irradiance, temperature conditions, nutrient enrichment, water movement and degree of wave. In Nuniarchara, *Ulva lactuca* or BARI Seaweed-2 has been grown in ponds or ditches made on sand-flat. There are evidence in literature that this seaweed can effectively be grown in net methods. Therefore, in this study we used two types of nets-synthetic and coir, to cultivate BARI Seaweed-2 in open sea. We found that between synthetic and coir nets the maximum yield was obtained in synthetic net. The highest average fresh yield was recorded on synthetic net about 7.7 ton/h which was equivalent to 0.62 ton dry yield per hectare. On the other hand, the maximum average yield was found in coir net 3.26 ton/h which was equivalent to average dry yield 0.45 ton/h. In case of both synthetic and coir net the highest production was found on each rope in March month that was 298.2 g and 209.7 g respectively. Among January, February and March the highest yield performance was observed in March month due to lower infestation of Enteromorpha. The maximum average length of seaweed was recorded on synthetic net 26.86 cm but the coir net showed 20 cm. Finally, it can be said that synthetic net could be the best option compare to coir net for the BARI Seaweed-2 cultivation.

Table 7. Production of BARI Seaweed-2 in open sea using synthetic and coir net

Types of rope	Month	Total weight of seed (g)	Fresh weight of seaweed (g)	Fresh weight of seaweed (ton/h)	Dry weight of seaweed (g)	Dry weight of seaweed (ton/h)
Synthetic	January	100	1262	3.1	176.6	0.45
	February	105	1904	4.7	266.5	0.67
	March	100	2130	5.3	298.2	0.74
	Total	305	5296	13.1	741.3	1.86
	Average	101.66	1765.33	4.37	247.1	0.62
	Sd.	2.88	450.30	1.14	63.07	0.15
coir	January	100	1089	2.7	152.4	0.38
	February	100	1363	3.4	190.8	0.47
	March	100	1498	3.7	209.7	0.52
	Total	300	3950	9.8	552.9	1.37
	Average	100	1316.66	3.26	184.3	0.45
	Sd.	0	208.39	0.51	29.19	0.07

Conclusion

Yield of BARI Seaweed-2 in synthetic net (4.37 ton ha^{-1}) is higher than in coir net (3.26 ton ha^{-1}). Durability of synthetic net is longer than coir net in sea water.

RESEARCH-EXTENSION AND POPULARIZATION OF VEGETABLES AND SPICES CULTIVATION ON FLOATING BED

INTEGRATED NUTRIENT MANAGEMENT FOR TURNIP ON EX-SITU FLOATING BED WASTE INCORPORATED LAND

SELIM AHMED AND AFM RUHUL QUDDUS

Abstract

A nutrient management trial was conducted at the Aamgram, Sadar, Madaripur during the rabi, 2020-21 and 2021-22 to determine fertilizer dose for turnip on ex-situ floating bed waste incorporated land and to increase the yield and economic return of turnip through minimum use of chemical fertilizers. The experiment was laid out in randomized complete block (RCB) design. Four treatments were considered asT_1 (Recommended Fertilizer Dose; RFD) = $N_{101}P_{60}K_{40}S_{25}Zn_3B_1$ kg ha^{-1} (FRG, 2018), T_2 (RFD+Organic) = T_1 + 8 t ha^{-1} decomposed floating bed waste,T_3 (RFD + Organic) = T_1 + 4 t ha^{-1} decomposed floating bed waste andT_4 (Farmer's practice) = $N_{92}P_{56}K_{40}S_{25}Zn_3B_1$ kg ha^{-1}. Combination of chemical fertilizer and floating decomposed waste in T_2 treatment exhibited relatively higher single card weight. The average highest card yield (17.91 t ha^{-1}) was obtained from T_2 followed by T_3(16.94 t ha^{-1}). The lowest card yield (15.64 t ha^{-1}) was recorded in farmer's practice (T_4). Average the highest gross return (Tk. 197010 ha^{-1}), gross margin (Tk. 114510 ha^{-1})and BCR (2.39) were obtained from also T_2 treatment where combination of recommended fertilizer dose and 8 t ha^{-1}decomposed floating bed waste was incorporated in soil.

Introduction

Floating agriculture (locally *vasoman/dhapchash*) is an age old practice for crop production in the low-lying areas of the south and south-western regions of Bangladesh. Farmers generally grow selected vegetable and spice crops and its seedlings on water hyacinth made floating bed during rainy reason. After harvesting of the monsoon crops, the decomposed floating bed is incorporated with the soil at the same place/land (in-situ) or with the soil in other place/land (ex-situ) for cultivation of succeeding winter crops. The local farmers opine that ex-situ incorporation of the organic waste of decomposed floating bed with the soil (where no floating agriculture is practiced) need less amount of chemical fertilizer for winter crop (like potato, cabbage, turnip, broccoli etc.) production. Determination of optimum fertilizer dose for turnip on ex-situ floating bed incorporated plain land is therefore needed for increasing the yield and economic return of turnip. Thus, minimum use of chemical fertilizers as well as increase the soil fertility through floating agriculture practices in Bangladesh will be possible. The present study was undertaken to determine fertilizer dose for turnip on ex-situ floating bed waste incorporated land and to increase the yield and economic return of turnip through minimum use of chemical fertilizers

Materials and method

The nutrient management trial was conducted at the Aamgram, Sadar, Madaripur during the rabi, 2020-21 and 2021-22 to determine fertilizer dose for turnip on ex-situ floating bed waste incorporated land and to increase the yield and economic return of turnip through minimum use of chemical fertilizers. The experiment was laid out in randomized complete block (RCB) design with two replications. Four treatments were considered asT_1 (Recommended Fertilizer Dose; RFD) = $N_{101}P_{60}K_{40}S_{25}Zn_3B_1$ kg ha^{-1} (FRG, 2018), T_2 (RFD+Organic) = T_1 + 8 t ha^{-1} decomposed floating bed waste,T_3 (RFD + Organic) = T_1 + 4 t ha^{-1} decomposed floating bed waste andT_4 (Farmer's practice) = $N_{92}P_{56}K_{40}S_{25}Zn_3B_1$ kg ha^{-1}. Recommended fertilizer dose for turnip in 10m^2 plot was 220 g urea, 300 g DAP, 80 g MP, 135 g gypsum, 8 g zinc sulphate monohydrate and 6 g boric acid. Hybrid variety was used as planting material in the study. The unit plot size was 4.8m x 3.6m. Twenty five days old seedlings were transplanted in 2-3 December 2020-21 and 19 December, 2021-22 maintaining 60 cm × 45 cm spacing. All kinds of fertilizers were applied as liquid form in three equal splits at 15, 30 and 50 days after transplanting (DAT). The liquid form of plant nutrients was applied around the crop plants. Zinc fertilizer is not allowed to mix with phosphatic fertilizer. Fertilizers were applied after weeding of the plot. The crop was harvested on 4-6 February 2021 during the study period. Data on yield contributing characters and yield were collected during maturity stage. The collected data were analyzed with excel.

Results and Discussion

Card yield and yield attributes of turnip as influenced by different fertilizer packages during 2020-21 and 2021-22 were presented in Table 1 and Table 2. The average highest plant height (44.8cm) was

recorded in T_2 where RFD+ 8 t ha^{-1} decomposed floating bed waste was used followed by T_3 (42.91cm).The average lowest plant height (41.59 cm) was recorded in farmer's practice (T_4). Average card length was ranged between 9.60 cm (T_4) to 10.81cm (T_2). The average highest card circumference (35.55 cm) was obtained from T_2 followed by T_3 (34.58 cm). The average lowest card circumference was 33.01 cm which was found from T_4 treatment. The average maximum weight of single card (604.15 g) was observed in T_2 followed by T_3 (573.08 g). The lowest weight of single card was noted in T_4 (529.40 g). Combination of chemical fertilizer and floating decomposed waste in T_2 treatment exhibited relatively higher single card weight suggested that additional plant nutrients from inorganic and organic sources were needed for optimum card growth and development as compared with other treatments. However, the average highest card yield (17.91 t ha^{-1}) was obtained from T_2 followed by T_3 (16.94 t ha^{-1}). The highest card yield was the cumulative effect of card length, card circumference and single card weight. The average lowest card yield (15.64 t ha^{-1}) was recorded in T_4 (Table 3).

Average the highest gross return (Tk. 197010 ha^{-1}), gross margin (Tk. 114510 ha^{-1}) and BCR (2.39) were obtained from also T_2 treatment where combination of recommended fertilizer dose and 8 t ha^{-1}decomposed floating bed waste was incorporated in soil. The minimum gross margin (Tk. 98515 ha^{-1}) and BCR (2.34) was observed in farmer's practice (Table 5.

Farmers' opinion

Farmers are happy to see the result of higher card yield in combination of recommended fertilizer dose and 8 t ha^{-1}decomposed floating bed waste.

Table 1. Yield and yield contributing characters of turnip as influenced by fertilizer management packages during 2021-22

Treatments	Plant population m^{-2}	Plant height (cm)	Card length (cm)	Card circumference (cm)	Single card weight (g)	Card yield (t ha^{-1})
T_1 (RFD)	3.70	40.94 b	10.30 a	33.22 ab	504.16 c	14.95 bc
T_2 (RFD+8 tha^{-1}Organic)	3.70	44.70 a	10.36 a	34.40 a	544.20 a	16.16 a
T_3 (RFD+ 4 tha^{-1} Organic)	3.70	41.22 b	10.38 a	32.86 bc	520.76 b	15.36 b
T_4 (Farmer's practice)	3.70	40.18 b	9.54 b	31.62 c	497.60 c	14.66 c
CV(%)		2.83	5.09	3.05	1.75	2.28

Table 2. Yield and yield contributing characters of turnip as influenced by fertilizer management packages during 2020-21

Treatments	Plant population m^{-2}	Plant height (cm)	Card length (cm)	Card circumference (cm)	Single card weight (g)	Card yield (t ha^{-1})
T_1 (RFD)	3.70	44.2 a	10.45b	34.6b	582.1c	17.23bc
T_2 (RFD+8 tha^{-1} Organic)	3.70	44.9 a	11.25 a	36.7 a	664.1a	19.66a
T_3 (RFD+4 tha^{-1} Organic)	3.70	44.6 a	10.65 b	36.3a	625.4b	18.52b
T_4 (Farmer's practice)	3.70	43.0 b	9.65c	34.4b	561.2 d	16.62c
CV(%)	ns	2.96	7.05	2.98	5.87	3.32

Table 3. Yield and yield contributing characters of turnip as influenced by fertilizer management packages (average of two years)

Treatments	Plant population m^{-2}	Plant height (cm)	Card length (cm)	Card circumference (cm)	Single card weight (g)	Card yield (t ha^{-1})
T_1 (RFD)	3.70	42.57	10.38	33.91	543.13	16.09
T_2 (RFD+8tha^{-1}Organic)	3.70	44.80	10.81	35.55	604.15	17.91
T_3 (RFD+4tha^{-1}Organic)	3.70	42.91	10.52	34.58	573.08	16.94
T_4 (Farmer's practice)	3.70	41.59	9.60	33.01	529.40	15.64

T_1 (Recommended Fertilizer Dose) = $N_{101}P_{60}K_{40}S_{25}Zn_3B_1$ kg ha^{-1} (FRG, 2018), T_2 (RFD+Organic) = T_1 + 8 t/ha decomposed floating bed waste, T_3 (RFD+Organic) = T_1 + 4 t/ha decomposed floating bed waste and T_4 (Farmer's practice) = $N_{92}P_{56}K_{40}S_{25}Zn_3B_1$ kg ha^{-1}

Table 4. Cost and returns analysis of turnip as influenced by fertilizer management package,2021-22

Treatment	Card yield (t ha^{-1})	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})
T_1 (RFD)	14.95	179400	77750	101650
T_2 (RFD+8tha^{-1}Organic)	16.16	193920	85750	108170
T_3 (RFD+4tha^{-1}Organic)	15.36	184320	81750	102570
T_4 (Farmer's practice)	14.66	175920	76770	99150

Input price (Tk/kg): Urea: 16, TSP: 22, MoP: 15, Gypsum: 10, Zinc sulphate: 220, Boric acid: 220, Decomposed floating bed waste: 1
Output price (Tk kg^{-1}): Turnip: 12

Table 5. Cost and returns analysis of turnip as influenced by fertilizer management package 2020-21

Treatment	Card yield (t ha^{-1})	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})
T_1 (RFD)	17.23	172300	71250	101050
T_2 (RFD+Organic)	19.66	196600	79250	117350
T_3 (RFD+Organic)	18.52	185200	75250	109950
T_4 (Farmer's practice)	16.62	166200	70280	95920

Input price (Tk/kg): Urea: 16, TSP: 22, MoP: 15, Gypsum: 10, Zinc sulphate: 220, Boric acid: 220, Decomposed floating bed waste: 1
Output price (Tk kg^{-1}): Turnip: 10

Table 5. Cost and returns analysis of turnip as influenced by fertilizer management package (av. 2 yrs)

Treatment	Card yield (t ha^{-1})	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR (Over VC)
T_1 (RFD)	16.09	176990	74500	102490	2.38
T_2 (RFD+8tha^{-1}Organic)	17.91	197010	82500	114510	2.39
T_3 (RFD+4tha^{-1}Organic)	16.94	186340	78500	107840	2.37
T_4 (Farmer's practice)	15.64	172040	73525	98515	2.34

Input price (Tk/kg): Urea: 16, TSP: 22, MoP: 15, Gypsum: 10, Zinc sulphate: 220, Boric acid: 220, Decomposed floating bed waste: 1
Output price (Tk kg^{-1}): Turnip: 11

Conclusion

Average two years result reveals that, combination of recommended fertilizer dose ($N_{101}P_{60}K_{40}S_{25}Zn_3B_1$ kg ha^{-1})with 8 tha^{-1}decomposed floating bed waste (T_2 treatment)gave the highestcard yield and monetary return (BCR 2.39).

INTERCROPPING OF NON-CREEPERS WITH CREEPER VEGETABLES ON FLOATING BED CUM TRELLIS (NON-TIDAL MODEL)

SELIM AHMED AND AFM RUHUL QUDDUS

Abstract

An intercropping based activity was conducted at Amgram, Hijalbari and Baikinthapur area under Rajoir upzilla of Madaripur district during the Kharif II season, 2019-20 and 2020-21 to increase the vegetable crop productivity using floating agriculture technology and to popularize among the neighbor farmers for extending floating agriculture system. Tow treatments were considered as T_1 = Bottle gourd + Red amaranth, T_2 = Sweet gourd + Red amaranth.The variety of creeper vegetables were for bottle gourd (BARI Lau-3), sweet gourd (BARI Mistikumra-2) and non-creeper vegetables were like Red amaranth (var.BARI Lalshak-1). Each floating bed considered as one treatment. The three years result reveals that, the highest yield was obtained from bottle gourd (25.27 tha^{-1}) intercropped with red amaranth (6.63 tha^{-1}) and second was sweet gourd (23.95) tha^{-1} with red amaranth (6.89 tha^{-1}). The yield increased 11% and income increased 27% in bottle gourd with red amaranth intercropped combination in against of sweet gourd with red amaranth.

Introduction

In Rajaor upzilla of Madaripur district has many water bodies or canals near road side that are connected to Lower Kumar River. Water bodies remain unusable specially in monsoon period. Some enthusiastic farmers like farmers of Gopalganj grow creeper vegetables on floating bed made of conventional way. But cultivation of creeper vegetables on conventional floating bed is not suitable enough due to lack of wider space on it for proper growth and development of the creeper vegetables. Recently, a technology namely “Floating Bed cum Trellis (non-tidal model)” has been developed for growing creeper vegetables successfully. In this system, seedlings of creeper vegetables are transplanted on floating bed but their growth and development take place on trellis as made between two floating beds. In this system, different non-creeper vegetables could be cultivated as intercrops (Red amaranth, coriander leaves etc) with creeper vegetables on floating bed without hampering the growth and development of the creeper vegetables. Practices of intercropping would increase the crop productivity and economic return of the floating agriculture system under flooded ecosystem. In this respect, the present experiment was undertaken to evaluate the intercropping performances of different non-creepers with creeper vegetables on “Floating Bed cum Trellis (non-tidal model)” under flooded ecosystem in non- tidal areas of Madaripur.

Materials and Methods

The activities were conducted at Amgram, Hijalbari and Baikinthapur area under Rajoir upzilla of Madaripur district during Kharif II season, 2019-21 to increase the vegetable crop productivity using floating agriculture technology and to popularize among the neighbor farmers of floating agriculture system. The work was conducted in floating bed and each floating bed considered as one treatment. Tow treatments were considered as T_1 = Bottle gourd + Red amaranth, T_2 = Sweet gourd + Red amaranth, and non-creeper vegetables were like Red amaranth (var. BARI Lalshak-1). The size of each floating bed was 9.15 m X 1.37m (30ft long x 4.5ft wide) and size of whole trellis (between two floating beds) were 9.15m x 7.47m (30ft long x 24.5 ft wide). The two rows of creeper crop were grown on each floating bed maintaining 1.5 m plant to plant distance. The seedlings per hill was 2 for all. Uniform size, healthy 10-15 days old seedlings of creeper plants were selected for transplanting. The intercropped non-creeper vegetables like Red amaranth was grown in between two rows of creeper vegetables. The agronomic management (date of planting, age of seedling and fertilizer dose) were showed in Table 1. The fertilizer dose (For 10 m^2 floating bed area) were different applying on vegetables.

All the chemical fertilizers were applied on floating bed in liquid form. The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed except Zinc and

B fertilizer. The zinc sulphate and boric acid were applied as foliar spray. Sometimes the crop was irrigated as when necessary. The pheromone trap was used for controlling insect instead of pesticide. Harvesting date was also stated on Table 1. Data on plant population (m^{-2}), fruits plant^{-1}(no), individual fruit weight (kg) and fruit yield (t ha^{-1}) were recorded. The data on yield and yield attributes were analyzed.

Result and Discussions

Performance of creeper vegetables were presented in Table 10. The plant populations at harvest period per plot were 16 for each of creeper vegetables. The fruits plant^{-1}(no) were 7.20 and 5.10 for bottle gourd and sweet gourd, respectively. Yield performance of creeper and non-creeper vegetables were presented in Table 11. The single fruit weight was 1.57 kg and 2.08 kg bottle gourd and sweet gourd, respectively. The highest yield was obtained from bottle gourd (25.27 tha^{-1}) intercropped with red amaranth (6.63 tha^{-1}) and second was sweet gourd (23.95) tha^{-1} with red amaranth 6.89 tha^{-1}. The lowest yield was obtained from yard long bean (11.50 tha^{-1}) and red amaranth (17 tha^{-1}).

Farmers' Opinion

- Yields of bottle gourd with red amaranth was higher
- Higher demand to customers along with higher market price due to pesticide free production
- More profitable
- Less availability of water hyacinth in dry season as a result repair or refill of floating bed may not possible
- Neighboring farmers showed interest to grow vegetables following modern technique of floating bed

Table 1. Agronomic management of creeper and non-creeper vegetables as intercrop grown on floating bed at Amgram under Rajoir upzilla, Madaripur kharif II, 2019

Intercropping	Treatment	Crops and variety	Planting date	Age of seedling	Fertilizer dose (kgha^{-1})	Harvesting date
Creeper crops	T_1	Bottle gourd (BARI Lau-3)	11-15 July 2019	10-13	$N_{24}P_{27}K_{15}S_6Zn_1B_1$	64-102 DAP
	T_2	Sweet gourd (BARI Mistikumra-2)	11-15 July 2019	10-13		67-104 DAP
Non-creeper crops	T_1+T_2	Red amaranth (BARI Lalshak-1)	20 July 2019	--	--	25-46 DAP

Table 2. Growth and yield of creeper vegetables grown on floating bed at Amgram Rajair, Madaripur during Kharif II, 2019

Treatments	Pl. popu. plot^{-1}	Fruits pl^{-1} (no)	single fruits wt (g)	Fruit wt/trelli (67.25 m^2 (kg)	Fruit length (cm)	Fruit dia (cm)
T_1 (Bottle gourd)	16	7.0	1610	180	28.75	30.70
T_2 (Sweet gourd)	16	5.0	2090	140	9.13	54.60

Table 3. Yield of non-creeper vegetables grown on floating bed as intercropped at Amgram, Rajair,Madaripur during Kharif II, 2019

T_1 yield (t ha^{-1})		T_2 yield (t ha^{-1})	
Bottle gourd	Red amaranth	Sweet gourd	Red amaranth
26.85	5.20	22.30	5.40

Table 4. Agronomic management of creeper and non-creeper vegetables as intercrop grown on floating bed at Amgram and Hijalbari under Rajoir upzilla, Madaripur kharif II, 2020

Intercropping	Treatment	Crops and variety	Planting date	Age of seedling	Fertilizer dose (kgha^{-1})	Harvesting date
Creeper crops	T_1	Bottle gourd (BARI Lau-3)	01-20 Sep 2020	10-12	$N_{24}P_{27}K_{15}S_6Zn_1B_1$	63-100 DAP
	T_2	Sweet gourd (BARI Mistikumra-2)	01-20 Sep 2020	10-12		68-103 DAP
Non-creeper crops	T_1+T_2	Red amaranth (BARI Lalshak-1)	20 Aug-10 Sep 2020	--	--	26-47 DAP

Table 5. Growth of creeper vegetables grown on floating bed at Amgram and Hijalbari, Rajoir, Madaripur during Kharif II, 2020

Treatments	Pl. pop plot^{-1}	Fruits pl^{-1} (no)	single fruits wt (g)	Fruit wt/trelli (67.25 m^2 (kg)	Fruit length (cm)	Fruit dia (cm)
T_1 (Bottle gourd)	16	7..25	1645	193	29.15	30.60
T_2 (Sweet gourd)	16	5.75	2140	197	9.25	55.20

Table 6. Yield of creeper and non-creeper vegetables grown on floating bed as intercropped at Amgram and Hijalbari, Rajoir, Madaripur during Kharif II, 2020

T_1 yield (t ha^{-1})		T_2 yield (t ha^{-1})	
Bottle gourd	Red amaranth	Sweet gourd	Red amaranth
23.30	6.50	27.80	7.80

Table 7. Agronomic management of creeper and non-creeper vegetables as intercrop grown on floating bed at Amgram and Baikhunthapur under Rajoir, Madaripur kharif II, 2021

Intercropping	Treatment	Crops and variety	Planting date	Age of seedling	Fertilizer dose (kgha^{-1})	Harvesting date
Creeper crops	T_1	Bottle gourd (BARI Lau-3)	27-29 July 2021	12-15	$N_{24}P_{27}K_{15}S_6Zn_1B_1$	52-95 DAP
	T_2	Sweet gourd (BARI Mistikumra-2)	27-29 July 2021	12-15	$N_{24}P_{27}K_{15}S_6Zn_1B_1$	53-98 DAP
Non-creeper crops	T_1+T_2	Red amaranth (BARI Lalshak-1)	29 July 2021	--	--	24-47 DAP

Table 8. Growth of creeper vegetables grown on floating bed atAmgram and Baikhunthapur Rajoir, Madaripur during Kharif II, 2021

Treatments	Pl. pop plot^{-1}	Fruits pl^{-1} (no)	single fruits wt (g)	Fruit wt/trelli (67 m^2 (kg)	Fruit length (cm)	Fruit dia (cm)
T_1 (Bottle gourd)	16	7.35	1465	172	28.42	29.68
T_2 (Sweet gourd)	16	4.53	2017	146	8.83	54.18

Table 9. Yield of creeper and non-creeper vegetables grown on floating bed as intercropped at Amgram and Baikhunthapur, Rajoir, Madaripur during Kharif II, 2021

T_1 yield (t ha^{-1})		T_2 yield (t ha^{-1})	
Bottle gourd	Red amaranth	Sweet gourd	Red amaranth
25.63	8.15	21.74	7.41

Table 10. Average Growth of creeper vegetables grown on floating bed at Baikhunthapur, Rajoir, Madaripur during Kharif II, 2019-2021 (Av. of 3 years)

Treatments	Pl. pop plot^{-1}	Fruits pl^{-1} (no)	single fruits wt (g)	Fruit wt/trelli (67.25 m^2 (kg)	Fruit length (cm)	Fruit dia (cm)
T_1 (Bottle gourd)	16	7.20	1573	182	28.77	30.33
T_2 (Sweet gourd)	16	5.10	2082	161	9.07	54.66

Table 11. Average Yield of creeper and non-creeper vegetables grown on floating bed as intercropped at Baikhunthapur, Rajoir, Madaripur during Kharif II, 2019-2021 (Av. of 3 years)

T_1 yield (t ha^{-1})		T_2 yield (t ha^{-1})	
Bottle gourd	Red amaranth	Sweet gourd	Red amaranth
25.27	6.63	23.95	6.89

Table 12. Average Cost and return of intercroppingcreeper and non-creeper vegetablesat Amgram and Baikunthpur Rajoir, Madaripur during Kharif II 2019-21 (Av. of 3 years)

Treatments	Fruit yield (plot kg^{-1})	Gross return (Tk plot^{-1})	*TVC (Tk plot^{-1})	Gross margin (Tk plot^{-1})	Income increased (%)	Remarks
T_1 (Bottle gourd + Red amaranth)	182.0 + 15.0	4850.0.	2460	2390	27% in T_1 over T_2	Profitable
T_2 (Sweet gourd + Red amaranth)	161.0+16	4345	2460	1885		

Input price (TVC): Bed: structure cost (Seed: 50, ferlilizer: 50, bamboo (borok): Tk.800, labor: Tk.1200,)Tk. 2100/structure. One structure can use continuing 2 times, so one time preparing cost is Tk. 1050 (i.e.2100/2)
Input price (TVC): Trellis: Net: 340, bamboo (borok): Tk.2400, bamboo (Tolla): Tk.1500) Tk. 4240/. One trellis can use continuing 3 times, so one time preparing cost is Tk.1413 (i.e.4240/3)(N.B: bitter gourd trellis is smaller in size than bottle gourd amd sweet gourd, so the cost is half. Output price (Tk kg^{-1}): Bottle gourd -25, Sweet gourd - 25 and Red amaranth: 20

Conclusion

From the three years study it reveals that floating bed cum trellis (non-tidal model)" is a good way for production of creeper vegetables with non-creeper simultaneously. Bottle gourd with red amaranth (197 kg plot^{-1}) performed better followed by sweet gourd (177 kg plot^{-1}). The yield increased 11% and income increased 27% in bottle gourd with red amaranth intercropped combination in against of sweet gourd with red amaranth.

PERFORMANCE OF DIFFERENT SHORT DURATION NON-CREEPER VEGETABLES INTERCROPPED WITH BOTTLE GOURD ON THE FLOATING BED CUM TRELLIS OF CUMILLA REGION

MM BASHIR AND SK BHOWAL

Abstract

A performance trial of bottle gourd varieties as intercropping system was conducted at the Kolikunda, Nasirnagar, Brahmanbaria during 2021-22 to see the intercropping performances of different non-creepers with creeper vegetables like bottle gourd on "Floating Bed cum Trellis'. The bottle gourd variety BARI Lau-4 was tested in the trial. From the trial in the floating bed, the significantly highest fruit yield was found from Bottle gourd + Coriander intercropping system (63.4 t/ha) and the lowest from Bottle gourd + Chilli (41.1 t/ha). Among the inter crops, highest vegetable yield was found from spinach (23.1 t/ha) and the lowest from Chilli (8.4 t/ha). From cost and return analysis, the highest gross return (Tk. 1929000

ha^{-1}) and gross margin (Tk. 1778550 ha^{-1}) were found from Bottle gourd + Coriander intercropping system in floating bed followed by Bottle gourd + Chilli system.

Introduction

In Gopalganj, Barishal and Pirojpur districts, farmers traditionally cultivate vegetables (like okra, red amaranth, panikachu etc.) on water hyacinth made floating bed. They also produce seedlings of different types of vegetable crops. However, cultivation of creeper vegetables on conventional floating bed is not suitable enough due to lacking of wider space on it for proper growth and development of the creeper vegetables. Recently, a technology namely "Floating Bed cum Trellis (non-tidal model)" has been developed for growing creeper vegetables successfully. In this system, seedlings of creeper vegetables are transplanted on floating bed but their growth and development take place on trellis as made between two floating beds. In this system, different non-creeper vegetables could be cultivated as intercrops with creeper vegetables on floating bed without hampering the growth and development of the creeper vegetables. Practices of intercropping would increase the crop productivity and economic return of the floating agriculture system under flooded ecosystem. In this respect, the present experiment has been undertaken to evaluate the intercropping performances of different non-creepers with creeper vegetables on "Floating Bed cum Trellis (non-tidal model)" under flooded ecosystem in non-tidal areas of Bangladesh.

Material and Methods

The experiment was conducted at Kolikunda, Nasirnagar, Brahmanbaria district during, 2021-22 to examine the intercropping performance of different non-creeper vegetables with bottle gourd in floating bed cum trellis for the area and to increase the crop intensity and economic return of farmers. The work was conducted in floating bed and each floating bed considered as one treatment. The bottle gourd variety BARI Lau-4 was tested in the trial. Four intercropped combinations i.e T_1 = Bottle gourd + Red amaranth, T_2 = Bottle gourd + coriander, T_3 = Bottle gourd + Chilli, T_4 = Bottle gourd + Spinach were tested in the experiment. The size of each floating bed was 9.15 m x 1.37m (30ft long x 4.5ft wide) and size of whole trellis (between two floating beds) was 9.15m x 4.57m (30ft long x 15ft wide). The two rows of bottle gourd was grown on each floating bed maintaining 1m plant to plant distance. The bottle gourd seedlings per hill was 2. Uniform size, healthy 10-12 days old seedlings of bottle gourd were transplanted on 1-2February, 2022. Red amaranth (BARI Lalshak-1), Coriander (BARI Dhonia-2), Chilli (BARI Morich-2), Spinach (BARI Palongshak-1) were intercropped with bottle gourd on 02 February 2022. The fertilizer dose was 71 kg urea, 180 kg diammonium phosphate, 40 kg muriate of potash, 44 kg gypsum, 3 kg zinc sulphate and 4 kg boric acid/ha. All the chemical fertilizers will be applied on the floating bed in application of liquid form. All kinds of fertilizers will be applied in five equal splits at 15, 25, 35, 45 and 55 days after transplanting (DAP). The liquid form of plant nutrients will be applied around the crop plants as well as on the floating bed. Zinc fertilizer is not allowed to mix with phosphatic fertilizer. The zinc sulphate and boric acid can be applied as foliar spray. Sometimes the crop was irrigated as when necessary. The pheromone trap was used for controlling insect instead of pesticide. Bottle gourd harvesting was started during 13March and continuous up to 03May 2022. Different intercrops were harvested as an when it was matured. Data on fruits plant^{-1} (no), individual fruit weight (kg) and fruit yield (t ha^{-1}) were recorded. The data was analyzed to examine the treatments effects and the mean differences were adjudged by (LSD) statistics10 analytical software- Tallahassee, SLA, USA.

Results and discussion

Yield and yield contributing characters of bottle gourd varieties and intercrop vegetables at floating bed cum trellis has shown table 1. From the trial it was revealed that the highest number of bottle gourd fruits/plant was recorded from Bottle gourd + Coriander intercropping system (9.2) and the lowest from Bottle gourd + Chilli combination (7.1). The individual fruit weight was statistically varying with different inter crop combinations. From the trialed intercrop combinations, the highest fruit yield was found from Bottle gourd + Coriander intercropping system (63.4 t/ha) and the lowest from Bottle gourd + Chilli (41.1 t/ha). Among the intercrops, highest vegetable yield was found from spinach (23.1 t ha^{-1}) and the lowest from Chilli (8.4 t/ha). From cost and return analysis, the highest gross return (Tk. 1929000 ha^{-1}) and gross margin (Tk. 1778550 ha^{-1}) were found from Bottle gourd + Coriander intercropping system in floating bed followed by Bottle gourd + Chilli system.

Farmer's opinion

Farmer's have chosen the Bottle gourd + Coriander intercropping system for its high yielding potentiality, profitability in floating bed system.

Table 1. Yield and yield contributing characters of bottle gourd as intercropped with different vegetables at floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22

Treatments	Fruits/plant (no.)	Individual Fruits Wt. (kg)	Inter crop Yield (kg/ha)	Yield (t/ha)
Bottle gourd + Red amaranth	8.1	2.9	22.8	54.5
Bottle gourd + Coriander	9.2	3.3	18.5	63.4
Bottle gourd + Chilli	7.2	3.1	8.4	41.1
Bottle gourd + Spinach	7.4	3.4	23.1	46.4
LSD (0.05)	1.78	0.32	2.11	5.01
CV (%)	12.1	8.10	11.8	9.78

Table 2. Cost and return analysis of bottle gourd as intercropped with different vegetables at floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22

Treatments	Gross return (Tk. ha^{-1})	TVC (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
Bottle gourd + Red amaranth	1001000	100450	900550
Bottle gourd + Coriander	1929000	150450	1778550
Bottle gourd + Chilli	1419000	150450	1268550
Bottle gourd + Spinach	926000	110450	815550

* TVC includes labour, land preparation, seed, fertilizers and Insecticides, Price: Bottle gourd = 10 Tk/kg, Red amaranth = 20 Tk/kg, Coriander leaf = 70Tk/kg, Chilli = 120Tk/kg, Spinach = 20Tk/kg,

Conclusion: It was the results of second year study. To make a final conclusion there is a need to repeat the experiment next year.

ECONOMIC PERFORMANCE OF RELAY INTERCROPPING OF VEGETABLE AND SPICES UNDER FLOATING BED CULTIVATION IN SYLHET REGION

M. I. NAZRUL

Abstract

An experimentation was evaluated the yield performances of some vegetable and spice crop on floating bed in farmers field. Twelve farmers were selected from each experimental site and four beds have been constructed by each farmer. The main component of beds (floating agriculture) was water hyacinth and base was made with the help of rectangular bamboo frame. Three crop sequences including vegetable and spice have been selected as per farmers choose viz. combination-1: sweet gourd + tomato + onion + kangkong; combination-2: bottle gourd + brinjal + garlic + kangkong, combination-3: watermelon + tomato + onion + kangkong, and combination-4: cucumber + brinjal + garlic + kangkong were used as treatment in different beds. The experiment was setup in randomized complete block design with six disperse replications. Crops were transplanted in line sowing. The cumulative yields and economic performance of four different crop combinations grown under floating bed revealed that the maximum gross return (Tk. 2626800 ha^{-1}) and gross margin (Tk. 1073267 ha^{-1}) was obtained from combination-3, followed by combination-1. Though higher gross

return and margin was recorded in combination-3 but higher benefit cost ration (1.77) was obtained from combination-1 (sweet gourd + tomato + onion + kang kong) followed by combination-3 (water melon + tomato + onion + kangkong); it might be due to higher total equivalent yield and lower cost of production; but combination-4 (cucumber + Brinjal + Garlic + Kang kong) showed the lower economic performance (Table 4).

Introduction

Climate change brings up a significant change in the agricultural practices of the low laying and flood prone areas of Bangladesh (Awal, 2014). Due to these changes, some parts of the country remain waterlogged for a prolonged period. To overcome this problem, farmers in these areas are adopting alternative cultivation techniques (Kabir et al., 2020). Floating gardening is one of the techniques where plants are grown on a bio-land or floating bed of water hyacinth, algae or plant residues (Islam et al., 2019). It is being practiced in southern floodplains of Bangladesh, particularly in the Barishal, Gopalganj and Pirojpur district (Chowdhury and Moore, 2017; Islam et al., 2019). Irfanullah et al. (2011) studied the contribution of this practice to rebuild life after devastating flood in northern Bangladesh and found its positive impacts on nutritional security, household income and land-use capacity.

The Sylhet region is North-Eastern part of Bangladesh, which consisting more than 300 haors. Most of the lands remain submerged for a long time during the monsoon season. Agriculture and fishing are the main occupation in these areas. The people of haor areas do not have enough homestead areas to produce vegetables. So, scarcity of vegetables enhances high price and cannot buy and intake sufficient vegetables as a result malnutrition is a serious problem in said areas.

The floating garden may help to alleviate poverty by increasing food security and economic safety for poor household of haor region. This can cope with climate change in an economically viable way and ensure sustained use of wetland resources in the haor. Indeed, the floating garden has improved their livelihood status. The haor farmers' effort to produce vegetables through "Vasoman Chash" following the practice exists in southern part of our country. But the monsoon agro climatic condition is quite different between two regions which need scientific improvement of this innovative technology as per demand of farmers. The present research attempts to apply a bio-land or floating bed experimentation has been undertaken to develop economically viable floating vegetable cultivation method and to introduce different vegetables over the season in Sylhet.

Materials and Methods

An experiment was conducted in floating beds at farmer's field of Fenchuganj, Golapganj under the Sylhet district. Twelve farmers were selected from each experimental site and four beds have been constructed by each farmer. The main component of beds (floating agriculture) was water hyacinth and with the help of rectangular bamboo frame. Three crop sequences with vegetable and spice combinations have been selected as per farmers choose viz. combination-1: Sweet gourd + Tomato + Onion + Kangkong; combination-2: Bottle gourd + Brinjal + Garlic + Kangkong, combination-3: Watermelon + tomato + Onion + Kangkong, and combination-4: cucumber + Brinjal + Garlic + Kangkong were used as treatment in different beds. The experiment was setup in randomized complete block design with six disperse replications. The crops were transplanted in line sowing. The beds were prepared on mid-July 2020 with water hyacinth in (1.0-1.4 m) 4-5 feet of height and 1-2 inches covered with composted mixture clay soil. The bed size was 9.14 m x 1.40 m (30 ft × 4.5 ft × 3.5-4.0 ft). Each floating bed was supported with bamboo pillars to protect from wind and water wave. A mixture of NPKS (200-250 g) was applied in each bed during cultivation. The insecticides was applied as a when necessary for protecting the crop. The data were recorded during harvesting vegetables. Twenty-five days old seedlings of each crop were transplanted in beds at 1st week of August 2020 with maintaining the recommended spacing. Bamboo trellis was made and placed between two beds supporting with the bamboo pillars for each vine crops. The fruits of vegetables and spices grown in different beds were harvested at marketable stage during October to February 2021. Intercultural operations were done as and when necessary. Chemical insecticide Desis and Tilt @ 2ml L^{-1} of water was sprayed for controlling the cut worm and other fungal diseases. Prior to harvest 10 randomly selected plants from each variety were tagged for collecting data. Data on harvested fruits yield recorded bed wise. The fruit yields were converted in to per hectare.

Results and discussion

The average fruit yield of sweet gourd, bottle gourd, cucumber and water melon were weight from the selected 13 m^2 area in each floating bed and fruit yields were recorded harvest stage. Total yields were expressed in kg bed^{-1} and t ha^{-1}, among four cucurbits the maximum average fruit yields 258 kg bed^{-1} and 61.79 t ha^{-1} were found in bottle gourd followed by watermelon and sweet gourd. Maximum gross return (Tk.1588520 ha^{-1}) and gross margin (Tk.841720 ha^{-1}) was obtained from water melon followed by bottle gourd. But with higher benefit cost ration of 2.03 was provided by bottle gourd it might be due to higher fruit yield and lower cost of cultivation. On the contrary, lower yield and economic return was obtained from cucumber (Table 1).

The average yields of kangkong, tmato and brinjal were weight from the selected 13 m^2 area in each bed and data was recorded at harvest. Total yields were expressed in kg bed^{-1} and t ha^{-1}, among three different crops grown in floating bed the maximum average fresh yield 193 kg bed^{-1} and 46.60 t ha^{-1} were found in tomato followed by kangkong and lower yiled was produced by brinjal. Higher gross return (Tk. 559200 ha^{-1}) and gross margin (Tk. 280825 ha^{-1}) with maximum benefit cost ration of 1.29 was obtained from tomato (Table 2).

The average yields of chilli, coriander, garlic, and onion were weight from each floating bed at harvest. Hereafter, total yields were converted in kg bed^{-1} and t ha^{-1}, among four tested speices crops the maximum average yield 33.10 kg bed^{-1} and 8.71 t ha^{-1} were found from chilli followed by onion. On the contrary, maximum gross return (Tk. 699580 ha^{-1}) and gross margin (Tk. 305080 ha^{-1}) with higher benefit cost ration of 1.77 was harnest from coriander. It is mainly due to higher market price of coriander. But the lower yield and economic performance was found in onion among the tested spices in floating bed (Table 3).

The average yields of cabbage, cauliflower and bati shak were weight from the selected 13 m^2 area in each bed and data was recorded 55 to 120 days after transplanting of seedlings. Total yields were expressed in kg bed^{-1} and t ha^{-1}, among tested ee cole crops the maximum average fresh yield 221.25 kg bed^{-1} and 554.56 t ha^{-1} were found in cabbage. It was also provided the maximum gross return (Tk. 543600 ha^{-1}) and gross margin (Tk. 270100 ha^{-1}) with higher benefit cost ration of 1.99. But the vegetable bati shak did not performed well and produced lower yield and economic return among the tested vegetable in floating bed (Table 4).

The cumulative yields and economic performance of four different crop combinations viz. combination-1: Sweet gourd + Tomato + Onion + Kangkong; combination-2: Bottle gourd + Brinjal + Garlic + Kangkong, combination-3: Water melon + tomato + Onion + Kangkong, and combination-4: cucumber + Brinjal + Garlic + Kangkong were presented in table-5. Results revealed that the maximum total equivalent yield (156.24 t ha^{-1}) was produced by crop combination-2, followed by combination-1.

Combined economic performance of vegetebles and spices grown under different combinations in floating bed varied with the variation of crops and their yields with local market price. The table of economics revealed that maximum gross return (Tk. 2626800 ha^{-1}) and gross margin (Tk. 1073267 ha^{-1}) was obtained from combination-3, followed by combination-1.

Though higher gross return and margin was recorded in combination-3 but higher benefit cost ration (1.77) was obtained from combination-1 (sweet gourd + tomato + onion + kang kong) followed by combination-3 (water melon + tomato + onion + kangkong); it might be due to higher total equivalent yield and lower cost of production; but combination-4 (cucumber + Brinjal + Garlic + Kang kong) showed the lower economic performance (Table 6).

Farmer's opinion

Farmers are very happy with the produced vegetable and spices in the same floating bed due to fresh harvest and meetup family nutrition family nutrition. It is also good option for utilization of water hyacinth and water bodies round the year especially during summer when vegetable crisis in the market.

Table 1. Yield and yield economic return of sweet gourd, bottle gourd, cucumber, and water melon under floating bed cultivation at Baniachanj, 2021-22

Crop	Fruit yield		Gross return	Total variable	Gross margin	BCR
	(kg bed^{-1})	(t ha^{-1})	(Tk.ha^{-1})	cost (Tk.ha^{-1})	(Tk.ha^{-1})	
Sweet gourd	206	48.70	584400	310850	273550	1.88
Bottle gourd	258	61.79	617900	304325	313575	2.03
Cucumber	95	22.20	444000	298660	145340	1.49
Watermelon	151	39.71	1588520	946800	841720	1.68

Price of output (Tk.kg-1): Sweet gourd-12, Bottle gourd-10, Cucumber-20, Watermelon-40

Table 2. Yield and yield economic return of chilli, kangkong and tomato under floating bed cultivation at Golapganj, Sylhet 2021-22

Crop	Fruit/leaf yield		Gross return	Total variable	Gross margin	BCR
	(kg bed^{-1})	(t ha^{-1})	(Tk.ha^{-1})	cost (Tk.ha^{-1})	(Tk.ha^{-1})	
Kang kong	95.15	22.95	229500	176870	52630	1.29
Tomato	193.03	46.60	559200	278375	280825	2
Brinjal	42.35	11.14	200520	162008	38512	1.24

Price of output (Tk.kg-1): Kang Kong- 10, Tomato-12, Brinjal-18

Table 3. Yield and yield economic return of chilli, coriander, garlic, and onion under floating bed cultivation at Fenchuganj and Baniachanj locations, 2021-22

Crop	Yield		Gross return	Total variable	Gross margin	BCR
	(kg bed^{-1})	(t ha^{-1})	(Tk.ha^{-1})	cost (Tk.ha^{-1})	(Tk.ha^{-1})	
Chilli	33.10	8.71	306000	196620	109380	1.55
Coriander	24.12	7.36	699580	394500	305080	1.77
Garlic	26.07	6.86	514500	447100	67400	1.15
Onion	31.57	8.30	249000	151488	97512	1.64

Price of output (Tk.kg-1): Chili- 40, Coriander- 95, Garlic-75, Onion-30

Table 4. Yield and yield economic return of cabbage, cauliflower and bati shak under floating bed cultivation at Baniachanj, 2020-21

Crop	Vegetable yield		Gross return	Total variable	Gross margin	BCR
	(kg bed^{-1})	(t ha^{-1})	(Tk.ha^{-1})	cost (Tk.ha^{-1})	(Tk.ha^{-1})	
Cabbage	221.25	54.56	543600	273500	270100	1.99
Cauliflower	170.17	36.79	441480	255700	185780	1.73
Bati shak	75.52	17.57	210840	195200	15640	1.08

Price of output (Tk.kg^{-1}): Cabbage- 10, Cauliflower-12, Batishak-12

Table 5. Equivalent yields of crops grown under different combinations in floating bed at Fenchuganj during 2021-22

Combination-1					**Combination-2**				
Sweet gourd EY (t ha^{-1})				Total EY (t ha^{-1})	Bottle gourd EY (t ha^{-1})				Total EY (t ha^{-1})
Sweetgourd	Tomato	Onion	Kangkong		Bottlegourd	Brinjal	Garlic	Kangkong	
48.70	46.60	20.75	19.13	135.18	61.79	20.05	51.45	22.95	156.24
Combination-3					**Combination-4**				
Water melon EY (t ha^{-1})					Cucumber EY (t ha^{-1})				
Watermelon	Tomato	Onion	Kangkong		Cucumber	Brinjal	Garlic	Kangkong	
39.71	13.98	6.23	5.74	65.67	22.20	10.03	25.73	11.38	69.34

Table 6. Combined economic performance of vegetables and spices grown under different combinations in floating bed at Fenchuganj during 2021-22

Crop combinations	Total equivalent yield (t ha^{-1})	Gross return ($Tk.ha^{-1}$)	Total variable cost ($Tk.ha^{-1}$)	Gross margin ($Tk.ha^{-1}$)	BCR
Combination-1	135.18	1622160	917583	704577	1.77
Combination-2	156.24	1562400	1090303	472097	1.43
Combination-3	65.67	2626800	1553533	1073267	1.69
Combination-4	69.34	1386800	1084638	302162	1.28

EFFECT OF POLYTHENE MULCH ON THE YIELD OF BABY WATERMELON ON FLOATING BED CUM TRELLIS

MM BASHIR AND SK BHOWAL

Abstract

The experiment was conducted at the Kolikunda, Nasirnagar,Brahmanbaria during 2021-22 to study the effect of polythene mulch on the yield of baby watermelon on floating bed cum trellis under submerged ecosystem. From the trial in the floating bed, the significantly highest fruit yield was found from polythene mulch method (45.5 t/ha) and the lowest from no mulch technique (32.6 t/ha). From cost and return analysis, the highest gross return (Tk. 2275000 ha^{-1}) and gross margin (Tk. 2173550 ha^{-1}) were found from polythene mulch technique followed by no mulch.

Introduction

Farmers of the southern and south-western regions of Bangladesh traditionally cultivate a few number of vegetable and spice crops on water hyacinth made floating bed during monsoon under submerged ecosystem. Only the floating bed is not so suitable for cultivation of creeper type of vegetables due to lacking space on the bed. Recently, floating bed cum trellis has been developed at RARS, Rahmatpur, Barishal for cultivation of creeper type of crops. However, in rainy season, the available plant nutrients are leached out to the water body from the floating bed due to heavy rainfall, which hamper the growth and development of the crop plants and ultimately give lower yield. Application of black polythene mulch on the floating bed may reduce the leaching out of plant nutrients from the bed that will increase the nutrient use efficiency as well as yield of baby watermelon. Therefore, the experiment has been designed to study the effect of polythene mulch on the yield of baby watermelon on floating bed cum trellis under submerged ecosystem.

Material and Methods

The experiment was conducted at Kolikunda, Nasirnagar, Brahmanbaria district during, 2021-22to study the effect of polythene mulch on the yield of baby watermelon on floating bed cum trellis under submerged ecosystem. The work was conducted in floating bed and each floating bed considered as one treatment. Hybrid black berry variety was tested in the trial. The size of each floating bed was 9.15 m x 1.37m (30ft long x 4.5ft wide) and size of whole trellis (between two floating beds) was 9.15m x 4.57m (30ft long x 15ft wide). The two rows of baby watermelon were grown on each floating bed maintaining 1m plant to plant distance. The watermelon seedlings per hill were 2. Uniform size, healthy 10-12 days old seedlings were transplanted on 20-21 March, 2021. Two treatments i.eT_1 = Polythene mulch; T_2 = No mulch were considered in the trial. The fertilizer dose was; 70g urea, 94 g diammonium phosphate, 27g muriate of potash, 24g gypsum, 3g zinc sulphate, 6g boric acid/10 sqm area (BARC, 2012). All the chemical fertilizers will be applied on the floating bed in application liquid form. All kinds of fertilizers will be applied in five equal splits at 15, 25, 35, 45 and 55 days after transplanting (DAP). The liquid form of plant nutrients will be applied around the crop plants as well as on the floating bed. Zinc fertilizer is not allowed to mix with phosphatic fertilizer. The zinc sulphate and boric acid can be applied as foliar spray. Sometimes the crop was irrigated as when necessary. The pheromone trap was used for controlling insect instead of pesticide. Harvesting was started during 21May, 2021 and continuous up to 19 June 2021. Data on fruits plant^{-1} (no), individual fruit weight (kg) and fruit yield (t ha^{-1}) were recorded. The data was analyzed to examine the treatments effects and the mean differences were adjudged by (LSD) statistics10 analytical software- Tallahassee, SLA, USA.

Results and discussion

Yield and yield contributing characters of baby watermelon as affected by polythene mulch at floating bed cum trellis has shown table 1. From the floating bed system adaptive trial, it was revealed that the highest number of fruits/plant was recorded from Polythene mulch treatment (5.6) and the lowest from no mulch treatment (4.1). It's may be the no weed competition in polythene mulch treatments compared to the no mulch treatment. The highest individual fruit weight was shown by Polythene mulch method (1.36 kg) that was followed by no mulch method in floating bed system. From the trialed methods, the highest fruit yield was found from polythene mulch treatment (45.5 t/ha) and the lowest from no mulch. From cost and return analysis, the highest gross return (Tk. 2275000 ha^{-1}) and gross margin (Tk. 2173550 ha^{-1}) were found from polythene mulch technique followed by no mulch**.**

Farmer's opinion

Farmer's have chosen the baby watermelon production by polythene mulch technique for its high yielding potentiality, excellent fruit size and shape in floating bed system.

Table 1. Yield and yield contributing characters of baby watermelon as affected by mulching at floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22

Treatments	Fruits/plant (no.)	Individual Fruits Wt. (kg)	Yield (t/ha)
T_1 = Polythene mulch	5.6	1.36	45.5
T_2 = No mulch	4.1	1.12	32.6
Level of significance (0.05)	*	*	*

Table 2. Cost and return analysis of baby watermelon as affected by mulchingat floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22

Treatments	Gross return (Tk. ha^{-1})	TVC (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
Polythene mulch	2275000	101450	2173550
No mulch	1630000	70450	1559550

* TVC includes labour, land preparation, seed, fertilizers and Insecticides, Price: baby watermelon = 50 Tk/kg

Conclusion

It was the results of second year study. To make a final conclusion there is a need to repeat the experiment next year.

PERFORMANCE OF DIFFERENT INTERCROPPING SYSTEM RED AMARANTH WITH COLE CROPS IN FLOATING BED AT GOPALGANJ REGION

M M HOWLADER

Abstract

Three intercropping system viz. Cauliflower + red amaranth, Cabbage + red amaranth and Knolkhol + red amaranth were taken to test the suitability for intercrop in floating agriculture. The experiment was conducted at Kotalipara, Tungipara and Moksedpur during the rabi season of 2021-`22. Among the three intercropping Cauliflower+ Red amaranth gave the highest gross margin (1413.30 Tk./bed) and BCR (1.78) while the lowest gross margin (1012.20 Tk./bed) and BCR (1.56) was recorded from Cabbage + Red amaranth intercropping.

Introduction

Floating agriculture is a practice to grow crops especially vegetables for the utilization of water logging area. It is a conventional practice in southern part of Bangladesh where most of the land remains waterlogged for longer period of time. Different vegetable crops (cucumber, bottle gourd, bitter gourd, tomato, brinjal, snake gourd, yard long bean etc.) are grown on floating bed under submerged ecosystem and it is a promising alternative method of vegetable production to meet the food security in the southern part of the country. Even though floating agriculture is an old practice but no research has been conducted on intercropping of vegetables. Vegetables which described above are sown and/or transplanted maintaining certain spacing. But there is a scope to introduce short duration leafy vegetables to grow between spacing of the vegetables techniques of vertical expansion of crop production. It increases total productivity per unit area than sole cropping. Therefore, the present study was undertaken to observe the performance of intercropping against the conventional sole vegetable cultivation.

Materials and Methods

The experiment was carried out on water hyacinth based floating bed at atKotalipara, Tungipara and Moksedpur during the *rabi*season of 2021-`22. The size of each bed was 9.15mx 1.37m. Three intercrop viz. Cauliflower + red amaranth, Cabbage + red amaranth and Knolkhol + red amaranth were tested under this study. Seeds and seedlings were sown and planted from 15/11/2021 to 25/11/2021. Cauliflower, Cabbage and Knolkhol were transplanted with the spacing of 60cm x 40cm and seeds of red amaranth were broadcasted between spacing of two rows. All kinds of intercultural operations were done as and when necessary. The harvesting date of crops was 15/01/2022 to 31/01/2022.

Result and Discussion

There were a significant difference was found among the intercropping systems (Table-1).Though the highest red amaranth yield (30.43 kg/plot) was found in Knolkhol +Red-amaranth in intercrop but the highest mean gross margin (Tk.1413.30 Tk./bed) as well as BCR (1.78) was found from cauliflower and red amaranth intercrop may be due to higher price of cauliflower than cabbage and knolkhol. The lowest gross margin (1012.20 Tk./bed) and BCR (1.56) was recorded from Cabbage + Red amaranth intercropping.

Farmers' opinion: Farmers and their neighbor's choose cauliflower+red amaranth intercrop for its best performance in respect of gross margin with BCR.

Table-1. Mean yield and profitability of the different intercropped in floating bed at different locations during rabi 2021-22

Treatments	Locations	Yield (kg/bed)		Total Gross Return (Tk/bed)	TVC (Tk/bed)	Gross Margin (Tk/bed)	BCR
		Cabbage/ Cauliflower/ Knolkhol	Red amaranth				
Cauliflower + red amaranth	Tungipara	113	31.20	3293	1800	1493	1.82
	Kotalipara	106	26.30	3044.50	1800	1244.50	1.69
	Moksrdpur	115	28.52	3302.80	1800	1502.80	1.83
	Mean	**111.33**	**28.67**	**3213.30**	**1800**	**1413.30**	**1.78**
Cabbage + red amaranth	Tungipara	126	26.9	2923.50	1800	1123.5	1.62
	Kotalipara	123	23.2	2808	1800	1008	1.56
	Moksrdpur	116	25.7	2555.5	1800	755.5	1.42
	Mean	**121.66**	**26.26**	**2812.23**	**1800**	**1012.20**	**1.56**
Knolkhol + red amaranth	Tungipara	102	33.3	3049.5	1800	1249.5	1.69
	Kotalipara	95	29.8	2822	1800	1022	1.57
	Moksrdpur	91	28.2	2698	1800	898	1.50
	Mean	**96**	**30.43**	**2856.45**	**1800**	**1056.45**	**1.59**

Cost/bed: 1800/-, Price (Tk./kg): Cauliflower = 25-/, Cabbage =20/, Knolhol= 25/- and Red amaranth=15Tk.

Conclusion: Among the three intercropping system, red amaranth with cauliflower was more suitable in the context of the yield and profitability.

ADAPTIVE TRIAL OF BARI BRINJAL VARIETIES IN FLOATING BED

M. MOHIUDDIN

Abstract

Adaptive trial of BARI winter brinjal varieties was conducted at the Kishoreganj sadar and Karimganj upazilla of Kishoreganj district during 2021-22 to examine a suitable brinjal variety for the area. Two BARI developed varieties such as BARI begun-6 and BARI begun-10 were tested. The significantly highest yield was found from BARI begun-10 (34.68 t/ha) and the lowest from BARI begun-6 (32.88 t/ha). From financial analysis, BARI begun-10 gave the highest gross return (485588 Tk/ha), gross margin (317068 Tk/ha) and benefit cost ratio (2.88) followed by BARI begun-6.

Introduction

Farmers living in the low-lying areas traditionally grow selected vegetable and spice crops and their seedlings on water hyacinth made floating bed during monsoon season. As spice crop, only turmeric crop is grown on floating bed besides, seedlings of brinjal also produced on floating bed. It can be mentioned that the low-lying lands become submerge during monsoon season due to heavy rainfall, which is not suitable for brinjal production in this season. Cultivation of brinjal on floating bed will make available in the market during monsoon season. Considering the facts, the experiment has been undertaken to evaluate the yielding abilities of selected brinjal varieties as well as to introduce this crop on floating bed in flooded ecosystem.

Material and Methods

The experiment was conducted at Kishoreganj sadar and Karimganj upazilla of Kishoreganj district during 2021-22 to examine the suitable variety of brinjal on floating bed for that area. The experiment was laid out in a randomized complete block design with three dispersed replications. Varieties were BARI begun-6 and BARI begun-10. The unit bed sizes were 9.15 m x 1.37 m. Seedlings were planted on 05 November 2021 followed by 100 cm x 75 cm spacing. The recommended fertilize doses were applied Urea-47gm, DAP-214g, MoP-48g, Gypsum-24g, Zinc-02g and Boric acid-05g per bed respectively. All the chemical fertilizers will be applied on the floating bed in liquid form. All kinds of fertilizers will be applied in five equal splits at 15, 25, 35, 45 and 55 days after transplanting. The liquid form of plant nutrients will be applied around the crop plants as well as on the floating bed. This year did not appear any major disease of brinjal. BARI begun-6 and BARI begun-10 were started to harvest at 16 February 2022 to April 2022. Data on yield were recorded and presented in the table.

Results and discussion

BARI begun-10 gave the highest yield (34.68 t/ha), gross amrgin (317068 Tk/ha) and BCR 2.88 followed by BARI begun-6.

Farmer's opinion

In between two varieties farmer's have chosen the BARI begun-10 for its high yielding potentiality, market demand and excellent colour.

Table 1. Yield and economic performance of brinjal on floating bed in Kishoreganj, 2021-22

Treatments	Yield (kg/bed)	Yield (Kg/ha)	Gross return (Tk./ha)	TVC (Tk/ha)	Gross margin (Tk./ha)	BCR
BARI begun-6	41.26	32883.67	361720.37	166520	195200.37	2.172234
BARI begun-10	43.52	34684.86	485588.04	168520	317068.04	2.881486

* TVC includes cost of bed preparation, labour, price of seedlings, fertilizers and insecticides, price: BARI begun-6=11 and 10 = 14 tk/kg

Conclusion

It was the results of second year study. To make a final conclusion there is need to repeat the experiment next year.

ADAPTIVE TRIAL OF BARI TOMATO VARIETIES ON FLOATING BED

M. MOHIUDDIN

Abstract

Adaptive trial of BARI tomato varieties was conducted at the Kishoreganj sadar and Karimganj upazilla of Kishoreganj district during 2021-22 to examine a suitable tomato variety for the area. Two BARI developed varieties such as BARI tomato-19 and BARI tomato-21were tested. The significantly highest yield was found from BARI tomato-21 (51.63 t/ha) and the lowest from BARI tomato-19 (41.72 t/ha). From financial analysis, BARI tomato-21 gave the highest gross return (516288 Tk/ha), gross margin (345593 Tk/ha) and benefit cost ratio (3.02) followed by BARI tomato-19.

Introduction

Farmers living in the low-lying areas traditionally grow selected vegetable and spice crops and their seedlings on water hyacinth made floating bed during monsoon season. As spice crop, only turmeric crop is grown on floating bed Besides, seedlings of tomato also produced on floating bed. It can be mentioned that the low-lying lands become submerge during monsoon season due to heavy rainfall, which is not suitable for tomato production in this season. Cultivation of tomato on floating bed will make available in the market during monsoon season. Considering the facts, the experiment has been undertaken to evaluate the yielding abilities of selected tomato varieties as well as to introduce this crop on floating bed in flooded ecosystem.

Material and Methods

The experiment was conducted at Kishoreganj sadar and Karimganj upazilla of Kishoreganj district during 2021-22 to examine the suitable variety of tomato on floating bed for that area. The experiment was laid out in a randomized complete block design with three dispersed replications. Varieties were BARI tomato-19 and BARI tomato-21. The unit bed sizes were 9.15 m x 1.37 m. Seedlings were planted on 05 November 2021 followed by 60 cm x 40 cm spacing. The recommended fertilize doses were applied Urea-47gm, DAP-214g, MoP-48g, Gypsum-24g, Zinc-02g and Boric acid-05g per bed respectively. All the chemical fertilizers will be applied on the floating bed in liquid form. Urea was applied 3 equal splits at 10, 25 and 40 days after transplanting. MoP was applied in 3 equal splits as basal dose at land preparation time and 25 and 40 days after transplanting. The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed. This year did not appear any major disease of tomato. BARI tomato-19 and BARI tomato-21 were started to harvest at 20 February 2022 to April 2022. Data on yield were recorded and presented in the table.

Results and discussion

The highest yield per bed was recorded from BARI tomato-21 (64.78 kg) and lowest from BARI tomato-19 (52.35 kg). BARI tomato -21 gave the highest gross return Tk. 516288/ha, gross margin Tk. 345593/ha and BCR 3.02 followed by BARI tomato-19.

Farmers' opinion

Farmers choose BARI tomato-21 for its high yield potential, attractive colour and market demand.

Table 1. Yield and economic performance of tomato on floating bed in Kishoreganj, 2020-21

Treatments	Yield (kg/bed)	Yield (t/ha)	Gross return (Tk./ha)	TVC (Tk/ha)	Gross margin (Tk./ha)	BCR
BARI tomato-19	52.35	41722.25	417222.52	170695	246527.52	2.44
BARI tomato-21	64.78	51628.8	516287.96	170695	345592.96	3.02

Conclusion

In the haor areas like Kishoreganj floating agriculture is disseminating day by day. So, Purpose of more dissemination and meet up to vegetable crisis further continuation is needed.

ADAPTIVE TRIAL OF SELECTED TURMERIC VARIETIES ON FLOATING BED

MM BASHIR, SK BHOWAL, MM HAWLADER AND S AHMED

Abstract

Adaptive trial of turmeric varieties was conducted at the Kolikunda, Nasirnagar, Brahmanbaria and Tungipara, Kotalipara in Gopalganj and Rajoir upzilla of Madaripur district during 2021-22 to examine a suitable turmeric variety in floating bed for the area. Three BARI developed varieties such as BARI Holud-3, BARI Halud-4and BARI Halud-5 along with a local cultivar were tested. From the trial in floating bed, the significantly highest yield was found from BARI Halud-5and the lowest from local in both the locations. From cost and return analysis, BARI Halud-5 gave the highest gross return, gross margin followed by BARI holud-4.

Introduction

In Bangladesh total spices production is about 4.5 lakh tons and 11.5 lakh tons are imported to fulfill the national demand. Turmeric (*Curcuma longa*) is one of the most important spice crops in Bangladesh as well as in south Asia. Local variety covers the greater portion of turmeric growing areas in Cumilla region. Farmers traditionally practice this low yielding local variety for its production and thus get poor yield. If they practice and accept the BARI developed high yielding turmeric variety they have the possibility to obtain smart yield in plane land. But in floating agriculture system, BARI developed high yielding turmeric varieties have the greater opportunity to adopt and cover the floating area with cultivation. Therefore, the study was undertaken to find out the appropriate variety in floating system for turmeric in Cumilla region.

Material and Methods

The experiment was conducted at Kolikunda, Nasirnagar, Brahmanbaria and Tungipara and Kotalipara in Gopalganj district during 2021-22 to examine the suitable variety of turmeric in floating bed system for that area. The experiment was laid out in a randomized complete block design with three dispersed replications. Varieties were BARI Halud-3, BARI Halud-4, BARI Halud-5 and a local cultiver. The unit bed sizes were 4.5 ft x 30 ft. The mother rhizomes were planted on 16 May 2021 in Brahmanbaria and 04-07 July 2021 in Gopalganj followed by 60 cm x 25 cm spacing. The recommended fertilize doses were applied Urea-95gm, DAP-90g, MoP-105g, Gypsum-47g and Boric acid-07g per bed respectively. All the chemical fertilizers were applied on floating bed in liquid form. All kinds of fertilizers were applied in five equal splits at 1 month interval after 15 days of transplanting. The lequid form of plant nutrients was applied around the crop plants as well as on the floating bed. Any major disease of turmeric was not appear. Nevertheless mancozeb and otostine were applied to control leaf blotch and rhizome rot of turmeric. Harvesting was done at 05-10 January, in Brahmanbaria and 23-27 February in Gopalgan 2022. Data on yield and economic return were recorded .

Results and discussion

Cumilla: From the trialed turmeric varieties, the highest fresh yield was found from BARI Halud-5 (69 t/ha) and the lowest from local cultivar (21.6 t/ha). From cost and return analysis, the highest gross return (Tk. 690000 ha^{-1}) and gross margin (Tk. 556250 ha^{-1}) were found from BARI Halud-5 followed by BARI Halud-4 variety (Table-1).

Gopalganj: Significant difference was found among the tested turmeric varieties in respect of yield and profitability (Table-1). BARI Holud-5 gave highest yield it was 94.04 t/ha where lowest yield was found local variety and it were 56.19 t/ha. The highest gross margin (1992467) and BCR (1.73) were found from the same varietyand the lowest (1.03) were found from local variety.

Faridpur: From the trialed turmeric varieties, the highest fresh yield was found from BARI Halud-4 (11.5 t/ha) and the lowest from local cultivar (8.76 t/ha). From cost and return analysis, the highest gross return (Tk. 345000 ha^{-1}) and gross margin (Tk. 211250 ha^{-1}) were found from BARI Halud-4 followed by BARI Halud-5 variety (Table-1).

Farmer's opinion

Among the varieties, farmers have chosen the BARI Halud-5 for its high yielding potentiality and excellent color in floating bed system.

Table 1. Yield and economic return of turmeric varieties at floating bed in Cumilla, Gopalganj and Faridpur district during 2021-22.

District	Variety	Fresh Yield (t/ha)	Gross return (Tk. ha^{-1})	TVC (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
Cumilla	BARI Halud-3	46.5	465000	133750	331250
	BARI Halud-4	55.0	550000	133750	416250
	BARI Halud-5	69.0	690000	133750	556250
	Local	21.6	216000	133750	82250
Gopalganj	BARI Holud-3	62.96	3148097	2709755	438342.7
	BARI Holud-4	79.3	3965009	2709755	1255254
	BARI Holud-5	94.04	4702221	2709755	1992467
	Local	56.19	2809378	2709755	99623.33
Faridpur	BARI Holud-4	11.5	345000	133750	211250
	BARI Holud-5	9.4	282000	133750	148250
	Local	8.76	280320	133750	146570

In Cumilla* TVC includes labour, land preparation, seed, fertilizers and Insecticides, Price: Turmeric = 10Tk/kg and in Gopalganj, Bed cost= 2800; Seed (5 kg) = 300; others cost (Tk./bed) = 300 and Price (Tk./kg): Turmeric-50.

Conclusion

BARI developed all varieties performed better in floating bed system. To make a final conclusion there is a need to repeat the experiment next year.

ADAPTIVE TRIAL OF DIFFERENT OKRA VARIETIES ON FLOATING BED

MM HAWLADER MM BASHIR AN, SK BHOWA

Abstract

The experiment was carried out on water hyacinth based floating bed at Tungipara, Moksedpur and Kotalipara in Gopalganj district and Kulikunda, Nasirnagar, under B. Baria district during the year of 2021-22 to observe the performance of three commercial hybrid varieties in Gopalganj and two commercial hybrid varieties in Cumilla on floating bed. Three local hybrid variety viz. BARI derosh-1, Santi (local) and Lucky (local) in Gopalganj and Santi with Daiji in Cumilla were tested under this experiment. Among the varieties Santi gave highest yield, gross margin and BCR which were 77.67kg/bed, 918 Tk./bed and1.51, respectively.

Introduction

Farmers living in the low-lying areas of the south and south-western regions of Bangladesh cultivated selected vegetable and spice crops on floating bed during monsoon season as adaptation practices under submerged ecosystem. But the adaptation research on okra under floating agriculture system is not conducted yet. Recently BARI developed some okra varieties and also some popular local varieties were available in local market. Therefore, the experiment was taken to evaluate the performances of different okra varieties in floating agriculture ecosystem in Bangladesh

Material and Methods

The experiment was carried out on water hyacinth based floating bed at Tungipara, Kotalipara and Moksedpur in Gopalganj and Nasirnagar in B. Baria district during the year of 2021-22. Three Okra varieties viz. BARI Derosh-1, Santi and Lucky under Gopalganj and two varieites viz. Nulac and Daiji under B. Baria were tested under this experiment. The size of each bed was 9.15mx 1.37m. Seeds of okra were sown on 31 July 2021 to 04 August 2021 in Gopalganj and 14 July to 09 September 2021 in B. Baria with spacing of 30 cm x 25 cm. All kinds of intercultural operations were done as and when necessary. During the crop growing period aphid, ants and caterpillars infestation were observed and these were controlled by using bio-pesticide. The crop was harvested from 20 September to 30 October 2021 in Gopalganj and 24 August to mid November 2021 in B. Baria.

Results and discussion

Gopalganj: Significant difference was found among the tested varieties in respect of yield and profitability (Table 1). The highest yield (61.90 t/ha), gross margin (731897 Tk./ha) and BCR (1.51) were recorded from the variety Santi. The lowest yield (64 kg/bed), gross margin (440 Tk./bed) and BCR 1.24 were found from the variety Lucky. At the same time BARI Derosh-1 gave yield, gross margin and BCR were 70.67 kg/bed, 673.33 Tk. /bed and 1.37, respectively.

Cumilla: From the on-farm trial of Okra, it was observed that the highest fruit yield was recorded in Nulac and minimum in Daiji. The highest gross return (Tk. 546750 ha^{-1}) and gross margin (Tk. 445750 ha^{-1}) were found in Nulac and lower in Daiji (Table 1).

Farmers' opinion: Farmers and their neighbors are interested to cultivated okra variety Santi in floating bed for its higher yield.

Table-1. Yield and profitability of different okra varieties grown on floating bed at Gopalganj and Cumilla district during the year of 2021-`22

Varieties	Yield (t/ha)	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
Gopalganj					
BARI Derosh-1	56.32	1971211	1434576	536635	1.37
Santi	61.90	2166473	1434576	731896.8	1.51
Lucky	51.01	1785250	1434576	350674.1	1.24
Cumilla					
Nulac	12.15	546750	101000	445750	5.41
Daiji	9.28	417600	101000	316600	4.14

Price: Okra-Tk. 35/kg; Cost/ bed: 1800/-

Conclusion: Considering yield of okra it could be concluded that Santi is best among the three varieties for cultivation in floating bed.

ADAPTIVE TRIAL OF BITTER GOURD VARIETIES ON FLOATING BED CUM TRELLIS IN CUMILLA REGION

MM BASHIR AND SK BHOWAL

Abstract

Adaptive trial of bitter gourdvarieties was conducted at the Kolikunda, Nasirnagar,Brahmanbaria during 2021-22to examine a suitable bitter gourd variety in floating bed cum trellis for the area. Three hybrid bitter gourd varieties such as Tiya, Papiyaand Godzilla were tested in the trial. From the trial in floating bed, the significantly highest fruit yield was found from Hybrid Korola Teya (44.9 t/ha) and the lowest from Papiya (28.3 t/ha). From cost and return analysis, Hybrid Korola Teyagave the highest gross gross return (Tk. 898000 ha^{-1}) and gross margin (Tk. 828550 ha^{-1}) among the tested varieties.

Introduction

Farmers traditionally cultivate vegetable crops on water hyacinth made floating bed. Only the floating bed is not so suitable for cultivation of creeper type of vegetables due to lacking of wider space on the floating bed for proper growth and development of the creeper vegetables. Recently, non-tidal model of floating bed cum trellis (FBT) has been developed for cultivation of the creeper type of vegetable crops in non-tidal areas of Bangladesh. However, the performances of different high yielding varieties of creeper vegetables should be tested at farmers' fields by using floating bed cum trellis system. Therefore, the adaptive trials of creeper vegetables like bitter gourd have been undertaken for selecting most suitable varieties of different creeper vegetables for floating bed cum trellis system at farmers' fields in Cumilla region.

Material and Methods

The experiment was conducted at Kolikunda, Nasirnagar, Brahmanbaria district during, 2021-22 to examine a suitable bitter gourd variety in floating bed cum trellis for the area and to increase the crop intensity and economic return of farmers. The work was conducted in floating bed and each floating bed considered as one treatment. Three hybrid bitter gourd varieties such as Tiya, Papiya and Godzilla were tested in the trial. The size of each floating bed was 9.15 m x 1.37m (30ft long x 4.5ft wide) and size of whole trellis (between two floating beds) was 9.15m x 4.57m (30ft long x 15ft wide). The two rows of bitter gourdwas grown on each floating bed maintaining 1m plant to plant distance. The bitter gourd seedlings per hill was 2. Uniform size, healthy 10-12 days old seedlings were transplanted on 09-10September, 2021. The fertilizer dose was; 53g urea, 135g diammonium phosphate, 30g muriatic of potash, 33g gypsum, 2g zinc sulphate, 4g boric acid. All the chemical fertilizers were applied on floating bed in liquid form. All kinds of fertilizers were applied in five equal splits at 15,25,35,45 and 55 days after transplanting (DAP). Zinc fertilizer is not allowed to mix with phosphatic fertilizer. The zinc sulphate and boric acid were applied as foliar spray. Sometimes the crop was irrigated as when necessary. The pheromone trap was used for controlling insect instead of pesticide. Harvesting was started during 8 October to 05December 2021. Data on fruits plant^{-1} (no), individual fruit weight (kg) and fruit yield (t ha^{-1}) were recorded. The data was analyzed to examine the treatments effects and the mean differences were adjudged by (LSD) statistics10 analytical software- Tallahassee, SLA, USA.

Results and discussion

Yield and yield contributing characters has shown table 1. From the trial it was revealed that the highest number of fruits/plant was recorded from Hybrid KorolaTeya (85.1) and the lowest from Hybrid Korola Papiya (72.6). The highest individual fruit weight was shown by Hybrid Korola Teya (105.2 g) that was followed by Hybrid Korola Godzilla and the lowest in Papiya (78.4 g). From the trialed bitter gourd varieties, the highest fruit yield was found from Hybrid Korola Teya (44.9 t/ha) and the lowest fromPapiya (28.3 t/ha). From cost and return analysis, the highest gross return (Tk. 898000 ha^{-1}) and gross margin (Tk. 828550 ha^{-1}) were found from Hybrid KorolaTeyafollowed by other tested varieties**.**

Farmer's opinion

Among the hybrid varieties, farmer's have chosen the Hybrid KorolaTeyafor its high yielding potentiality, vigorous growth, excellent fruit size, shape and color in floating bed system.

Table 1. Yield and yield contributing characters of bitter gourd varieties at floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22

Varieties	Fruits/plant (no.)	Individual Fruits Wt. (g)	Yield (t/ha)
Hybrid KorolaTeya	85.1	105.2	44.9
Hybrid KorolaPapiya	72.6	78.4	28.3
Hybrid Korola Godzilla	78.7	101.5	40.3
LSD (0.05)	4.78	2.32	6.01
CV (%)	10.1	7.10	9.53

Table 2. Cost and return analysis of bitter gourd varieties at floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22

Treatments	Gross return (Tk. ha^{-1})	TVC (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
Hybrid KorolaTeya	898000	69450	828550
Hybrid KorolaPapiya	566000	69450	496550
Hybrid Korola Godzilla	806000	69450	736550

* TVC includes labour, land preparation, seed, fertilizers and Insecticides, Price: Bitter gourd = 20Tk/kg

It was the results of second year study. To make a final conclusion there is a need to repeat the experiment next year.

ADAPTIVE TRIAL OF BOTTLE GOURD VARIETIES ON FLOATING BED CUM TRELLIS IN CUMILLA REGION

MM BASHIR AND SK BHOWAL

Abstract

Adaptive trial of bottle gourd varieties was conducted at the Kolikunda, Nasirnagar,Brahmanbaria during 2021-22 to examine a suitable bitter gourd variety in floating bed cum trellis for the area. Three bottle gourd varieties such as BARI Lau-4, BARI Lau-5 and Hybrid Lau Gohona were tested in the trial. From the trial in the floating bed, the significantly highest fruit yield was found from BARI Lau-4 (82.5 t/ha) and the lowest from BARI Lau-5 (71.4t/ha). From cost and return analysis, highest gross return (Tk. 825000 ha^{-1}) and gross margin (Tk. 754550 ha^{-1}) were found from BARI Lau-4 among the tested varieties.

Introduction

In the low-lying areas of Barishal and Pirojpur districts, farmers traditionally produce seedlings of different vegetable crops on floating bed during monsoon season. Majority of the produced seedlings (about 60-70%) belongs to bottle gourd. The ecosystems on floating bed and plain land conditions might be quite different. Recently, non-tidal model of floating bed cum trellis (FBT) has been developed for cultivation of the creeper type of vegetable crops in non-tidal areas of Bangladesh. However, the performances of different high yielding varieties of creeper vegetables should be tested at farmers' fields by using floating bed cum trellis system. Therefore, the adaptive trials of creeper vegetables like bottle gourd have been undertaken for selecting most suitable varieties of bottle gourd for floating bed cum trellis system at farmers' fields in Cumilla region.

Material and Methods

The experiment was conducted at Kolikunda, Nasirnagar, Brahmanbaria district during, 2021-22 to examine a suitable bottle gourd variety in floating bed cum trellis for the area and to increase the crop intensity and economic return of farmers. The work was conducted in floating bed and each floating bed considered as one treatment. Three bottle gourd varieties such as BARI Lau-4, BARI Lau-5 and Hybrid Lau Gohona were tested in the trial. The size of each floating bed was 9.15 m x 1.37m (30ft long x 4.5ft wide) and size of whole trellis (between two floating beds) was 9.15m x 4.57m (30ft long x 15ft wide). The two rows of bottle gourd was grown on each floating bed maintaining 1m plant to plant distance. The bottle gourd seedlings per hill was 2. Uniform size, healthy 10-12 days old seedlings were transplanted on 10-15 September, 2021. The fertilizer dose was; 71 kg urea, 180 kg diammonium phosphate, 40 kg muriate of potash, 44 kg gypsum, 3 kg zinc sulphate and 4 kg boric acid/ha. All the chemical fertilizers will be applied on the floating bed in application liquid form. All kinds of fertilizers will be applied in five equal splits at 15, 25, 35, 45 and 55 days after transplanting (DAP). The liquid form of plant nutrients will be applied around the crop plants as well as on the floating bed. Zinc fertilizer is not allowed to mix with phosphatic fertilizer. The zinc sulphate and boric acid can be applied as foliar spray. Sometimes the crop was irrigated as when necessary. The pheromone trap was used for controlling insect instead of pesticide. Harvesting was started during 8 October and continuous up to25 December 2021. Data on fruits plant^{-1} (no), individual fruit weight (kg) and fruit yield (t ha^{-1}) were recorded. The data was analyzed to examine the treatments effects and the mean differences were adjudged by (LSD) statistics10 analytical software- Tallahassee, SLA, USA.

Results and discussion

Yield and yield contributing characters of bottle gourd varieties at floating bed cum trellis has shown table 1. From the adaptive trial it was revealed that the highest number of fruits/plant was recorded from BARI Lau-4 (9.2) and the lowest from BARI Lau-5 (7.1). The highest individual fruit weight was shown by Hybrid Lau Gohona (3.4kg) that was followed by BARI Lau-4 and the lowest in BARI Lau-5 (2.9 g). From the trialed bottler gourd varieties, the highest fruit yield was found from BARI Lau-4 (82.5 t/ha) and the lowest from BARI Lau-5 (71.4 t/ha). From cost and return analysis, the highest gross return (Tk. 825000 ha^{-1}) and gross margin (Tk. 754550 ha^{-1}) were found from BARI Lau-4 followed by other tested varieties**.**

Farmer’s opinion

Farmer’s have chosen the BARI Lau-4 for its high yielding potentiality, excellent fruit size and shape in floating bed system.

Table 1. Yield and yield contributing characters of bottle gourd varieties at floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22.

Varieties	Fruits/plant (no.)	Individual Fruits Wt. (kg)	Yield (t/ha)
BARI Lau-4	9.2	3.3	82.5
BARI Lau-5	7.1	2.9	71.4
Hybrid Lau Gohona	7.4	3.4	78.1
LSD (0.05)	1.78	0.32	5.01
CV (%)	12.1	8.10	9.78

Table 2. Cost and return analysis of bottle gourd varieties at floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22

Treatments	Gross return (Tk. ha^{-1})	TVC (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
BARI Lau-4	825000	70450	754550
BARI Lau-5	714000	70450	643550
Hybrid Lau Gohona	781000	70450	710550

* TVC includes labour, land preparation, seed, fertilizers and Insecticides, Price: Bottle gourd = 10Tk/kg

Conclusion: It was the results of second year study. To make a final conclusion there is a need to repeat the experiment next year.

ADAPTIVE TRIAL OF SWEET GOURD VARIETIES ON FLOATING BED CUM TRELLIS IN CUMILLA REGION

MM BASHIR AND SK BHOWAL

Abstract

Adaptive trial of sweet gourd varieties was conducted at the Kolikunda, Nasirnagar, Brahmanbaria during 2021-22 to examine a suitable bitter gourd variety in floating bed cum trellis for the area. Two sweet gourd varieties such as Hybrid Mistikumra Orange Ball and Hybrid Mistikumra Maxima were tested in the trial. From the trial in the floating bed, the significantly highest fruit yield was found from Hybrid Mistikumra Orange Ball (55.5 t/ha) and the lowest from Maxima (50.6t/ha). From cost and return analysis, the highest gross return (Tk. 555000 ha^{-1}) and gross margin (Tk. 484550 ha^{-1}) were found from Hybrid Mistikumra Orange Ball followed by rest one tested varieties.

Introduction

The farmers of Gopalganj and some part of Barishal district generally cultivate selected vegetable and spice crops on water hyacinth made floating bed during monsoon season. The traditional floating bed is built up with various types of local materials such as water hyacinth, topapana and dulalilata (Islam and Atkins, 2007). The water hyacinth (*Eichhorniacrassipes*) contains smaller proportion of macronutrients (nitrogen 1.16%, phosphorus 0.094%, potassium 0.13%, calcium 1.02%, magnesium 0.15% and sulphur 0.69%) and trace amount of micronutrients (iron 1.57%, zinc 0.09% and copper 0.01%). Regarding the physical properties of water hyacinth plants, the pH is somewhat acidic (pH 5.80) and the water holding capacity is approximately 50% (Lekshmi and Viveka, 2011). Only the traditional floating bed is not suitable enough for cultivating pumpkin due to lacking of required space on the bed and large canopy size of the pumpkin plant. Recently, floating bed cum trellis (non-tidal model) has been developed for creeper vegetables cultivation like pumpkin.Therefore, the adaptive trials of creeper vegetables like sweet gourd have been undertaken for selecting most suitable varieties of sweet gourd for floating bed cum trellis system at farmers' fields in Cumilla region.

Material and Methods

The experiment was conducted at Kolikunda, Nasirnagar, Brahmanbaria district during, 2021-22to examine a suitable sweet gourd variety in floating bed cum trellis for the area and to increase the crop intensity and economic return of farmers. The work was conducted in floating bed and each floating bed considered as one treatment. Two sweet gourd varieties such as Hybrid Mistikumra Orange Ball and Hybrid Mistikumra Maxima were tested in the trial. The size of each floating bed was 9.15 m x 1.37m (30ft long x 4.5ft wide) and size of whole trellis (between two floating beds) was 9.15m x 4.57m (30ft long x 15ft wide). The two rows of sweet gourd was grown on each floating bed maintaining 1m plant to plant distance. The sweet gourd seedlings per hill were 2. Uniform size, healthy 10-12 days old seedlings were transplanted on 20-21October, 2021. The fertilizer dose was; : 71g urea, 180g diammonium phosphate, 40g muriate of potash, 44g gypsum, 3g zinc sulphate, 6g boric acid/10 sqm area (BARC, 2012). All the chemical fertilizers will be applied on the floating bed in application liquid form. All kinds of fertilizers will be applied in five equal splits at 15, 25, 35, 45 and 55 days after transplanting (DAP). The liquid form of plant nutrients will be applied around the crop plants as well as on the floating bed. Zinc fertilizer is not allowed to mix with phosphatic fertilizer. The zinc sulphate and boric acid can be applied as foliar spray.Sometimes the crop was irrigated as when necessary. The pheromone trap was used for controlling insect instead of pesticide. Harvesting was started during 5 December, 2021 and continuous up to 25 January 2022. Data on fruits plant^{-1} (no), individual fruit weight (kg) and fruit yield (t ha^{-1}) were recorded. The data was analyzed to examine the treatments effects and the mean differences were adjudged by (LSD) statistics10 analytical software- Tallahassee, SLA, USA.

Results and discussion

Yield and yield contributing characters of sweet gourd varieties at floating bed cum trellis has shown table 1. From the floating bed system adaptive trial, it was revealed that the highest number of fruits/plant was recorded from Hybrid Mistikumra Orange Ball(5.9) and the lowest from Maxima (3.4). The highest individual fruit weight was shown by Hybrid Mistikumra Orange Ball (3.4 kg) that was followed by Maxima. From the trialed sweet gourd varieties, the highest fruit yield was found from Hybrid Mistikumra Orange Ball(55.5 t/ha) and the lowest from Maxima. From cost and return analysis, the highest gross return (Tk. 555000 ha^{-1}) and gross margin (Tk. 484550 ha^{-1}) were found from Hybrid Mistikumra Orange Ball followed by rest one tested varieties**.**

Farmer's opinion: Farmer's have chosen the Hybrid Mistikumra Orange Ballfor its high yielding potentiality, excellent fruit size and shape in floating bed system.

Table 1. Yield and yield contributing characters of sweet gourd varieties at floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22

Varieties	Fruits/plant (no.)	Individual Fruits Wt. (kg)	Yield (t/ha)
Hybrid Mistikumra Orange Ball	5.9	3.4	55.5
Hybrid Mistikumra Maxima	4.1	2.9	50.6
LSD (0.05)	1.08	0.22	4.01
CV (%)	11.1	8.10	10.78

Table 2. Cost and return analysis of sweet gourd varieties at floating bed cum trellis of Nasirnagar, Brahmanbaria during the year 2021-22

Treatments	Gross return (Tk. ha^{-1})	TVC (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})
Hybrid Mistikumra Orange Ball	555000	70450	484550
Hybrid Mistikumra Maxima	506000	70450	435550

* TVC includes labour, land preparation, seed, fertilizers and Insecticides, Price: Sweet gourd = 10 Tk/kg

Conclusion: It was the results of first year study. To make a final conclusion there is a need to repeat the experiment next year.

ADAPTIVE TRIAL OF DIFFERENT LEAFY VEGETABLES ON FLOATING BED

M M HOWLADER

Abstract

The experiment was carried out on water hyacinth based floating bed at Tungipara, Kotalipara ,Kashiani and Moksedpur in Gopalganj district during the year of 2021-22. The aim of the study was to identify the suitable leafy vegetable for floating bed and increase farmers income. Three leafy vegetables viz. Red amaranth, Amaranth and Spinach were tested under this experiment. Among the leafy vegetables red amaranth gave highest gross margin and BCR which were 548.75 Tk./ bed and 1.30.

Introduction

Vegetables are important part of healthy eating and provide a source of many nutrients including potassium, fiber, folate (folic acid) and vitamins A, E and C. Potassium may help to maintain healthy blood pressure. Dietary fiber form vegetables helps to reduce blood cholesterol levels and lower risk of heart disease. Folate helps to body form healthy red blood cells. For this each person is required to take 250g vegetables per day to get vitamins and minerals. Vegetables are mainly grown on high and medium high lands. But farmers living in the low-lying areas traditionally grow selected vegetables on water hyacinth made floating bed during monsoon season. Under floating bed agriculture system the farmers cultivate only a few numbers of vegetable crops. But the floating bed crops should be diversified to make profitable of the traditional floating agriculture practices. In this respect, adaptation of leafy vegetables can be introduced in floating agriculture system. So this program was taken to identify the suitable leafy vegetables for floating agriculture system.

Material and Methods

The experiment was carried out on water hyacinth based floating bed at Tungipara, Kotalipara ,Kashiani and Moksedpur in Gopalganj district during the year of 2021-22 with four dispersed replication. The size of bed was 9.15m x1.37m. Red amaranth (BARI lalshak-1), Amaranth (Gheekanchan) and Spinach (BARI Palanshak-2) were sowing from the date of 15 October 2021 to 20 December 2021, during the period red-amaranth and amaranth (Gheekanchan) were sown in three time and spinach was sown in two time with the spacing of 30 cm line sowing. All kinds of intercultural operations were done as and when necessary. During the crop growing period insect and disease were controlled by applying bio-pesticide. The harvesting date of different leafy vegetables was from 12/11/2021 to 17/01/2022.

Result and Discussion

There were a significant difference was found among the tested leafy vegetables in respect of yield and profitability (Table-1).Among these leafy vegetables, Red-amaranth gave highest gross margin and BCR it were 548.75TK./bed and 1.30, respectively. At the same time the lowest yield, gross margin and BCR was recorded from Amaranth and it were -11.25 Tk./bed and 0.99, respectively.

Farmers' opinion

Farmers and their neighbors are interested to cultivated red amaranth in floating bed for its higher profitability.

Table -1. Yield and profitability of different leafy vegetables on floating bed during 2021-22

Varieties	Yield (kg/bed)				Mean yield (kg/bed)	Gross Return (Tk/bed)	TVC (Tk/bed)	Gross Margin (Tk/bed)	BCR
	Tungipara	Kotalipara	Kashiani	Moksedpur					
Red-amaranth	98.5	89.3	95.2	92.8	93.95	2348.7	1800	548.75	1.30
Amaranth	75.4	70.5	69.8	70.5	71.55	1788.7	1800	-11.25	0.99
Spinach	133.8	128.4	124.6	120.3	126.77	1901.6	1800	101.62	1.05

Price (Tk/kg): Red amaranth =25/-, Amaranth= 25-/ and Spinach-15, Cost per bed (Tk): 1800/-

Conclusion: Red amaranth was profitable among the three leafy vegetable viz. Red-amaranth, Amaranth and Spinach for cultivation in floating bed.

ADAPTIVE TRIAL OF BARI HYBRID TOMATO VARIETIES ON FLOATING BED

SELIM AHMED AND RUHUL QUDDUS

Abstract

Adaptive trial of BARI tomato winter varieties was conducted at Baikunthapur under Rajoir upzilla of Madaripur district during 2021-22 to examine a suitable tomato variety for the area. Two BARI developed varieties such as BARI hybrid tomato-5 and BARI hybrid tomato-10 and one local hybrid variety were tested. The significantly highest fruit yield was found from BARI hybrid tomato-5 (30.30 t ha^{-1}) and the lowest from local hybrid tomato variety (22.70 t ha^{-1}).

Introduction

Farmers living in the low-lying areas traditionally grow selected vegetable and spice crops and their seedlings on water hyacinth made floating bed during monsoon season. As spice crop, only turmeric crop is grown on floating bed besides, seedlings of tomato also produced on floating bed. It can be mentioned that the low-lying lands become submerge during monsoon season due to heavy rainfall, which is not suitable for tomato production in this season. Cultivation of tomato on floating bed will make available in the market during monsoon season. Considering the facts, the experiment has been undertaken to evaluate the yielding abilities of selected tomato varieties as well as to introduce this crop on floating bed in flooded ecosystem.

Materials and Methods

The experiment was conducted at Baikunthapur under Rajoir upzilla of Madaripurdistrict during 2021-22 to find out the suitable variety of tomato on floating bed for that area. The experiment was laid out in a randomized complete block design with three dispersed replications. Varieties were BARI hybrid tomato-5, BARI hybrid tomato-10 and one local hybrid variety. The unit bed sizes were 9.15 m x 1.37 m. Seedlings were planted on 19 December, 2021 followed by 60 cm x 40 cm spacing. The fertilizer dose was $N_{160}P_{60}K_{40}S_{20}Zn_2$ and B_1 kgha^{-1} and applied in the form of urea, triple super phosphate, muriate of potash, gypsum and boric acid, respectively. All chemical fertilizers were applied on the floating bed in liquid form. Urea and MOP was applied two equal splits at 15 and 35 days after transplanting. The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed. This year did not appear any major disease of tomato. All tomato were started to harvest at 24 February 2022 to March 2022. Data on yield were recorded and presented in the table.

Results and Discussion

From Table 1, the significantly highest fruit yield was found from BARI hybrid tomato-5 (30.30 t ha^{-1}) and the lowest from local hybrid tomato variety (22.70 t ha^{-1}).

Farmers' opinion: Farmers choose BARI Hybrid Tomato-5 for its high yield potential, attractive color and market demand.

Table 1. Yield and yield attributes of hybrid tomato variety grown on floating bed at Baikunthapur, Rajoir, Madaripur during 2021-22

Variety	Days to 50% flowering	Final pl. pop (m^{-2})	No of fruits plant $^{-1}$	Single fruit wt. g)	Fruit yield 23 m^2 plot^{-1}(kg)	Fruit yield (tha^{-1})
BARI Hybrid Tomato-5	59 b	4.17	35.0 a	47.75 a	70.0	30.30 a
BARI Hybrid Tomato-10	62b	4.17	31.5 b	44.5 b	59.0	25.40 b
Local Hybrid Tomato	64 a	4.17	29.5 b	42.5 b	52.0	22.70 b
CV (%)	5.60	-	5.98	3.13	-	7.39

Conclusion

In the Rajoir areas like Madaripur floating agriculture is disseminating day by day. So, purpose of more dissemination and meet up to vegetable crisis further continuation is needed.

ADAPTIVE TRIAL OF BARI WINTER ONION VARIETIES ON FLOATING BED

SELIM AHMED AND RUHUL QUDDUS

Abstract

The adaptive trial of BARI winter onion varieties was conducted at Baikunthapur under Rajoir upzilla of Madaripur district during 2021-22 to find out a suitable onion variety for that area. Two BARI developed varieties such as BARI Piaz-1, BARI Piaz-4 and one local were tested. The significantly highest yield was found from BARI Piaz -4 (8.75 t ha^{-1}) and the lowest from local (5.35 t ha^{-1}).

Introduction

Farmers living in the low-lying areas traditionally grow selected vegetable and spice crops and their seedlings on water hyacinth made floating bed during monsoon season. As spice crop, only turmeric crop is grown on floating bed besides, seedlings of onion also produced on floating bed. It can be mentioned that the low-lying lands become submerge during monsoon season due to heavy rainfall, which is not suitable for onion production in this season. Cultivation of onion on floating bed will make available in the market during monsoon season. Considering the facts, the experiment has been undertaken to evaluate the yielding abilities of selected onion varieties as well as to introduce this crop on floating bed in flooded ecosystem.

Materials and Methods

The experiment was conducted at Baikunthapur under Rajoir upzilla of Madaripurdistrict during 2021-22 to find out the suitable variety of onion on floating bed for that area. The experiment was laid out in a randomized complete block design with three dispersed replications. Varieties were BARI Piaz-1, BARI Piaz-4 and local. The unit bed sizes were 9.15 m x 1.37 m. Seedlings were planted on 27 December, 2021 followed by 15 cm x 1 cm spacing. The recommended fertilize doses were applied $N_{115}P_{52}K_{75}S_{20}Zn_2$ and B_1 kgha^{-1}. All the chemical fertilizers were applied on the floating bed in liquid form in two equal splits at 25 and 50 days after transplanting. The liquid form of plant nutrients were applied around the crop plants as well as on the floating bed. This year did not appear any major disease of onion. BARI Piaz-1 and BARI Piaz-4 and local variety were harvested on 13-16 April, 2022 (107-110 DAT). Data on yield were recorded analyzed (MSTATC) and presented in the table.

Results and Discussion

The significantly highest bulb yield was found from BARI Piaz-4 (8.75t ha^{-1}) then BARI Piaz-1 (6.15t ha^{-1}) and the lowest from local (5.35 t ha^{-1}).

Farmer's opinion

Among the three varieties farmers have chosen the BARI Piaz-4 for its high yielding potentiality but BARI Piaz-1 and local also liked for its market demand and color.

Table 1. Yield and yield attributes of onionvariety grown on floating bed at Baikunthapur, Rajoir, Madaripur during 2021-22.

Variety	Plant height (cm)	No of leaves plant^{-1}	No of bulb (m^{-2})	Single bulb wt (g)	Bulb yield 23 m^{2}plot^{-1} (kg)	Bulb yield (t ha^{-1})
BARI Piaz-1	41.2 b	8.0 b	72 a	19.6 b	14.12 b	6.15
BARI Piaz-4	44.8 a	8.80 a	69 ab	29.0 a	20 a	8.75
Local	40.8 b	7.50 b	68 b	18.0 c	12.25 c	5.35
CV (%)	2.74	4.29	3.10	2.82	4.95	-

Conclusion

It was the results of first year study. To make a final conclusion there is need to repeat the experiment next year.

CHILLI PRODUCTION ON FLOATING BED IN KISHOREGANJ

M. MOHIUDDIN

Abstract

The pilot production program was conducted at Karimganj, Nikli and Kishoreganj sadar upazila's of Kishoreganj during the rabi season 2021-22 to popularize and disseminate the BARI developed chilli variety on floating bed among the farmers in the water logged haor area. Three chilli varieties such as BARI Morich-3, Hybrid and Local were selected for this program. Chilli hybrid variety (16.21 tha^{-1}) performed better followed by BARI Morich-3

(12.37 tha[-1]) and the lowest was local variety (6.48 tha[-1]). The gross return (405250 Tk/ha), gross margin (319280 Tk/ha) and BCR (4.11) were calculated from the hybrid chili variety.

Introduction

In Bangladesh total spices production is about 4.5 lakh tons and 11.5 lakh tons are imported to fulfill the national demand. Chilli is one of the most important spices crops in plain land of Kishoreganj district during *Rabi* season. It can be mentioned that the low-lying lands become submerge during monsoon season due to heavy rainfall, which is not suitable for chilli production in this season. The production of green chilli during rainy season reduces remarkably due to declining of suitable land for cultivation of this crop that ultimately increases the price of green chilli in the market. Cultivation of chilli crop on floating bed will make available of green chilli in the market during monsoon season. Considering the facts, the experiment was undertaken to evaluate the yielding abilities of selected chilli varieties as well as to introduce this crop on floating bed in flooded ecosystem.

Materials and Methods

An activity was conducted at Karimganj, Nikli and Kishoreganj sadar upazila's of Kishoreganj district during rabi season, 2021-22 to popularize and disseminate suitable chilli variety on floating bed and to introduce chilli crop under floating agriculture system in Kishoreganj areas. The work was performed in floating bed and each floating bed considered as one treatment. Three chilli varieties (BARI Morich-3, hybrid, and local) were selected for this program. The size of each floating bed was 9.15m x 1.37m (30ft long x 4.5ft wide). The number of crop row/bed was 3, plant to plant distance and number of seedling/hills was 50 cm and 1, respectively. Uniform size, healthy 20-22 days old seedlings of chilli were transplanted on 18 November 2021. The fertilizer dose (For 10 sqm floating bed area) was 47g urea, 214g diammonium phosphate, 48g muriate of potash, 24g gypsum, 2g zinc sulphate, 5g boric acid, All the chemical fertilizers was applied on the floating bed in liquid form. All kinds of fertilizers was applied in five equal splits at 15, 25, 35, 45 and 55 days after transplanting. The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed. The zinc sulphate and boric acid were applied as foliar spray. Sometimes the crop was irrigated when as necessary. Harvesting was started during 02-30 March, 2022. Data on yield were recorded and presented in the table.

Result and discussions

The highest yield per bed was recorded from hybrid chilli (20.34 kg) and lowest from local variety (8.13 kg). The local yield was the lowest among all the planted chilli due to water hyacinth of floating bed became almost rotten and roots touch the water as a result less number of chilli was harvested.

Hybrid variety gave the highest gross return Tk. 405250/ha, gross margin Tk. 309250/ha and BCR 4.11 followed by BARI Morich-3 and local due to low yield performance.

Farmers' Opinion

- Farmers were happy to get good yield from floating bed.
- Higher market price and highly demandable to customers due to fresh
- Less availability of water hyacinth in dry season as a result refill or remake may not possible of floating bed

Table 1. Yield and economic analysisof chilli on floating bed at Kishoreganj during 2021-22

Variety	Production (kg/bed)	Yield (Tk./ha)	Gross return (Tk./ha)	TVC (Tk./ha)	Gross margin(Tk./ha)	BCR(Over TVC)
BARI Morich-3	15.52	12.37	309250	85970	223280	3.14
Hybrid	20.34	16.21	405250	85970	319280	4.11
Local	8.13	6.48	162000	85970	76030	1.64

Conclusion

From second year study it may be concluded that floating bed is good way for production of chilli.

PERFORMANCE OF DIFFERENT CUCURBITS ON FLOATING BED IN SUMMER SEASON

M M HOWLADER

Abstract

An experiment was carried out with three cucurbits viz. Bottle gourd, Bitter gourd and Sweet gourd to observe their suitability and profitability during the kharif season of 2021-22. The experiment was conducted in floating bed at Tungipara, Moksedpur and Kotalipar in Gopalganj district. Among these vegetables, bottle gourd gave highest income gross and BCR it was 1775 Tk./ bed and 1.99, respectively.

Introduction

Vegetables are important part of healthy eating and provide a source of many nutrients, including potassium, fiber, folate (folic acid) and vitamins A, E and C. Potassium may help to maintain healthy blood pressure. Dietary fiber from vegetables helps reduce the blood cholesterol levels and lower risk of heart disease. Folate helps to body form healthy red blood cells. For this each person is required to take 250g vegetables per day to get vitamins and minerals. Vegetables are mainly grown on high and medium high lands. But farmers living in the low-lying areas traditionally grow selected vegetables on water hyacinth made floating bed during monsoon season. Under floating bed agriculture system, the farmers cultivate only a few numbers of vegetable crops. But the floating bed crops should be diversified to make profitable of the traditional floating agriculture practices. In this respect, different cucurbit crops can be introduced and observed their suitability in floating agriculture system. So this study was taken to identify the suitable cucurbit for floating agriculture in summer season.

Materials and Methods

The experiment was conducted on water hyacinth based floating bed at Tungipara,Kotalipar and Moksedpur inGopalganj district with three dispersed replication. The unit bed size was 9.15m (30 feet) x 1.37m (4.5 feet). Three cucurbit vegetables viz. bottle gourd (BARI Lau-4), bitter gourd (Tia) and sweet gourd (Sweety) were taken as treatments. The transplanting date of different crops was 20/06/2021 and the harvesting dates were 10/08/2021-15/09/2021. Bottle gourd, bitter gourd and sweet gourd were transplanted with the spacing of 2mx1m, 1mx1m and 2mx1m, respectively. All kinds of intercultural operations were done as and when necessary. During the crop growing period insect and disease were controlled by applying bio pesticide.

Result and Discussion

There were a significant difference was found in tested cucurbits in respect of yield and profitability (Table-1). There were three cucurbits viz. Bottle gourd, Bitter gourd and Sweet gourd were tested under this experiment. Among these vegetables, bottle gourd gave highest yield, gross margin and BCR its were 145 kg/bed, 1775 TK./bed and 1.99, respectively. At the same time the lowest yield, gross margin and BCR was recorded from bitter gourd and it were 60 kg/bed, 300 TK./bed and 1.16, respectively.

Farmers' opinion:

Farmers are showed their interested to grow bottle gourd in *kharif* season because of its higherprofitability.

Table-1. Yield and profitability of different cucurbits under floating agriculture system during the *Kharif*season of 2021-`22

Varieties	Yield (kg/bed)			Mean yield (kg/bed)	Gross Return (Tk./bed)	TVC (Tk/ bed)	Gross Margin (Tk/bed)	BCR
	Tungipara	Moksedpur	Kotalipara					
Bottle gourd	157	136	143	145.33	3575	1800	1775	1.99
Bitter gourd	63	57	60	60	2100	1800	300	1.16
Sweet gourd	85	80	82	82.33	2460	1800	660	1.36

Price (Tk/kg): Price (Tk/kg): Bottle gourd-25/-, Bitter gourd-35/- and Sweet gourd-30/-

Conclusion: Among the three cucurbits (viz. bottle gourd, sweet gourd and bitter gourd) bottle gave highest yield and profitability.

PILOT PRODUCTION PROGRAM OF SOME SLEETED CROPS ON FLOATING BED IN KISHOREGANJ

M. MOHIUDDIN, MM BASHIR, SK BHOWAL AND MM HAWLADER

Production programs with different vegetables and spices crops like bitter gourd, sweet gourd, bottle gourd, cabbage (hybrid), Cauliflower, onion, garlic and flower at Kishoreganj sadar and Karimganj area under Kishoreganj and Broccoli, cabbage (hybrid), Cauliflower and Knolhol were conducted on floating bed at Tungipara, Kotalipara, Kashiani and Muksedpur in Gopalganj districts and Sponge gourd, Sweet gourd, Bottle gourd, Bittier gourd, Ridge gourd, Okra, Brinjal, Tomato, Gimakolmi, Cucumber and Baby water melon were grown in Cumilla during the year round, 2021-22 to study the performances of selected vegetables and spices crops on floating bed system and to popularize those crops among the farmers. The work was performed in floating bed and each floating bed considered as one treatment. The size of each floating bed was 9.15m x 1.37m (30ft long x 4.5ft wide). The two or three or four rows of vegetables and spices were grown on each floating bed maintaining standard spacing for each of these vegetables and spices in the bed. Data on yield and cost with return showed in Table1.

Kishoreganj: Among the vegetables, highest yield was found from bottle gourd (54.63 t/ha) followed by cabbage (46.59 t/ha), sweet gourd (38.57 t/ha), cauliflower ((24.40 t/ha) and bitter gourd (22.81 t/ha), respectively. Among the spices, highest yield was observed in onion (15.79 t/ha) and lowest in garlic (5.92 t/ha), respectively. Among the vegetables, highest gross return, gross margin and Benefit over full cost was calculated at Tk. 279551/ha, Tk. 217101/ha and 3.59 from cabbage and the lowest gross return (Tk. 212114/ha), gross margin (Tk. 143624/ha) and Benefit over full cost (2.53) from sweet gourd, respectively. On the other hand, among the spices crops, onion gave the highest gross return (Tk. 315766/ha), gross margin (Tk. 237206/ha) and Benefit over full cost (3.36) and the lowest gross return (Tk. 236864/ha), gross margin (Tk. 171364/ha) and Benefit over full cost (2.92) found from garlic, respectively.

Gopalganj: Among the vegetables, highest yield was found from cabbage (96.04 t/ha) followed by cauliflower (87.87 t/ha), Knolkhol (84.68 t/ha) and Broccoli (78.70 t/ha), respectively. Among the vegetables, highest gross return, gross margin and Benefit over full cost was calculated at Tk. 3075372/ha, Tk. 1640796/ha and 2.14 from cauliflower and the lowest gross return (Tk. 1920738/ha), gross margin (Tk. 486162/ha) and Benefit over full cost (1.34) from cabbage, respectively.

Cumilla: The highest yield was obtained from Bottle gourd (65.2 t/ha) followed by Gimakalmi (52.63), Brinjal (52.2 t/ha) and tomato (50.2 t/ha). The highest gross return was obtained from Baby watermelon (Tk. 2496600/ha) followed by Bottle gourd (Tk. 1304000/ha). BCR also highest in Baby watermelon (17.50)

Farmers' opinion

Farmers and their neighbors are interested to cultivated cauliflower in floating bed for its higher profitability.

Table 1. Yield and economic analysis of different vegetables on floating bed in Kishoreganj during 2021-22.

Variety	Production (kg/bed)	Yield (t/ha)	Gross return (Tk./ha)	TVC (Tk./ha)	Gross margin (Tk./ha)	BCR
Kishoreganj						
Bitter gourd (Tiya)	28.62	22.81	273717	76580	197137	2.97
Sweet gourd (Dhaka-1)	48.39	38.57	212114	68490	143624	2.53
Bottle gourd (BARI lau-4)	68.54	54.63	218502	65840	152662	2.69
Cabbage (Metal hybrid)	58.46	46.59	279551	62450	217101	3.59
Cauliflower (0777)	30.62	24.40	244037	63250	180787	3.10
Onion (BARI piaz-4)	19.81	15.79	315766	78560	237206	3.36
Garlic (BARI rosun-3)	7.43	59.21	236864	65500	171364	2.92
Gopalganj						
Broccoli	98.75	78.70	2754585	1434576	1320009	1.92
Cauliflower	110.25	87.87	3075372	1434576	1640796	2.14
Cabbage	120.50	96.04	1920738	1434576	486161.9	1.34
Knolkhol	106.25	84.68	2116996	1434576	682419.8	1.47
Cumilla						
Sponge gourd (Green King)	39.02	31.10	622000	140500	481500	4.43
Sweet gourd (Hybrid Maxima)	51.57	41.10	822000	140500	681500	5.85
Bottle gourd (Hybrid Gohona)	81.81	65.20	1304000	140500	1163500	9.28
Bittier gourd (Tiya)	39.40	31.40	942000	140500	801500	6.70
Ridge gourd (Green Bangla Hybrid)	51.46	41.01	1230300	140500	1089800	8.76
Okra (Nolok)	20.83	16.60	332000	101000	231000	3.29
Brinjal (BARI Begun-10)	65.50	52.20	1044000	101000	943000	10.34
Tomato (BARI Tomato-19)	62.99	50.20	502000	130000	372000	3.86
Gimakolmi (Panpata)	66.04	52.63	1052600	101000	951600	10.42
Cucumber (Green Bangla Hybrid)	35.81	28.54	856200	140000	716200	6.12
Baby watermelon (Sweet Black 2)	52.21	41.61	2496600	142000	2354600	17.58

Conclusion

Considering the yield and profitability cauliflower was best among the four Cole crops viz. Brocolli, Cabbage, Cauliflower and Knolkhol for cultivation in floating bed.

PRODUCTION PROGRAM OF TOMATO ON FLOATING BED

M M HOWLADER

The production program of tomato was carried out on water hyacinth based floating bed atTingipara, Kotalipara, Kashiani and Muksudpur in Gopalganjdistrict during the winter season of 2021-22. The Unit bed size was 9.15m x 1.37m. The seedlings of tomato were transplanted on 10 October 2021. The crop harvesting date was from 18/12/2021 to 08/02/2022. Variety Bipul plus was used under this production program. Yield and profitability were given in table at below.

Table1. Yield and profitability of tomato grown on floating bed at four locations of Gopalganj district during the year of 2021-22

Location	Yield (Kg/bed)	Gross return (Tk./bed)	Total variable cost (Tk./bed)	Gross margin (Tk./bed)	BCR
Tungipara	128.80	3864	1900	1964	2.03
Kotalipara	110.40	3312	1900	1412	1.74
Kashiani	106.70	3201	1900	1301	1.68
Muksudpur	114.20	3426	1900	1526	1.80
Average	116.03	3481	1900	1580.75	1.83

Price (Tk./kg): Tomato-30, Cost per bed (Tk.): 1900 (Labor-1600, Bamboo- 250, Seed-50)

Conclusion: The average yield, gross margin and BCR was of tomato was found 116.03 kg/bed, 1580.75 Tk./bed and 1.83, respectively.

PRODUCTION PROGRAM OF NON-CREEPERS WITH CREEPER VEGETABLES ON FLOATING BED

A F M RUHUL QUDDUS AND SELIM AHMED

Abstract

An intercropping based activity was conducted at Amgram and Baikunthapur area under Rajoir upzilla of Madaripur district during 2021-22 to increase the vegetable crop productivity using floating agriculture technology and to popularize among the neighbor farmers for extending floating agriculture system. Three treatments were considered as T_1 = Bottle gourd + Red amaranth, T_2 = Sweet gourd + Red amaranth and T_3 = Bitter gourd + Red amaranth. The variety of creeper vegetables were for bottle gourd (hybrid dyana), sweet gourd (hybrid Dhaka-2), Bitter gourd (BARI korola-2) and non-creeper vegetables were like Red amaranth (var.BARI Lalshak-1). Each floating bed considered as one treatment. The highest yield was obtained from sweet gourd (20.14 tha^{-1}) intercropped with red amaranth (6.74 tha^{-1}) and the second highest was in bottle gourd (19.33 tha^{-1}) with red amaranth (7.39 tha^{-1}). It was the lowest among all the planted creeper vegetables due to water hyacinth of floating bed became almost rotten and roots became touch the water as a result a smaller number of bottle gourds was harvested.The lowest yield was obtained from bitter gourd (12.65 tha^{-1}) and red amaranth (7.83 tha^{-1}).

Introduction

In Rajaor upzilla of Madaripur district has many water bodies or canals near road side that are connected to Lower Kumar River. Water bodies remain unusable specially in monsoon period. Some enthusiastic farmers like farmers of Gopalganj grow creeper vegetables on floating bed made of conventional way. But cultivation of creeper vegetables on conventional floating bed is not suitable enough due to lack of wider space on it for proper growth and development of the creeper vegetables. Recently, a technology namely "Floating Bed cum Trellis (non-tidal model)" has been developed for growing creeper vegetables successfully. In this system, seedlings of creeper vegetables are transplanted on floating bed but their growth and development take place on trellis as made between two floating beds. In this system, different non-creeper vegetables could be cultivated as intercrops (Red amaranth, coriander leaves etc) with creeper vegetables on floating bed without hampering the growth and development of the creeper vegetables. Practices of intercropping would increase the crop productivity and economic return of the floating agriculture system under flooded ecosystem. In this respect, the present experiment was undertaken to evaluate the intercropping performances of different non-creepers with creeper vegetables on "Floating Bed cum Trellis (non-tidal model)" under flooded ecosystem in non- tidal areas of Madaripur.

Materials and Methods

The activities were conducted at Amgram and Baikunthapur area under Rajoir upzilla of Madaripur district during 2021-22 to increase the vegetable crop productivity using floating agriculture technology and to popularize among the neighbor farmers of floating agriculture system. The work was conducted in floating bed and each floating bed considered as one treatment. Three treatments were considered as T_1 = Bottle gourd + Red amaranth, T_2 = Sweet gourd + Red amaranth and T_3 = Bitter gourd + Red amaranth. The variety of creeper vegetables were for bottle gourd (hybrid dyana), sweet gourd (hybrid Dhaka-2), Bitter gourd (BARI korola-2) and non-creeper vegetables were like Red amaranth (var.BARI Lalshak-1). The size of each floating bed was 9.15 m X 1.37m (30ft long x 4.5ft wide) and size of whole trellis (between two floating beds) were 9.15m x 6m (30ft long x 20 ft wide). The two rows of creeper crop were grown on each floating bed maintaining 1.5 m plant to plant distance. The seedlings per hill was 2 for all. Uniform size, healthy 12-16 days old seedlings of creeper plants were selected for transplanting. The intercropped non-creeper vegetables like Red amaranth was grown in between two rows of creeper vegetables. The agronomic management (date of planting, age of seedling and fertilizer dose) were showed in Table 1. The fertilizer dose (For 10 sqm floating bed area) were different applying on vegetables. All the chemical fertilizers were applied on floating bed in liquid form. The liquid form of plant nutrients was applied around the crop plants as well as on the floating bed except Zinc and B fertilizer. The zinc sulphate and boric acid were applied as foliar spray. Sometimes the crop was irrigated as when necessary. The pheromone trap was used for controlling insect instead of pesticide. Harvesting date was also stated on Table 1. Data on plant population (m^{-2}), fruits plant^{-1}(no), individual fruit weight (kg) and fruit yield (t ha^{-1}) were recorded. The data on yield and yield attributes were analyzed mathematically.

Table1. Agronomic management of creeper and non-creeper vegetables as intercrop grown on floating bed at Amgram and Baikunthpur under Rajoir upzilla, Madaripur kharif II 2020

Intercropping	Treatment	Crops and variety	Planting date	Age of seedling	Fertilizer dose (kgha^{-1})	Harvesting date
Creeper crops	T_1	Bottle gourd (hybrid dyana)	28 Oct 2021	12-16	$N_{24}P_{27}K_{15}S_6Zn_1B_1$	63-117 DAP
	T_2	Sweet gourd (BARI Mistikumra-2)	28 Oct 2021	12-15	$N_{24}P_{27}K_{15}S_6Zn_1B_1$	69-120 DAP
	T_3	Biiter gourd (hybrid Dhaka-2)	31May 2021	12	$N_{69}P_{35}K_{75}S_{18}Zn_{4.3}B_{1.3}$	55-96 DAP
Non-creeper crops	T_1+, T_2 + and T_3	Red amaranth (BARI Lalshak-1)	31May-28Oct 2021	--	--	26-44 DAP

Result and discussions

Performance of creeper vegetables were presented in Table 2. The plant populations at harvest period per plot were 16 for each of creeper vegetables. The fruits plant^{-1}(no) were 5.45, 4.10 and 34.0 for bottle gourd, sweet gourd and bitter gourd, respectively. Yield performance of creeper and non-creeper vegetables were presented in Table 3. The single fruit weight was 1.49 kg, 2.07 kg and 93.0 gm kg for bottle gourd, sweet gourd and bitter gourd, respectively. The highest yield was obtained from sweet gourd (20.14 tha^{-1}) intercropped with red amaranth (6.74 tha^{-1}) and second highest was bottle gourd with red amaranth. The lowest yield was obtained from bitte gourd (12.65 tha^{-1}) and red amaranth (7.83 tha^{-1}).It was the lowest among all the planted creeper vegetables due to water hyacinth of floating bed became almost rotten and roots touch the water as a result a smaller number of bottle gourds was harvested.

Farmers' Opinion

- Yields of all vegetables obtained higher over conventional practice

- Higher demand to customers along with higher market price due to pesticide free production
- Initially invest cost is higher
- Less availability of water hyacinth in dry season as a result repair or refill of floating bed may not possible
- Neighboring farmers showed interest to grow vegetables following modern technique of floating bed

Table 2. Growth of creeper vegetables grown on floating bed at Amgram and Baikunthpur, Rajoir, Madaripur during 2021-2022

Treatments	Pl. pop plot^{-1}	Fruits pl^{-1} (no)	single fruits wt (g)	Fruit wt/trelli (67.25 m^2 (kg)	Fruit length (cm)	Fruit dia (cm)
T_1 (Bottle gourd)	16	5.45	1486	130	28.75	28.95
T_2 (Sweet gourd)	16	4.10	2065	135.46	8.40	53.10
T_3 (Bitter gourd)	16	34.0	93	50.60	14.72	5.26

Table 3. Yield of creeper and non-creeper vegetables grown on floating bed as intercropped at Amgram and Baikunthpur, Rajoir, Madaripur during 2021-2022

T_1 yield (t ha^{-1})		T_2 yield (t ha^{-1})		T_3 yield (t ha^{-1})	
Bottle gourd	Red amaranth	Sweet gourd	Red amaranth	Bitter gourd	Red amaranth
19.33	7.39	20.14	6.74	12.65	7.83

Table 4. Cost and return of different creeper and non-creeper vegetablesat Amgram and Baikunthpur Rajoir, Madaripur during 2021-22

Treatments	Fruit yield/ plot (kg)	Gross return (Tk plot^{-1})	*TVC (Tk plot^{-1})	Gross margin (Tk plot^{-1})	Remarks
T_1(Bottle gourd+ Red amaranth)	130.0 + 17.0	3590.0.	2460	1130	Profitable
T_2 (Sweet gourd+Red amaranth)	135.46+15.50	3697	2460	1237	
T_3 (Bitter gourd+Red amaranth)	50.60+18	1842	1813	29	Profitable

Input price (TVC): Bed: structure cost (Seed: 50, ferlilizer: 50, bamboo (borok): Tk.800, labor: Tk.1200,)Tk. 2100/structure. One structure can use continuing 2 times, so one time preparing cost is Tk. 1050 (i.e.2100/2)

Input price (TVC): Trellis: Net: 340, bamboo (borok): Tk.2400, bamboo (Tolla): Tk.1500) Tk. 4240/. One trellis can use continuing 3 times, so one time preparing cost is Tk.1413 (i.e.4240/3) (N.B: bitter gourd trellis is smaller in size than bottle gourd amd sweet gourd, so the cost is half.

Output price (Tk kg^{-1}): Bottle gourd -25.25, Sweet gourd - 25.25,Bitter gourd -30 and Red amaranth: 20

Conclusion

From the study it reveals that floating bed cum trellis (non-tidal model)" is a good way for production of creeper vegetables with non-creeper simultaneously. Sweet gourd with red amaranth performed better followed by bottle gourd with red amaranth.

PRODUCTION PROGRAM OF SPICES USING FLOATING BED AND EX SITU IN MADARIPUR

SELIM AHMED AND AFM RUHUL QUDDUS

Production program with different spices crops like turmeric (BARI Halud-4) on floating bed, onion (BARI Piaz-5) and garlic (BARI Rasun-1)) on ex-situ bed were conducted at Baikunthapur Hijalbari and Amgram area under Rajoir upzilla of Madaripur during 2021-22 to study the performances of selected spices crops using different floating agriculture technology and to popularize those varieties among the neighbor farmers. The work was performed in floating ex-situ bed and each floating bed considered as one treatment. The size of each floating bed was 10 m X 1.37 m. The two rows of turmeric were grown maintaining 25 cm plant to plant spacing. The ten rows of onion and garlic were grown in each floating bed maintaining standard spacing. Weeding and watering of bed was done timely and pest management was also done by use of organic pesticide like sex pheromone trap, bio-pesticide etc. The agronomic management of different spices crop was given in Table 1. Data of fruit yield per plot (kg plot^{-1}) were recorded. The fertilizer application method of each crop was given in below:

Turmeric: All kind of fertilizer were applied on the floating bed in five equal splits each one moth interval after 25 days after planting.

Onion: The fertilizer dose for 10 square meter area of bed was 240g urea, 260g TSP, and 150 g MoP, 110g gypsum, 5.5 g zinc sulphate mono hydrate and 6g boric acid. All kinds of fertilizer were applied as liquid form in two equal splits at 25 and 50 days after transplanting (DAT).

Garlic: The fertilizer dose for 10 square meter area of ex situ bed was 270g urea, 260g TSP, and 330g MoP. All kinds of fertilizer were applied as liquid form in two equal splits at 25 and 50 days after planting (DAS).

Farmers' Opinion

- Plain land was inundated due to flood but turmeric was grown on floating bed.
- Family demand can meet up of onion and garlic when market price is high
- Neighboring farmers showed interest to grow spices following floating technique.

Table 1. Agronomic management of different spices crop using floating technology at Baikunthapur Hijalbari and Amgram under Rajoir upzilla, Madaripur during 2021-22

Floating technology	Crop	Variety	Planting date	Age of seedling	Fertilizer dose (kgha^{-1})	harvesting date
Floating bed	Turmeric	BARI Halud-4	03 Aug. 2021	--	$N_{44}P_{18}K_{53}S_{8.5}B_1$	03April 2022 (243 DAP)
	Onion	BARI Piaz-5	11 Nov. 2021	30	$N_{115}P_{52}K_{75}S_{20}$ Zn_2B_1	05 March 2022 (80 DAT)
Ex situ bed	Garlic	BARI Rasun-1	02 Nov 2021	--	$N_{125}P_{52}K_{165}$	04April 2022 (153 DAP)

Table 2. Yield of different spices at Baikunthapur Hijalbari and Amgram, Rajoir, Madaripur during 2021-22

Floating technology	Crops	Variety	Yield (kg)	Remarks
Floating bed (23m^{2}plot^{-1})	Turmeric	BARI Halud-4	26	Fresh and organic food & insecticide free Need locality awareness, build up safe food corner near to market
	Onion	BARI Piaz-5	30	
Ex situ bed (10m^{2}plot^{-1})	Garlic	BARI Rasun-1	8	

Table 3. Cost and return of different spices at Baikunthapur Hijalbari and Amgram Rajoir, Madaripur during 2021-22

Crops	Crop yield/ 23m^{2}plot (kg)	Gross return (Tk plot^{-1})	*TVC (Tk plot^{-1})	Gross margin (Tk plot^{-1})	Remarks
Turmeric	26	520	1105	-585	Non- profitable but can consider as an alternate growing place for turmeric/onion
Onion	30	750	1105	-355	
Garlic	08	400	260	140	Profitable

Input price (TVC): structure cost (Seed: 160, ferlilizer: 50, bamboo: Tk.800, labor:Tk.1200,):Tk. 2210/structure. One structure can use continuing 2 times, so one time preparing cost is Tk. 1105 (i.e.2210/2).

Input price (TVC): Garlicstructure cost (Seed+ ferlilizer: 60, labor:Tk.200,):Tk. 260/structure.

Output price (Tk kg^{-1}): Halud-20, Onion- 25 and Garlic-50

Conclusion

From the study, it reveals that floating agriculture is a good way for production of spices crop. Turmeric and onion gave the best performance than garlic but both are non- profitable except garlic. All floating products are poisonous free so it is human health oriented.

ADAPTIVE TRIAL, DEVELOPMENT OF PRODUCTION TECHNOLOGY AND COMMUNITY-BASED PILOT PRODUCTION PROGRAM OF SUMMER TOMATO IN BANGLADESH

IMPACT OF GRAFTING AND MULCHING TECHNOLOGY ON GROWTH, YIELD AND QUALITY OF SUMMER TOMATO VARIETIES

M F HOSSAIN, Q NAHER, M AKHTAR HOSSAIN, K U AHMED, M S ALAM, M R ALOM, M S RAHMAN, MM BASHIR, MAH TALUKDER AND M M BASHIR

Abstract

A multilocation trial has been carried out at 7 OFRD stations, MLT sites under BARI and farmers' fields located at Gazipur, Jashore, Bogura, Pabna, Rajshahi, Cumilla, and Rangpur during 2021-22 to evaluate the effect of different management packages (grafting and mulching techniques) on BARI developed summer tomato production. The tested variety was BARI Hybrid Tomato-8 (BHT-8). Significant variations on yield and other related traits were observed among the tested location. It was revealed that non-grafted plant contributed to higher fruit yield over the grafted plants. Mulching has a positive yield response over the non-mulch condition. Between the polythene mulch and straw mulch, straw mulch facilitated higher yield over the polythene mulch. Grafted plants with mulching provided higher fruit yield over non-grafted plants without mulch treatment. The results suggest that grafted plants with mulching exhibited positive response on summer tomato production. However, the trial should be repeated next season with intensive observation and uniform data set across the testing location to obtain conclusive results.

Introduction

Protected and semi-protected cultivation of tomatoes has been gaining importance in Bangladesh for the last 20 years especially in the summer rainy season. High return from the unit plot has offered young farmers an opportunity to invest and take agriculture as a profession. Low height tunnels, and high-density planting are the common practices often face weed and wilt incidence which incurred cost and yield reductions. Mulching is one of the important techniques or practices of covering the soil to make more favorable conditions for plant growth, development, efficient crop production, and reduced weed production. It also improves the microbial activity of the soil by improving the environment around the root zone. Black films, commonly used for this purpose, ensure weed-free conditions, limit evaporation and increase soil temperature. Wilt disease is the potential threat for growing tomato during summer season, and thereby, grafting on Wilt resistant stocks (BARI Begun-8 and EG203) has been standardized by Olericulture division of BARI, which is being practiced by the farmers at different locations. Grafted seedling is gaining popularity as an enterprise in the summer tomato growing zone. However, grafting and mulching techniques were adequately studied in the research field. To evaluate the impact of grafting and mulching techniques on summer tomato at farmers' field is deemed imperative. Therefore, the present study was undertaken to optimize the grafting techniques, mulching methods, and suitable variety to evaluate the combinations in farmers' field conditions and increase the productivity and income of farmers.

Materials and Methods

The experiment was conducted at On-Station and on-farm by OFRD under BARI during June 2021-2022. BARI Hybrid Tomato-8 was used in this experiment. The experiment was laid out in RCB design with four replications. There were six treatments viz. T_1= No Mulch + Non grafting, T_2= Polythene Mulch + Non-Grafting, T_3= Straw Mulch + Non-Grafting, T_4= No Mulch + Grafting, T_5= Straw Mulch + Grafting, and T_6= Polythene Mulch + Grafting. The unit plot size was 1.2 m ×4 m with plant spacing of 60 cm × 40 cm. Twenty-five days old non-grafted and grafted seedlings were transplanted during June to September, 2021. The fertilizers were used 253-90-125-22-5.5-2 kg ha^{-1} N-P-K-S-Zn-B and Cowdung 10 t ha^{-1}. Half of cowdung and P and entire amount of S and B were applied during final land preparation. The remaining half of cowdung and P were applied during pit preparation before a week of planting. The entire N and K were applied in 3 equal installments of 25, 40 and 55 days after seedling transplanting. Plant protection measures were taken as required. Other intercultural operations were done when necessary. Harvest of tomatoes was started on18 October 2021 and continued up to 18 December 2021. At maturity, different data were collected accordingly and subjected to statistical analysis. The gross economic return was calculated based on the prevailing market price of the commodities.

Results and Discussion

The yield and other characters of Tomato are shown in Table 1. Results revealed that parameter studied in this experiment varied widely over the locations and among the treatment implied. The fifty percent plant flowering in the treatment T1 ranges 22-38 days where the lowest days required at Gazipur (22 days) and the highest was in Bogura (38 days), the average of this treatmet was 32 days. In the treatment T2, T3, T4, T5 and T6 the ranges were 24-39, 26-38, 21-43, 22-44, and 22-44 days respectively for flowering. The treatment variations was very narrow over the location, its took around 33 days. Days to first harvest varied over the locations ranges in T1, T2, T3, T4, T5 and T6 were 48-87, 50-87, 49-89, 52-83, 44-85, 47-84 days respectively. Interestingly in all treatments it took around 60 days after planting. This parameter is very important to design commercial agriculture. The longevity of the productive plant found the highest in grafted with mulched plant. This result support the production increment of grafted plant. Number of fruits per plant found large variations over the location which was ranges 16-36, 18-38, 18-40, 18-35, 16-39 and 19-42 in T1, T2, T3, T4, T5 and T6 respectively. It is revealed that the grafted plant set more fruits than the non-grafted one in every location with little exception. Individual fruits weight also varied over locations. The heaviest fruits were observed on Gazipur and the smallest fruits were in Cumilla. Yield per plant found higher in all treatment over the control across locations. The highest fruit yield was found in Jashore and the lowest in Cumilla. Reduction of wilt was the main goal of the experiment and it was revealed that the grafted plant minimized the wilt infection than the non-grated plant. Feeding insects like Leaf miner, Jassid, whitefly, Hopper, Thrips, etc. were observed in all the treatments.

Farmers' Opinion

The yield performance under no mulch along with non-grafted seedlings is higher than other both plastic and straw mulch.

Table 1. Yield contributing traits, yield and other characters of Tomato affected by grafting and mulching during summer season, 2021.

Treatment	Location	DFPF	DFH	DLH	NFPP	IFW (g)	YPP (kg)	Yield (t ha^{-1})	Price / kg (Tk.)	% Wilt
T_1	Bogura	38.0	49.0	108.0	26.1	46.1	1.3	29.9	60.0	6.1
	Cumilla	35.0	53.0	79.0	16.9	38.1	1.4	10.7	70.0	6.9
	Jeshore	37.0	51.0	83.0	36.0	54.0	2.1	63.9	80.0	2.3
	Pabna	35.0	87.0	79.0	36.0	49.1	2.3	40.8	70.0	1.7
	Rangpur	26.0	63.0	137.3	35.7	38.3	2.0	16.9	85.5	28.3
	Gazipur	22.0	48.0	97.0	35.0	68.0	2.1	38.5	80.0	14.0
	Average	***32.2***	***58.5***	***97.2***	***30.9***	***48.9***	***1.9***	***33.4***	***74***	**9.9**
T_2	Bogura	39.0	51.0	108.0	28.2	48.2	1.3	30.5	60.0	5.1
	Cumilla	34.8	58.0	80.0	18.7	43.6	1.8	11.2	70.0	6.8
	Jeshore	36.0	56.0	85.0	36.0	56.0	2.2	37.0	80.0	
	Pabna	36.0	87.0	131.0	36.0	44.9	2.3	45.0	70.0	1.6
	Rangpur	26.7	64.0	137.0	29.1	42.8	2.3	18.1	85.5	27.7
	Gazipur	24.0	50.0	107.0	38.0	62.0	2.9	39.6	80.0	12.0
	Average	***32.7***	***61.0***	***108.0***	***31.0***	***49.6***	***2.1***	***30.2***	***74***	**10.6**
T_3	Bogura	38.0	52.0	108.0	27.8	49.4	1.4	31.3	60.0	4.9
	Cumilla	34.8	54.0	80.0	18.5	42.8	1.9	11.8	70.0	10.0
	Jeshore	37.3	57.0	85.0	36.0	57.7	3.6	62.9	80.0	4.3

Treatment	Location	DFPF	DFH	DLH	NFPP	IFW (g)	YPP (kg)	Yield (t ha^{-1})	Price / kg (Tk.)	% Wilt
	Rangpur	29.0	66.0	138.3	33.7	41.1	2.3	21.4	70.0	25.0
	Pabna	37.0	89.0	122.2	36.0	47.6	2.0	47.0	85.5	1.7
	Gazipur	26.0	49.0	110.3	40.0	78.0	2.9	40.2	80.0	8.6
	Average	***33.7***	***61.2***	***107.3***	***32.0***	***52.8***	***2.3***	***35.8***	***74***	***9.1***
T_4	Bogura	43.0	55.0	110.0	23.4	44.8	1.2	27.7	60.0	3.6
	Cumilla	38.0	58.0	90.0	18.3	41.0	1.9	10.4	70.0	3.0
	Jeshore	32.0	52.0	95.0	34.0	60.3	2.8	61.3	80.0	5.7
	Pabna	37.0	83.0	123.0	28.0	44.3	2.6	45.4	70.0	1.2
	Rangpur	21.3	58.0	131.3	31.6	37.5	2.0	19.9	85.5	18.3
	Gazipur	26.0	52.0	109.0	35.0	72.0	2.9	42.1	80.0	0.0
	Average	***32.9***	***59.7***	***109.7***	***28.4***	***50.0***	***2.2***	***34.4***	***74***	***5.3***
T_5	Bogura	44.0	57.0	110.0	25.9	48.2	1.3	28.4	60.0	3.0
	Cumilla	38.0	58.0	92.0	16.7	42.5	1.9	11.8	70.0	2.5
	Jeshore	34.0	56.0	95.0	39.0	59.0	2.4	63.4	80.0	4.7
	Pabna	37.0	85.0	121.0	34.0	45.9	2.7	48.7	70.0	1.5
	Rangpur	22.3	59.3	132.3	34.5	40.7	2.1	22.2	85.5	24.0
	Gazipur	22.0	44.0	109.0	39.0	65.0	3.2	56.0	80.0	0.0
	Average	***32.9***	***59.9***	***109.9***	***31.5***	***50.2***	***2.3***	***38.4***	***74***	***5.9***
T_6	Bogura	44.0	58.0	110.0	25.5	47.2	2.1	28.0	60.0	3.1
	Cumilla	38.0	59.0	99.0	19.7	46.5	2.4	11.3	70.0	2.5
	Jeshore	34.0	54.0	94.0	35.0	57.3	3.1	60.8	80.0	4.3
	Pabna	36.0	84.0	122.0	36.0	40.7	3.3	28.4	70.0	
	Rangpur	22.0	59.0	132.0	32.0	38.3	2.2	20.8	85.5	20.7
	Gazipur	23.0	47.0	121.0	42.0	71.0	2.9	56.0	80.0	0.0
	Average	***32.8***	***60.2***	***113.0***	***31.7***	***50.2***	***2.7***	***34.2***	***74***	***6.1***

T_1= No Mulch + non-Grafting, T_2= Polythene Mulch + non-Grafting, T_3= Straw Mulch + non-Grafting, T_4= No Mulch + Grafting, T_5= Straw Mulch + Grafting, T_6= Polythene Mulch + Grafting

DFPF: days to fifty percent flowering, DFH: days to first harvest, DLH: days to last harvest, NFPP: number of fruits per plant, IFW: individual fruit weight, YPP: yield per plant

Conclusion

The results revealed that grafted plants with mulching provided higher fruit yield over non-grafted plants without mulch treatment. The results suggest that grafted plants with mulching exhibited positive response on summer tomato production. However, the trial should be repeated next season with intensive observation and uniform data set across the testing location to obtain conclusive results.

ON-FARM ADAPTIVE TRIAL OF BARI DEVELOPED SUMMER HYBRID TOMATO VARIETIES IN DIFFERENT LOCATIONS OF BANGLADESH

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Abstract

An experiment was conducted at the FSRD site/MLT sites of Dinajpur, Rangpur, Gaibandha, Bogura, Barind, Rajshahi, Pabna, Kushtia, Jashore, Khulna, Faridpur, Bhola, Patuakhali, Tangail, Mymensing, Sherpur, Kishoreganj, Gazipur, Narsingdi, Sylhet, Cumilla, Noakhali, Bandarban and Cox'sbazer during kharif II, 2021. BARI developed two summer tomato varieties viz. BARI Hybrid Tomato-8 (BHT-8) and BARI Hybrid Tomato-11 (BHT-11) with two

advanced lines viz. Cross-4 and Cross-12 were included in the study to evaluate the performance in the respective sites. The trial was laid out in RCB design with 3 compact replications. Experiment was damaged in some sites viz. Rangpur, Gaibandha, Bandarban etc. Maximum virus infestation was observed in Cross-4 (38.33%) followed by BHT-8 (26.67 %) and Cross-12 (26.67%). The lowest virus infestation was observed in BHT-11 (23.33%). In most cases BHT-8 performed better across all the locations, while BHT-11 performed better in the northern districts of the country. Between two advance lines, Cross-12 performed better in all the locations. BARI Hybrid Tomato-11 and Cross-12 was overall accepted through the farmer's evaluation regarding more number of fruit plant^{-1}, fruit structure, shape, keeping quality as well as yield

Introduction

Tomato (*Solanum lycopersicum*) is one of the most popular and widely grown vegetables in the world ranking second in importance to potato in many countries. But as a processing crop it ranks first among the vegetables. It is most highly praised for its outstanding nutritive value and is consumed widely. It is a major source of vitamins and minerals and also rich in medicinal value. It is one of the most popular salad vegetables and is taken with great relish. In European countries tomato is popularly known as the golden apple or love apple. It is also an excellent source of Vitamin C (20.9-22.5 mg per 100 g) and is commonly referred to as poor man's orange. Global tomato production has increased 291 percent since 1961, reaching 108 million metric tons in 2002, while yield increased 64 percent reaching an average of 36 tons per hectare (FAS/ USDA, September 2003). The top five tomato-producing countries in the world are the United States, China, Turkey, Italy and India. The area under tomato cultivation in Bangladesh is 28.53 thousand hectares and production is 415.49 thousand metric ton and the average yield is 14.57 t ha^{-1} (BBS, 2020). Although the figure both in terms of production and area seems very low which needs to be validated, there is lot more potential to increase the area and production of tomato in Bangladesh.

Tomato is an annual warm-season crop and requires a relatively long season to produce. The climatic conditions play a major role to produce tomato. Among the environmental conditions, the temperature has profound influence on tomato production. The extremes of summer or winter conditions affect the crop, and the varieties should be suitably selected to overcome this problem. Extremely high temperatures, that is, 38^{0}C generally caused a marked decreased in pollen germination of almost all cultivars of tomato. Environmental factor such as light intensity, temperature, moisture markedly influence the process of fruit set of tomato and subsequent fruit development and yield. A well-drained, fairly light fertile loam soil with a fair moisture holding capacity is ideal for growing a good crop of tomato. Tomato prefers a soil reaction ranging from pH 6.0 to 7.0. Tomato is a high-value cash crop grown throughout the country. It is an important and popular vegetable in Bangladesh and normally grown in winter season. Its cultivation is limited in the summer season throughout the country due to the adverse weather conditions of this period, specially temperature (both day and night), humidity, rainfall and light intensity, which are the basic limiting factors of tomato production. High day and night temperatures above 32°C and 21°C were reported as limiting fruit-set due to an impaired complex of physiological process in the pistil, which results in floral or fruit abscission. So prevailing temperature in our county during the summer and rainy seasons is high and not favorable for tomato cultivation.

But demand and market price of tomato during summer and the rainy season is very high in Bangladesh. Hybrid tomato varieties have many advantages compared to open-pollinated (OP) varieties. Hybrids usually produce higher yields and generally matured earlier and more uniformly compared to OP varieties. Many hybrids have better fruit quality, heat tolerant and disease resistance capacity. Therefore, summer tomato production in Bangladesh is gaining popularity day by day during last couple of years. Recently, BARI has developed some hybrid summer tomato varieties which are able to produce flowers and fruits even under high-temperature conditions. Moreover, BARI currently working with some advanced lines to develop new summer hybrid varieties. So, the present study was undertaken to observe the performance of different summer tomato varieties along with two lines and one commercial hybrid varieties in the farmer's field condition with the following objectives:

- To evaluate the performance of summer hybrid tomato variety at farmers' field condition.
- To popularize and disseminate the BARI developed summer hybrid tomato variety at farmer's level.

Materials and Methods

The experiment was carried out at the FSRD site/MLT sites of Dinajpur, Rangpur, Gaibandha, Bogura, Barind, Rajshahi, Pabna, Kushtia, Jashore, Khulna, Faridpur, Bhola, Patuakhali, Tangail, Mymensing, Sherpur, Kishoreganj, Gazipur, Narsingdi, Sylhet, Cumilla, Noakhali, Bandarban and Cox'sbazer during kharif II, 2021. BARI developed two summer tomato varieties viz. BARI Hybrid Tomato-8 (BHT)-8 and BARI Hybrid Tomato-11 (BHT-11) with two advanced lines viz. Cross-4 and Cross-12 were included in the study to evaluate the performance in the respective sites. In some sites, one commercial variety also included in this study. The experiment was laid out in randomized complete block design having three replications. The unit plot size was 12.0 m x 2.4 m. Plant to plant and row to row spacing as 60 cm x 40 cm, respectively. The field was fertilized at the rate of 10 t ha^{-1} cowdung, 210 kg ha^{-1} of N in the form of Urea, 50 kg ha^{-1} of P in the form of TSP and 75 kg ha^{-1} of K in the form of MoP. Half of cowdung, the whole amount of TSP and half of MoP were applied during final land preparation. The remaining half of the cowdung was applied during pit preparation. The rest amount of MoP and entire amount of Urea were top dressed in three equal installments at 12, 27 and 46 days after transplanting. Intercultural operations and irrigation were done as and when necessary for the proper growth of the crop. The seeds were sown on seed bed and thirty days old seedlings were transplanted in the main field. A one-meter-wide channel was made in between two beds to facilitate drainage. The tomato was started to harvest 60-65 days after transplanting. The hormone, Tomatoton (2%) was sprayed into flowers at the anthesis stage (30-35 days after transplanting) in each tunnel. Intercultural operations and weeding were done as and when necessary. Irrespective of location insecticides (viz. Imitaf, Admire and Pegasus etc.) and fungicides (viz. Dithane M-45, Provex, Autostin, Desis and Ridomil gold etc.) were used for controlling pest and disease. Bio control measures like yellow sticky trap was also applied at 34-40 DAT to control *Aphid, Jassid* etc. To control blossom end disease Calcium chlorite was sprayed @ 4.0 mg L^{-1}. Harvesting was started at 50-60 DAT and finished at 125-130 DAT with a number of total 08 times harvesting irrespective of varieties. Data on yield and yield contributing characters were taken and analyzed statistically.

Results and Discussion

1. Barind, Rajshahi

Yield and yield component of tomato responded significantly due to different tomato hybrids (Table 1). Days to flowering and maturity were considered for choosing suitable variety. Among the tested tomato hybrids, BARI tomato hybrid-11 (BHT-11) took least days for their flowering (24 days) and fruit maturity (55 days). The BHT-8 was second regarding fruit maturity (56.67 days) while Cross-12 acquired the highest number of days for its maturity (59). Individual fruit weight was not differed significantly among the hybrids and ranging from 64-68 g. The BHT-11 produced the highest no. of fruits plant^{-1} (66). Among the three hybrids the highest fruit yield was found in BHT-11 (55.38 t ha^{-1}). BHT-8 ranked second considering fruit yield (44.50 t ha^{-1}). The Cross-12 contributed the lowest yield (34.44 t ha^{-1}). However, the fruit yield in BHT-11 was higher among the tested hybrids due to higher no. of fruits per plant and relatively more no. of harvesting.

Market prices of tomato in early season remain higher compared to later one. Gross return and gross margin were much higher in BHT-11 than other hybrids due to higher fruit yield and also market price (Table 3). In respect of economic analysis, the maximum gross return (Tk. 3597372 ha^{-1}), gross margin (Tk. 2362372 ha^{-1}) and BCR (2.92) were obtained from BHT-11. The lowest gross return (Tk. 1938890 ha^{-1}), gross margin (Tk. 703890 ha^{-1}) and BCR (1.57) were recorded in Cross-12 (Table 3). However gross return in each harvest is shown in Table 1. The BHT-11 produced fruit continuously throughout the life cycle and more in early period of harvest when market price of tomato was higher and that contributed to higher gross margin.

Table 1. Agro-economic performance of hybrid tomato varieties at High Barind Tract during 2021-22

Variety /Lines	DF (days)	DM (days)	PH (cm)	Fruit Plant^{-1}	IFW (g)	Yield (t ha^{-1})	Cost and return analysis (Tk. ha^{-1})		
							GR	TC	GM
BHT-8	28.67a	56.67b	153.63	55.67b	67.97	44.50b	3069128	1235000	1834128
BHT-11	24c	54.67c	144.93	66a	64.53	55.38a	3597372	1235000	2362372
Coss-12	26.33b	59.33a	141.26	30.67c	65.73	34.44c	1938890	1235000	703890
$LSD_{(0.05)}$	0.93	1.51	14.08	7.83	11.85	3.40	-	-	-
CV (%)	1.55	1.17	4.24	6.80	7.92	5.84	-	-	-

Note: DF= Days to flowering, DM= Days to maturity, PH= Plant height, IFW= Individual fruit weight, GR= Gross return, TC= Total cost and GM= Gross margin.

2. Charfashion upazila, Bhola

Yield and yield attributing characters are presented in (Table 2). Plant height was highest in BHT-11 (152.50 cm) followed by commercial hybrid, *Marvelous* (149.25 cm), BHT-8 (142.25 cm), Cross12 (141.52 cm) and Cross 4 (138.25 cm), respectively. The highest fruit per plant (26.52) was obtained from BHT-8 followed by cross-12 (24.26). The maximum individual fruit weight (77.12 g) was obtained from *Marvelous* followed by BHT-8 (72.65 g) and the lowest from cross 4 (63 g). The highest fruit yield (40.39 t ha^{-1}) was recorded in BHT-8 and followed by Cross 12 (38.80 t ha^{-1}) and the lowest yield was obtained from Cross 4 (31.25 t ha^{-1}).

The highest gross return (Tk. 2827300 ha^{-1}) was found in BHT-8 variety followed by Cross-12 (Tk. 2716000 ha^{-1}), BHT-11 (Tk. 2668400 ha^{-1}), Marvelous (Tk. 2544500 ha^{-1}) and Cross 4 (Tk. 2187500 ha-1) respectively against total cost of Tk. 1245000 ha^{-1}. The highest gross margin (Tk. 1582300 ha^{-1}) was also obtained from BHT-8 and the lowest from Cross 4 (Tk. 942500 ha^{-1}).

Table 2. Agro-economic performance of hybrid tomato varieties at Charfashion, Bhola ,d 2021-22

Variety/ lines	Variety /Lines	pH (cm)	Fruits plant^{-1} (no.)	IFW (g)	Yield plant^{-1} (kg)	Yield (t ha^{-1})	Cost and return analysis (Tk. ha^{-1})		
							GR	TC	GM
BHT-8	BHT-8	142.25	26.52	72.65	1.65	40.39	2827300	1245000	1582300
BHT-11	BHT-11	152.50	23.14	70.25	1.50	38.12	2668400	1245000	1423400
Cross 4	Coss-12	138.25	16	63.35	1.16	31.25	2187500	1245000	942500
Cross 12	$LSD_{(0.05)}$	141.52	24.26	67.50	1.57	38.80	2716000	1245000	1471000
Marvelous	CV (%)	149.25	20	77.12	1.37	36.35	2544500	1245000	1299500
$LSD_{(0.05)}$		NS	**	NS	*	**	-	-	-
CV (%)		12.63	9.61	11.23	6.51	8.26	-	-	-

Note: PH= Plant height, IFW= Individual fruit weight, GR= Gross return, TC= Total cost and GM= Gross margin. Average market price of tomato @ Tk.70 kg^{-1}.

3. MLT site, Cox's bazar

Average yield and yield attributing characters of different summer tomato varieties and lines are presented in Table 3. The maximum number of tomato fruits Plant^{-1} was recorded from BHT-8 (21.0). On the other hand, the highest (67.8 g) individual fruit weight and fruit yield (46.8 t ha^{-1}) was recorded from BHT-11 (Table 7) while the line Cross-4 showed the lowest yield of fruit (32.2 t ha^{-1}). The highest gross return (Tk. 3744000 ha^{-1}) and gross margin (Tk. 1889000 ha^{-1}) was also obtained from BHT-11 and the lowest (Tk. 2576000 ha^{-1} and Tk. 721000 ha^{-1}) in Cross-4 line (Table 3).

Table 3. Agro-economic performance of hybrid tomato varieties at Cox's bazar during the Kharif season of 2021

Varieties/ lines	Plant height (cm)	Fruits plant^{-1} (no.)	IFW (g)	Fruit yield (t ha^{-1})	Cost and return analysis (Tk. ha^{-1})		
					GR	TC	GM
BHT-8	96	21.0	52.4	40.0	3200000	1855000	1345000
BHT-11	104.60	17.4	67.8	46.8	3744000	1855000	1889000
Cross-4	100	14.6	58.4	32.2	2576000	1855000	721000
Cross-12	98.60	16.2	58.0	34.8	2784000	1855000	929000
LSD (0.05)	1.57	2	3.44	1.23			
CV (%)	7.15	8.43	4.22	5.34			

IFW= Individual fruit weight, GR= Gross return, TC= Total cost and GM= Gross margin. Average market price of tomato @ Tk. 80 kg^{-1}.

4. MLT site, Cumilla

Average yield and yield attributing characters of different summer tomato varieties and lines are presented in Table 4. The highest per cent of plant mortality due to bacterial wilt were recorded from BHT-11 (12.6%) as compared to others. Maximum number of fruits per plant (22), fruit yield per plant (0.445) and fruit yield per hectare (16.7) was recorded from the variety BHT-8 and the lowest from the line Cross-4. The highest individual fruit yield was recorded from the BHT-8 (44.3 g) and the lowest from the line Cross-4 (39.8 g). The highest gross return (Tk. 1169000 ha^{-1}) and gross margin (Tk. 584600 ha^{-1}) were also obtained from BHT-8 and the lowest (Tk. 812000 ha^{-1} and Tk. 227600 ha^{-1}) in Cross-12 advance line.

Table 4. Agro-economic performance of hybrid tomato varieties in Cumilla region during the Kharif season of 2021

Varieties/ lines	Fruits plant^{-1} (no.)	IFW (g)	Yield plant^{-1} (kg)	Yield (t ha^{-1})	Cost and return analysis (Tk. ha^{-1})			Plant protection (%)	
					GR	TC	GM	Virus infestation	Wilt
BHT-8	22.0	44.3	0.445	16.7	1169000	584400	584600	6.2	7.6
BHT-11	20.0	40.7	0.390	15.1	1057000	584400	472600	8.2	12.6
Cross-4	21.8	39.8	0.380	13.1	917000	584400	332600	14.6	8.4
Cross-12	19.0	43.4	0.276	11.6	812000	584400	227600	9.6	10.0
LSD (0.05)	4.65	3.82	0.036	3.313	-	-	-	6.811	4.252
CV (%)	16.31	13.50	7.18	16.98	-	-	-	51.22	31.98

IFW= Individual fruit weight, GR= Gross return, TC= Total cost and GM= Gross margin. Average market price of tomato @ Tk. 70 kg^{-1}.

5. MLT site, Dinajpur Sadar

Yield, yield contributing characters and virus infestation of four varieties/lines varied significantly (Table 5). The maximum time for 50% flowering was recorded from local variety (39.33 days after transplanting (DAT)). But the minimum time for 50% flowering was recorded from BHT-11 (33.33) and BHT-8 (333.67). The similar trends were also recorded from 100% flowering times among the different varieties. Fruit bearing time also varied significantly among the varieties. The maximum time is required for 1st bearing in commercial variety (43.67 DAT). The minimum time is needed for 1st bearing in BHT-8 (38.67 DAT) which is statistically similar with BHT-11(41.67 DAT) and Cross-4 (3.67 DAT) and Cross-12 (41 T). The fruit weight per plant was recorded BHT-8 (1227.99). The lowest fruit weight per plant was counted from Cross-12 (825.08 g). The Yield of different varieties also varied significantly. The maximum yield was recorded from BHT-8 (42.6 t ha^{-1}) which was followed by Cross-4 (39.43 t ha^{-1}), BHT-11 (33.9 t ha^{-1}) and the lowest yield was recorded from Local variety (26.9 t ha^{-1}). Wilting and virus infestation is a major problem of summer tomato in Dinajpur region (Table 5). The maximum percentage of wilting infected plants (20.8%) was observed in commercial variety *Rani*. The minimum percentage of wilting infected plants was recorded from cross-12 (8.3%). The leaf curl diseases is mainly caused by virus and infected through insects probably due to high temperature and high humidity in summer at Dinajpur which is most suitable for insects. The highest numbers of leaf curl virus infected plants were counted from BHT-8 (41.7%) and the minimum were counted from local variety *Rani* (8.3%).

Table 5: Agro-economic performance of hybrid tomato varieties at the MLT site, Dinajpur Sadar during Kharif II, 2021

Varieties/ lines	50% DF (days)	100% DF (days)	Dft. (days)	Fruits plant^{-1} (no.)	Fruit Weight plant^{-1} (g)	Yield (t ha^{-1})	Plant protection (%)	
							Virus infestation	Wilt
BHT-8	33.67	38.33	38.67	19.27	1227.93	42.6	41.7	16.7
BHT-11	33.33	37.67	41.67	16.60	1085.97	33.9	29.2	12.5
Cross-4	35.67	38.67	39.67	22.20	1135.77	39.43	12.5	16.7
Cross-12	36	39.33	41	14.07	825.07	27.23	16.7	8.3
Rani	39.33	43.67	45.67	8.67	860.67	26.9	8.3	20.8
LSD $_{(0.05)}$	2.72	2.45	4.13	4.65	113.13	3.52	-	-
CV (%)	4.05	3.3	5.31	16.31	5.85	5.5	-	-

Note: DF=days to flowering, Dft= Days to fruiting, Rani = a commercial hybrid tomato,

6. FSRD site, Faridpur

Yield, yield contributing characters and virus infestation of four varieties/lines varied significantly (Table 6). Early 50% flowering was observed in Cross-4 (19.67 DAT) and late was from Cross-12 (27.33 DAT). Statistically similar number of fruits per plant was calculated from BHT-8, BHT-11 and Cross-12 (25.67 to 27.67). The lowest number of fruits per plant (19) was found in Cross-4. The highest individual fruit weight was observed in Cross-12 (49.23 g) followed by Cross-4 (48.03 g). The lowest single fruit weight was obtained from BHT-11 (43.43 g). Maximum virus infestation was observed in Cross-4 (38.33%) followed by BHT-8 and Cross-12 (26.67%). The lowest virus infestation was observed in BHT-11 (23.33%). The highest fruit yield was attained from BHT-8 (29.93 t ha^{-1}) which was statistically similar with Cross-12 (29.73 t ha^{-1}) and BHT-11 (29.25 t ha^{-1}). The lowest fruit yield was found from Cross-4 (18.41 t ha^{-1}) might be due to lowest number of fruits per plant and maximum virus infestation.

Table 6: Agro-economic performance of hybrid tomato varieties at the FSRD site, Faridpur during Kharif II, 2021

Variety/ Lines	50% Flowering (days)	Fruits plant^{-1} (no.)	Individual fruit wt. (g)	Yield plant^{-1} (kg)	Fruit yield (t ha^{-1})	Virus infestation (%)
BHT-8	25 b	27.33 a	46.37 b	1.27 a	29.93 a	26.67 b
BHT-11	26.67 ab	27.67 a	43.43 c	1.18 a	29.25 a	23.33 b
Cross-4	19.67 c	19.33 b	48.03 ab	0.93 b	18.41 b	38.33 a
Cross-12	27.33 a	25.67 a	49.23 a	1.26 a	29.73 a	26.67 b
CV (%)	3.99	4.05	2.09	4.67	7.34	11.59

7. MLT site, Gaibandha Sadar

Yield and yield attributing characters of different summer tomato varieties are presented in Table 7. All the yield-related characters were statistically significant except plant height. Plant height among the genotypes ranged from 73.0–77.9 cm. The highest plant mortality was recorded in BHT-8 (55.60%) followed by Cross-4 (35.7%), BHT-11 (28.3%) and Cross-12 showed the lowest mortality (18.4%). Maximum virus-infected plant was found in BHT-8 (60.67%), followed by BHT-8 (25.21%) and Cross-4 (18.66). The lowest virus-infected plants were found Cross-12 (15.22%). The maximum number of fruits plant^{-1} (10.9) was found in Cross-12 (13.6) followed by BHT-11(11.1) and BHT-8 (10.9). Cross-4 had the minimum fruit plant^{-1} (10.2). The highest fruit yield was recorded in Cross-12 (9.60 t ha^{-1}) followed by BHT-11 (8.80 t ha^{-1}) and BHT-8 (7.40 t ha^{-1}). Cross-4 produced the lowest fruit yield (7.10 t ha^{-1}).

Table 7. Agro-economic performance of hybrid tomato varieties in Gaibandha during *Kharif-II* season of 2021

Variety/Lines	Plant height (cm)	Mortality (%)	Virus-infected plant (%)	Fruits plant^{-1}	Fruit yield (t ha^{-1})
BARI Hybrid Tomato-8	73.0	55.6 a	60.67 a	10.9 b	7.40 bc
BARI Hybrid Tomato-11	77.9	28.3 b	25.21 b	11.1 b	8.80 ab
Cross 4	76.4	35.7 b	18.66 c	10.2 b	7.10 c
Cross 12	75.2	18.4 c	15.22 c	13.6 a	9.60 a
$LSD_{(0.05)}$	ns	8.5	4.2	9.9	8.4
CV (%)	8.42	12.3	7.0	8.1	8.6

8. MLT site, Jashore Sadar

Results presented in the (Table 8) indicated that a significant variation was noted in days to 50% flowering, days to 1st harvest, no. of fruits plant^{-1}, individual fruit weight (g) and fruit yield (t ha^{-1}). The maximum days to 50% flowering was 45 found at Cross-12 which was statistically similar with BHT-11 (42). The days to 1st harvest was 68 DAP from BHT-8 and late was 77 DAP from BHT-11 which was statistically similar with 74 DAP from Cross-12. The highest number of fruits plant^{-1} was BHT-11 (40) which was statistically similar with BHT-11(37). The maximum individual fruit weight was 73.0 g from BHT-11and minimum was 58.0 g from BHT-8. The highest yield recorded from 64.2 t ha^{-1} from BHT-11. The second highest fruit yield was 62.3 t ha^{-1} from BHT-8 and lowest yield was 62.1 t ha^{-1} from Cross-12.

Table 8: Growth and yield parameters of summer tomato varieties at Jashore during 2021

Variety/ Lines	50% flowering (days)	1st harvest (days)	Fruit plant^{-1} (no.)	Individual fruit weight (g)	Fruit yield (t ha^{-1})
BHT-8	36	68	37.0	58.0	62.3
BHT-11	43	77	40.0	62.7	64.2
Cross-12	45	74	31.0	73.0	62.1
CV (%)	5.40	2.75	3.0	0.76	0.76
LSD	2.43	2.82	2.62	4.41	1.09

9. MLT site Satkhira

Results presented in the (Table 9) indicated that a significant changes of days to 50% flowering, days to 1st harvest, no. of fruits plant^{-1}, individual fruit weight (g) and fruit yield (t ha^{-1}). The maximum days to 50% flowering was 42 found at Cross-12 which was statistically similar with BHT-11 (40.33) and minimum was 30 from Cross-4 which was statistically similar with BHT-8 (34). The days to 1st harvest was 63 DAP from Cross-4 which was statistically similar with BHT-8 (64 DAP) and late was 76 DAP from Cross-12 which was statistically similar with 75 DAP from BHT-11. The highest number of fruits plant^{-1} was BHT-8 (32.53) which was statistically similar with Cross-4 (31.60). The maximum individual fruit weight was 52.40 g from BHT-8 and minimum was 40.53 g from Cross-12. The highest yield recorded from 69.37 t ha^{-1} from BHT-8. The second height fruit yield was 68.13 t ha^{-1} from Cross-4 and lowest yield was 48.87 t ha^{-1} from BHT-11.

Table 9: Growth and yield parameters of summer tomato varieties at Satkhira during 2021

Variety/Lines	50% Flowering (days)	1st harvest (days)	Fruit plant^{-1} (no.)	Individual fruit weight (g)	Fruit yield (t ha^{-1})
BHT-8	34 b	64 b	32.53 a	52.40 a	69.37 a
BHT-11	40.33 a	75 a	27.80 b	41.13 c	48.87 b
Cross-4	30 b	63 b	31.60 a	49.06 b	68.13 a
Cross-12	42 a	76 a	27.26 b	40.53 c	51.66 b
$LSD_{(0.05)}$	5.43	3.82	0.97	0.87	6.80
CV (%)	7.44	2.75	1.64	0.95	5.72

10. MLT site Hossainpur, Kishoreganj

Yield, yield contributing characters and virus infestation of four varieties/lines varied significantly (Table 10). Yield was calculated at 31.22, 34.35, 17.33 and 15.12 t ha^{-1} from BHT-8, BHT-11, Cross-4 and Cross-12, respectively. The lowest fruit yield was found from Cross-12 (15.12 t ha^{-1}) might be due to highly virus infestation. The gross return was found highest in BHT-11 (Tk. 1202250 ha^{-1}) followed by BHT-8 (Tk. 1092700 ha^{-1}) and Cross-4 (Tk. 606550 ha^{-1}), respectively. Gross margin and BCR was calculated highest in BHT-11 and lowest from the Cross-12. Maximum virus infestation was observed in Cross-12 (42%) followed by Cross-4 (38.41%) and BHT-8 (17.07 %). The lowest virus infestation was observed in BHT-11 (15.11%).

Table 10: Agro-economic performance of hybrid tomato varieties at MLT site Hossainpur, Kishoreganj during 2021-22

Variety	Days to flowering (50%)	Virus infestation (%)	Fruit yield (t ha^{-1})	Gross return (Tk./ha)	TVC (Tk./ha)	Gross margin (Tk./ha)	BCR
BHT-8	30.15	17.07	31.22	1092700	364550	728150	3
BHT-11	32.21	15.11	34.35	1202250	364550	837700	3.30
Cross-4	35.41	38.41	17.33	606550	364550	242000	1.66
Cross-12	41	42	15.12	529200	364550	164650	1.45

11. MLTsite, Kushtia sadar

Yield and yield attributing characters are presented in (Table 11). Plant height was highest in BHT-8 (148.25 cm) and followed by Commercial hybrid (149.25 cm), Cross-12 (141.52 cm), BHT-11(140.50 cm), and Cross-4 (138.25 cm), respectively. The highest fruit per plant (30.52), individual fruit weight (75.65 g) and yield (50.39 t ha^{-1}) were recorded in BHT-8 and followed by Commercial hybrid (45.35 t ha^{-1}), Cross-12 (38.80 t ha^{-1}), BHT-11(35.35 t ha^{-1}) and Cross-4 (33.25 t ha^{-1}), respectively. Irrespective of varieties total cost (TC) was calculated Tk. 1125000 ha^{-1} (Table 2). The highest gross margin (Tk. 2150000 ha^{-1}) was found in BHT-8 variety followed by Commercial hybrid (Tk. 18230000 ha^{-1}), Cross-12 (Tk. 1397000 ha^{-1}), BHT-11 (Tk. 1198000 ha^{-1}) and Cross-4 (Tk. 1036000 ha^{-1}), respectively.

Table 11. Agro-economic performance of hybrid tomato varieties at Kushtia sadar during 2020-21

Variety/line	Fruits $plant^{-1}$ (no.)	IFW (g)	Yield $plant^{-1}$ (kg)	Yield (t ha^{-1})	Pest Infestation (%)		Cost and return analysis (Tk. ha^{-1})		
					Virus	Wilt	GR	TC	GM
BHT-8	30.52	75.65	2.20	50.39	15	10	3275000	1125000	2150000
BHT-11	24	70.25	1.70	35.35	20	12	2298000	1125000	1198000
Cross 4	23	68.35	1.82	33.25	22	8	2161000	1125000	1036000
Cross 12	20	67.50	1.75	38.80	25	10	2522000	1125000	1397000
CHV	28	75	1.95	45.35	20	12	2948000	1125000	1823000
CV(%)	9.61	11.23	6.51	8.26	11.70	7.33	-	-	-
F-test	*	NS	*	**	NS	NS	-	-	-

IFW= Individual fruit weight, GR= Gross return, TC= Total cost and GM= Gross margin. Average market price of tomato @ Tk. 65 kg^{-1}.

12. MLT site, Netrakona

Yield and yield contributing characters of BARI hybrid tomato has been presented in Table 12. It was observed that yield and yield contributing characters were significantly differed among the materials except individual fruit weight. The maximum days for 50% flowering, first harvest and last harvest were taken by Cross-12 as 41.3, 72.0 and 127.7 days, respectively and the minimum days were recorded by BHT-8 as of 37.7 days, 61.7 days and 112.0 days, respectively. Considering the number of fruits per plant, the highest number of fruits per plant was obtained from cross-12 (45.8) which was statistically similar with BHT-8 (43.81). The lowest number of fruits per plant was found from cross-4 (33.16) that was statistically similar with BHT-11 (36.89). There was no statistical difference among the crosses and varieties in case of individual fruit weight. The highest fruits yield were produced from cross-12 (75.4 t ha^{-1}) followed by BHT-8 (67.4 t ha^{-1}) and the lowest fruits yield was obtained from Cross-4 (44.3 t ha^{-1}). Number of fruits per plant and individual fruit weight might be responsible for more yield of Cross-12. Virus and bacterial infestation were minimum in Cross-12 (1.19% & 3.57%) and maximum in Cross-4 (7.85% & 14.28%). The highest gross return and gross margin was obtained from Cross-12 (Tk. 5277773 ha^{-1} and Tk. 3679469 ha^{-1}) followed by BHT-8 (Tk. 4716631 ha^{-1} and Tk. 3118327 ha^{-1}) and the lowest gross return and gross margin was obtained from cross 4 (Tk. 3097940 ha^{-1} and Tk. 1499636 ha^{-1}, respectively).

Table 12. Agro-economic performance of hybrid tomato varieties at Kunia, Netrakona during Kharif- 2021

Variety/ line	DF (days)	DFH (days)	DLH (days)	IFW (g)	Fruits plant (no.)	Yield (t ha^{-1})	Pest Infestation (%)		Cost and return analysis (Tk. thousand ha^{-1})		
							Virus	Wilt	GR	TC	GM
BHT-8	37.7	61.7	112.0	60.1	43.81	67.4	2.12	7.38	4717	1598	3118
BHT-11	41.0	62.3	123.3	59.7	36.89	55.9	4.52	11.19	3911	1598	2313
Cross 4	40.3	70.3	115.7	52.87	33.16	44.3	7.85	14.28	3098	1598	1500
Cross 12	41.3	72.0	127.7	64.83	45.8	75.4	1.19	3.57	5278	1598	3679
LSD $_{(0.05)}$	1.37	2.42	4.3	ns	5.82	17.75	2.37	2.65			
CV (%)	1.71	1.82	1.18	13.87	12.45	14.65	30.38	14.62			

Note: DF = Days to 50% flowering, DFH = Days to first harvest, DLH = Days to last harvest, GR= Gross return, TC= Total cost and GM= Gross margin. Average market price of tomato @ Tk. 70 kg^{-1}.

13. MLT site Shibpur, Narsingdi

Yield, yield contributing characters and virus infestation of four varieties/lines varied significantly (Table 13). Early 50% flowering was observed in Cross-4 (21.67 DAT) and late was from Cross-12 (28 DAT). Statistically similar number of fruits per plant was calculated from BHT-8, BHT-11 and Cross-12 (26.33 to 28.05). The lowest number of fruits per plant (17.33) was found in Cross-4. The highest individual fruit weight was observed in Cross-4 (46 g) followed by BHT-8 (42 g). The lowest single fruit weight was calculated from BHT-11 (37.67 g). Maximum virus infestation was observed in Cross-4 (47%) followed by BHT-8 (43.33%) and Cross-12 (41.67%). The lowest virus infestation was observed in BHT-11 (38.33%). The highest fruit yield was calculated from BHT-11 (26.63 t ha^{-1}) and the second highest yield was found Cross-12 (25.02 t ha^{-1}) . The lowest fruit yield was found from Cross-4 (16.31 t ha^{-1}) due to might be lowest number of fruits per plant and maximum virus infestation. BARI Hybrid Tomato-11 and Cross-12 was overall accepted through the farmer's evaluation in case of fruit numbers in bunch, fruit structure, shape, keeping quality and yield.

Table 13: Agro-economic performance of hybrid tomato varieties at Shibpur and the MLT site Raypura, Narsingdi during Kharif II, 2021

Variety	50% flowering (days)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Virus infestation (%)	Fruit yield (t ha^{-1})
BHT-8	26.33 a	25.67 a	42 b	43.33 ab	19.49 c
BHT-11	28.05 a	22.33 a	37.67 c	38.33 b	26.63 a
Cross-4	21.67 b	17.33 b	46 a	47 a	16.31 d
Cross-12	28 a	24 a	38 c	41.67 ab	25.02 b
CV (%)	9.81	3.02	6.76	1.32	3.01

14. FSRD site, Ganggarampur, Pabna

Data on yield contributing characters and yield are presented in Table-14. Yield contributing characters varied significantly among the tested lines/varieties. The locally commercial hybrid summer tomato *Mintu* demonstrated maximum days for attaining its first fruit whereas Cross-4 required minimum days. The highest number of fruits plant^{-1} (21.7) was attained from Cross-4 which was statistically similar with Cross-12, BHT-8 and BHT-11. The lowest number of fruits plant^{-1} (17.9) was attained from *Mintu*. Maximum individual fruit weight (43.3 g) was found from *Mintu* which was statistically identical to Cross-12, BHT-8 and BHT-11 while minimum individual fruit weight (38.2 g) was recorded in Cross-4. The highest fruit yield (39.8 t ha^{-1}) was obtained from Cross-12 which was identical with BHT-11. However, the lowest fruit yield (34.7 t ha^{-1}) was recorded in BHT-8. Cost and return analysis are presented in Table-14. Regarding economic benefit, maximum gross return (Tk. 1992350 ha^{-1}) and gross margin (Tk. 781850 ha^{-1}) was obtained from Cross-12 which was followed by BHT-11. However, minimum gross return (Tk. 1737350 ha^{-1}) and gross margin (Tk. 526850 ha^{-1}) was noted in BHT-8.

Table-14. Agro-economic performance of hybrid tomato varieties at FSRD site, Ganggarampur, Pabna during the *rabi* season of 2021-22.

Lines/ Variety	1st harvest (days)	Fruits plant^{-1} (no.)	Individual fruit wt. (g)	Yield (t ha^{-1})	Cost and return analysis (Tk. thousand ha^{-1})		
					GR	TC	GM
BHT-8	73	28.1	40.7	34.7	1737	1211	527
BHT-11	74	28.8	42.8	37.0	1852	1211	642
Cross-4	71	29.7	38.2	35.7	1786	1211	576
Cross-12	72	29.4	41.8	39.8	1992	1211	782
Mintu	78	25.9	43.3	35.5	1773	1211	562
CV (%)	3.70	4.17	4.7	5.22			
$LSD_{0.05}$	2.24	1.81	3.36	3.64			

Note: GR= Gross return, TC= Total cost and GM= Gross margin. Average market price of tomato @ Tk. 50 kg^{-1}.

15. MLT Puthia, Rajshahi

Yield and other characters of Tomato are shown in Table 15. The longest harvesting period was observed in Cross-12 (60 days) followed by BHT-11 (58 days), BHT-8 (28 days) and Cross-4 (28 days). Maximum number of fruits per plant (43.4) was observed in BHT-11 followed by Cross-12 (26.8), BHT-8 (22.1) and Cross-4 (15.3). The highest individual fruit weight was obtained from Cross-12 (59.29 g) followed by BHT-8 (53.59 g) and Cross-4 (51.66 g). The lowest individual fruit weight was obtained from BHT-8 (45.52 g). The highest individual fruit weight per plant was obtained from BHT-11 (1.83 kg) followed by Cross-12 (1.35 kg) and BHT-8 (1.23 kg). The lowest individual fruit weight per plant was obtained from Cross-4 (0.565 kg). The highest fruit yield (55.5 t ha^{-1}) was also obtained from BHT-11 followed by Cross-12 (51.77 t/ha), BHT-8 (34.44 t ha^{-1}) and the lowest was in Cross-4 (18.58 t/ha). The highest gross return (Tk. 2775000 ha^{-1}) and gross margin (Tk. 1882620 ha^{-1}) was recorded from BHT-11 followed by Cross-12 (Tk. 2588500 ha^{-1} and Tk 1696120 ha^{-1}), BHT-8 (Tk. 1722000 ha^{-1} and Tk. 829620 ha^{-1}), and the lowest obtained from Cross-4 (Tk. 929000 ha^{-1} and Tk. 36620 ha^{-1}). Virus infestation and Bacterial wilt were found lower in Cross-12 followed by BHT-11, BHT-8 and highest in Cross-4.

Table 15. Agro-economic performance of hybrid tomato varieties at MLT site Puthia, Rajshahi during 2021-2022

Treatment	Harvesting period (days)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Yield plant^{-1} (kg)	Fruit yield (t ha^{-1})	Pest Infestation (%)		Cost and return analysis (Tk. thousand ha^{-1})		
						Virus	Wilt	GR	TC	GM
BHT-8	28	22.1 b	53.59 b	1.23 c	34.44 b	59.28	4.76	1722	892	830
BHT-11	58	43.4 a	45.52 c	1.83 a	55.5 a	27.85	2.38	2775	892	1882
Cross 4	28	15.3 c	51.66 b	0.565 d	18.58 c	78.57	10.71	929	892	36
Cross 12	60	26.8 b	59.29 a	1.35 b	51.77 a	24.16	1.19	2589	892	1696
LSD	-	2.23	3.45	0.122	9.12	-	-	-	-	-
CV%	-	5.98	3.71	8.11	12.43	-	-	-	-	-

Note: GR = Gross return, TC = Total cost and GM = Gross margin. Average market price of tomato @ Tk. 50 kg^{-1}.

16. MLT site, Sonatola, Bogura

Yield, yield contributing characters and virus infestation of four varieties/lines varied significantly (Table 16). Early 50% flowering was observed in Cross-4 (24.87 DAT) and late in Cross-12 (32.41 DAT). A statistically similar number of fruits per plant was calculated from BHT-8, BHT-11 and Cross-12 (27.63 to 31.71). The lowest number of fruits per plant (23.47) was found in Cross-4. The highest individual fruit weight was observed in Cross-12 (51.18 g), followed by Cross-4 (48.46 g). The lowest single fruit weight was calculated in BHT-11 (44.17 g). The highest fruit yield was calculated from BHT-8 (30.12 t ha^{-1}), which was statistically similar to Cross-12 (29.78 t ha^{-1}) and BHT-11 (29.70 t ha^{-1}). The lowest fruit yield was found from Cross-4 (21.88 t ha^{-1}) due to the lowest number of fruits per plant and maximum virus infestation. Maximum virus infestation was observed in Cross-4 (33.67%), followed by BHT-8(28.54%) and Cross-12 (27.49%). The lowest virus infestation was observed in BHT-11 (24.36%). that BARI Hybrid Tomato-11 and Cross-12 were overall accepted through the farmer's evaluation in case of fruit numbers in the bunch, fruit structure, shape, keeping quality and yield. Higher fruit yield contributed to the higher gross return (Tk.1807200 ha^{-1}) in BARI Hybrid Tomato-8followed by Cross-12 (Tk.1786800 ha^{-1}), BARI Hybrid Tomato-11(Tk.1792800 ha^{-1}) and lowest in Cross-4 (Tk.1312800 ha^{-1}). Similarly, the highest gross margin (Tk.914800 ha^{-1}) was recorded from BHT-8 followed by Cross-12 (Tk.894400 ha^{-1}) and the lowest in Cross-4 (Tk.420400 ha^{-1}) (Table 16).

Table 16: Agro-economic performance of hybrid tomato varieties at the MLT site, Sonatola, during Kharif-II, 2021 season

Varieties /lines	Days to 50% flowering (days)	Fruits $plant^{-1}$ (No.)	Individual fruit wt. (g)	Yield (t ha^{-1})	% Virus infestation	Economic Analysis (Tk. thousand ha^{-1})		
						GR	TC	GM
BHT-8	28.95 b	29.28 ab	48.23 b	30.12 a	28.54 b	1807	892	915
BHT-11	29.53 ab	31.71 a	44.17 c	29.70 a	24.36 b	1782	892	890
Cross-4	24.87 c	23.47 c	48.46 ab	21.88 b	33.67 a	1313	892	420
Cross-12	32.41 a	27.63 b	51.18 a	29.78 a	27.49 b	1787	892	894
CV (%)	4.57	4.66	3.14	7.34	8.38	-	-	-

Note: GR = Gross return, TC = Total cost and GM = Gross margin. Average market price of tomato @ Tk. 60 kg^{-1}.

Farmers Opinion

Variety/lines	Farmer's opinion
BARI Hybrid Tomato-8	• Most of the farmers of Satkhira, Netrakona preferred this variety due to round shape and fleshy fruit and higher fruit bearing resulting high fruit yield than that of other genotypes. • But poor storage quality is concern as it's soften fruit coat.
BARI Hybrid Tomato-11	• Farmers of Bhola, Cox's bazer, Dinajpur, Faridpur, Jashore, Narsingdi, Pabna, Rajshahi like this variety due to its oblong fruit shape and prolong keeping quality as hardy fruit coat during harvesting as compared to other variety/lines.
Cross-4	• Farmers didn't like this genotype due to fruits are flattened and softens quickly resulting poor storage quality. • But, individual fruit size is bigger than that of other varieties/line.
Cross - 12	• Farmers of Netrakona, Pabna preferred this advanced line. The fruit shape is oblong and hardy during harvesting. Keeping quality better than that of BARI Hybrid Tomato-8 and Cross 4. • But, individual fruit weight is lower than that of other varieties/line. • Wilt infestation was higher in Dinajpur as compare to other genotype.

Conclusion

BARI Hybrid Tomato-8 is a mega variety throughout the country specially Satkhira, Brahmanbaria, Netrakona, Sylhet region. On the contrary, BARI Hybrid Tomato-11 also accepted by the farmers of new areas viz. Bhola, Cox's bazer, Dinajpur, Faridpur, Jashore, Narsingdi, Pabna, Rajshahi etc. The advanced line Cross-12 also performed better in some locations viz. Barind area, Rajshahi, Pabna, Netrakona etc that can be released as a variety. This is the first year study, therefore for solid conclusion the trial need to repeat in yhe next year.

Obstacles identified

- Low soil pH (4.52 -5.02).
- High concentrations of virus-infected plants.
- High plant mortality (%).
- Severe root-knot nematode infection at fruiting stage resulting in gradual wilting of the plant.
- Heat stress symptom confuses the farmers with virus symptoms.
- Shyness of farmers on innovative technology adaptation.

COMMUNITY BASED PILOT PRODUCTION PROGRAM OF BARI DEVELOPED SUMMER HYBRID TOMATO VARIETIES IN COX'SBAZAR REGION

Introduction

Tomato is an important and popular vegetable in Bangladesh. Cultivation and availability of tomato are limited in summer season. The prevailing temperature in our country during summer and rainy season is high and unfavorable for winter tomato cultivation. Due to demand of tomato during summer season the market price is very high even some business men stored winter tomato for selling purposes during summer season. BARI has developed some hybrid summer tomato varieties which are able to produce flowers and fruits even under high temperature. BARI Hybrid Tomato-4, BARI Hybrid Tomato-8, BARI Hybrid Tomato-10 and BARI Hybrid Tomato-11 varieties are popular for summer season cultivation. So, community based pilot production program was undertaken with those varieties in different districts of the country viz. Dinajpur, Rangpur, Gaibandha, Bogura, Rajshahi, Barind area, Pabna Kushtia, Jashore, Satkhira, Khulna Faridpur, Bhola, Manikganj, Gazipur, Narsingdi, Sylhet, Moulovibazer, Brahmanbaria, Cumilla, Noakhali, Bandarban and Cox'sbazer. Among the district, farmers of Moulovibazer, Brahmonbaria, Satkhira, and Jashore are very familiar to produce summer tomato. On the other hand, summer tomato cultivation is not a common practice among the farmers of other districts. Therefore, community based pilot production program was undertaken to popularizes BARI developed summer hybrid tomato varieties among farmers of those selected areas.

Materials and Methods

Community based pilot production program (CBPPP) was conducted in MLT/FSRD sites of Dinajpur, Rangpur, Gaibandha, Bogura, Rajshahi, Barind area, Pabna Kushtia, Jashore, Satkhira, Khulna Faridpur, Bhola, Manikganj, Gazipur, Narsingdi, Sylhet, Moulovibazer, Brahmanbaria, Cumilla, Noakhali, Bandarban and Cox'sbazer to popularizes BARI developed summer hybrid tomato varieties among farmers during the summer season, 2021. The planting materials were BARI Hybrid Tomato-4 (BHT-4), BARI Hybrid Tomato-8 (BHT-8), BARI Hybrid Tomato-10 (BHT-10) and BARI Hybrid Tomato-11 (BHT-11) varieties. A total of 447 *bigha* land were covered with help of 350 co-operator farmers for CBPPP throughout the country. Seeds were sown under poly-tunnel and 50-60 mesh net-house and 25-30 days old seedlings were transplanted on main field under poly-tunnel. Spacing in a bed was maintained 60cm×40cm and two beds were laid under one tunnel where bed-bed distance were 30 cm. Between two tunnel, 100 cm gap was maintained.

The field was fertilized at the rate of 10 t ha^{-1} cowdung, 210 kg ha^{-1} of N in the form of Urea, 50 kg ha^{-1} of P in the form of TSP and 75 kg ha^{-1} of K in the form of MoP. Half of cowdung, the whole amount of TSP and half of MoP were applied during final land preparation. The remaining half of the cowdung was applied during pit preparation. The rest amount of MoP and entire amount of Urea were top dressed in three equal installments at 12, 27 and 46 days after transplanting. Intercultural operations and irrigation were done as and when necessary for the proper growth of the cropThe tomato was started to harvest 60-65 days after transplanting. The hormone, Tomatoton (2%) was sprayed into flowers at the anthesis stage 30-35 days after transplanting in each tunnel. Intercultural operations and weeding were done as and when necessary. Irrespective of location insecticides (viz. Imitaf, Admire and Pegasus etc.) and fungicides (viz. Dithane, M-45, Provex, Autostin, Desis and Ridomil gold etc.) were used for controlling pest and disease. Bio control measures like yellow sticky trap was also applied at 34-40 DAT to control *Aphid, Jassid* etc. To control blossom end disease at the end of the bottom of the tomato calcium chlorite was sprayed @ 4.0 mg L^{-1}. Harvesting was started at 50-60 DAT and finished at 125-130 DAT with a number of total 08 times harvesting irrespective of varieties. Ten plants were randomly selected for tagging and data on yield and yield contributing characters were taken from those tagged plants.

Results and Discussion

Community based pilot production programs (CBPPP) with BARI developed summer hybrid tomato were conducted during *Kharif 2021* in different locations of Bangladesh. BARI hybrid Tomato-4, BARI hybrid Tomato-8, BARI hybrid Tomato-10 and BARI hybrid Tomato-11 were included as planting materials in this program. A total of 412 farmers who were involved as co-operator and cultivated 447.15 *bigha* of land throughout the country.

BARI hybrid Tomato-4: BHT-4 was grown in Bhola, Cox'sbazer and Netrakona district. There were only 5 farmers, grown 4.75 *bigha* of land under these three districts (Table 1). The highest yield (56.71 t ha^{-1}) was recorded in Nerakona followed by Bhola (35.24 t ha^{-1}) and Cox'sbazer (34.35 t ha^{-1}). In respect of fruit yield, BHT-4 performed better in Nerakona district as compare to other district due to less infestation of insects and diseases especially bacterial wilt. At Bhola, 25% leaf curl virus infestation was noticed during the crop growth stage. The highest GM (Tk. 2371431 ha^{-1}) was obtained in Nerakona, while it was recorded as Tk. 1209150 and Tk.930000 ha^{-1} in Bhola and Cox'sbazer district, respectively. So higher rate of return i.e. GM were found in Nerakona district than those of two districts due to higher fruit yield as well as high market price.

BARI hybrid Tomato-8: BHT-8 is mega variety in summer season, cultivated throughout the country. A total of 393 farmers, cultivated 433.5 *bigha* of land in 18 districts viz. Bandarban, Bhola, Bogura, Cumilla, Dinajpur, Faridpur, Gaibandha, Jashore, Satkhira, Khulna, Kishoreganj, Kushtia, Netrakona, Nasrsingdi, Pabna, Lalmonirhat, Rangpur, Rajshahi, and Tangail (Table 2). Among these districts, Satkhira covered the highest land area (358 *bigha*) with the help of 322 co-operator farmers and the average yield was 41.20 t ha^{-1}. The highest fruit yield (62.78 t ha^{-1}) was recorded in Jashore followed by Nerakona (60.72 t ha^{-1}) Kushtia (51.64 t ha^{-1}), Rajshahi (49.62 t ha^{-1}), Khulna (46.70 t ha^{-1}), Bhola (38.60 t ha^{-1}), Dinajpur (38.25 t ha^{-1}), Pabna (36.35 t ha^{-1}) and Faridpur (36.22 t ha^{-1}). Middling fruit yield was observed in the district of Kishoregaj (32.38 t ha^{-1}), Bandarban (28.38 t ha^{-1}), Narsingdi (27.80 t ha^{-1}), Bogura (26.87 t ha^{-1}), Lalmonirhat (26.47 t ha^{-1}) and Rangpur (19.45 t ha^{-1}). While no satisfactory fruit yield was found in Gaibandha (8 t ha^{-1}) and Tangail (5.49 t ha^{-1}) because of severe infestation of bacterial wilt as well as low pH level in soils of both district. In some district plant mortality was observed in Bhola (20%), Gaibandha (15%), Kushtia (26%), Narsingdi (35%), Lalmonirhat (20%), Rangpur (35%) and Tangail (5%) due to leaf curl virus, while mortality also found in Gaibandha (60%), Narsingdi (13%), Lalmonirhat (13%), Rangpur (19%) and Tangail (65%) due to attract of bacterial wilt.

BARI hybrid Tomato-10: BHT-10 was grown in Bhola, Cox'sbazer and Netrakona district. There were only 6 farmers, grown 3.80 *bigha* of land under these three districts (Table 3). The highest yield (63.76 t ha^{-1}) was recorded in Nerakona followed by Cox'sbazer (43.40 t ha^{-1}) and Bhola (37.21 t ha^{-1}). Cosidering fruit yield, BHT-10 performed well in Nerakona district as compare to other district due to less infestation of insects and diseases especially bacterial wilt. At Bhola, 18% leaf curl virus infestation was noticed during the crop growth stage, while other two sites was free of pest infestation because regular spraying of insecticide and fungicide. The highest GM (Tk. 2864581 ha^{-1}) was obtained in Nerakona, followed by and in Bhola (Tk. 1347050 ha^{-1}) and Cox'sbazer (Tk.1183000 ha^{-1}) district respectively. So higher rate of return i.e. GM were found in Nerakona district than those of two districts due to higher fruit yield as well as high market price.

BARI hybrid Tomato-11: BHT-11 was grown in Barind area, Bhola and Rajshahi district. A total of 8 farmers, grown 5.10 *bigha* of land under these three districts (Table 4). The highest yield (55.68 t ha^{-1}) was recorded in Rajshahi followed by Barind area (45.73 t ha^{-1}) and Bhola (40.68 t ha^{-1}). In respect of fruit yield, BHT-11 performed better in Rajshahi district as compare to other two sites due to less infestation of insects and diseases especially bacterial wilt. At Bhola, 15% leaf curl virus infestation was noticed during the crop growth stage. The highest GM (Tk. 1891610 ha^{-1}) was obtained in Rajshahi, while it was recorded as Tk. 1589950 and Tk.1478314 ha^{-1} in Bhola and Barind area, respectively. So higher rate of return i.e. GM were found in Rajshahi district than those of two sites due to higher fruit yield as well as high market price.

Farmer's opinion

- Farmers opined that BARI Hybrid Tomato-8 and Tomato-11 are very demandable in the market during summer and early winter season.
- But they need disease free grafted seedling for growing in summer season.
- Farmers need quality seeds
- The also wanted to grow in more area in next year.

Table 1. Agro-economic performance of BARI Hybrid Tomato-4 under production program during *Kharif 2021* at different locations of Bangladesh.

Locations	No. of farmers	Area (*Bigha*)	Mortality by Pest Infestation (%)		Yield (tha^{-1})	Economic Analysis (Tk. ha^{-1})		
			Virus	Wilt		GR	TC	GM
Bhola	1	0.75	25	-	35.24	2466800	1257650	1209150
Cox'sbazer	2	1	-	-	34.35	2784000	1855000	929000
Netrakona	2	3	-	-	56.71	3969735	1598304	2371431
Total	5	4.75	-	-	-	-	-	-

Table 2. Agro-economic performance of BARI Hybrid Tomato-8 under production program during *Kharif 2021* at different locations of Bangladesh.

Location	No. of farmers	Area (*Bigha*)	Mortality by Pest Infestation (%)		Fruit yield (t ha^{-1})	Economic Analysis (Tk. ha^{-1})		
			Virus	Wilt		GR	TC	GM
Bandarban	1	0.85	-	-	28.38	2554200	1272424	1281776
Bhola	2	3	20		38.60	2702000	1257650	1444350
Bogura	2	2	-	-	26.87	1612200	892400	719800
Cumilla	4	2.80	-	-	16.05	1123500	584400	539100
Dinajpur	2	1.70	-	-	38.25	2677500	1262250	1415250
Faridpur	2	2	-	-	36.22	2535400	1268320	1267080
Gaibandha	4	2.50	15	60	8.09	-	-	-
Jashore	20	20	-	-	62.78	-	-	-
Satkhira	322	358	-	-	41.20	-	-	-
Khulna	2	1.50	-	-	46.70	-	-	-
Kishoreganj	3	1.20	-	-	32.38	971400	346850	624550
Kushtia	-	26	26		51.64	-	-	2231438
Netrakona	10	3	-	-	60.72	4250744	1598304	2652440

Location	No. of farmers	Area (*Bigha*)	Mortality by Pest Infestation (%)		Fruit yield (t ha^{-1})	Economic Analysis (Tk. ha^{-1})		
			Virus	Wilt		GR	TC	GM
Narsingdi	2	1.25	35	13	27.80	224000	1168578	1055422
Pabna	4	1.21	-	-	36.35	1817500	1210500	607000
Lalmonirhat	1	1.14	20	13	26.47	2263185	1358232	904953
Rangpur	4	3	35	19	19.45	1662975	1358232	304743
Rajshahi	4	1.20	-	-	49.62	2481000	892390	1588610
Tangail	4	1.15	5	65	5.49	549000	544255	4745
Total	393	433.5	-	-	-	-	-	-

Table 3. Agro-economic performance of BARI Hybrid Tomato-10 under production program during *Kharif 2021* at different locations of Bangladesh.

Locations	No. of farmers	Area (*Bigha*)	Mortality by Pest Infestation (%)		Yield (tha^{-1})	Economic Analysis (Tk. ha^{-1})		
			Virus	Wilt		GR	TC	GM
Bhola	1	0.50	18		37.21	2604700	1257650	1347050
Cox'sbazer	4	2.50			43.4	3038000	1855000	1183000
Netrakona	1	0.80			63.76	4462885	1598304	2864581
Total	6	3.80	-	-	-	-	-	-

Table 4. Agro-economic performance of BARI Hybrid Tomato-11 under production program during *Kharif 2021* at different locations of Bangladesh.

Locations	No. of farmers	Area (*Bigha*)	Mortality by Pest Infestation (%)		Yield (t ha^{-1})	Economic Analysis (Tk. ha^{-1})		
			Virus	Wilt		GR	TC	GM
Barind, Rajshahi	4	4	-	-	45.73	2524701	1046388	1478314
Bhola	1	0.50	15		40.68	2847600	1257650	1589950
Rajshahi	3	0.60	-	-	55.68	2784000	892390	1891610
Total	8	5.10	-	-	-	-	-	-

Conclusion

Tomato cultivation in summer season is very profitable. But it needs to successfully control the wilting diseases. For this regard, soil amendment and grafted but disease-free tomato seedling may be the alternate options. Community-based pilot production program with high value summer hybrid tomato varieties will help to popularize those varieties among the farmers.

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ADAPTATION AND SCALING UP AGROFORESTRY FOR LIVELI-HOOD IMPROVEMENT OF FARMERS IN AGRICULTURAL ECOSYSTEM OF BANGLADESH

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Executive Summary

Agroforestry is a dynamic land use system and important strategic research area for enhancing national agricultural productivity and food and nutrition security. Livelihood improvement is usually a very complex process and it is a great challenge to improve the livelihood of the farmers of different agro-ecosystems by adaptation of agroforestry system in their traditional agricultural system. Therefore, the program was designed and executed under the sub-project entitled "Adaptation and Scaling up Agroforestry for Livelihood Improvement of Farmers in Agricultural Ecosystem of Bangladesh" to adopt the agroforestry system and to scale out the developed technologies of agroforestry system among the farmers of different agro-ecosystems for better utilizing their land resources as well as to increase the productivity and income. The program was coordinated by On-Farm Research Division (OFRD), BARI with two implementing components (OFRD, BARI and Pomology Division, HRC, BARI) at different locations of Plain land, Rainfed, Coastal and Hill ecosystems. The activities of the sub-project were started from May 2018 at 05 (five) Farming System Research and Development (FSRD) sites of OFRD, BARI named Ganggarampur (Pabna), Ajoddhapur (Rangpur), Godagari (Rajshahi), Dumki (Patuakhali) and Tetulia para (Bandarban) and at research station of Jashore and Khagrachori district under Pomology Division, HRC, BARI. The project activities were uninterruptly continued from January 2019 to October 2021 under Pandemic situation. A total of 24 of activities were done for maximizing the total productivity from the existing land resources of fourty farmers considering the (i) homestead production system, (ii) crops and cropping system, (iii) on-farm verification trials and (iv) production program in agroforestry system. All components of agroforestry programs such as vegetables, fruits, fooders, spices, high value crops and even cropping patterns were brought under agroforestry system for improving the technological intervention and income from each of the components. Villages under the FSRD sites of the OFRD of the irrespective of locations have been considered under agroforestry activities. On the basis of PRA and base line survey report, farmers need based technologies were intervened among small, marginal and small farmers. The activities were conducted for the improvement of location specific existing fruit based agroforestry system due to rapid extension of fruit orchards at the field level of different ecosystem. Research activities were also conducted at homestead level with existing fruits and non-fruits trees and year round vegetables at Pabna, Rajshahi and Patuakhali addressing plain land, rainfed and coastal ecosystem. OFRD Pabna has established some agroforestry activities with the high value crops (Cabbage, Cauliflower, Tomato, and Broccoli etc.), pulse crops (Lentil and Grass pea) and oilseed crop (Mustard) in the selected mango, guava and litchi orchards at field level. Research activities on mango based agroforestry with cauliflower and cabbage were conducted at FSRD site Ajoddhapur, Rangpur. Development of cropping pattern like Mustard-Sesame, Potato-T. *Aus*-T. *Aman* rice, and Lentil-Mungbean-T. *Aman* rice with existing mango-based agroforestry system has been developed at Pabna, Rangpur and High Barind Tract Rajshahi. Mango-based agroforestry with shade tolerant perennial crops like Turmeric and Ginger has been developed at Pabna and Rangpur. In Patuakhali, different vegetables have grown in association with homestead trees, roadside trees and sorjan based fruit trees. In Bandarban, different creeper vegetables were grown in association with fruit trees in the hill slope. The activities under this sub-project seem encouraging for the farmers of different locations. Average production of vegetables and fruits was achieved 513 kg and 469 kg per farm from homestead agroforestry which contributed higher family consumption (181g head^{-1} day^{-1}), distribution and selling and total income (Tk. 6191 farm^{-1}). In Patuakhali, farm income increased

168% after intervention of homestead agroforestry. System productivity of mango based agroforestry has increased by 74.06, 46.39, 30.18, 27.74 and 22% due to adoption of high value crops like field pea, radish, cabbage, cauliflower and tomato at Pabna. System productivity has also increased 2 to 3 fold under Litchi and Guava based agroforestry with pulse (Lentil, field pea and grasspea), and vegetable crop (cauliflower, cabbage, broccoli and tomato) at Pabna. In addition, fodder crop, cropping pattern, shade tolerant crop with mango-based agroforestry demonstrated encouraging production and farmers' income at different locations. In Banderban, BARI developed creeper vegetables with mango orchards exhibited encouraging return. Multistoried agroforestry was found more productive and profitable at Jashore and Khagrachari. However, rapid expanded fruit tree-based orchards are opening good scope for agroforestry based intensive production results in incremental yield and economic return per unit area. However, satisfactory improvement regarding production, consumption, family nutrition, women employment opportunity reflected due to development of agroforestry activities under this project. The results of all the activities under agroforestry system imply at five locations of the country are presented here and continuing to create the opportunity for the resource-poor farmers to improve their livelihood in different ecosystem.

Keywords: Agroforestry system, food security, homestead model, livelihood, plainland, coastal, rainfed, hill.

Background of the sub-project

The arable land of Bangladesh is shrinking at the rate of 86,000 hectares every year (BBS, 2008) due to high population density and enormous pressure on natural resources. In addition, climate change accelerated the intensity and frequency of occurrences of salinity, storms, drought, irregular rainfall, high temperature, flash floods, etc. eventually pose serious threat on crop production and food security. In such situation, a comprehensive research and development effort is needed to increase production per unit arable land through agroforestry. Agroforestry system can contribute stable income, food and nutrition security, savings and insurance and a potential means of risk management under climate change induced stress (Akter et al. 1989; Evans 1988). At present the research addressing soil and water conservation, reduce soil erosion, livestock feed management, fuel energy, tree-crop interaction for higher productivity and environmental benefit under integrated agroforestry system are getting high priority to combat climate change challenges (SAC, 2015). In hill ecosystem, agroforestry (contour hedgerows) on steep hill slopes (40-50%) can reduce soil erosion by 55-80% and runoff by 30-70% compared to shifting cultivation (Khisa, 2001).

BARI has developed Multi Strata Fruit Orchard (MSFO) suitable for preventing soil erosion and degradation and increased cropping intensity in hill areas (Paul and Hossain, 2001). On- Farm Research Division of Bangladesh Agricultural Research Institute (BARI) has developed homestead based agroforestry model through holistic approach in its 9 FSRD sites in different ecosystem increased production (50.93 and 146.56%), food intake (68.67 and 124%) farm net income (326% and 115%) from homestead agroforestry with year-round vegetables and fruits respectively over existing farmers practice (OFRD, 2015). Presently the research on screening of crops and their management under the niche of rapidly growing fruit orchard in rural areas is gaining increasing demand by the farmers.

The Bangladesh Agricultural Research Council (BARC) has identified new potential area of agroforestry research and development at cropland, homestead, hill, coastal, rainfed and charland under different ecosystem and given priority on coordinated research aiming food and nutrition security of peoples in those stress environments. Therefore, the proposed research concept is designed to conduct research aiming to find out innovative technologies and dissemination of developed agroforestry technologies in different ecosystem of Bangladesh.

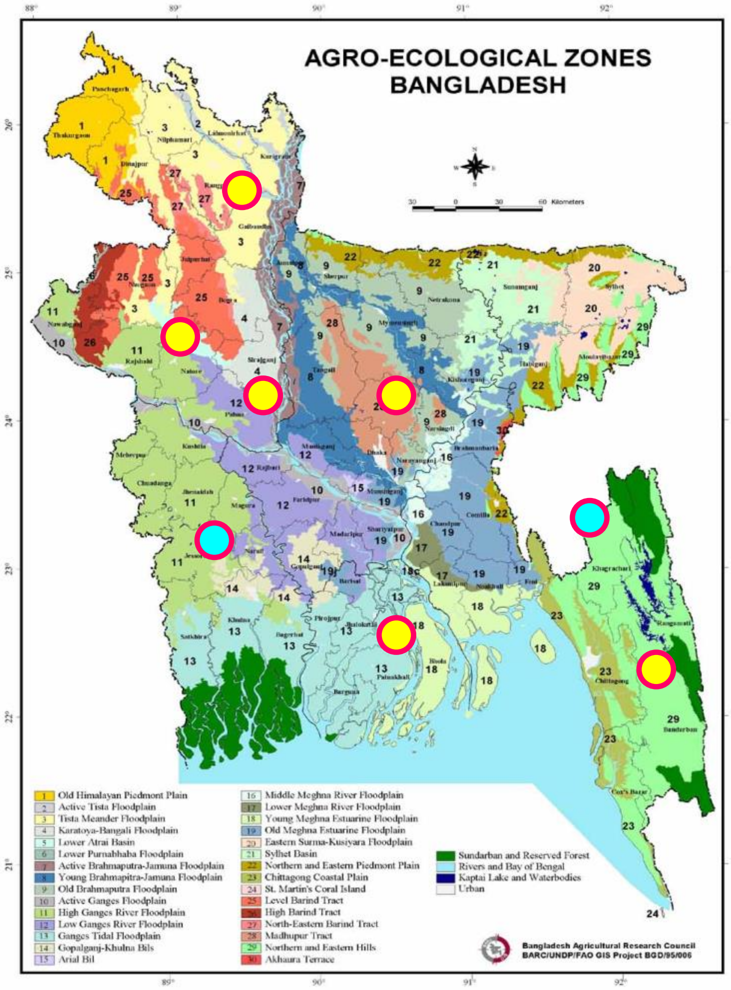

Fig. 1. Locations of implementation sites under the sub-project

Plain land ecosystem

Pabna area: The Pushpapara FSRD site is located 13 Kilometer east of Pabna town. It belongs to AEZ 11 (High Ganges River Floodplain) and AEZ 12 (Low Ganges River Floodplain). The land types are mainly medium high land (45.5%) and medium low land (35.3%). The increasing trend of fruit tree orchard in this area is opening scope of agroforestry based production. Farmers usually grow some perennial spices crops in association with fruit trees which requires long time for income generation. Recently agricultural land is shrinking sharply. Haphazard growing of some vegetable crops under the niche of fruit trees are practicing at the farmers' field. Many orchards are not under this practice. Homestead based year-round vegetables in association with quick growing fruits are opening better scope for income generation of resource poor farm household. Growing high value vegetables and pulse crops in fruits orchards can be better options for higher productivity and income generations.

Rangpur area: The Ajoddhapur FSRD site of Rangpur belongs to AEZ 3 (Tista Meander Floodplain). In the site area, farmers are mostly resource poor. Due to poor management practice, lacks of quality seeds and saplings farmers usually get lower production and economic return. Growing of early vegetables (especially Tomato) is a common practice by the farmers which results in higher market price. Recently establishment of fruit orchards is gradually increasing in the area. Fruit orchards can be utilized for vegetable production under agroforestry system. Adoption of Eucalyptus, Sissoo and other trees in the crop land is very common which can be utilized as support for creeper vegetables. However, identification suitable crops/vegetables for growing with trees is limited. Suitable tree-crop combination can ensure higher productivity and economic benefit for resource poor farmers.

Rainfed ecosystem

Rajshahi area: The Kadamshahar FSRD site is 20 km far away from Rajshahi town. The land types are mainly high land and medium high land representing AEZ-26 (High Barind Tract). The rainfall is erratic and ranged from1200-1300 mm. Soil moisture sharply declines in winter season. In the rabi season crops are mainly grown in rainfed condition. Due to low yield and return from field crops farmers are adopting fruit trees in their crop field which results in more production and economic return. However, some field crops such as wheat, mustard, mungbean, potato are cultivating in tree orchards. But the suitable crops for agroforestry systems are still not well identified. In addition, year-round vegetables and fruits production, creeper vegetables in unproductive trees in agroforestry systems in homestead area can uplift income generation and family nutrition.

Jessore area: This area belongs to AEZ 11 (High Ganges River Floodplain) and has good scope for growing high value vegetables and fruits in the shape of agroforestry. The high land and medium high land is utilized for intensive high value vegetables. Rapidly increasing fruit orchards (mango, litchi, guava etc) can be utilized for growing different vegetables and spices crops. HRC, BARI taking initiative to grow vegetables in association with the existing fruit orchards.

Coastal ecosystem

Patuakhali area: The FSRD site represents AEZ 13 (Ganges Tidal Floodplain). The land escapes mainly clay dominant. Major soils are silty clay loam to silty clay (80%) and rest of the (20%) silt loam. The drainage condition is mainly poor. Soil reaction ranges from medium acidic to moderately alkaline (SRDI 2000). Seven types of major farming systems exist in the areas. Among the dominant farming systems Crops +Poultry + Fisheries + Agro forestry is one of them. The recognized items of income of the farmers are crop, livestock, fisheries, poultry, homestead, agro-forestry etc. Vegetable scarcity is dominant in the areas. Most of the farmers' produce vegetable in homestead condition using open sunny places, roofs, trellis, fences, fruit less trees etc. The homesteads of the localities are full of fruit trees and timber trees. Some farmers use these trees as trellis for cucurbit production.

Hill ecosystem

Banderban and Khagrachari area: The area represents AEZ 29 (Northern and Eastern Hills). There are many established fruit orchards in hill slope of Banderban and Khagrachari district which give only one crop in a year. There are ample opportunities to turn these perennial fruit orchards into two to three crops area and thus increase the productivity and cropping intensity. This area has great potentiality for growing different fruits and vegetables. Mixed crop cultivation is more profitable for the farmers than mono-crop fruit cultivation. Creeper vegetables may be a good source of vegetables as well as to protect soil erosion through the hill slopes.

The proven technologies of agroforestry systems in crop land and homestead was included in the program. Strengthen inter-institutional cooperation and linkage through quick participations of research, extension & development agencies. Overall, the project is aimed to increase the production, income, employment opportunity, nutrition etc. and ultimately enhances livelihood status of the target farms towards poverty alleviation of the respective sites as mentioned above.

Sub-project general objective

Farmers' livelihood improvement and ensuring food security through adoption of innovative agro-forestry technologies.

Sub-project specific objectives (OFRD, BARI Component)

(i) To develop innovative agroforestry technology through adaptive research in agriculture eco-system (rainfed, coastal, charland and hill) of Bangladesh

(ii) To adopt BARI developed homestead, cropland and hill agroforestry technologies in the respective eco-system through active participation of the stakeholders

(iii) To assess the productivity, income and environmental benefits of the developed agroforestry practices and its contribution to food security and poverty alleviation

Sub-project specific objectives (Pomology Division, HRC, BARI Component)

(i) To identify potential agroforestry practices in Khagrachari and Jessore areas

(ii) To find out suitable lower and middle storied crops in fruits based agroforestry

(iii) To assess land utilization efficiency and economic return (BCR)

7. Implementing locations

Agroforestry systems research and development activities were carried out at FSRD site Pabna, Rangpur, Rajshahi, Patuakhali and Banderban under OFRD, BARI including plain land, rainfed, coastal and hill eco-systems. The activities were also conducted at Khagrachari and Jessore under Pomology Division, HRC, BARI. On the basis of farmer's traditional practices, their needs and choices, growing of high value vegetables crops, spices, cereals, pulses and other crops in association with existing fruits/unproductive trees in homestead and crop field the research and development program was incorporated under the project.

Component-1: OFRD, BARI

FSRD site Ganggarampur, Pabna: Pirpur, Kasarpur, Madhupur and Jafrabad villages under Pabna Sadar upazila of Pabna district were selected for agroforestry research and development activities Ganggarampur has a distance of eighteen km from the upazila head quarter and is located at the east side (24°03′ N latitude and 89°38′ E longitude; AEZ-11).

FSRD site Ajoddhapur, Rangpur: Two villages named South Ajoddhapur and Jhautary village under Rangpur Sadar upazila of Rangpur district were considered for FSRD activities. Ajoddhapur has a distance of sixteen km from the upazila head quarter and is located at the west side (25°40′ N latitude and 89°10′ E longitude; AEZ-3).

FSRD site Basantapur, Godagari, Rajshahi: The Agroforestry activities was conducted at farmers field of Farming System Research and Development site, Basantapur, Godagari, Rajshahi (Lat. 24º24´ N; long. 88º26´ E; 26 masl) This site was comprised of three villages viz., Dhatma, Udpur and Baslitala. The site belongs to the agro-ecological zone of High Barind Tract (AEZ-26).

FSRD site Jamla, Dumki, Patuakhali : The project activities were undertaken in two FSRD site of coastal non-saline area at Jamla in Dumki Upazilla under Patuakhali districts. The site were located North-Eastern part (22°24′ N latitude and 90°23′ E longitude; AEZ-13) and 20 Km distance from the District head quarter.

FSRD site Tukhung para, Bandarban: In Bandarban district, Tukhung para of sadar upazila and Tetulia para of Rowangchari upazila were selected for agroforestry research and development activities. Tukhung para has a distance of ten km from the upazila head quarter and is located at the northern side (22°24′ N latitude and 92°20′ E longitude; AEZ-29). Tetulia para has a distance of twelve km from the upazila head quarter and is located at the east side (22°17′ N latitude and 92°23′ E longitude; AEZ-29).

Component-2: Pomology Division, HRC, BARI

RARS Jashore and HARS, **Khagrachari:** The research activities under Pomology Division, HRC, BARI were conducted in two locations; one at RARS, Jashore and another at HARS, Khagrachari. The research field in RARS Jashore (AEZ-11) was located at 23°18′ N latitude and 89°19′ E longitude; and HARS, Khagrachari (AEZ-29) was 23°81′ N latitude and 92°03′ E longitude.

Methodology in brief

Agroforestry systems research and development activities was carried out at FSRD site Pabna, Rangpur, Rajshahi, Patuakhali and Banderban of OFRD, BARI under plain land, rainfed, coastal and hill eco-systems and. The activities were carried out at Khagrachari and Jessore under

Pomology Division, HRC, BARI. On the basis of farmer's traditional practices, their needs and choices, several alternatives of technologies of high value vegetables crops, spices, cereals, pulses and other crops in association with existing fruits/unproductive trees in homestead and field level have incorporated with active participation of the farmers. According to the aim of the project, suitable farmers from different categories viz. landless, marginal and small having major components of agroforestry systems and sizable homestead under single ownership were targeted and six farm households from each site which covered two villages was selected. Existing fruit orchards suitable for agroforestry research works was selected for each location. Prior to implement the project activities, a baseline survey of individual households was carried out. The detail information regarding livelihoods pattern of each household especially total resources inventory, liabilities, Agroforestry related technology used, level of input used, output obtained, income and expenditure status, labor availability of the farms of previous year was documented. Based on the potentials, suitable agroforestry based technological options were addressed to the farmers. Accordingly, farmers' selected suitable technology was adjusted with their need for livelihood improvement. Existing scenario/practices on vegetables, spices, cereals, pulses and fruits production in agroforestry systems, fruit tree management, marketing of the produce and some off-farm activities was identified as their major potential components. Integrated approach was followed for income generation and livelihood improvement of the farmers. The FSRD team of the respective sites and scientific staff of pomology division of HRC, BARI was facilitated the cooperators intend for technological intervention to maximize the productivity of the farm components. Local service provider (LSP) was developed for more sustainability. In case of technological adoption, some advanced methods/techniques were fine-tuned. Pilot production programs were taken in third year including new farmers with the fine-tuned appropriate technologies obtained suitable in first year interventions. Farm component wise data on production, farm level utilization, economic return, livelihood parameter and other socio-economic status was recorded from different locations and tabulated after appropriate statistical analysis.

Research Highlights

i) DEVELOPMENT OF HOMESTEAD AGROFORESTRY WITH VEGETABLES AND FRUITS CROPS IN BARIND AREAS

Background: Homestead is considered as one of the important production unit for rural households of Bangladesh. There are about 20 million homesteads in the country. Year round production of vegetables and fruits in different niches of homestead can play a vital role for food and family nutrition. Every homestead in the country has unplanned fruit and non-fruit trees. Growing of different vegetables in association with existing trees can mitigate the growing demand of food and nutrition security as well as increase family income. Regarding this concern development of homestead agroforestry is deemed imperative in barind areas.

Objectives:

i) to increase year round availability of vegetables and fruits in rainfed ecosystem
ii) to increase homestead production for food, nutrition and income generation

Methodology: Available production niches of the homestead areas were brought under cultivation with the suggested vegetables and fruits following Barind model. Quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Coconut etc.) were managed through pruning, pest control, fertilization and irrigation. Diffrent vegetables were grown under niches of existing fruit and un productive trees during rabi, kharif-I and kharif-II season following recommended management practices as per Barind Model.

Key findings:

- Satisfactory production of vegetables per homestead (513 kg) contributes 64.91, 10.53 and 24.76%, family consumption, distribution and sells respectively.

- The average consumption per head per day was 181 g. From the above results, it was found that under homestead agroforestry intake of vegetables increased to a significant level (on an average 181 g h^{-1} day^{-1} instead of 96 g h^{-1} day^{-1} base mark), which helped the farmers to meet the demand of vegetables and to reduce the daily expenditure of vegetable purchase.
- After intervention of the proven and improved technologies in the homestead, fruits production has increased significantly. Good amount of fruits production was found during the study period (469 kg $homestead^{-1}$)

Keywords: Homestead, agroforestry, vegetables, fruits, food and nutrition

ii) DEVELOPMENT OF HOMESTEAD AGROFORESTRY SYSTEM THROUGH VEGETABLE AND FRUITS CULTIVATION IN COASTAL ECOSYSTEM

Background: Food and nutrition security in the coastal areas is great concern. There are deficiency of fruits and vegetables in the coastal ecosystem due to unfavourable climate and edaphic factors. Homestead is considered as one of the important production unit for rural households of Bangladesh. There are about 20 million homesteads in the country. Year round production of vegetables and fruits in different niches of homestead can play a vital role for food and family nutrition. Every homestead in the country has unplanned fruit and non-fruit trees. Growing of different vegetables in association with existing trees can mitigate the growing demand of food and nutriton security as well as increase family income. Regarding this concern development of homestead agroforestry is deemed imperative in coastal areas.

Objectives:

i) to increase year round availability of vegetables and fruits in coastal ecosystem
ii) to increase homestead production for food, nutrition and income generation

Methodology: Available production niches of the homestead areas were brought under cultivation with the suggested vegetables and fruits following Lebukhali model. Lebukhali model has developed for producing year round vegetables and fruits in 6-7 production niches. Quick growing fruit trees (Guava, Papaya, Lemon, Ber, Banana etc.) along with other existing fruit trees (Mango, Coconut etc.) were managed through pruning, pest control, fertilization and irrigation. Different vegetables were grown under niches of existing fruit and un productive trees during rabi, kharif-I and kharif-II season following recommended management practices as per Lebukhali model.

Key findings:

- Per farm vegetable production was the highest during rabi season (107 kg) and the lowest in kharif-II season (51 kg).
- Average production of vegetables per farm was higher at sunny open spaces (51 kg). Average production of vegetables and fruit per farm was 212 kg and 52 kg, respectively.
- The comparative study showed that total vegetable production and income increased 168% after intervention

Keywords: Coastal ecosystem, homestead, agroforestry, vegetables and fruits.

iii) DEVELOPMENT OF HOMESTEAD AGROFORESTRY WITH VEGETABLES AND FRUITS CROPS IN PABNA AREAS UNDER PLAIN LAND ECOSYSTEM

Background: Sustainable food and nutrition security for rural farm families is a growing concern and reflected in national agricultural policy of Bangladesh. Due to shrinkage of agricultural cultivable land, homestead areas of rural farming are being considered as an important production unit for food and nutrition security. In this connection agroforestry system based production approach was taking into consideration.

Objectives:

i) To increase year round availability of vegetables and fruits in plain land ecosystem
ii) To increase homestead production for food, nutrition and income generation

Methodology: Two co-operator farmers homestead area was selected for the development of homestead agroforestry. Scientific personnel of FSRD team provided training and necessary suggestions to the selected farmers on homestead agroforestry production systems. In case of homestead 1, around 19 decimal of homestead area was brought under homestead agroforestry system production which included fruit trees (mango) and high value vegetables whereas around 6 decimal area was brought under homestead agroforestry system production which included non-fruit trees (mahogany) and high value vegetables for homestead 2. In homestead 1, tomato, brinjal, country bean and bitter gourd was grown in association with mango trees with area coverage of 3, 3, 4 and 3 decimal of homestead area, respectively during 2019. Turmeric was grown in between mango trees with an area of 6 decimal. In homestead 2, elephant foot yam and country bean was grown in unutilized spaces of the trees. Standard management practices were followed for all crops and fruit trees.

Key findings:

- Total production of mango (var. BARI Aam-4) and vegetables (Tomato, Brinjal, Bitter gourd and Country bean)/spice (Turmeric) was 386 and 771 kg, respectively from 3-4 decimal and 6 decimal fruit tree based homestead agroforestry (homestead 1).
- In case of homestead 2, total production of vegetables (Elephant foot yam and Country bean) was 345 kg from 3 decimal non-fruit tree based homestead agroforestry.
- Regarding economic benefit, relatively higher gross return (Tk. 36920 ha^{-1}) and gross margin (Tk. 27740 ha^{-1}) was obtained from homestead 1 as compared with homestead 2 attaining gross return (Tk. 8625 ha^{-1}) and gross margin (Tk. 5425 ha^{-1}).
- Considering per unit economic benefit, growing bitter gourd (27 Kg dec.$^{-1}$), tomato (54 kg dec.$^{-1}$) and brinjal (62 Kg dec.$^{-1}$) with mango orchard is found more profitable.

Keywords: Homestead, agroforestry, vegetables and fruits.

iv) DEVELOPMENT OF LITCHI-BASED AGROFORESTRY WITH LENTIL

Background: Litchi is popular and commercially profitable fruit crops in Pabna region. The increasing trend of litchi tree orchard in Pabna area is opening good scope of agroforestry based production. In most cases the ground space of litchi orchard is remain unused. So the unutilized space can be easily utilized with suitable crops. Nutrient enriched crops especially pulse crops are getting priority for family nutrition of rural household. Due to competition with other rabi crops, pulse growing area are gradually declining. Considering this issue growing lentil crop in association with litchi fruit orchards can be better options for higher productivity and income generation.

Objective:

- To increase system productivity and farmers' income in lentil based agroforestry system

Methodology: The experiment was carried out during 2018-19 and 2019-20 to evaluate the performance of pulse crop in agroforestry system and to increase productivity and farmers' income. Among the pulse crops, lentil was selected for growing with litchi orchard in this study. The seeds of lentil (*var*. BARI Masur-8) were sown on November 07-30. Application of fertilizers and other intercultural operation were made as per recommendation of pulse and fruit crops. The crop was harvested on March 12-18, 2019. The litchi fruit was harvested on June 02-08, 2020. Data on yield of pulse crop and litchi fruits were recorded.

Key findings:

- Agroforestry system with lentil showed relatively higher productivity with lentil (1.75 t ha^{-1}) and litchi (6.40 t ha^{-1}) as compare to sole litchi (6.50 t ha^{-1}) cultivation.

- The litchi equivalent yield (LEY) of the agroforestry system with lentil was 5.51 and 7.71 while relatively lower LEY (4.32 and 6.50) was noted in sole litchi culture during 2018-19 and 2019-20 respectively.
- Higher gross return (Tk. 551000 and Tk. 771000 ha^{-1}) and gross margin (Tk. 477000 and Tk. 693900 ha^{-1}) was also obtained from the agroforestry system during the successive years

Keywords: Litchi, lentil**,** agroforestry, litchi equivalent yield, gross return. gross margin

v) DEVELOPMENT OF LITCHI-BASED AGROFORESTRY SYSTEM WITH HIGH VALUE CROPS

Background: In most cases the ground space of litchi orchard is remain unused. So the unutilized space can be easily utilized with suitable crops. Development of agroforestry based production is deemed important for raising sustainable total production per unit area of land. High value vegetable crops specially cauliflower, cabbage, broccoli and others crops are getting priority for income generation and family nutrition of rural household. Considering this issue growing high value vegetable crops in association with litchi fruit orchards can be better options for higher productivity and income generation

Objective:

- To increase system productivity and farmers income in litchi based agroforestry system with high value crops

Methodology: The experiment was carried out during the *rabi* season of 2019-20. Around eleven years aged litchi orchard was selected for the study. The kinds of vegetables were selected according to choice and preference of the co-operator farmers and agronomic feasibility. Cauliflower, cabbage and broccoli were chosen for planting with litchi trees. Thirty days old seedlings of cauliflower (*var*. Snow white), cabbage (*var*. Atlas 70) and broccoli (*var*. BARI Broccoli-1) were transplanted on November 29, 2019 with maintaining spacing of 60 cm x 45 cm for all vegetables. Application of fertilizers and other intercultural operation were made as per recommendation of individual crops. The harvesting of cauliflower was initiated on February 11 and continued up to February 18, 2020. The harvesting of cabbage was initiated on February 22 and continued up to March 10, 2020. The harvesting of broccoli was initiated on January 25 and continued up to February 08, 2020. The harvesting of litchi was initiated on May 24 and continued up to June 10, 2020. Data on yield of vegetables and guava fruits were recorded.

Key findings:

- Litchi based agroforestry system with high value vegetable crops showed relatively higher productivity with cauliflower (40.70 t ha^{-1}), cabbage (68.45 t ha^{-1}), broccoli (16.65t ha^{-1}) and litchi (7.10, 5.50 and 5.85 t ha^{-1}) as compare to sole litchi (6.80 t ha^{-1}) cultivation
- Maximum fruit equivalent yield was obtained from litchi+ cauliflower (13.21 t ha^{-1}) followed by litchi + cabbage (10.98 t ha^{-1}) and litchi + broccoli (9.18 t ha^{-1}).
- Regarding economic benefit, higher gross return (Tk. 1321000 ha^{-1}) and gross margin (Tk. 1162900 ha^{-1}) was achieved from litchi + cauliflower followed by litchi + cabbage and litchi + broccoli.
- The tested vegetables grown in litchi based agroforestry system exhibited remarkably higher gross return and gross margin compared to sole litchi orchard.
- However, litchi based agroforestry system with cauliflower demonstrated almost double return as compare to sole litchi orchard.

Keywords: Litchi, cauliflower, cabbage, broccoli, litchi equivalent yield, economic return

vi) DEVELOPMENT OF GUAVA BASED AGROFORESTRY SYSTEM WITH HIGH VALUE CROPS

Background: The increasing trend of fruit tree orchard in Pabna area is opening good scope of agroforestry based production. Guava is now a popular fruit and its off season fruiting and handsome market price encourage the farmers to establish more guava orchards. For this reason, many farmers have established guava orchards. Guva trees have small canopy structure which favours more sunlight to the ground as compared to other densed canopy fruits. In some cases, farmers grow some perennial spices crops in association with fruit trees which requires long time for income generation. Many orchards are not under this practice. Growing high value vegetable crops in fruits orchards can be better options for higher productivity and income generation.

Objective:

- To increase system productivity and farmers' income in guava based agroforestry system with high value crops

Methodology: The experiment was carried out at extrapolation areas of FSRD site Ganggarampur, Pabna Sadar, Pabna during three consecutive years (2018-19 to 2020-21) to evaluate the performance of high value crops in agroforestry system and to increase productivity and farmers income. Different high value crops such as tomato, cauliflower and cabbage were selected for guava based agroforestry system in this study. Around 4 years aged guava (var. BARI Peyara-2) orchard was selected for the study during 2018.Thirty days old seedlings of tomato (var. BARI Tomato-19), cauliflower (var. Snow white) and cabbage (var. Atlas 70) were transplanted on November 19-December 05 during the consecutive years with maintaining spacing of 60 cm x 50 cm for tomato and 60 cm x 45 cm for both cauliflower and cabbage. Application of fertilizers and other intercultural operation were made as per recommendation of individual crops. The harvesting of tomato was initiated on February 12 and continued up to March 25. The harvesting of cauliflower was initiated on January 14 and continued up to March 11, 2021. The harvesting of cabbage was initiated on January 07 and continued up to March 15. The harvesting of guava was initiated on February 15 and continued up to March 25. Data on yield of vegetables and guava fruits were recorded.

Key findings:

- Guava based agroforestry system with high value vegetable crops showed relatively higher productivity with tomato (60.08 t ha^{-1}), cauliflower (58.51 t ha^{-1}), cabbage (75.23 t ha^{-1}) and guava (4.17, 4.81 and 4.36 t ha^{-1}) as compare to sole litchi (4.49 t ha^{-1}) cultivation.
- Maximum guava equivalent yield was obtained from guava+ tomato (22.18 t ha^{-1}) which was followed by with guava + cauliflower (18.69 t ha^{-1}) and guava+ cabbage (15.86 t ha^{-1}).
- Minimum guava equivalent yield was recorded in sole guava (4.49 t ha^{-1}). Regarding economic benefit, higher gross return (Tk. 938667 ha^{-1}) and gross margin (Tk. 783867 ha^{-1}) was achieved from guava + tomato followed by guava+ cauliflower and guava+ cabbage.

Keywords: Guava, cauliflower, cabbage, tomato, fruit equivalent yield, economic return

vii) PERFORMANCE OF BITTER GOURD VARIETIES UNDER MANGO BASED AGROFORESTRY SYSTEM IN HILL SLOPES OF BANDARBAN

Background: Around 45866 ha area of land in Bandarban district is under year round mono-crop fruit cultivation. Introducing agroforestry system can be more profitable in this region. Incorporation of summer vegetables like bitter gourd at hill slope of Bandarban under mango based agroforestry system can be introduced. Cultivation can be done by making pit to minimize soil erosion. Hill farmers of Bandarban usually cultivate different local and hybrid varieties of bitter gourd. BARI has developed a good number of bitter gourd varieties which are high yielding, tolerant to different pest and diseases and seed producing potentiality. Hence, the study is important one.

Objective: To evaluate the performances of different bitter gourd varieties under mango based agroforestry system and to increase production and economic return in hill slopes of Banderban

Methodology: The experiment was conducted at the 2-3 years old mango gardens of the farmers' field of Tetulia para hill slopes in Bandarban during the kharif-1 season of 2020 and 2021. Average spacing of mango trees was 6 m×4 m, clean bole height was 1.5-2 m, canopy spread was 1 m×1 m and tree height was 2 m. So, there was some gaps between the tree canopy in the garden, where direct sunlight may reach to the under storey crops. Three varieties of bitter gourd viz. BARI Korola-3, BARI Korola-4 and Hybrid Tiya were used as under storey crop. The experiment was laid out in Randomized Complete Block (RCB) Design with five dispersed replications. The unit plot size was 10 m × 8 m. The plant to plant spacing was 4 m × 1.5 m for each variety. Pit-pit distance was 1.5 m. Pit size was 45 cm × 45 cm × 40 cm and prepared by digging. The seeds were sown direct to the pit on 2 March, 2020 and 15 may, 2021. Insecticide and fungicide were sprayed as and when necessary to control the pest and diseases. Harvesting was done during 3 May to 1 July, 2020 and 10 July to 2 September, 2021.

Key findings:

- The highest fruit yield (7.49 t ha^{-1}) and maximum economic return was found from BARI Korola-4 followed by Hybrid Tiya (7.44 t ha^{-1}) and lowest yield (5.43 t ha^{-1}) from BARI Korola-3 under mango agroforestry system.

Keywords: Hill, Banderban, bitter gourd, mango based agroforestry, yield, and return

viii) DEVELOPMENT OF MANGO BASED AGROFORESTRY WITH TURMERIC AT FARMERS' FIELD UNDER PLAIN LAND ECOSYSTEM

Background: Sustainable food and nutrition security for rural farm families is a growing concern and reflected in national agricultural policy of Bangladesh. Due to shrinkage of agricultural land agroforestry system based production approach is taking into consideration. Turmeric is a perennial crop and can be grown easily under niche of mango orchards.

Objective:

- To increase system productivity and farmers income in plain land ecosystem

Methodology: Around 8-9 years aged mango orchard was selected for this study. Rhizome of local turmeric variety was planted on May 15, 2020 maintaining spacing of 60 cm x 25 cm under niche of the selected mango orchard. Recommended management practices were followed for turmeric and mango.

Key findings:

- Mango agroforestry system with turmeric showed relatively higher productivity with turmeric (12.25 t ha^{-1}) and litchi (3.15 t ha^{-1}) as compare to sole mango (3.12 t ha^{-1}) cultivation.
- The higher system productivity in terms of mango equivalent yield (MEY) of the agroforestry system with turmeric was 8.02 t ha^{-1} while relatively much lower MEY (3.12 t ha^{-1}) in sole mango cultivation.
- The highest gross return (Tk. 401000 ha^{-1}) and gross margin (Tk. 260500 ha^{-1}) and satisfactory MBCR (2.13) was also obtained from agroforestry system.

Keywords: Mango based agroforestry, turmeric, plainland ecosystem, yield, and return

ix) PERFORMANCE OF PULSES IN MANGO BASED AGROFORESTRY SYSTEM IN HIGH BARIND TRACT

Background: In Bangladesh, fruit orchards especially Mango, Litchi and Guava have increased considerably over last few years. As High Barind Tract has 94% high land, there is a big scope to cultivate fruit in the main crop field. Thus, vast area is going under orchard every year, which may be a threat for attaining self-sufficiency in food especially in vegetables and pulses. In these circumstances, cultivation of some pulse crops under agroforestry system could be a good option for increasing food production from the same piece of land. In the tropics and sub-tropics, rapid degradation of soil organic matter is a major problem, where through cereal production less chance to add biomass in the soil. To sustain productivity of soil, production of leguminous crops may be helpful. Keeping this view in mind, the present experiment has been undertaken to select pulse crop(s) suitable for agroforestry system.

Objectives:

i) To select suitable pulse crops in mango based agroforestry system in high barind tract
ii) To increase productivity and farmers' income

Methodology: The field experiment was conducted at Farming System Research and Development (FSRD) site, Basantapur, Godagari, Rajshahi during 2020-21 to find out the performance of mango based agroforestry with pulse crops. The experimental area was high land of silty clay loam soils and belongs to the Amnura series of HBT under Agro Ecological zone 26 (Anonymous, 1988). About 8-10 years old mango orchard was selected for the trial. The orchard with local popular variety of mango (*Khirshapat)* was selected for the study. Four pulses named, Chickpea (var. BARI Chola-5), Lentil (var. BARI Masur-8), Grass pea (var. BARI Kheshari-1) and Pea (var. BARI Motor-3) were tested in the mango orchard. The experiment was laid out in a Randomized Complete Block Design with three dispersed replications. The land was prepared by ploughing and cross ploughing with power tiller. Fertilizers were applied at the rate of 80-40-90-30-2 kg N- P-K-S-B ha^{-1} for pulses and mango cultivation. Chickpea, lentil, pea and grass pea seeds were broadcasted at 25 November, 2020. During final land preparation, all the fertilizer was applied for pulses as recommended dose and fertilizer was applied on late-September for mango as ring placement. The pulse crops and mango were harvested on 8-26 March and 5-10 June, 2020 respectively. Data for pulses and mango were recorded plot wise and converted to ton per hectare. Recorded data were analyzed statistically using "Analysis of variance (ANOVA)" with open-source software R (R Core Team, 2019).

Key findings:

- The seed yield of pea, grass pea, chickpea and lentil was recorded 1.18, 1.26, 1.40 and 1.56 t ha^{-1} and fruit yield of mango was noted 8.20, 8.32, 8.70 and 8.40 in association with pulse crop under agroforestry system as compared to sole mango (7.85 t ha^{-1}).
- The mango+chickpea system was recorded the highest mango equivalent yield (MEY) (11.26 t ha^{-1}) than rest of the system.
- The mango+grass pea (9.30 t ha^{-1}) and mango+pea (9.21 t ha^{-1}) systems were found to be equally effective. However, the sole mango system recorded the lowest MEY (7.85 t ha^{-1}).
- Among the different system, mango + chickpea had a maximum gross return (Tk. 394100 ha^{-1}), gross margin (Tk. 300070 ha^{-1}) and MBCR (4.04) than all other system.
- The minimum gross return (Tk. 274750ha^{-1}) and gross margin (Tk. 210250 ha^{-1}) was found in sole crop of mango.

Keywords: Agro-forestry system, grass pea, chickpea, pea, mango equivalent yield, crop productivity

x) PRODUCTION OF FODDER CROP UNDER MANGO BASED AGROFORESTRY SYSTEM

Background: Intensive utilization of agricultural land for food based crops results in shrinkage of free grazing land for cattle. Production of fodder crops for feed management of cattle is now being considered as a priority issue for livestock sector. Establishment of fruit orchard is rapidly expanded in Pabna region. High land and medium high land is being brought under fruit cultivation. Development of high yield potential fruits varieties with dwarf canopy structure enhance increasing trend of fruit cultivation in rural areas. Development of agroforestry based production is deemed important for raising sustainable total production per unit area of land. Napier is a popular high yield potential fodder crop and can be grown under niches of fruit trees.

For this reason, the production program was undertaken to increase fodder production and farmers' income.

Objectives:

To evaluate the performance of fodder crop in agroforestry system and to increase fodder production and farmers' income

Methodology: The production program was carried out at farmers' field of FSRD site Ganggarampur, Pabna Sadar, Pabna during 2020-21. An existing 5 years aged unutilized mango orchard with an area of 33 decimals was selected at FSRD site, Ganggarampur, Pabna during 2020-21. The variety of mango of the selected orchard was BARI Am-4. Exotic variety (var. Pakchong) of napier grass was used for this production program. The cuttings of napier grass was planted in between spaces of mango fruit trees maintaining spacing of 100 cm x 50 cm on December 10, 2018 (Table 1). Fertilizer management was done for fodder and fruit crops for better crop growth. Other management practices were done when required. The harvesting of fodder crop was initiated on July 15 and continued up to December 24, 2020. Mango fruit was harvested on July 5-12, 2020.

Key findings:

- The biomass yield of fodder crop and fruit yield of mango was recorded 22.5 and 2.80 t ha^{-1}, respectively under agroforestry system as compared to sole crop of mango (2.80 t ha^{-1}).
- The mango equivalent yield (MEY) of the agroforestry system with fodder crop was 5.16 while relatively lower MEY (3.60) was noted in sole mango cultivation.
- Higher gross return (Tk. 309600 ha^{-1}) and gross margin (Tk. 218260. ha^{-1}) was also obtained from agroforestry system with fodder crop.
- The results indicated that this agroforestry technology with mango and fodder crop found more profitable and contributed to the higher production and economic return as compared to farmers traditional sole mango cultivation.

Keywords: Sole mango, fodder crop, mango equivalent yield, gross return, crop productivity.

xi) DEVELOPMENT OF MANGO BASED AGROFORESTRY WITH PULSE CROP

Background: Mango is popular and commercially profitable fruit crops in Pabna region. The increasing trend of mango tree orchard in Pabna area is opening good scope of agroforestry based production. In most cases the ground space of mango orchard is remain unused. So the unutilized space can be easily utilized with suitable crops. Nutrient enriched crops specially pulse crops are getting priority for family nutrition of rural household. Due to competition with other crops, pulse growing areas are gradually declining. Growing pulse crops in kharif season is really a challenge due to unfavourable climate. However, an effort was made to develop mango based agroforestry with kharif pulse specially blackgram. Considering this issue growing pulse crops in association with mango fruit orchards can be better options for higher productivity and income generation.

Objectives:

- To evaluate the performance of pulse crop in agroforestry system
- To increase productivity and farmers' income

Methodology: The experiment was carried out at farmers' field of FSRD site Ganggarampur, Pabna during 2020 to evaluate the performance of pulse crop in agroforestry system and to increase productivity and farmers' income. About 5 years aged mango orchard (var. BARI Aam-4) was selected for the study. Blackgram was selected for growing with mango orchard in kharif season. The seeds of blackgram (*var*. BARI Mash-3) were broadcasted in the unutilized spaces of existing mango orchard on August 19, 2020. Application of fertilizers and other intercultural operation were made as per recommendation of pulse and fruit crops. The crop was harvested on November 05, 2020. The mango was harvested on July 05-07, 2020. The details of crop management practices are presented in Table 1. Data on yield of blackgram and mango fruits were recorded and necessary table were prepared with mean values.

Key findings:

- The seed yield of blackgram and fruit yield of mango was recorded 1.29 and 3.50 t ha^{-1}, respectively under agroforestry system as compared to sole crop of mango (3.50 t ha^{-1}).
- The mango equivalent yield (MEY) of the agroforestry system with blackgram was 5.65 while relatively lower MEY (3.50) was recorded in sole mango cultivation.
- Higher gross return (Tk. 339000 ha^{-1}) and gross margin (Tk. 274300 ha^{-1}) was also obtained from the agroforestry system.

Keywords: Blackgram, mango equivalent yield, crop productivity, farmers' income

xii) FEASIBILITY OF GROWING SHADE TOLERANT CROPS UNDER MANGO BASED AGROFORESTRY SYSTEM

Background: In Pabna district, there is a scenario of increasing different fruits orchard at the farmers' field. About 3-4 years after planting of mango orchard farmers get some economic return from fruits of these orchards only during the fruiting seasons. The ground niches of these orchards are traditionally utilized with some spices sporadically or remain fallow. However, up to 6-7 years aged of mango orchard the ground niche can be successfully utilized with growing of different high value vegetables crops. So, cultivation of some shade tolerant crops under niche of fruit trees may be a good option for the farmers to produce more production and generate additional income from these fruit orchards. In this connection, suitable research is deemed imperative to screen some vegetable crops with regards to evaluate the magnitude of their shade tolerance capacity and productivity under niche of existing sole fruit orchards. Therefore, the present study was undertaken at farmer's field to find out some shade tolerant crops which can be produced successfully in mango orchard and to increase total productivity and farmers' income.

Objectives: To find out some shade tolerant crops this can be produced successfully in mango orchard and to increase total productivity and farmers' income.

Methodology: The experiment was conducted at FSRD site, Ganggarampur, Pabna during 2020-21. Two management condition viz. a) agroforestry and b) open field along with five crops namely field pea (var. BARI Motor-3), radish (var. BARI Mula-1), cabbage (var. Atlas-70), cauliflower (var. Snow white) and tomato (var. BARI Tomato-19) were selected for growing under niche of mango orchard in this trial. The experiment was laidout in RCB factorial design with three dispersed replications. The plot size was 6m × 5m. The spacing was 30 cm × 10 cm for field pea, 40 cm × 15 cm for radish, 60cm × 45cm for cabbage and cauliflower and 75cm × 50cm for tomato. The crops were planted on November 17, 2020. Fertilizers were applied as per recommendation of fertilizer recommendation guide (FRG'2018). The harvesting of pea, radish cabbage, cauliflower and tomato were done on March 04-10, January 20 to February 15, February 15-28, March 01-10 and February 28 to March 15, respectively. Weeding was done on December 20, 2020. Other intercultural operations were done as and when required. The relevant data on different parameters were measured at respective stages.

Key findings:

- The yield of field pea, radish, cabbage, cauliflower and tomato was recorded 1.29,40.77, 65.42, 38.38 and 69.60 t ha^{-1} which was relatively low under agroforestry system as compared to open land (2.13, 56.06, 80.91, 41.98 and 82.53 t ha^{-1}) but the system productivity increased by 13.58, 35.37, 84.50, 71.43 and 158.69% in case of field pea, radish, cabbage, cauliflower and tomato under agroforestry system.
- Regarding economic benefit maximum gross return (Tk. 1134500 ha^{-1}) and gross margin (Tk. 947650 ha^{-1}) was found from tomato followed by cabbage and cauliflower under agroforestry system.

Keywords: High value vegetables crops, tomato, cabbage, cauliflower, field pea, crop productivity and economic return

xiii) PRODUCTION OF CAULIFLOWER AND CABBAGE UNDER MANGO BASED AGROFORESTRY SYSTEM

Background: The utilization of the nitches of mango orchard by growing vegetables may be an alternative avenue to overcome the increasing demand of vegetables for increasing population. Regarding this view, the present study was conducted with mango based agroforestry in association with cauliflower at farmers' field to assess the productivity and economic return.

Objectives:

To evaluate the performance of cauiliflower and cabbage at mango based agroforestry systems at Ajodhapur, FSRD site Rangpur.

Methodology: A field experiment was carried out at the agroforestory farm, Ajodhapur, FSRD site, under OFRD, BARI Rangpur during 2020-2021 to evaluate the performance of cauliflower and cabbage under mango based agroforestry system. The experiment was conducted in newly established four years old Mango orchard where the spacing of tree saplings was 10 m×10 m. The experiment was laid out in RCBD with three dispersed replications. Before planting the seedlings of cauliflower and cabbage, the land was fertilized by using fertilizer as per required doses (FRG' 2018). Seedlings of cauliflower and cabbage were planted on 5-10 November 2020 in main plots. All P and K were applied at the time of final land preparation. N was applied in three equal. Plant protection measures were taken as required. Other intercultural operations were done when necessary. The crop was harvested from 01 to 10 February 2021. Production of cauliflower and cabbage included costs of field preparation, planting, irrigation, organic manure and synthetic fertilizer, plant protection chemicals, and harvesting were included. The gross margin was calculated by subtracting cost of production from the gross return.

Key findings:

- The cauliflower (var. Snow white) and cabbage (var. Atlas-70) under mango based agroforestry system exhibited satisfactory yield (33.88 and 54.55 t ha^{-1}), gross return (Tk 271040 and Tk. 381850 ha^{-1}) as well as the gross margin (Tk.109140 and Tk. 219950 ha^{-1}).

Keywords: Mango equivalent yield, cauliflower, cabbage crop productivity, gross margin

xiv) DEVELOPMENT OF SORJAN-BASED AGROFORESTRY SYSTEM WITH QUICK GROWING FRUITS AND VEGETABLES IN COASTAL AREA

Background: In coastal areas agricultural production through Sorjan system is an age old traditional practice adopted by the farmers. Unplanned cultivation with low yielding varieties of vegetables and fruits and unutilized water bodies often results in lower production and economic. High yielding popular varieties of quick growing fruits and vegetables along with modern management practices would contribute higher production and income. In addition, seasonal fish culture in ditches also may be a good technology for poor farm households. Regarding this concern an integrated production system including fruits, vegetables, fishes through sorjan method is deemed imperative for sustainable production in coastal ecosystem like Patuakhali. Therefore, the present study was undertaken to increase production and income of farm households in Patuakhali.

Objectives: To evaluate sorjan based agroforestry system with quick growing fruits and vegetables for increasing production and farmer's income.

Methodology: In coastal region farmers usually cultivate vegetables or timber trees in sorjan bed. In this study farmer's existing sorjan was renovated and cultivated high value vegetables and quick growing fruits in dyke in a sequential order round the year. The average size of sorjan was 30 decimals. This sorjan has three beds and two canals. The average length and wide of sorjan bed was 55 m × 24 m. Each bed was 2 m wide at the top and more or less 1 m height above ground level. Existing sorjan of cooperative farmers was renovated providing with all sorts of required inputs like seeds, fertilizers and pesticides. In kharif-II season, cucumber, snake gourd, ridge gourd, bottle gourd, Indian spinach, jute as vegetables and sweet gourd were cultivated. Quick growing fruits like Papaya, Guava and Banna were cultivated in sorjan bed. Seasonal fish like tilapia and thaiputi was cultivated within sorjan ditch in kharif season. The yield performance and cost return analysis of vegetables; fruits insorjan based agroforestry was recorded.

Key findings:

- Cultivation of high value vegetables with quick growing fruits in sorjan based agroforestry system showed satisfactory yield of vegetables (230 kg sorjan^{-1}) and fruits (245 kg sorjan^{-1}) during the study period which generated total gross return of Tk 14325 sorjan^{-1} and gross margin of Tk 10325 sorjan^{-1}.
- Moreover, additional income may be possible from fish cultivation in the sorjan ditch.

Keywords: Vegetables, fruits, crop productivity, farmer's income

xv) PERFORMANCE OF SWEET GOURD VARIETIES UNDER FRUIT TREE BASED AGROFORESTRY SYSTEM IN HILL SLOPES OF BANDARBAN

Background: Chittagong hill tracts has great potentiality for growing different types of fruit specially mango, litchi, banana, pineapple, papaya, citrus etc. This region is about one tenth of the total area of Bangladesh and has great potentiality for growing different fruits and vegetables. Around 45866 ha area of land in Bandarban district is under fruit cultivation which may be increased more. The underneath fallow land of newly established fruit orchard in hill slope of Bandarban can be utilized to ensure high return. Agroforestry system can be more profitable than mono-crop fruit cultivation. But incorporation of all kind of vegetables at hill slope is not possible like plain land or valleys due to soil erosion. Therefore, introducing creeper vegetables is a good option where tillage practice can be avoided and plantation is done by making pit to check soil erosion. In this study performance of BARI released sweet gourd varieties under mango+papaya based agroforestry systems was observed. To use the land more efficiently, papaya was planted in between two mango trees in mango base agroforestry system to introduce mango+papaya based agroforestry system of 2-3 yeras old mango orchard. Papaya is a short duration fruit tree which can add extra farm income for 2-3 years at the early establishment period (0-3 years) of mango orchard. For this reason, present study was undertaken to find out the performance of BARI released sweet gourd varieties under mango+papaya based agroforestry system in the hill slopes of Bandarban.

Objectives:

To evaluate the performance of of different sweet gourd varieties in mango+papaya based agroforestry

Methodology: The experiment was conducted at the 2.5 years old mango gardens of the farmers' field of Tetulia para hill slopes in Bandarban during the rabi season of 2020-21. Average spacing of mango trees was 6 m × 4 m, clean bole height was 1.5 m, canopy spread was 2 m × 2 m and tree height was 2.5 m. So, there was much gaps between the tree canopy in the garden and direct sunlight may reach to the under storey crops. Three sweet gourd varieties viz. V_1=BARI Mistikumra-2, V_2=BARI Hybrid Mistikumra-2 and V_3=Hybrid Maya used as treatments under Mango+Papaya based agroforestry system and the experiment was laid out in RCBD design with three dispersed replications. The unit plot size was 6m×4m. The spacing was 4m×2m for each sweet gourd varieties. One papaya plant was planted in between two mango trees in a mango row to utilize the land more efficiently. Hence the distance between two papaya trees became 6m and average spacing of papaya trees was 6m×4 m. In this agroforestry plantation system, one bed of vegetable was cultivated maintaining 2m pit-pit distance. Pit size was 45cm×45cm×40cm and prepared by digging. Papaya seedlings were planted on 17 March to 18 March, 2020 and sweet gourd seeds were sown directly to the pits of different planting system on 11 November,

2020. Irrigation was provided when necessary. Insecticide and fungicide were sprayed to control the pest and diseases after leaf emergence. Data was recorded and analyzed by using Statistic 10 computer program.

Key findings:

- The highest sweet gourd yield (11.89 t ha^{-1}), mango equivalent yield (25 t ha^{-1}), gross return (Tk. 998210 ha^{-1}), gross margin (Tk. 670210 ha^{-1}) and BCR (3.04) was obtained from mango+papaya+BARI Mistikumra-2 agroforestry system
- This might be suitable for the hilly areas of Bandarban because of higher crop productivity, better land and time utilization as well as economic return.

Keywords: Sweet gourd yield, Bandarban, crop productivity, mango equivalent yield

xvi) PERFORMANCE OF DIFFERENT CREEPER VEGETABLES UNDER MANGO BASED AGROFORESTRY SYSTEM IN HILL SLOPES OF BANDARBAN

Background: Chittagong hill tracts has great potentiality for growing different types of fruit specially mango, litchi, banana, pineapple, papaya, citrus etc. This region is about one tenth of the total area of Bangladesh and has great potentiality for growing different fruits and vegetables. There are many established fruit orchards in hill slope of Bandarban. Agroforestry system can be more profitable than mono-crop fruit cultivation. But incorporation of all kind of vegetables at hill slope is not possible like plain land or valleys due to soil erosion. Vegetables like sweet gourd, marpha and bottle gourd are being cultivated in traditional Jhum practice. The present study has been undertaken to evaluate the performances of these vegetables in mango+papay based agroforestry system to increase production and economic return.

Objectives: To evaluate the performance of of different creeper vegetables in mango based agroforestry system

Methodology: The experiment was conducted at the 2.5 years old mango gardens of the farmers' field of Tetulia para hill slopes in Bandarban during the rabi season of 2020. Average spacing of mango trees was 6 m × 4 m, clean bole height was 1.5 m, canopy spread was 2 m × 2 m and tree height was 2.5 m. So, there was much gaps between the tree canopy in the garden and direct sunlight may reach to the under storey crops. Three creeper vegetables viz. sweet gourd, bottle gourd and marpha were used as under storey crop. The experiment was laid out in Randomized Complete Block (RCB) Design with three replications. The unit plot size was 6m×4m. The spacing was 4m×2m for each sweet gourd varieties. In Mango+Papaya based agroforestry system, one papaya plant was planted in between two mango trees in a mango row to utilize the land more efficiently. Hence the distance between two papaya trees became 6m and average spacing of papaya trees was 6m×4 m. In this agroforestry plantation system, one bed of vegetable was cultivated maintaining 2m pit-pit distance. Pit size was 45cm×45cm×40cm and prepared by digging. Papaya seedlings were planted on 17 March to 18 March, 2020 and seeds of sweet gourd, bottle gourd and marpha were sown directly to the pits of different planting system on 11 November, 2020. Irrigation was provided when required. Insecticide and fungicide were sprayed to control the pest and diseases after leaf emergence. Data was recorded and analyzed by using Statistic 10 computer program.

Key findings:

- Maximum vegetable yield (27.38 t ha^{-1}) was found from bottle gourd followed by sweet gourd (13.39 t ha^{-1}) and minimum yield (10.09 t ha^{-1}) from marpha under agroforestry system.
- Maximum mango equivalent yield was found from bottle gourd (27.79 t ha^{-1}), sweet gourd (25.89 t ha^{-1}), marpha (21.31 t ha^{-1}) and lowest in sole mango (2.08 t ha^{-1}).
- Maximum gross return, gross margin and BCR (Tk. 1111600 ha^{-1}, Tk. 786600 ha^{-1} and 3.42 respectively) was obtained from mango+papaya+bottle gourd combination.

Keywords: Creeper vegetables, gross return, crop productivity and economic return.

Achievement of Sub-project by objectives (Tangible form): Technology generated/ developed

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e., product obtained, visible, measurable)	Outcome (short term effect of the research)
a) General objective: Farmers' livelihood improvement and ensuring food security through adoption of innovative agro-forestry technologies	Development of innovative agroforestry technology: Mango+high value crops Litch+ high value crops Guava+ high value crops Mango+pulse crops Mango+Oil seed crops Mango+Fodder crops	-Enhancement of 2 to 3 fold production and income under agroforestry over sole fruit -	Higher income creates more access to food and nutrition security
b) Specific objective: (i) To develop innovative agroforestry technology through adaptive research in agriculture eco-system (rainfed, coastal, charland and hill) of Bangladesh	Developpment of Agroforestry technologies in Rainfed, Coastal, Hill and Plainland ecosystem. 1. Mango based agroforestry with pulse crop for rainfed area 2. Mango, Litchi and Guva based agroforestry with high value vegetables crop for plainland 3. Homestaed agroforestry for Plainland, rainfed and coastal ecosystem 4. Mango based agroforestry with vegetables for Hill ecosystem	-Mango+ Lentil system increase 46.75% system productivity over sole mango -88.54% higher intake of vegetables under homestead agroforestry - System productivity increased by 74.06, 46.39, 30.18, 27.74 and 22% in case of field pea, radish, cabbage, cauliflower and tomato under mango based agroforestry system	-Higher production of vegetables and fruits -Hiigher family consumption -Higher income generation
(ii) To adopt BARI developed homestead, cropland and hill agroforestry technologies in the respective eco-system through active participation of the stakeholders	-BARI developed fruit varieties like BARI Aam-3, BARI Am-4 has been adopted in mango based agroforestry in plainland, rainfed, coastal and hill areas - BARI developed vegetables like BARI Tomato-19, BARI Motor-3, BARI Broccoli-1, BARI Mula-1 has been adopted in mango based agroforestry in different ceosystem -BARI developed pulse (BARI Masur-8) and oil seed crop (BARI Sarisha-17) -BARI Panikachu-1 with homestead fruit orchard -BARI Technology Mango+ elephant footyam agroforestry has been adopted successfully	-Rapid develop fruit orchards with BARI Aam-3, BARI Aam-4, BARI peyara-2 and BARI Malta-1 in rural areas. -Nearly 30 homestead agroforestry with BARI developed fruits and vegetables has been expanded in Pabna areas. -BARI Malta-1 became more available at urban and ryral market -Sorjan based agroforestry with BARI varieties gaining popularity in costal areas	More expansion of BARI fruit varieties and NARS institutes technology at the field level
(iii) To assess the productivity, income and environmental benefits of the developed agroforestry	-Recording of data on production, consumption, income	-Production of vegetables increase by129% -Consumption incresae 116%	-Higher purchase capacity -Better health condition

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e., product obtained, visible, measurable)	Outcome (short term effect of the research)
practices and its contribution to food security and poverty alleviation		-Income increase174%	

Information/knowledge generated/policy generated

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
a) General objective: Farmers' livelihood improvement and ensuring food security through adoption of innovative agro-forestry technologies	-Provide formal and informal training - Visit innovative agroforestry plot -Participatory planning	-Build up capacity of Scientists, DAE personnel and farmers -Gain knowledge on crop selection for agroforestry technology	-Motivated neighboring farmers adopted agroforestry technology
(ii) To adopt BARI developed homestead, cropland and hill agroforestry technologies in the respective eco-system through active participation of the stakeholders	-Joint planning with OFRD team, DAE personnel, NGO representative, farmers - Orientation of BARI developed varieties of fruit, vegetables, pulses, spices, oil seed crop -Discussion on different technical issues of agroforestry technologies	- Co-operator farmers have been selected due to motivation	-Implemented agroforestry activities at the field level
(iii) To assess the productivity, income and environmental benefits of the developed agroforestry practices and its contribution to food security and poverty alleviation	-Regular observation on production and income	- Information on actual enhancement of production and income	-Improvement of livelihood of the farmers

Effectiveness in Policy Support (if applicable)

- Development of multistoried agroforestry in different ecosystem can play a pivotal role regarding mitigation of climate change induced crop failure, enhancing vertical productivity for achieving SDGs.
- Crop land agroforestry system reduces greenhouse effect through C sequestration by crops and trees.
- Integrated agroforestry system opens a greater scope for uplifting food and nutrition security and hence it will attract greater attention to formulate policy planning for poverty reduction.

Technology/Knowledge generation/Policy Support (as applied)

i. Immediate impact on generated technology (commodity and non-commodity)

- Increases 2 to 3 time's higher production and economic return in the same piece of land due to adoption of high value crops like vegetables, pulses, spices etc. with existing fruit orchards.

- Develop enterpreneurship to supply chain of seedling of fruit trees, vegetables, spices and oil seed crop for greater extension of agroforestry technologies.
- Homestead agroforestry open employment opportunity and enhance income generation for rural women.

ii. Generation of new knowledge that help in developing more technology in future

- Community based seedling raising by women could open new concept for community based nursery management and income generation
- Relatively safe food production under agroforestry technology can develop supply chain for safe food market outlets
- Due to higher production of vegetables and fruits create an opportunity for unemployed youth lead community market.
- Greater adoption of agroforestry system and eventual benefit could help efficient land use system
- Rapidly growing fruit orchards could open greater scope for adoption of NARS institutes technologies in the agroforestry system in future.

iii. Technology transferred that help increased agricultural productivity and farmers' income

- Guava based agroforestry system with high value vegetable crops like tomato, cauliflower, cabbage, broccoli
- Litchi based agroforestry system with high value vegetable crops like cauliflower, cabbage, broccoli
- Mango based agroforestry system with high value vegetable crops like tomato, cauliflower, cabbage, broccoli, field pea
- Integrated homestead agroforestry with year round fruits and vegetables
- Mango based agroforestry with pulse crops (Lentil) in rainfed area
- Sorjan based agroforestry (fruits+ vegetables) in coastal ecosystem
- Mango based agroforestry with vegetables in Hill ecosystem
- Mango based agroforestry with fodder crops

iv. Policy Support

- Development of multistoried agroforestry in different ecosystem can play a vital role regarding mitigation of climate change induced crop failure, enhancing vertical productivity for achieving SDGs.
- Crop land agroforestry system reduces greenhouse effect through C sequestration by crops and trees.
- Integrated agroforestry system opens a greater scope for uplifting food and nutrition security and hence it will attract greater attention to formulate policy planning for poverty reduction.

Lessons Learned

i. Agroforestry is the intensive production system which ensures year round crop production and cash income.

ii. Rapidly growing fruit orchards can be brought under agroforestry system which could enhance total production and income generation of rural farming.

iii. Fallow land can be utilized in agroforestry system

iv. Enhance development of entrepreneurship for seedling raising of fruit trees and different vegetables and their marketing.

v. Motivational program/Training/Group discussion/Development of LSP would be helpful for wide scale adoption of agroforestry technologies.

Challenges (if any)

1. Problems/ Constraints

i. Lack of labour in crop growing season
ii. Some difficulties faced in management of fruit trees due to standing associated crops
iii. Land preparation with power tiller is difficult in some existing fruit orchards due to relatively dense planting of fruit trees
iv. Delay in fund release hampers execution and set up of the experiments
v. Lack of skillness of farmers on crop and fruit tree management in agroforestry system
vi. Lack of quality seeds/seedlings of high yielding crop varieties at the field level
vii. Lack of transport facilities for the agroforestry produce from the distant plot to the market
viii. Lack of scientific staff having good understanding of necessary data collection from the agroforestry system at field level
ix. Lack of training facility for farmers, scientific staff and scientific personnel on agroforestry technologies
x. Sometimes lower market price of the produce make the farmers disinterested to the agroforestry system based production

Suggestions for future planning (if any)

- For successful adoption of agroforestry technologies Local Service Provider (LSP) needs to be established at each location for sustainable seed/seedling production and supply chain to the farmers.
- In situ training on efficient management practices for crops and fruit trees in agroforestry system for capacity build up of the community farmers.
- Long-term project support needed to scale up viable agroforestry technologies in homestead and crop field.
- Multidisciplinary team including Agronomist, Soil Scientist, Entomologist, Pathologist Economist and Farmers should be engaged for the development of viable agroforestry technologies.
- Development of mini tillage machine could be helpful for land preparation in the fruit orchards in case of large scale adoption of agroforestry technologies.
- Strengthening of market linkage for the agroforestry produce in the community and urban level
- Safe food production technologies like environment friendly bio rational pesticides should be made available at the community level for producing safe fruits and vegetables under agroforestry system.

MITIGATING RISK AND SCALING-OUT PROFITABLE CROPPING SYSTEM INTENSIFICATION PRACTICES IN THE SALT-AFFECTED COASTAL ZONES OF THE GANGES DELTA

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Progress Summary

The project entitled "Mitigating risk and scaling-out profitable cropping system intensification practices in the salt-affected coastal zones of the Ganges Delta" is built on the achievements of Phase 1 (CSI4CZ) and aims to sustainably increase cropping intensity, diversity, and productivity in the salt-affected coastal zones of the Ganges Delta by mitigating risk and scaling-out profitable cropping system intensification practices achieved through integrated soil, water and crop management. The On-Farm Research Division (OFRD) of Bangladesh Agricultural Research Institute (BARI) is leading the scaling-out of several potential farming and/or cropping system technologies which were validated and developed in Phase 1 (CSI4CZ). In the Rabi season of 2021-22 OFRD, BARI Khulna and Patuakhali has successfully conducted experiments and scaling-out program on zero-tillage potato, zero-tillage garlic, watermelon, seedling transplanting of maize and sunflower. For large-scale dissemination, farmers' training and field days were organized in the presence of local farmers and different stakeholders. Different news media covered the updates and success stories of the farmers who participated in this project. Overall, farmers of that locality have become confident that fallow land could be brought under cultivation with the technologies demonstrated under this project.

Expt. 1: Upscaling of zero tillage potato with mulch in coastal saline area of Bangladesh

Abstract

An upscaling program of zero tillage potato production was conducted in two upazilas viz. Dacope and Koyra of Khulna district during 2021-22. There were 47 farmers involved under this program covering a total of 554 decimal land. Two potato varieties viz. BARI Alu-72 and BARI Alu-73 were sown by pressing with hands into moist land immediately after the transplanted Aman (T. Aman) rice harvest between the 1st and 3rd week of December 2021. Rice straw as well as water hyacinth were used as mulch. A significant yield variation was observed among the varieties and farmers' fields. The range of tuber yield was between 15.10 to 20.69 t ha^{-1} and the mean tuber yield was 17.4 t ha^{-1}. Various factors influenced tuber yield including initial soil water content and compost application rate.

Introduction

Most of the land of the coastal saline area of Bangladesh remains fallow after the T. Aman rice harvest, which is mainly due to several biophysical barriers attributed to the area. Hence, to increase cropping intensity, several technologies have been tested in that area from a recently completed project funded by ACIAR, Australia, and KGF, Bangladesh.

Based on demonstration plots of the project, potato production through the zero tillage method appeared promising and a lot easier to establish than other technologies. Hence, an upscaling program of zero tillage potato production was undertaken in 2021-22.

Materials and Methods

An upscaling program of potato production under zero tillage practice was conducted at two upazilas viz. Koyra and Dacope of Khulna district. There were 47 farmers involved in the trial, covering total 554 decimal land. Among the farmers, 37 of them were from Dacope and 10 from Koyra. Different farmers received different potato varieties as per the availability of seed potatoes (Table 1). Seed potatoes (50-60 g) were sown by pressing with a hand into the moist soil after T. Aman rice harvest. The sowing date ranges from the 1st to 3rd week of December 2021. Before sowing, each plot was fertilized with urea, TSP, MoP and Zypsum at varying rates applied by different farmers. Immediately after sowing the seed potatoes were covered with compost and/or poultry litter and finally covered with rice straw and/or water hyacinth mulch at 8-15 cm thick. There were notable variations in management practices followed by respective farmers. For example, varying plant populations per unit area due to different spacings, amount and thickness of mulches, amount and frequency of fertilizer and irrigation application, etc. In addition to these, there was inherent variability of the land, e.g. initial soil moisture, residual nutrient and source of irrigation water.

Results and Discussion

The field duration of zero tillage potato ranged from 81 to 103 days based on different harvest dates (Table 1). A significant yield variation was observed among the varieties and farmers' fields. The range of tuber yield was between 15.10 to 20.69 t ha^{-1} and the mean tuber yield was 17.39 t ha^{-1}. It was observed that several factors influenced variation in tuber yield, for example, initial soil moisture, residual nutrient, irrigation frequency, quality of irrigation water, different spacings, amount and frequency of fertilizer application, mulch thickness and amount, etc. We also observed that tuber yield was higher in those farmers who sown when soil moisture was at field capacity and applied a higher amount of compost (5-7 t ha^{-1}).

Table 1. List of location-wise farmers, land area, potato variety, sowing date, harvest date and field duration in zero tillage potato production in three upazilas of Khulna district during 2021-22.

Sl. No.	Farmer	Location	Land area (dec)	variety	sowing date	harvest date	Duration (days)	Yield (t/ha)
1	Monmothonath Ghosh, Gokul Chandra Ghosh, Ponkoj Roy, Dipankar Roy, Dhirendronath Roy, Nitai Ghosh Narayan Ghosh, Kitish Ghosh, Robindronath Ghosh Prodip Ghosh, Md.Hamid Sardar	Dacope	55	BARI Alu-72	20-Dec-21	19-Mar-22	87	18.89
2	Akhil Halder	Dacope	17	BARI Alu-72,73	22-Dec-21	14-Mar-22	82	19.07
3	Shahidul Shekh	Dacope	8	BARI Alu-72	23-Dec-21	11-Mar-22	81	20.16
4	Shimul Roy	Dacope	18	BARI Alu-72	29-Dec-21	21-Mar-22	82	19.72
5	Shohidul Shekh (Member)	Dacope	8	BARI Alu-73	28-Dec-21	23-Mar-22	85	17.99
6	Chayan Roy	Dacope	20	BARI Alu-72	27-Nov-21	10-Mar-22	103	20.69
7	Subroto Roy	Dacope	3	BARI Alu-73	22-Dec-21	19-Mar-22	87	19.69
8	Diponkor Roy Animesh Roy Gosai Roy Ruidash Roy Nritojoy Roy Sukhdeb Deb	Dacope	45	BARI Alu-72,73	22-Dec-21	18-Mar-22	86	18.60
9	Subroto Roy Amodini Roy	Dacope	24	BARI Alu-72	16-Dec-21	6-Mar-22	80	19.47
10	Narayan Roy Rifatul Sheikh	Dacope	10	BARI Alu-72	26-Dec-21	19-Mar-22	83	16.85

Sl. No.	Farmer	Location	Land area (dec)	variety	sowing date	harvest date	Duration (days)	Yield (t/ha)
11	Monojit Roy	Dacope	17	BARI Alu-72	23-Dec-21	14-Mar-22	81	18.25
12	Mehedi Hasan	Dacope	10	BARI Alu-78	22-Dec-21	17-Mar-22	85	18.80
13	Jogodish Roy Sumon Roy Habibullah Shekh Aajarot Sordar Ebrahim Shekh Sushanto Roy Gouri Roy	Dacope	45	BARI Alu-72,73	26-Dec-21	25-Mar-22	85	17.72
14	Radhika Mondol	Dacope	12	BARI Alu-73	21-Dec-21	18-Mar-22	87	19.67
15	Gupi Mondol	Dacope	13	BARI Alu-73	22-Dec-21	17-Mar-22	85	18.10
16	Kajol Roy	Dacope	17	BARI Alu-72,73	24-Dec-21	15-Mar-22	81	17.89
17	Sujit Roy	Dacope	72	BARI Alu-72,73,78	22-Dec-21	15-Mar-22	83	15.78
18	Rabindranath Dhali	Koyra	30	BARI Alu-72,73	19-Dec-21	18-Mar-22	89	15.32
19	Mostafijur Rahman	Koyra	15	BARI Alu-72,3	21-Dec-21	23-Mar-22	92	15.20
20	Karimunnasa	Koyra	10	BARI Alu-72,3	22-Dec-21	13-Mar-22	81	15.22
21	Asadul Islam	Koyra	15	BARI Alu-72,73	17-Dec-21	26-Mar-22	99	15.24
22	Rashid Dhali	Koyra	15	BARI Alu-72,73	20-Dec-21	17-Mar-22	87	15.17
23	Saleha Khatun	Koyra	15	BARI Alu-72,73	14-Dec-21	12-Mar-22	88	15.25
24	Al Mamun	Koyra	15	BARI Alu-72,73	12-Dec-21	16-Mar-22	94	15.20
25	Shabaz Ali	Koyra	15	BARI Alu-72,73	20-Dec-21	18-Mar-22	88	15.22
26	Nazrul Islam	Koyra	15	BARI Alu-72,73	21-Dec-21	17-Mar-22	86	15.24
27	Harun Or Rashid	Koyra	15	BARI Alu-72,73	19-Dec-21	11-Mar-22	82	15.10
		Total	554				Average	17.39

Conclusion

A significant yield variation was observed among the varieties and farmers' fields. The range of tuber yield was between 15.10 to 20.69 t ha^{-1} and the mean tuber yield was 17.39 t ha^{-1}. Various factors influenced tuber yield including initial soil water content and compost application rate.

Expt. 2: Upscaling of zero tillage garlic in coastal saline area of Bangladesh

Abstract

An upscaling program of zero tillage garlic product was conducted in three upazilas viz. Dacope, Koyra and Batiaghata of Khulna district during 2021-22. There were 57 farmers involved under the expansion program covering a total of 141 decimal of land. Popular garlic variety, BARI Roshun-1 was used for upscaling and sown by pressing into moist soil immediately after T. Aman harvest between 2nd and 3rd week of December 2021. Due to heavy rainfall in January 2021, most of the plots were affected to some degree. From Batiagahata, no harvest was possible. The range of bulb yield varied from 0.08 to 4.08 t ha^{-1}.

Introduction

Most of the land of the coastal saline area of Bangladesh remains fallow after T. Aman harvest, which is mainly due to several biophysical barriers attributed to the area. Hence, in order to increase cropping intensity, several technologies have been tested in that area from a recently completed project funded by ACIAR, Australia and KGF, Bangladesh. Based on demonstration plots of the project, garlic production through the zero tillage method appeared promising and a lot easier to establish. Hence, an upscaling program of zero tillage garlic production was undertaken in 2021-22.

Materials and Methods

An upscaling program of garlic production under zero tillage practice was conducted at three upazilas viz. Koyra, Dacope and Batiaghata of Khulna district. There were 57 farmers involved in the trial, which was in total 141 decimal land. Among the farmers, 8 of them were from Koyra, 44 were from Dacope and 5 from Batiaghata. Popular garlic variety, BARI Roshun-1 was planted by pressing with hand into the moist soil after T. Aman harvest. The sowing date ranges from the 2nd to 3rd week of Decemeber 2021. Before sowing, each plot was fertilized with urea, TSP, MoP and Zypsum @ 13, 16, 20 and 7 kg. Immediately after sowing the cloves were covered with rice straw mulch at 8-10 cm thick, the weight of which ranges from 5.69 to 6.94 t ha^{-1}. Some farmers also used rice husk along with rice straw. Two to three light irrigations were applied during the growing period. However, there were variations initial moisture, residual fertility, in irrigation water quality and timing of application. The crop was harvested from 10 to 25 April 2022. The crop of Batiaghata could not harvested because of rain damage in January 2022. In fact, all fields were affected by heavy rain.

Results and Discussion

The field duration of garlic ranges from 95 to 124 days based on different maturity and harvest date. Bulb yield of garlic also varied widely from 0.08 t ha^{-1} to 4.08 t ha^{-1} (Table 2). Variation in yield is due to the inundation of most of the fields during heavy rainfall in January.

Table 2. List of location wise farmers, sowing date, harvest date, field duration, land area and bulb yield of garlic production under zero tillage practice in two upazilas of Khulna district, 2021-22

Sl. No.	Location	Farmer	Sowing date	Harvest date	Duration (days)	Area (decimal)	Plot yield (kg)	bulb yield (t ha^{-1})
1	Koyra	Al Mamun	13-Dec-21	9-Apr-22	117	0.5	3.84	1.90
2	Koyra	Emdadul Haque	19-Dec-21	9-Apr-22	111	0.5	3.716	1.84
3	Koyra	Zahangir Hossain	21-Dec-21	10-Apr-22	110	0.5	2.642	1.31
4	Koyra	Abdus Salam	20-Dec-21	8-Apr-22	109	0.5	4.161	2.06
5	Koyra	Krishna Dhali	24-Dec-21	13-Apr-22	110	0.5	3.68	1.82
6	Koyra	Ayesha Khatun	25-Dec-21	14-Apr-22	110	0.5	3.139	1.55
7	Koyra	Abdul Kalan	20-Dec-21	12-Apr-22	113	0.5	3.127	1.54
8	Koyra	Shahadat Hossain	31-Dec-21	15-Apr-22	105	0.5	2.562	1.27
9	Dacope	Monmothonath Ghosh Gokul Chandra Ghosh Ponkoj Roy, Dipankar Roy Dhirendronath Roy Nitai Ghosh,Narayan Ghosh Kitish Ghosh, Robindronath Ghosh, Prodip Ghosh Md.Hamid Sardar	22-Dec-21	25-Apr-22	124	23	227	2.44
10	Dacope	Akhil Halder	22-Dec-21	6-Apr-22	105	7	43	1.52
11	Dacope	Shahidul Shekh	27-Dec-21	20-Apr-22	114	1.5	17	2.80
12	Dacope	Shimul Roy	29-Dec-21	24-Apr-22	116	1.5	11	1.81
13	Dacope	Shohidul Shekh (Member)	23-Dec-21	26-Apr-22	124	1	9	2.22
14	Dacope	Chayan Roy Subroto Roy Diponkor Roy Animesh Roy Gosai Roy, Ruidash Roy Nritojoy Roy, Sukhdeb Deb	2-Jan-22	26-Apr-22	114	3	21	1.73
15		Animesh Roy Gosai Roy Ruidas Roy Mritunjoy Roy Shukdeb Roy	4-Jan-22	22-Apr-22	108	45	217	1.19
16	Dacope	Subroto Roy Amodini Roy	5-Jan-22	25-Apr-22	110	13	74	1.41
17	Dacope	Narayan Roy	3-Jan-22	22-Apr-22	109	1	4	0.99
18	Dacope	Rifatul Shekh	20-Jan-22	25-Apr-22	95	3	22	1.81
19	Dacope	Monojit Roy	17-Jan-22	23-Apr-22	96	4	13	0.80

20	Dacope	Mehedi Hasan	12-Jan-22	26-Apr-22	104	3.5	29	2.05
21	Dacope	Jogodish Roy Sumon Roy Habibullah Shekh Aajarot Sordar Ebrahim Shekh Sushanto Roy Gouri Roy	1-Jan-22	22-Apr-22	111	23	84	0.90
22	Dacope	Radhika Mondol Gupi Mondol	30-Dec-21	22-Apr-22	113	2	33	4.08
23	Dacope	Kajol Roy	3-Jan-22	24-Apr-22	111	1.5	11	1.81
24	Dacope	Sujit Roy	4-Jan-22	22-Apr-22	108	4	27	1.67

Conclusion

Bulb yield of garlic yield under zero tillage practice ranged from 0.08 to 4.08 t ha^{-1}. Heavy rainfall at the vegetative stage affected the yield.

Expt. 3: Pilot production of watermelon in south-western coastal area

Watermelon cultivation is gaining popularity in the coastal saline belt of Bangladesh. The area of watermelon in the last 2020, 2021 and 2022 years were 0.038, 0.043 and 0.047 million hectares, respectively, and the production from those three years was 1.45, 1.77 and 1.92 million tonnes, respectively. About 10 to 12 years ago, the lands those were used to be fallow during the rabi season, now have been brought under watermelon cultivation. According to the monitoring and evaluation unit of the Department of Agricultural Extension (DAE), watermelon acreage has increased to nearly 47,000 hectares in 2021 than the previous year (The Financial Express, 2021). Farmers usually cultivate commercial varieties and many farmers are willing to cultivate watermelon. But due to high seed price and lack of knowledge of the production technology, a considerable area of land remain uncultivated. On-Farm Research Division of BARI brought some of the uncultivated lands under watermelon cultivation during the rabi 2022 season to intensify crop cultivation in the rice fallows. We supplied required seeds of both commercial hybrid varieties and BARI released open pollinated varieties and other production supports to the farmers of three coastal Upazilas of Khulna district viz. Koyra, Batiaghata and Dacope. There were thirty farmers involved in the pilot production program covering a 54.5 bigha area.

Seeds were sown from 12 February 2022 to 5 March 2022 and harvested between 20 April 2022 to 9 May 2022. In Koyra seeds were sown earlier than the other two Upazilas and harvested earlier. As a result, the highest yield (64.28 t/ha) was found from Koyra and due to late planting and delay harvest lowest yield was found from Batiaghata (41.25 t/ha). The market price was also higher in Koyra and farmers earned the highest profit, mainly because of early harvest and peak demand in the season. Whereas, farmers from Batiaghata earned the lowest income because of lower yield due to delayed sowing and inundation of fields during the growing period (Table 3).

Table 3. Brief description of watermelon area, yield and BCR from pilot production trials of three coastal districts of Khulna during 2022

Location	Number of Farmers	Area (Bigha)	Variety	Sowing Date	Harvest Date	Yield (t/ha)	Gross margin (Tk/ha)	BCR
Koyra	15	20	Pakeeza, BARI Tormuj-1, 2	12 Feb’22 to 20 Feb’22	20 Apr’22 to 27 Apr’22	64.28	602,460	4.56
Batiaghata	12	31.5	Pakeeza, BARI Tormuj-1, 2	19 Feb’22 to 5 Mar’22	23 Apr’22 to 9 May’22	41.25	77,294	1.45
Dacope	3	3	Pakeeza, BARI Tormuj-1, 2	21 Feb’22 to 25 Feb’22	26 Apr’22 to 4 May’22	48.82	423,200	3.25

Farmers' opinion

- Early sowing gave higher profit.
- BARI Tormuj-1 and 2 also gave higher yield.
- BARI Tormukj-2 is a yellow flesh variety, which has high market demand.

Observation

Watermelon cultivation is a cost and labour-intensive business as well as a risky venture because of unpredictable rainfall, and storms. Commercial hybrid seeds are very costly. In that case, BARI-released open-pollinated seeds can be a solution. In terms of production practice, several agronomic management practices should be optimized like spacing, fertilizer management, irrigation management etc. Farmers usually overdose on fertilizer which is subjected to loss to different pathways and creates environmental pollution. Delay sowing and poor drainage condition reduce yield and market price. Overall, watermelon cultivation is gaining popularity among farmers, so future research programs should be on optimizing agronomic management, postharvest processing and marketing.

Expt. 4: Characterization of new polders in coastal region

Abstract

A polder characterization program was conducted at polders named Polder No. 44 (Kachufatra, Taltoli, Borguna), Polder No. 46 (Sonatala, Kalapara, Patuakhali) & 48 (Diaramkhola, Kalapara, Patuakhali) to know the soil properties and salinity status of the crop fields during 2021-22. It was observed that the polder soils carry favorable physical and chemical properties for crop production with some limitations like N and B deficiency. Groundwater, pond water and canal water salinity were found 1.72-4.20 dS/m, 0.65-1.0 dS/m and 2.8 to 18.5 dS/m, respectively during 01 December 21 to 01 May 22. So, groundwater and reserved pond water should be considered to irrigate the crops instead of canal water.

Introduction

The coastal zone of Bangladesh includes 139 polders, low-lying tracts of land surrounded by embankments constructed in the 1960s and 1970s to protect farmers from saline water intrusion and tidal floods. Out of the 2.8 million ha in the coastal zone, almost half (1.2 million ha) are poldered. During 2016-2020 a project entitled 'Cropping systems intensification in the salt affected coastal zones of Bangladesh and West Bengal, India' was carried out at polder no-43 at Amtoli, Borguna. The findings of the project are applicable in the adjacent polders. So, 2nd face of the project entitled "Mitigating risk and scaling-out profitable cropping system intensification practices in the salt-affected coastal zones of the Ganges Delta" has been launched. The project activities will be done in polders no-44, 46 and 48 situated at Taltoli, Borguna and Kalapara, Patuakhali. To intervene findings of the previous project in new polders it is necessary to characterize the polders in terms of local ecology, land type, soil and water properties, existing cropping tradition, and socioeconomic status. So, the characterization of the polders has been undertaken to find out some intrinsic soil and water properties of three new polders.

Methodology

As per the objective a survey was conducted at new polders named Polder No. 44 (Kachufatra, Taltoli, Borguna), Polder No. 46 (Sonatala, Kalapara, Patuakhali) & 48 (Diaramkhola, Kalapara, Patuakhali) to know the cropping system and socioeconomic status of the farmers. Twelve soil samples from each site were collected for analyzing some intrinsic properties (*viz*. pH, EC, moisture content, bulk density, particle density, porosity, salinity and chemical properties). A piezometer was installed in each polder to find groundwater table depth and underground water salinity at 15 days intervals during Rabi season. Surface water, exist in pond and canal, and salinity was also measured. Data on soil physical and chemical properties of each polder, salinity status of groundwater, pond water and canal water were collected and analyzed statistically.

Results and Discussion

Knowledge of soil physical properties is essential for soil management as well as planning modern farming in a polder. Bulk density, porosity, organic matter, pH, etc are basic properties that influenced the soil characteristics of a region. Table 4 provides the pH and electrical conductivity (EC) of different polders at Kalapara, Patuakhali. The pH of soil samples ranges from 5.1 to 5.3 *i.e.* the soil samples were acidic in nature. On the other hand, the observed EC values were found between 0.2-0.5 dS/m indicating the soil samples were not saline during starting of the Rabi season. OM status of the polders was 1.1 to 1.3 which influenced the bulk density and porosity of the soil. Ranges of bulk density in soils were 1.14 to 1.49 g cm^{-3} while particle density was almost double of it *i.e.*, 2.35 to 3.0 g cm^{-3} which denoted the ideal condition of soils. As bulk density is an indicator of root penetration in the soil it indicates the favorable condition of plant growth in the sampling area of the studied polders in Kalalpara, Patuakhali.

The chemical properties of the polder soils are presented in Table 5. N status was found below the critical level in both polders but other macro elements were above the critical level. It means the N amendment is essential for crop production in the new polders 46 and 48. Among micronutrients, Boron was found below the critical level in Polder 46 but it was at per at Polder 48. The average groundwater table in the polders was 72 cm during December 202. It increased with time and reached pick (178 cm) during late April then it reduced with the onset of seasonal precipitation (Fig. 6). Groundwater, pond water, and canal water salinity were also measured with time. It was observed that the salinity of water in all sources increased with the advancement of the Rabi period. During 01 December 21 to 01 May 22 groundwater and pond water salinity increased 1.72-4.20 dS/m, 0.65-1.0 dS/m, respectively then it declined. Canal water salinity increased up to 01 April 22, 2.8 to 18.5 dS/m then it declined due to intrusion of tidal water in the canal.

Table 4. Soil physical properties of different polders

Polder No .	Location	pH	Ec (dS/m)	OM (%)	Particle density (g/cc)	Bulk density (g/cc)	Porosity (%)
46	Sonatala, Kalapara	5.3	0.3-0.5	1.3	2.35-2.59	1.45-1.49	49.39-52.67
48	Nobinpur, Kalapara	5.1	0.2-0.3	1.1	2.91-3	1.14-1.35	47.98-51.34

Table 5. Soil chemical properties of different polders

Polder No	K (meq/100 ml)	Total N (%)	P	S	B	Zn
			ppm			
46	0.18-0.20	0.07	10-12	19-21	0.08-0.1	1.0-1.2
48	0.12-0.20	0.06	12-21	15-17	0.20-0.32	0.7-1.0
C.L.	0.12	0.20	10	10	0.20	0.60

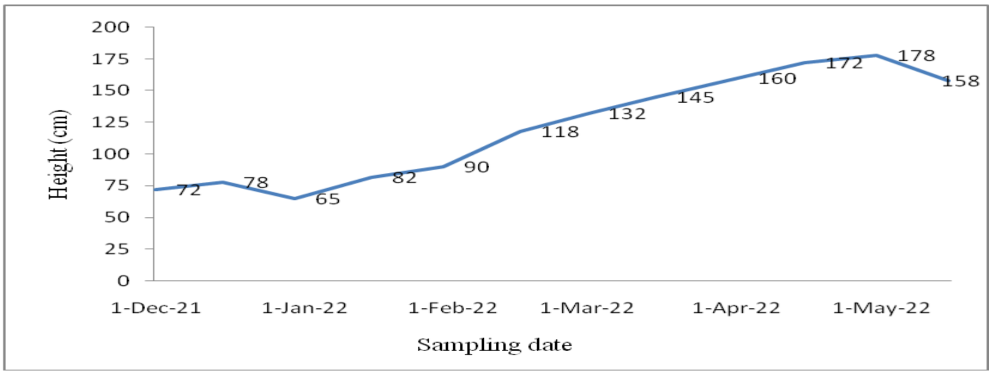

Fig. 6 Average groundwater table in the polders during Rabi season 2021-22

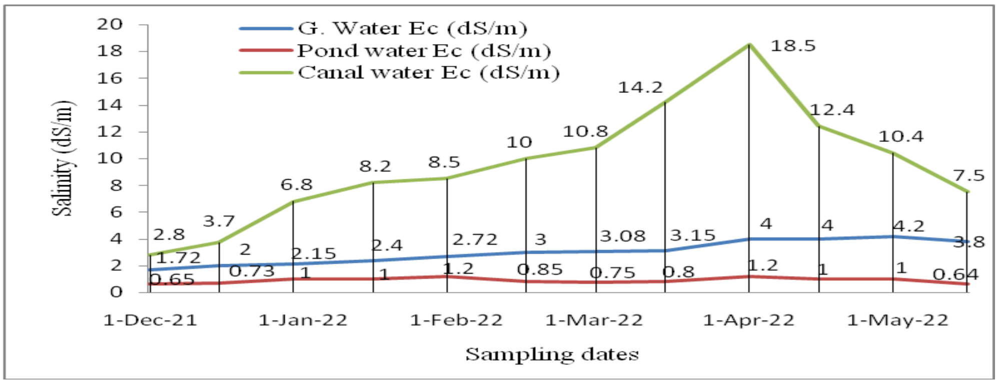

Fig. 7 Average groundwater, pond water and canal water salinity in the polders during Rabi season 2021-22

Conclusion

From the above discussion, It may be concluded that the soils of polders 46 & 48 carry favorable physical and chemical properties for crop production with some limitations like N and B deficiency. Groundwater and reserved pond water should be considered to irrigate the crops. To generate more information about the polder characterization program will be continued next year.

Expt. 5: Production of zero tillage garlic in coastal region

Abstract

A production program was conducted at polder 46 (Pakhemara, Patuakhali) in the Rabi season of 2021-22 to find out the performance of garlic production under zero tillage conditions. Two types of sowing methods i.e. T_1 = Sowing in zero till field and T_2 = Sowing in the ploughed field (traditional) were tested in the trial. A significant influence was found on growth, yield and yield contributing traits of garlic. It was also observed that all the studied traits were higher in zero-tillage conditions. Plant establishment was higher in zero tillage plots as the plants absorbed the required moisture during the early growing stage. The highest bulb yield (7.23 t/ha) was obtained from the zero tillage field compared to the tillage system (6.49 t/ha). The zero tillage system also gave the highest gross return (Tk. 361500) and gross margin (Tk. 263500) as its production cost was lower than the tillage system.

Introduction

Garlic (Allium sativum L) is an aromatic herbaceous plant and the second most widely used Allium after onion (Bose and Som, 1990). This crop is extensively cultivated in many countries of the world including Bangladesh as a popular spice crop. Garlic is a rich source of carbohydrates and phosphorus (Rahman et al., 2007). The average yield of garlic in this country is only 5.21 t/ha (BBS, 2012). The poor yield of garlic may be due to the lack of inadequate soil and water management practices with reference to soil water shortage in the soil profile. Zero tillage crop production needs low water requirements and other cultural practices. Fallow – Fallow - T. Aman is the major cropping pattern in the coastal region where some lands remain fallow in Rabi due to excessive moisture in the field. In these lands, garlic may be cultivated in zero tillage. With these views, the production trial has been undertaken with the above objectives.

Materials and Methods

The trial was conducted at MLT site Bauphal, Patuakhali in the rabi season of 2021-22 to observe the performance of garlic under zero tillage conditions. Two types of sowing methods i.e. T_1 = Sowing in the ploughed field (traditional) and T_2 = Sowing in zero till field was tested in the trial. The experiment was laid out in a randomized complete block design with 3 replications. The unit plot size was 8m x 5m. A local garlic variety was used as the test crop. The crop was planted in line, maintaining 15 cm x 10 cm spacing on the muddy soil just 2 to 3 days after harvesting T.

aman rice. Then the muddy soil surface was covered by rice straw. Planting was done manually using one clove per hole. The crop was fertilized with N_{155}-P_{35}-K_{125}-S_{20} kg /ha. One-third nitrogen was applied as basal and two third was top dressed in two equal installments at 25 and 50 days after planting. Other fertilizers were applied to the muddy soil as basal before planting and covering the soil surface with rice straw. In the case of the tillage system, the experimental plots were ploughed by a power tiller followed by laddering up to a depth of 10 cm were done until the desired depth was achieved for planting the clove. The plots were fertilized as zero tillage system cited above. The crop was planted on 02 December 2021 and harvesting was done on 10 April 2022 when the plants reached maturity showing the normal sign of drying out of most of the leaves and the top leaves started drying and natural dropping at the neck.

Results and Discussion

It was observed that the emergence of clove, plant height and leaf number was significantly influenced by planting systems. In the zero tillage plot the emergence of clove (89%), and plant height (49.74cm) were higher than tillage plots (82%, 47.31 respectively). The effects of the planting system on bulb diameter were significant and higher in the traditional planting system. It may be the loose soil structure in tillage plots. Bulb diameter was higher in tillage (7.98 cm) compared to zero-tillage (7.34 cm). The effects of planting system on number of cloves per bulb were insignificant. Statistically similar number of cloves was found in both the tillage system. The highest bulb yield was found in the zero-tillage (7.23 t/ha) compared to tillage (6.49 t/ha) system (Table 6). In the zero-tillage system, straw mulch was used after planting cloves which help to conserve soil moisture as well as suppressed weed infestation, therefore, vegetative growth of plant was improved. Zero-tillage system helps to increase water and fertilizer use efficiency of the crop as a result yield increase as compared to tillage condition (Triplett Jr & Dick, 2008). Zero tillage with mulch using water hyacinth (Kabir *et al.,* 2011) and rice straw (Islam *et al.,* 2015) significantly retained soil moisture and suppressed weed growth which enhanced crop growth and development (Karaye & Yakubu, 2006). Jamil *et al.* (2005) reported that straw mulch increased yield and yield contributing traits of garlic and they recommended straw mulch for garlic production. From the economic point, comparing both methods the highest gross return (Tk.361500), gross margin (Tk.263500) and BCR (3.68) were recorded from the zero tillage method and the lowest economic return was recorded from the tillage system (Tk.32500) and BCR (2.95), respectively.

Table 6. Plant populations, growth, and yield contributing parameters of Garlic at Bauphal, Patuakhali during 2021-22

Variety	% Emergence at 30 DAP	Plant height at 80 DAP	Bulb diameter (cm)	Cloves/bulb (Nos)	Bulb yield (t/ha)
T_1	82	47.31	7.98	13.76	6.49
T_2	89	49.74	8.05	14.89	7.23
P- value	0.93	0.045	0.48	0.046	0.07
$LSD_{0.05}$	NS	*	*	*	*

Table 7. Economic analysis of Garlic at Patuakhali during 2021-22

Variety	Yield (t ha^{-1})	Gross Return (Tk./ha)	Variable Cost (Tk/ha)	Gross Margin (Tk./ha)	BCR
T1	6.49	324500	110000	214500	2.95
T2	7.23	361500	98000	263500	3.68

Garlic Price (Tk/kg) = 50

Farmers Opinion

Farmers opined that this practice is new in the area. They were delighted to get a satisfactory yield in zero tillage garlic cultivation. They also opined to continue this low-cost, early planting no tillage garlic cultivation practice next year to increase garlic area in the region.

Conclusion

In zero-tillage system, seeds/bulbs are planted directly into untilled soil which contains previous crop residues. This system minimizes soil disturbance and allows crop residues to remain on the soil. It offers plants to absorb soil moisture for their initial development. Furthermore, zero-tillage conserved soil moisture during the entire growth period of crop as mulch is used. In these ways, zero tillage reduces irrigation frequency for garlic production consequently production costs are reduced. Available moisture at the root zone enhanced vegetative growth and ultimately improved yield in the zero-tillage system. This technology may be recommended for the coastal region.

Expt. 6: Validation trial of maize seedling transplantation in coastal area

Abstract

The experiment was conducted at Polder 48 (Kuakata, Patuakhali) during the Rabi season of 2021-2022 to establish a sowing practice for maize cultivation in the fallow saline coastal area after T. Aman rice harvest. Seeds/seedlings of hybrid Miracle variety were sown/transplanted in two planting systems (T_1=Direct seed sowing and T_2= 20 days old polybag seedling). The polybag seedlings establishment rate was higher (98%) and maturity came 20 days earlier than direct seed sowing. The highest grain yield was obtained from the seedling transplantation method (8.27 t/ha) and the lowest was obtained from the direct seed sowing method (7.46 t/ha).

Introduction

Maize (Zea mays L.) occupies one of the important cereal crops all over the world. It serves as food and oil for humans; feed for livestock and raw material for industry (Ullah and Ali, [1]. In the southern region, huge land remains fallow in the Rabi season after the harvest of T. Aman. Among these, a significant part is medium highland and the area would be about 50% of the total fallow land, where maize can be grown without competition or with less competition with Rabi crops. The cultivable areas in coastal districts are affected by varying degrees of salinity, but there is enough area that are non-saline. The most severe difficulties for crop production in the dry regions are high concentrations of toxic ions especially NaCl either in soil or in irrigation water (Ahmed, 2010). In Bangladesh, the total land area and production of maize are 395500 ha and 279500 m tons respectively (FAO, 2015). Hybrid maize varieties cultivation could be a breakthrough option for the southern region. But after T. Aman harvest land becomes dry crop establishment becomes very difficult. So, to find out a way to crop establishment polybag seedling transplantation may be an alternative. In this way, a huge fallow land in the rabi season could be under cultivation, so the socio-economic condition of the farmers would be changed. Considering the above facts the experiment was undertaken to observe the performance of hybrid maize seedlings transplantation in the coastal environment.

Materials and Methods

The experiment was conducted at MLT site Kuakata, Patuakhali, in the rabi season of 2021-22 to verify the effect of different planting methods for maize cultivation in the coastal area of Patuakhali under farmers' field conditions. There were two different methods used. T_1 = Direct seed sowing and, T_2 = 20 days old maize seedling transplantation. The experiment was laid out in RCB design with three compact replications having unit plot size 10 m x 10 m. Twenty days old seedlings were transplanted in a plot on 07 January 2021 and in another plot seeds were sown on the same day. Crops of transplanted plots were harvested on 25 April 2022 and 13 May 2022 of seed sowing plot. Fertilizers were applied @ 250-55-110-40-5-1.5 N-P-K-S-Zn-B Kg ha^{-1}respectively. A light irrigation was done after seedling transplantation. The crop was irrigated twice at 20 DAS and 55 DAS. Weeding was done after 7 days of irrigation. Data were collected plot-wise and analyzed statistically.

Results and Discussion

Morphological and yield influences by planting methods in different locations are presented in Tables 7& 8. In the seedling transplanting method plant establishment was higher (91%) than the direct seeding method (82%). Plants of direct seeding were somewhat taller than those transplanting one. Up to 30 days after transplanting plants were vigorous but after 60 days the plants of both treatments were alike. Tassels were produced 26-32 days earlier in transplanted plants than direct sowing plants consequently transplanted plants matured 25-30 days earlier. So, farmers get more return from the transplanting field due to early cob marketing. Cob length was almost similar but due to varying number of grain/cob (448.7 & 438.7) and 1000 grain weight (280 & 285) transplanting plants gave lower yield (7.46 t/ha ≈ 49995 cobs/ha) than direct seeding plants (8.27 t/ha ≈ 56660 cobs/ha). On an average each cob of transplanting and direct plantings plants cobs was sold Tk. 08 and Tk. 05 respectively. So, the highest gross return (Tk. 399960/ha) and BCR (4.17) were obtained from the transplanting method.

Table 8. Physiological influence of different planting methods at Kuakata

Treatment	Plant est. (%)	Plant height (cm)	Plant vigority*		Days to tasseling	Days to Maturity
			At 30 day	At 60 day		
T_1=Direct seed sowing	91	201.1	2	3	73	137
T_2= 20 days old polybag seedling	82	199.7	1	3	41	119

1 = poor growth, 2 = medium growth and 3= Good growth

Table 9. Yield and yield attributes of maize as influenced by planting methods at Kuakata**.**

Treatment	Cob length (cm)	Grains/cob (No)	1000-seed wt. (g)	Cob yield (No/ha)
T_1	17.1	448.7	285	56660
T_2	16.7	438.7	280	49995
T-value	4.30	5.02	3	0.439

Table 10. Economics of the treatments of the trial at Kuakata, Patuakhali during 2021-22

Treatments	Yield (No/ha)	Gross Return (Tk./ha)	Variable Cost (Tk/ha)	Gross Margin (Tk./ha)	BCR
T_1	56660	283300	90500	192800	3.13
T_2	49995	399960	96000	303960	4.17

Maize Price T_1- Tk. 5/Cob & T_2- Tk. 8/Cob

Farmers' opinion

Farmers showed interest in maize seedling transplantation as it offered early marketing of cobs and gross return is higher than the traditional system.

Expt. 7: Upscaling mechanized sunflower production in coastal region

Abstract

The up-scaling of mechanized sunflower production was conducted at polder No 43 (Amtoli), polder 44 (Taltoli), polder 46 (Kalapara) and 48 (Kuakata) during Rabi 2021-22. Mechanical sowing reduced land preparation and sowing cost by 50.94% over the conventional practice. It was also observed that mechanical threshing reduces threshing cost by 52% over manual threshing. So, if sunflower production could be mechanized, it would reduce production costs and sunflower will be sustained in the coastal region. Sunflower is very susceptible to birds. Bird damage can lead to the entire crop being destroyed and abandoned. Bird attacks on sunflower crops occur from the sowing stage. Sometimes they occur later, in almost case, affecting the flower head. Attacks can be very frequent and cause substantial damage to the sunflower crop. Bird repelling measures retained 21-27% more yield over control.

Introduction

Sunflower is an emerging crop in the coastal region. It is best suited to the coastal environment. It has ability to tolerate salinity at moderate level. So its area is increasing in southern Bangladesh. Currently, farmers prepare the soil to grow sunflower with 4–5 passes of rotary tillage beginning when the topsoil dried below field capacity (Mondal *et al.* 2015a). Rotary tillage accelerates the drying of the tilled surface soil but delays the sowing time, which can lead to lower yields with higher production cost. To sustain sunflower production coastal ecology-specific technologies need to be adopted to reduce production costs and increase farmers' income. BARI seeder, digital bird repelling device and thresher are coastal climate smart technologies that are suitable to reduce the production cost of sunflower. So, these up-scaling programs were undertaken to popularize and promote these types of machinery for sunflower production in the coastal region.

Approaches and Methodologies

The up-scaling of mechanized sunflower production was conducted at polder No 43 (Amtoli), polder 44 (Taltoli), polder 46 (Kalapara) and 48 (Kuakata) during Rabi 2021-22. The demonstrations were conducted under the project project "Mitigating risk and scaling-out profitable cropping system intensification practices in the salt-affected coastal zones of the Ganges Delta" funded by ACIAR & KGF. Required seeds, seeding machines, fertilizers, pesticides, bird repelling devices and threshers were supplied to the farmers. In all the sites Seeds of BARI Surjamukhi-2 were sown in line by the BARI seeder. Five types of approaches were taken to repel birds from flowering to harvest. For each 02 bighas 01 digital bird repealing device were set in the field. Land preparation and sowing was done by two wheel power tiller-operated seeder along with the traditional sowing method. Hanging red ribbons, making scarecrows, plastic bottle windmills and Bird repellent mechanical devices were used in individual plots to repel birds at the maturity stage. After harvesting, the heads were threshed immediately by a 'sunflower thresher'. Required time, labour and costs at all mechanized operations were counted and analyzed statistically.

Results and Discussions

Among the polders, sunflowers yield ranges from 0.73 to 2.01 t/ha (Table 10). In polder 48 sunflower yield was found higher than in other polders. Mechanical sowing reduced land preparation and sowing cost by 50.94% over the conventional practice. In coastal region sunflower are usually harvested in late April to early May. At that time sporadic seasonal rainfall started that hamper the threshing and drying of sunflowers. Damping of sunflower heads in dam weather reduces seed and oil quality. Manual threshing is also labour intensive. It was observed that mechanical threshing reduces threshing cost by 52% over manual threshing (Table 11). So, if sunflower production could be mechanized it would reduce production costs and sunflower will be sustained in the coastal region.

Table 11. Production of sunflower in different polder

Polder	Farmers Name	Area coverage (Bigha)	Sowing date	Harvesting date	Yield (t/ha)
43	Mosaref Hossain	03	07 Jan.22	20 Apr.22	0.80
43	Kabir Hossain	02	08 Jan.22	24 Apr.22	0.90
43	Md. Mostafa	04	07 Jan.22	22 Apr.22	0.73
43	Md. Ohidul Islam	01	06 Jan.22	18 Apr.22	0.75
44	Md Jafor Hawlader	01	04 Jan.22	24 Apr.22	1.05
44	Md. Salam Gazi	01	04 Jan.22	20 Apr.22	0.75
46	Md. Nazrul Islam	03	07 Jan.22	15 Apr.22	0.80
46	Mahananda	03	27 Dec.21	10 Apr.22	1.20
46	Md. Shahidul Islam	01	25 Dec.21	31 Mar.22	0.79
48	Md. Siddque Musulli	02	28 Dec.21	07. Apr.22	2.01
48	Md. Bellal Hossain	01	04 jan.22	12 Apr.22	1.76
48	Md, Sobuj Dewan	01	11 Jan22	18Apr.22	1.94
48	Md. Habibullah Mridha	01	11 Jan22	18Apr.22	1.66
		24			

Sunflower sowing, weeding and threshing is more laborious and labour intensive which increase the production cost. So, to make cost effective sunflower production in coastal region mechanized sunflower production was done at at polder No 43 (Amtoli), polder 44 (Taltoli), polder 46 (Kalapara) and 48 (Kuakata) during Rabi 2021-22

Table 12. Reduction of land preparation and sowing and threshing cost of sunflower by machine

Activities	Cost (Tk./ha)		Reduction of cost (%)
	Machine used	Conventional	
Land preparation & sowing	12510/-	25500/-	50.94
Threshing	3600/-	7500/-	52

Sunflower is very susceptible to birds. Bird damage can lead to the entire crop being destroyed and abandoned. Bird damage to sunflowers is recognized as an international economic problem for sunflower producers. Bird attacks on sunflower crops occur from the sowing stage. Sometimes they occur later, in almost case, affecting the flower head. Attacks can be very frequent and cause substantial damage to the sunflower crop. However, in order to limit the damage caused by these birds, measures have to be taken to protect the sunflower crop from its inception. Among the different repellent tools, the maximum seed yield (1.91 t/ha) of sunflower was obtained from plastic bottle windmill as a repellent tool which was followed by (1.90 t ha^{-1}), bird repellent mechanical device (1.82 t/ha), and hanging red ribbon (1.80 t/ha), making scarecrow while the minimum was in (1.50 t ha^{-1}) control. Due to the bird management approach yield retention increased 21-27% over control.

Table 13. Effect of different bird repelling devices

Treatment	Seed yield (t/ha)	Yield retention increase (%)
Hanging red ribbon	1.82	21.33
Making scarecrow	1.80	21.0
Plastic bottle windmill	1.91	27.0
Bird repellent mechanical device	1.90	27.0
Control	1.50	-

Challenges found

Challenges	Steps taken to remove
Delay sowing	Delay harvest of Aman and untimely rainfall delay sunflower sowing. Mechanized seeding may minimize these problems. So seeder machine was provided to the farmers to seeding in demonstration plot.
Seed unavailability	At the time of starting the scheme sunflower seeds of BARI varieties were not available in coastal region. Through this project 11 tons of BARI Surjamukhi-2 & 3 were produced and distributed among the farmers.
Management practice unknown	Before staring the scheme farmers did not know fertilizing rate and method, how and when to irrigate, pests and diseases management and intercultural operations technique. The farmers were trained about those crop management techniques after starting the scheme activities.
Lac of Irrigation facility	In coastal region irrigation water is scared due to salinity present in canal and underground water. So farmers were also trained on rationale use of reserved nonsaline water following alternate furrow irrigation system and conjunctive use of saline and nonsaline water.
Pests, diseases and massive bird attack	Root rot and bird attack is very common in sunflower field. To control these suitable fungicides/pesticides and bird repelling device has been developed and supplied to the farmers.

Difficult threshing	At the time of harvest onset of rain damage head of sunflower and reduced oil percentage and seed quality kept for next year seeding. To solve these limitations power thresher was supplied to the farmers.
Under developed Market channel	Till now sunflower market channel has not been developed. So farmers are not coming forward to large scale sunflower production. They are trained and awarded about the benefit of sunflower oil consumption. So local level small sunflower market has been developed that for a short period of harvesting time.

Recommendations

Based on three years of research and promotional work some recommendations may be drawn ay fallows

- Sunflower may be a substitute crop for grass pea/ cowpea in the coastal region where rainfall in November and December damaged grass pea/cowpea
- Sunflower-T. Aus-T. Aman pattern may be recommended against grass pea/cowpea-Fallow-T. Aman as its gross margin is more with MBCR more than 2.
- Delay sowing reduces yield, so sowing after 15 January should be discouraged.
- To reduce production cost BARI seeder and thresher may be used, they may reduce land preparation, sowing and threshing coast about 50 percent
- To control bird pests low-cost devices, plastic bottle windmill may be used to prevent yield damage

NUTRIENT MANAGEMENT FOR DIVERSIFIED CROPPING IN BANGLADESH (NUMAN)

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Progress Summary

Cropping intensification underpins food security in Bangladesh. Crop production of the country has increased by about 3 times compared to that in 1970's. Increased crop production through crop intensification has been supported by increased use of fertilizers. High intensity of cropping, decreasing arable lands and diversified cropping raises questions about the profitability and sustainability of current nutrient management. The challenge for the future is to develop nutrient management packages that will ensure sustainable improved crop production maintaining current nutrient levels, avoid nutrient deficiencies and imbalance or overuse of fertilizers. Recent evidence suggests that the yield gap between farmers' fertilizer rates and recommended rates is equivalent to a yield increase of 15-40 % for a range of crops including rice, wheat, maize, mustard, potato etc. Nutrient management packages for emerging cropping systems based on minimum soil disturbance and residue retention are still to be developed. In the southern coastal region, the major challenges are to increase cropping intensity from a single low input rice crop to double cropping on waterlogged and saline soils, and to develop fertilizer management packages under such difficult situation. There are opportunities to develop sustainable improved crop production system through improved and profit-making nutrient management practices for the existing intensive and emerging cropping systems. One of the objectives of this project is to develop and test tools for sustainable nutrient management in intensively cropped areas of north-west Bangladesh and in emerging cropping systems based on CA and on coastal zone soils of southern Bangladesh. Considering the above issues and also to fulfill project objectives with the project activities 2.2 and 2.4, On-Farm Research Division (OFRD) of BARI has designed four field experiments. Among those experiments, two were conducted on T. *Aus*-T. *Aman* rice-Sunflower and T. *Aus*-T. *Aman* rice-Sweet gourd cropping patterns at Amtoli of Borguna district to get the best nutrient management package for the component crops of these patterns. After completion of two years of cropping cycle, now large-scale dissemination trials of T. *Aus*-T. *Aman* rice-Sunflower and T. *Aus*-T. *Aman* rice-Sweet gourd cropping patterns are going on with the best nutrient management package. Another experiment was conducted at Jagannathpur of Thakurgaon district to evaluate the effect of fertilizer and tillage on Potato-Maize-T. *Aman* rice cropping pattern. This experiment has completed its two cropping cycles with a conclusion that farmers applied fertilizer doses offered the highest system productivity both in conventional tillage and reduced tillage systems. An experiment was also conducted at Botiaghata, Dacope and koyra of Khulna district for large scale evaluation of Khulna University (KU) developed NPK rates for dibbled sunflower after T. *aman* rice. At Khulna, the study identified that planting time plays an important role in crop emergence, establishment and yield as well. The recommended NPK rates of KU for dibbled sunflower was optimum for Hysun-33 but not for BARI surjomukhi-3. Therefore, a study should be taken to get optimum fertilizer doses for BARI surjomukhi-3 at the coastal region. The overall project activities are running well and this project will be completed within December of the current year.

Activity 2.2. Test fertilizer recommendations for emerging CA cropping systems (minimum soil disturbance and increased residue retention) of Bangladesh

Expt-1: Effect of sowing/planting method and fertilizer management on Potato-Maize-T. Aman cropping pattern in north-west Bangladesh

Abstract

The study was conducted at the farmers' fields of Jagannathpur, Thakurgaon with the aim to evaluate the effect of the planting method and fertilizer management on Potato-Maize-T. Aman rice cropping pattern. This study was started with T. *Aman* rice during 2018. Two factors were considered as treatments; Factor A was Tillage and Factor B was fertilizer doses. After completion of two-year of cropping cycle, the study revealed that the highest Aman rice equivalent yield (REY_{Aman}) was obtained from application of farmer's fertilizer dose under conventional tillage system and similar REY_{Aman} was also attained from application of farmer's fertilizer dose under strip tillage system. The lowest REY_{Aman} was found from rice crop manager based fertilizer dose under strip tillage system as well as conventional tillage system. Application of farmer's fertilizer dose under conventional tillage system also offered the highest gross return of REY_{Aman}.

Materials and Methods

The study was carried out at the farmers' fields of Jagannathpur, Thakurgaon to evaluate the effect of the planting method and fertilizer management on Potato-Maize-T. Aman rice cropping pattern. Two factors like Tillage and Fertilizer dose were considered as treatments for all the component crops of the pattern. In the case of the Tillage factor, non-puddle transplanting and conventional transplanting were considered for T. Aman rice, dibbling within the strip with rice straw mulch and conventional planting were considered for potato, and strip tillage and conventional tillage for maize. In the case of the Fertilizer dose factor, four treatments *viz*. F_1 = soil test-based fertilizer dose, F_2 = AEZ based recommended dose, F_3 = Farmer's practice, and F_4 = Rice Crop Manager were considered as treatments for T. Aman rice and Maize; and three treatments *viz*. F_1 = soil test-based fertilizer dose, F_2 = AEZ based recommended dose, and F_3 = Farmer's practice were considered as treatments for potato. The experimental design was factorial Randomized Complete Block (RCB) design with four (04) replications. The name of varieties, planting times and harvesting times of T. Aman rice, potato, and maize were given in Table 1.

Table 1. Varieties, planting times and harvesting times of T. Aman rice, Potato and Maize grown under Potato-Maize-T. Aman rice cropping pattern during 2018-2020 at Jagannathpur, Thakurgaon

Crop	Variety	Planting time	Harvesting time
T. Aman rice	BRRI dhan52	27 July- 05 August 2018 29 July-02 August 2019	16 November-04 December 2018 30 November 2019
Potato	BARI Alu-25 (Asterix)	19-20 December 2018 16 December 2019	12 March 2019 20 March 2020
Maize	Pioneer-92	25 March 2019 07 April 2020	28-29 June 2019 30 June 2020

The field data were collected on plant height, yield and yield contributing characters at harvest. The collected data were subjected to statistical analysis by using open-source software R (version 3.3.3). The means were separated based on the least significant difference (LSD) test at 5% level of significance. The laboratory analysis data were collected on initial soil samples.

Results

The system productivity of Potato-Maize-T.Aman rice cropping pattern for the first and second years have been shown in Table 2 and Table 3. The highest Aman rice equivalent yield (REY_{Aman}) was obtained from application of the farmer's fertilizer dose under conventional tillage system and similar REY_{Aman} was also attained from application of farmer's fertilizer dose under strip tillage system. The lowest REY_{Aman} was found from rice crop manager based fertilizer dose under strip tillage system as well as conventional tillage system and this happened because rice crop manager was only considered as treatment for rice and not for other crops. Application of farmer's fertilizer dose under conventional tillage system also offered the highest gross return of REY_{Aman}.

Table 2. Component crop yield, rice equivalent yield, and total rice (system) yield (t $ha^{-1}year^{-1}$) of Potato-Maize-T. Aman cropping pattern at Jagannathpur, Thakurgaon during 2018-2019

Treatment	Yield of crops in the pattern			T. Aman rice equivalent yield of crops in the pattern		Total rice (system) yield	Gross return of Aman rice equivalent yield (Tk. ha^{-1})
	T. Aman^{1st}	Potato^{1st}	Maize^{1st}	Potato	Maize		
T_1F_1	4.66	24.28	10.16	10	10.16	25.26	429420
T_1F_2	4.61	23.96	10.45	9.87	10.45	24.93	423810
T_1F_3	4.88	26.01	10.42	10.71	10.42	26.01	442170
T_1F_4	4.47	-	-	-	-	4.47	75990
T_2F_1	4.67	24.02	10.75	9.89	10.75	25.31	430270
T_2F_2	4.85	23.57	10.80	9.71	10.80	25.36	431120
T_2F_3	4.91	25.28	10.92	10.41	10.92	26.24	446080
T_2F_4	4.63	-	-		-	4.63	78710

Here, For T. Aman rice: T_1 = Non-puddled transplanting, T_2 = Conventional transplanting; For Potato: T_1 = Dibbling within strip and mulching with rice straw, T_2 = Conventional planting; For Maize: T_1 = Strip tillage, T_2 = Conventional tillage

F_1= Soil test based fertilizer dose, F_2= AEZ based Recommended dose, F_3= Farmer's practice and F_4= Rice Crop Manager (for rice)/Nutrient expert (for maize)

Market price (Tk./Kg): Rice = 17; Potato = 7; Maize = 17

Table 3. Component crop yield, rice equivalent yield, and total rice (system) yield (t $ha^{-1}year^{-1}$) of Potato-Maize-T. Aman cropping pattern at Jagannathpur, Thakurgaon during 2019-20

Treatment	Yield of crops in the pattern			T. *Aman* rice equivalent yield of crops in the pattern		Total *Aman* rice (system) yield (t ha^{-1})	Gross return of *Aman* rice equivalent yield (Tk. ha^{-1})
	T. *Aman*^{2nd}	Potato^{2nd}	Maize^{2nd}	Potato	Maize		
T_1F_1	4.79	21.19	9.84	7.42	9.84	22.05	441000
T_1F_2	4.80	20.60	10.01	7.21	10.01	22.02	440400
T_1F_3	4.85	22.99	10.12	8.05	10.12	23.02	460400
T_1F_4	4.70	-	-	-	-	4.70	94000
T_2F_1	4.79	22.23	10.07	7.78	10.07	22.64	452800
T_2F_2	4.82	21.90	10.20	7.67	10.20	22.69	453800
T_2F_3	4.87	23.72	10.22	8.30	10.22	23.39	467800
T_2F_4	4.77	-	-	-	-	4.77	95400

Market price (Tk./Kg): Rice = 20; Potato = 7; Maize = 20

Conclusion

The study concludes that application of farmer's applied fertilizer dose offered the highest system productivity and economic profit for Potato-Maize-T. Aman rice cropping pattern under conventional tillage system and even under reduced tillage system at Jagannathpur, Thakurgaon.

Activity 2.4: Develop and test fertilizer recommendations for coastal zone (saline and excessively wet) soils of southern Bangladesh

Exp-2: Nutrient Management with residue retention of T. Aus-T. Aman rice-Sunflower cropping pattern in coastal region

Abstract

The study was conducted at the farmers' fields of Amtoli, Barguna with the aim to evaluate the effect of crop residue and nutrient management on T. Aus-T. Aman rice-Sunflower cropping pattern. The experiment considered two factors *viz*. residue management and fertilizer dose as treatments. The study was initiated with T. Aus rice during 2018. After completion of two years of cropping cycles, the study found that application of AEZ based fertilizer dose and soil test-based fertilizer dose plus 25% NK offered the highest system productivity of T. Aus-T. Aman rice-Sunflower cropping pattern at Amtoli, Barguna.

Materials and Methods

The study was done at the farmers' fields of Sekendarkhali, Amtoli, Barguna and initiated with T. Aus rice during 2018. The initial soil samples were collected and analyzed before imposing the treatments. The study considered two factors as treatment; Factor A: Residue management and Factor B: Fertilizer dose. In the case of residue management factor, two treatments *viz*. with and without residue retention were considered. For Fertilizer dose factor, four treatments *viz*. T_1= Soil test based fertilizer dose + 25% NK, T_2 = AEZ based Recommended dose, T_3= Farmer's practice, and T_4= Rice Crop Manager were considered for T. Aus and T. Aman rice; and three treatments *viz*. T_1= Soil test based fertilizer dose + 25% NK, T_2 = AEZ based Recommended dose, and T_3= Farmer's practice for sunflower. The experimental design was factorial Randomized Complete Block (RCB) design with four (04) replications. The name of varieties, planting times and harvesting times of T. Aus rice, T. Aman rice, and Sunflower were given in Table 1.

Table 1. Varieties, planting times and harvesting times of T. Aus rice, T. Aman rice, and Sunflower under T. Aus-T. Aman rice-Sunflower cropping pattern during 2018-2019 at Amtoli, Barguna

Crop	Variety	Planting time	Harvesting time
T. Aus rice	BRRI dhan48	22-28 May 2018	16-18 August 2018
T. Aman rice	BRRI dhan39	30 August-03 September 2018	27 November-05 December 2018
Sunflower	BARI Surjomukhi-2	10 January 2019	17 April 2019

The field data were collected on plant height, yield and yield contributing characters at harvest. The collected data were subjected to statistical analysis by using open-source software R (version 3.3.3). The means were separated based on the least significant difference (LSD) test at 5% level of significance. The laboratory analysis data were collected on initial soil samples.

Results

The system productivity of T. Aus-T.Aman-Sunflower cropping pattern for the first year has been calculated in Table 1. The highest Aman rice equivalent yield (REY_{Aman}) was obtained from the application of AEZ-based recommended fertilizer dose under residue retention condition and similar REY_{Aman} was also attained from the application of soil test-based fertilizer dose under residue retention condition. The lowest REY_{Aman} was observed in the plots that received rice crop manager based fertilizer dose without any residue retention condition and this happened because rice crop manager was not enlisted as the treatment for fertilizer recommendation of sunflower. Application of AEZ based recommended fertilizer dose under residue retention condition also offered the highest gross return of REY_{Aman} and the lowest gross return was calculated from application of rice crop manager-based fertilizer dose without any residue retention condition.

Table 1. System productivity of T. Aus-T.Aman-Sunflower cropping pattern at Sekendarkhali, Amtoli, Borguna during 2018-19

Treatments	Grain yield of T. Aus (t/ha)	Grain yield of T. Aman (t/ha)	Grain yield of Sunflower (t/ha)	Rice Equivalent Yield of sunflower (t/ha)	*Total Rice Equivalent Yield (t/ha)	Gross return of Aman rice equivalent yield (Tk./ha)
STB	3.15	3.30	1.37	3.28	9.73	175140
RD	2.73	2.95	1.41	3.48	9.16	164880
FP	2.52	3.23	1.73	4.38	10.13	182340
RCM	2.87	3.01	-	-	5.88	97200
STB + R	3.33	3.34	1.88	4.67	11.34	204120
RD + R	3.27	2.60	2.22	5.63	11.50	207000
FP + R	2.63	2.95	1.72	4.34	9.92	178560
RCM + R	3.23	3.57	-	-	6.26	112680

STB = Soil test base fertilizers + 25% NK, RD = AEZ based recommended Fertilizers, FP = Farmer's practice, RCM = Rice Crop Manager based fertilizers, R = Residue, *T. Aman rice equivalent yield; Price (Tk./Kg): T.Aus: 15, T.Aman: 18, Sunflower: 50

Conclusion

The study revealed that application of AEZ based recommended fertilizer dose and Soil test-based fertilizer dose under residue retention condition offered the highest system productivity and economic benefit for T. Aus-T. Aman rice-Sunflower cropping pattern at Amtoli, Barguna.

Expt-3: Nutrient Management for T. *Aus*-T. *Aman* rice-Sweet gourd cropping pattern in coastal region

Abstract

The study was conducted at the farmers' fields of Amtoli, Barguna with the aim to evaluate the effect of nutrient management on T. Aus-T. Aman rice-Sunflower cropping pattern. The experiment had five treatments viz. T_1= Soil test-based fertilizer dose, T_2= Soil test-based fertilizer dose + 25% NK, T_3= Fertilizer dose as per FRG-2018, T_4= BAU soil kit, and T_5= Farmer's practice for T. Aus and T. Aman rice and four treatments viz. T_1= Soil test-based fertilizer dose, T_2= Soil test-based fertilizer dose + 25% NK, T_3= Fertilizer dose as per FRG-2018, and T_4= BAU soil kit for sunflower. After completion of two years of cropping cycles, the study found that application of soil test-based fertilizer dose plus 25% NK offered the highest system productivity of T. Aus-T. Aman rice-Sunflower cropping pattern at Amtoli, Barguna.

Materials and Methods

The study was done at the farmers' fields of Sekendarkhali, Amtoli, Barguna and initiated with T. Aus rice during 2018. The initial soil samples were collected and analyzed before imposing the treatments. The study considered five treatments viz. T_1= Soil test-based fertilizer dose, T_2= Soil test-based fertilizer dose + 25% NK, T_3= Fertilizer dose as per FRG-2018, T_4= BAU soil kit, and T_5= Farmer's practice for T. Aus and T. Aman rice and four treatments viz. T_1= Soil test-based fertilizer dose, T_2= Soil test-based fertilizer dose + 25% NK, T_3= Fertilizer dose as per FRG-2018, and T_4= BAU soil kit for sunflower. The experimental design was Randomized Complete Block (RCB) design with three (03) replications. The name of varieties, planting times and harvesting times of T. Aus rice, T. Aman rice, and Sunflower were given in Table 1.

Table 1. Varieties, planting times and harvesting times of T. Aus rice, T. Aman rice, and Sunflower under T. Aus-T. Aman rice-Sunflower cropping pattern during 2018-2021 at Amtoli, Barguna

Crop	Variety	Planting time	Harvesting time
T. Aus rice	Mala chyna (local) BRRI dhan48	15 June 2019 02-10 June 2020	28 August 2019 02 September 2020
T. Aman rice	BRRI dhan39 BRRI dhan49	10 September 2019 18 September 2020	11 December 2019 05 December 2020
Sunflower	BARI Surjomukhi-2	15-21 January 2020 08 January 2021	01-04 May 2020 08 April 2021

The field data were collected on plant height, yield and yield contributing characters at harvest. The collected data were subjected to statistical analysis by using open-source software R (version 3.3.3). The means were separated based on the least significant difference (LSD) test at 5% level of significance. The laboratory analysis data were collected on initial soil samples.

Results

The system productivity of T. *Aus*-T. *Aman* rice-Sunflower cropping pattern for the second year has been calculated in Table 2. The highest yields of T. *Aus* rice and Sunflower were recorded from application of soil test based (STB) fertilizer dose plus 25% NK and the highest T. *Aman* rice yield was obtained from BAU soil testing kit based fertilizer dose. However; analyzing the total system productivity results the highest *Aman* rice equivalent yield (REY_{Aman}) was found from application of STB recommended fertilizer dose with the highest gross return. The lowest REY_{Aman} and gross return were observed in the plots that received BAU soil testing kit based fertilizer dose and this happened because BAU soil testing kit was not considered for sunflower as a treatment though it did not provide any fertilizer recommendation for sunflower for the respective site.

Table 2. System productivity of T. *Aus*-T. *Aman* rice-Sunflower cropping pattern at Sekendarkhali, Amtoli, Borguna during 2019-20

Treatments	Grain yield of T. *Aus* rice (t/ha)	Grain yield of T. *Aman* rice (t/ha)	Grain yield of Sunflower (t/ha)	Rice Equivalent Yield of sunflower (t/ha)	*Total Rice Equivalent Yield (t/ha)	Gross return of *Aman* rice equivalent yield (Tk./ha)
STB	2.60	3.48	1.78	6.12	12.20	195200
STB+25%NK	3.53	3.64	2.11	7.25	14.42	230720
FRG-2018	2.77	3.77	1.76	6.05	12.59	201440
BAU soil kit	2.66	3.85	-	-	6.51	104160
FP	2.43	3.36	1.62	5.57	11.36	181760

Here, STB = soil test based fertilizer dose, STB+25% NK = soil test based fertilizer dose plus 25% NK, FRG-2018 = fertilizer dose based on the FRG-2018, FP = Farmer's applied fertilizer dose, *T. *Aman* rice equivalent yield; Price (Tk./Kg): T. *Aus* and T. *Aman* rice: 16, Sunflower: 55

Conclusion

The study revealed that application of Soil test-based fertilizer dose plus 25% NK offered the highest system productivity and economic benefit for T. Aus-T. Aman rice-Sunflower cropping pattern at Amtoli, Barguna.

Expt-4: Nutrient Management for T. *Aus*-T. *Aman* rice-Sweet gourd cropping pattern in coastal region

Abstract

The study was conducted at the farmers' fields of Amtoli, Barguna with the aim to evaluate the effect of nutrient management on T. Aus-T. Aman rice-Sweet gourd cropping pattern. The experiment had five treatments viz. T_1= Soil test-based fertilizer dose, T_2= Soil test-based fertilizer dose + 25% NK, T_3= Fertilizer dose as per FRG-2018, T_4= BAU soil kit, and T_5= Farmer's practice for T. Aus and T. Aman rice and four treatments viz. T_1= Soil test-based fertilizer dose, T_2= Soil test-based fertilizer dose + 25% NK, T_3= Fertilizer dose as per FRG-2018, and T_4= BAU soil kit for sweet gourd. After completion of two years of cropping cycles, the study found that application of soil test-based fertilizer dose plus 25% NK offered the highest system productivity of T. Aus-T. Aman rice-Sweet gourd cropping pattern at Amtoli, Barguna.

Materials and Methods

The study was done at the farmers' fields of Sekendarkhali, Amtoli, Barguna and initiated with T. Aus rice during 2018. The initial soil samples were collected and analyzed before imposing the treatments. The study considered five treatments viz. T_1= Soil test-based fertilizer dose, T_2= Soil test-based fertilizer dose + 25% NK, T_3= Fertilizer dose as per FRG-2018, T_4= BAU soil kit, and T_5= Farmer's practice for T. Aus and T. Aman rice and four treatments viz. T_1= Soil test-based fertilizer dose, T_2= Soil test-based fertilizer dose + 25% NK, T_3= Fertilizer dose as per FRG-2018, and T_4= BAU soil kit for sunflower. The experimental design was Randomized Complete Block (RCB) design with three (03) replications. The name of varieties, planting times and harvesting times of T. Aus rice, T. Aman rice, and Sweet gourd were given in Table 1.

Table 1. Varieties, planting times and harvesting times of T. Aus rice, T. Aman rice, and Sunflower under T. Aus-T. Aman rice-Sunflower cropping pattern during 2018-2021 at Amtoli, Barguna

Crop	Variety	Planting time	Harvesting time
T. Aus rice	BRRI dhan48	18 June 2019 02-10 June 2020	29 August 2019 04 September 2020
T. Aman rice	BRRI dhan39	08 September 2019 16 September 2020	10 December 2019 01 December 2020
Sweet gourd	Hybrid Bengal (Sweet)	18-24 January 2020 27 December 2020	05-12 April 2020 13 April 2021

The field data were collected on plant height, yield and yield contributing characters at harvest. The collected data were subjected to statistical analysis by using open-source software R (version 3.3.3). The means were separated based on least significant difference (LSD) test at 5% level of significance. The economic analysis was done. The laboratory analysis data were collected for initial soil samples, nutrient uptake (N,P, K and S) by leaf and stem at the highest tillering stage (for rice) and by leaf, stem/straw and grain/seed at harvest (for rice and sweet gourd).

Results

The system productivity of T. *Aus*-T. *Aman* rice-Sweet gourd cropping pattern has been calculated in Table 1. The highest *Aman* rice equivalent yield (REY_{Aman}) and the highest gross return was ensured from application of soil test based (STB) recommended fertilizer dose plus 25% NK. This happened because of getting the highest grain yield of T. *Aus* rice and the highest fruit yield of sweet gourd from the same treatment. The lowest REY_{Aman} and gross return were calculated from the farmer applied fertilizer dose.

Table 1. System productivity of T. *Aus*-T. *Aman* rice-Sweet gourd cropping pattern at Sekendarkhali, Amtoli, Borguna during 2019-20

Treatments	Grain yield of T. *Aus* (t ha^{-1})	Grain yield of T. *Aman* (t ha^{-1})	Fruit yield of Sweet gourd (t ha^{-1})	T. *Aman* rice equivalent yield of Sweet gourd (t ha^{-1})	Total Rice (system) Yield (t ha^{-1})	Gross return of *Aman* rice equivalent yield (Tk. ha^{-1})
STB	2.64	3.27	27.77	38.18	44.09	705440
STB+25%NK	3.53	3.50	39.53	54.35	61.38	982080
FRG-2018	3.35	3.58	32.34	44.47	51.40	822400
BAU soil kit	2.70	3.67	32.71	44.98	51.35	821600
FP	2.46	3.29	26.99	37.11	42.86	685760

Here, STB = soil test based fertilizer dose, STB+25% NK = soil test based fertilizer dose plus 25% NK, FRG-2018 = fertilizer dose based on the FRG-2018, BAU soil kit = fertilizer dose based on BAU soil testing kit, FP = Farmer's applied fertilizer dose, *T. *Aman* rice equivalent yield; Price (Tk./Kg): T. *Aus*: 16, T. *Aman*: 16, Sweet gourd: 22

Conclusion

The study revealed that application of soil test-based fertilizer dose plus 25% NK offered the highest system productivity and economic benefit for T. Aus-T. Aman rice-Sweet gourd cropping pattern at Amtoli, Barguna.

Expt-5: Large-scale evaluation of nutrient management for sunflower at dibbling method in coastal region

Abstract

The study was conducted at the farmers' fields at Dacope, Batiaghata and Koyra of Khulna district with the aim to evaluate the Khulna University (KU) developed fertilizer dose for dibble sunflower. The experiment considered two factors *viz*. variety and fertilizer dose as treatments. Two varieties *viz*. Hysun33 and BARI surjomukhi-3 were used to evaluate three fertilizer doses *viz*. F_1= Farmers' fertilizer doses, F_2= KU developed rate, and F_3= Soil test-based fertilizer dose. The study revealed that early planting is very important for good crop establishment and yield of BARI surjomukhi-3. The effects of variety on yield and yield contributing characters were significant whereas the effect of fertilizer dose and the interaction effects were non-significant. Hysun33 produced the highest seed yield and BARI surjomukhi-3 gave the lowest yield. Application of KU developed fertilizer doses helped Hysun33 to produce the maximum seed yield at Khulna district.

Materials and Methods

The study was conducted at the farmers' fields at Dacope, Batiaghata and Koyra of Khulna district with the aim to evaluate the Khulna University (KU) developed fertilizer dose for dibble sunflower. The experiment considered two factors *viz*. variety and fertilizer dose as treatments. Two varieties *viz*. Hysun33 and BARI surjomukhi-3 were used to evaluate three fertilizer doses *viz*. F_1= Farmers' fertilizer doses (N-P-K-S: 100-30-60-22 kg ha^{-1}), F_2= KU developed fertilizer dose (N-P-K-S-Zn-B: 150-30-60-30-4-2 kg ha^{-1}), and F_3= Soil test-based fertilizer dose. The experimental design was in Randomized Complete Block (RCB) design with five (05) dispersed replications. Planting times and harvesting times of dibbled sunflower were given in Table 1.

Table 1. List of farmers according to location and their sowing, harvest date and total field duration of sunflower during 2021-22

Sl. no.	Farmers name	Location	Date of Sowing	Date of harvest	Duration (days)	GPS
1.	Ayesha Khatun	Koyra	05 Jan 22	damaged	-	N 22.33268, E 89.30712
2.	Abdullah Sardar	do	30 Dec 21	do	-	N 22.33394, E 89.31131
3.	Debrota Mondal	do	31 Dec 21	do	-	N 22.33643, E 89.31159
4.	Kamruzzaman	do	29 Dec 21	10 Apr 22	102	N 22.32344, E 89.28799
5.	Rabindranath Dhali	do	28 Dec 21	11 Apr 22	104	N 22.33183, E 89.31531

6.	Mritunjoy Biswas	Batiaghata	07 Jan 22	20 Apr 22	103	N 22.72582, E 89.49873
7.	Do	do	10 Jan 22	21 Apr 22	102	N 22.72582, E 89.49873
8.	Bijoli Golder	do	09 Jan 22	22 Apr 22	102	N 22.72633, E 89.49844
9.	Rudra Protap	do	10 Jan 22	damaged	-	N 22.72633, E 89.49844
10.	Ganendra Ray	do	8 Jan 22	damaged	-	N 22.72633, E 89.49844
11.	Akhil Halder	Dacope	29 Dec 21	12 Apr 22	104	N 22.63045, E 89.51139
12.	Narayan Roy	do	31 Dec 21	3 Apr 22	93	N 22.61619, E 89.5073
13.	Manmato Ghosh	do	09 Jan 22	16 Apr 22	97	N 22.624, E 89.49876
14.	Dilip Halder	do	07 Jan 22	17 Apr 22	100	N 22.6240002, E 89.45767919
15.	Gobinda Halder	do	09 Jan 22	Damaged	-	N 22.59799, E 89.46197

Results

The results of initial soil samples of the three studied locations have been presented in Table 1.

Table 1. Physical and chemical properties of initial soil samples at Khulna during 2021

Name of the farmer	Textural Class	pH	OM (%)	Total N (%)	P (ppm/g soil)	K (meq./ 100 g soil)	S (ppm/g soil)	Zn (ppm/g soil)	B (µg/g soil)	B (ppm/g soil)
Botiyaghata	Clay Loam	7.3	1.8	0.09	16	0.39	34	1.3	0.22	0.22
Dacope	Clay Loam	8.3	1.0	0.05	5	0.41	39	0.4	0.17	0.17
Koyra	Loam	7.2	2.2	0.11	7	0.27	26	0.5	0.06	0.06
Critical Level		-	-	-	10	0.12	10	0.6	0.2	0.2

The study expressed that the effects of variety on plant height, head diameter, number of seeds head^{-1}, total seed weight head^{-1} and seed yield of dibbled sunflower were significant at Dacope and Batiaghata; however, non-significant on head diameter at Koyra (Table 2, Table 3 and Table 4). The effects of nutrient management were non-significant for plant height, yield contributing characters and yield. The interaction effects of variety and nutrient management were also found non-significant for plant height, head diameter, number of seeds head^{-1}, total seed weight head^{-1}, 1000-seed weight, and grain yield of dibbled sunflower.

In the case of variety, the tallest plants were found in Hysun33 and the shortest plants were in BARI surjomukhi-3 (Table 2) in all the locations. Hysun-33 gave the highest seed yield in all locations having the largest head with the highest number of seeds head^{-1} and total seed weight head^{-1}. The lowest yield was obtained from BARI surjomukhi-3.

Table 2. Effect of variety and nutrient management on plant length, yield attributes and yield of dibbled sunflower at Dacope, Batiaghata and Koyra of Khulna district during 2021-22

Treatments	Plant height (cm)	Head diameter (cm)	Number of seeds head^{-1}	Total seed weight head^{-1} (gm)	1000-seed weight (gm)	Grain yield (t ha^{-1})
Dacope						
Variety (A)	***	***	***	***	ns	***
Nutrient management(B)	ns	ns	ns	ns	ns	ns
A×B	ns	ns	ns	ns	ns	ns
Batiaghata						
Variety (A)	***	**	***	***	ns	***
Nutrient management(B)	ns	ns	ns	ns	ns	ns

Treatments	Plant height (cm)	Head diameter (cm)	Number of seeds head^{-1}	Total seed weight head^{-1} (gm)	1000-seed weight (gm)	Grain yield (t ha^{-1})
A×B	ns	ns	ns	ns	ns	ns
Koyra						
Variety (A)	**	ns	**	**	ns	***
Nutrient management(B)	ns	ns	ns	ns	ns	ns
A×B	ns	ns	ns	ns	ns	ns

Table 2. Effect of variety on plant height, yield contributing characters and yield of dibbled Sunflower at Dacope, Batiaghata and Koyra of Khulna district during 2021-22

Location	Plant length (cm)	Head width (cm)	Number of seeds head^{-1}	Total seed weight head^{-1} (g)	Grain yield (t ha^{-1})
Dacope					
Hysun33	124.1 a	14.16 a	869.31 a	78.09 a	2.79 a
BARI surjomukhi-3	59.3 b	9.88 b	388.60 b	33.62 b	1.30 b
Batiaghata					
Hysun33	129.6 a	13.97 a	438.89 a	44.67 a	1.73 a
BARI surjomukhi-3	60.4 b	10.73 b	203.48 b	16.28 b	0.63 b
Koyra					
Hysun33	146.3 a	16.55	1157.8 a	107.7 a	2.76 a
BARI surjomukhi-3	94.0 b	15.07	665.5 b	52.3 b	1.25 b

The results of the interaction effect of variety and nutrient management showed that the highest yield was produced by Hysun33 at KU developed fertilizer dose in all locations (Table 3). On the other hand, the lowest yield was obtained from BARI surjomukhi-3 at KU developed fertilizer dose in Batiaghata and Koyra; and from BARI surjomukhi-3 at farmer's applied fertilizer dose in Dacope.

Table 3. Interaction effect of variety and nutrient management on seed yield of dibbled Sunflower at Dacope, Batiaghata and Koyra of Khulna district during 2021-22

Variety (V)× Nutrient management (N)	Dacope	Batiaghata	Koyra
V_1N_1	2.94	1.48	2.74
V_1N_2	2.29	2.01	2.85
V_1N_3	3.14	1.69	2.71
V_2N_1	1.29	0.67	1.28
V_2N_2	1.31	0.51	1.20
V_2N_3	1.30	0.71	1.27

V_1 = Hysun33, V_2 = BARI surjomukhi-3, N_1 = Farmer's fertilizer dose, N_2 = KU developed fertilizer dose, N_3 = Soil test-based fertilizer dose

Conclusion

The study concludes that Hysun33 gave the highest yield at all locations. BARI surjomukhi-3 produced the lowest yield. Seed yield was non-significantly affected by the interaction of variety and nutrient management. However, numerically the highest yield was obtained from Hysun33 at Khulna University developed fertilizer doses, and the lowest yield was found in BARI surjomukhi-3 at farmer's applied fertilizer dose.

ARGO-METEOROLOGICAL INFORMATION SYSTEM DEVELOPMENT PROJECT (COMPONENT-C), BARI PART

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Introduction

Bangladesh has severely sufferer from extreme climatic event like drought, heavy rainfall, untimely rainfall, flash flood, cold spell, heat sepal, fluctuation of temperature, high temperature, salinity, waterlog conditions as well shifting of seasonal weather. Economy of Bangladesh mainly depends on agriculture. More than 80 percent human labor consumed by agriculture directly and indirectly. Agriculture implies 19 percent Gross Domestic Product (GDP) in the national economy of the country. More over due to climate change uncertainty arise which directly hamper sustainable crop production that seriously threatens our food security. We have transboundary rivers due to lake of basin ways management of that riverain area savior drought appear in the summer and winter. In the rainy season when excessive rainfall occurs it does flash flood and flood. Frequency of cyclone and storm surge happens randomly. We have developed so many technologies like drought and saline tolerant variety, weather forecast and prediction for early warning system towards guiding community farming.

Resource utilization and mobilization in the climate change scenario is the key to success for the country like Bangladesh. Community farming and integrated farming system can help the farmers to ensure sustainable food security. Crop zoning, crop suitability assessment and the utility of machining learning application in agriculture can guide and predict and exercise towards maintain sustainable production system. Crop modeling approach guide farmers for planning and decision making in adaptation to climate change towards ensuring sustainable production for food security to achieve the sustainable development goals (SDGs).

Bangladesh Agricultural Research Institute (BARI) is the largest multi crop government research institute does both commodity and non-commodity research. We have developed so may climate resilience technologies like salinity and drought tolerant varieties as well as technology packages such as sowing time adjustment, escaping drought and saline period, inter cropping, relay cropping mixed cropping, crop diversification and intensification to cope with climate change.

This project leads some advantages for getting development of crop models on maize and potato. That should experience and expertise from different interdisciplinary works that we can together learn and share our knowledge and views for facing climate change issues towards food security in the upcoming day how we can handle this.

Background

2.1 Impact of Temperature on Crop Production

Temperature can play a vital role in crop production. Vegetative and reproductive growth of a crop has depended on a temperature range. Crop production can severely suffer with exceeded the upper limit and below limit of temperature range for a particular variety that brands crop production constrains. Production of *Aman* rice decrease by 2.94, 53.06 and 17.28 tons respectively with the 1°C increase in maximum temperature at vegetative, reproductive and ripening stages.[1] Wheat and potato production can also suffer with the continuous increasing trend of maximum temperature by 2° C and 4° C may suffer up to 60% production loss from their achievable yield.[2] Higher temperature can be deficient on soil organic matter also.

2.2 Impact of Rainfall on Crop Production of Bangladesh

Rainfall has played a tremendous role in crop production. Every crop has a critical stage for its growth and development. Flooding and water logging condition may arise due to excessive rainfall that hamper crop production with extensive yield loss. It was noted that due to increase 1mm rainfall at vegetative, reproductive and ripening stages decreased *Aman* rice production by 0.036, 0.230 and 0.292 ton respectively.[3] Sometime crop production limits by the scarcity of water while irrigation coverage is only 56% as delivered by the Bangladesh Agriculture Development Corporation (BADC).

2.3 Impact of Sea Level Rise on Crop Production

Sea level rise affects agricultural productivity in the coastal zone of Bangladesh. It affects agriculture in various ways, i.e., by saline water intrusion through flooding and increasing frequency of cyclone and stagnant water by storm surge. Combined effects of these factors may determine the crop production in the coastal zone. Unavailability of fresh water and soil degradation is most common problem faced by the costal farmers. It was found that there was a loss of 69%. in rice production in 2003 compared to that in year 1985, 77% of which was due to conversion of rice field into shrimp cultivation and the rest was due to yield reduction.[4] Tide in the Bay of Bengal influence more of less 33 percent or 49,000 sq. km area in Bangladesh. Coastal inundation area will be increase day by day. Sea level rise up to 1-meter normal flood waves can be expected to increase from presently 7.4 meters to 9.1 meters that resulted about 15-17 million people displaced from the land inundation that cost 12-16% of total land area in Bangladesh.[5]

2.4 Impact of Flood on Crop Production

Flood has most common injure on crop production during the rainy season of Bangladesh. Flood caused reduction of agricultural production by 45% in the year of 1988.[6] Flash floods has become a regular phenomenon which leads to frequently loss of *Boro* rice production in the haor areas. Loss of *Boro* rice crop production due to flash floods has become a regular phenomenon in the haor areas over the recent years. Considering all the impact of climate change in agriculture would be more vulnerable in Bangladesh.

2.5 Impact of Cyclone on Crop Production

Cyclone cause huge injury to production of crop. About 70% of the annual *Aman* rice production was loss in the most affected area at the maturity stage of *Aman* rice which was reported by the FAO/GIEWS Global Watch (2007)[7] at the time of the passage of cyclone SIDR. According to the estimate by Department of Agricultural Extension of Bangladesh (DAE), the loss in rice equivalent yield is at some 1.23 million tonnes, with 535,707 tonnes in the four severely affected districts. Afterword's the loss of rice equivalent yield 555,997 tonnes in badly affected 9 districts and 203,600 tonnes in moderately affected 17 districts in Bangladesh.

2.6 Impact of Drought on Crop Production Due to Climate Change

Pre and post monsoon periods in Bangladesh drought severely arise. About 20 drought conditions has suffered by Bangladesh during last 50 years. Drought in the north-western Bangladesh had led to a shortfall of rice production of 3.5 million tons in the 1990s. If other losses, such as, to other crops (all rabi crops, Sugarcane, Tobacco, Wheat etc.) as well as to perennial agricultural resources, such as, bamboo, betel nut, fruits like Litchi, Mango, Jackfruit, Banana etc. are considered, the loss will be substantially much higher.[8]

Methodology

On-farm Research Division, Bangladesh Agricultural Research Institute (BARI) was executed experiments on maize and potato at six different locations under Argo-meteorological Information System Development Project (component-C), BARI part. The experiment was conducted at the six different locations of Bangladesh. Three locations (Rangpur, Pabna and Rajshai) were considered as drought, another two locations (Patuakhali and Khulna) were represented as costal saline areas and lastly one location Gazipur which represent plain land ecosystem. The objectivates of the experiments were to generate data for calibration of the crop model, to develop variety specific genetic co-efficient for maize and potato and to generate adaptation options for the farmers under climate change. The crops were potato and maize. The variety of maize were BARI Hybrid Maize 9, BARI Hybrid Maize 13, Nk-40, Pioneer and Pacific Gold. The variety of potato were BARI Alu-46, BARI Alu-53, BARI Alu-56, BARI Alu-72, BARI Alu-73 and BARI Alu-7 (Diamant). The experiments were conducted by following Randomized Complete Block (RCB) factorial for sowing dates experiments and Randomized Complete Block (RCB) spilt plot design for different levels. Experiments were conducted for two crops i.e., maize and potato among the six locations. The experiments on sowing date, fertilizer doze. First experiment on maize was varietal performance of hybrid maize with different sowing dates. The treatments were V_1 = BARI Hybrid Maize 9, V_2 = BARI Hybrid Maize 13, V_3 = Nk-40, V_4 = Elite, V_5 = Pacific Gold and different sowing dates were T_1 = 30 November, T_2 = 10 December, T_3 = 20 December, T_4 = 30 December. Second experiment on maize was varietal response of hybrid maize with different levels of nitrogen. The treatments were V_1 = BARI Hybrid Maize 9, V_2 = BARI Hybrid Maize 13, V_3 = Nk-40, V_4 = Elite, V_5 = Pacific Gold and different level of nitrogen were N_1 = 150, N_2 = 200, N_3 = 250, N_4 = 300, N_5 = 350, N_6 = Native fertility. In the fertilizer trail experiments main plot was considered as variety and in the sub-plot was consider as different level of nitrogen level. These same experimentations were also implemented on potato. First experiment on potato was varietal performance of potato with different sowing dates and the different treatments were V_1 = BARI Alu-25, V_2 = BARI Alu-53, V_3 = BARI Alu-72, V_4 = BARI Alu-73, V_5 = BARI Alu-7 (Diamant) and different sowing dates were T_1 = 30 November, T_2 = 10 December, T_3 = 20 December and T_4 = 30 December. Second experiment was varietal response of potato with different levels of nitrogen. The treatments were V_1 = BARI Alu-25, V_2 = BARI Alu-53, V_3 = BARI Alu-72, V_4 = BARI Alu-73, V_5 = BARI Alu-7 (Diamant) as control and the different level of nitrogen T_1 = 150, T_2 = 200, T_3 = 250, T_4 = 300, T_5 = 350, T_6 = Native fertility.

Three main parameters were considered in data collection i. e., agronomic practices, phenological data and physiological data.

3.1 The agronomic practices: The data set for maize and potato were no of weeding and date of action, no fertilizer application @ dose and date of action, no. irrigation and date of application, and no of pesticide application and date of application collected.

3.2 Phenological data: The data set for maize were date of transplanting, date of germination, date of tasseling, date of silking, date of Ear/cob initiation, physiological maturity of cob, date of harvesting and determination the required time between two leaves emergence recorded.

3.3 Physiological data: The data set for maize were Maximum Leaf area index at every 10-15 days interval up to harvest starting from 30 days after planting, Dry matter partitioning data of root, stem, leaf, cob and grain (when available) at every 10-15 days interval, Total dry matter (TDM) above ground part or including root (g/m^2) at every 10-15 days interval noted.

3.4 Yield and other contributing character: The data for maize were plant height (cm) from 10 plants, number of leaves /plants, number of cob(s)/plant, number of kernel/grain/cobs from 10 plant, 1000-kernel (grain) weight, Single cob weight (g) excluding grain, Grain yield (kg) at least 10 m^2 harvesting area, Grain yield (t ha^{-1}) at 10-12% moisture, Stover yield (t ha^{-1}) at sun dry and oven dry basis and Harvest Index noted.

3.5 Phenological data set for potato: The data were date of planting, date of germination, date of stolon initiation, date of germination, date of stolon initiation, date of tuber initiation, date of bulk initiation, Canopy coverage (maximum), Physiological maturity, date of harvesting and determination the required time of two leaves emergence recorded.

3.6 Physiological data set for potato: The data were maximum Leaf area index every 10-15 days interval up to harvest starting from 30 days after planting, dry matter partitioning data of root, stem, leaf, cob and grain (when available) at every 10-15 days interval, total dry matter (TDM) above ground part or including root and tuber (g/m^2) at every 10-15 days interval, shoot and root ratio and biomass and root ratio recorded.

3.7 Yield and other contributing character of potato: The data were Plant height (cm) from 10 hill or plants, Number of stems/hills from 10 hill or plants, Number of leaves/plant or hill from 10 hill or plant, Number of tuber/hill or plant from 10 plant or hill, Weight of tuber /hill or plant from 10 plant or hill, Single tuber wt. from plant from 10 hill or plant, Tuber yield in Kg from at least 10 m^2 harvested area and convert in to (t ha^{-1}), Dry foliage in Kg from at least 10 m^2 harvested area and convert in to (t ha^{-1}), Harvest index, Moisture (%) in tuber and Dry matter (%) in tuber recorded.

3.8 Soil data set: Soil data were collected considering various depth from 0-15, 15-30, 30-45,45-60 cm. Soil physical properties were examined with i.e., texture, bulk density, particle density, porosity. Soil chemical properties were examined i.e., pH, nitrogen, phosphorous, potassium, sulphur, calcium, cataion exchange.

3.9 Climatic Data set: long term climatic data set were prepared with the following parameter i.e., temperature minimum (°C), temperature maximum (°C), rainfall (mm) and sunshine hour. The data set were prepared from the Bangladesh Meteorological Department (BMD) data source during the period 1981 to 2021.

Results and Discussion

Optimization of sowing window of hybrid maize under different agro-climatic regions of Bangladesh

The experiments were conducted at six different locations under different agricultural climatic regions of Bangladesh. Three locations (Rangpur, Pabna and Rajshahi) were drought prone, two locations (Patuakhali and Khulna) were represented as costal (saline) and one location Gazipur was represent plain land ecosystem. Five hybrid maize varieties viz. V_1 = BARI Hybrid Maize 9, V_2 = BARI Hybrid Maize 13, V_3 = NK-40, V_4 = Pioneer, V_5 = Pacific Gold were used and four sowing dates viz. S_1 = 30 November, S_2 = 10 December, S_3 = 20 December, S_4 = 30 December. Twenty treatments (as combination) were placed in Randomized Complete Block (RCB) factorial design with three replications to find out the optimum sowing window of hybrid maize along with varietal performance over the locations. The highest grain yield (11.53 t ha^{-1}) was obtained from Rangpur and both Rajshahi and Gazipur locations gave the lowest grain yield (7.80 t ha^{-1}) over the six locations. BHM 9 gave the highest grain yield (9.69 t/ha) and NK 40 gave the lowest grain yield (8.52 t ha^{-1}) among the five hybrid maize varieties. November 30 sowing produced the highest grain yield (9.41 t ha^{-1}) and December 30 sowing produced the lowest grain yield (8.25 t ha^{-1}) among the four sowing dates. In case of the interaction between locations and varieties, all varieties performed the best results ranged from 11.50 t ha^{-1} to 11.58 t ha^{-1} at Rangpur and the lowest result was performed from NK 40 (7.28 t ha^{-1}) at Patuakhali location. In respect of the interaction between locations and sowing dates, December 10 sowing gave the highest grain yield (11.8 t ha^{-1}) at Rangpur and December 30 sowing gave the lowest grain yield (6.40 t ha^{-1}) in both Rajshahi and Gazipur locations. Considering the interaction effect between varieties and sowing dates, the highest grain yield (10.09 t ha^{-1}) was obtained from BHM 9 variety sown on December 20 and the lowest grain yield (7.72 t ha^{-1}) was obtained from Pioneer variety sown on December 30. Considering the interaction effect among locations, varieties and sowing dates, the highest grain yield (11.99 t h^{-1}) was obtained from NK 40 variety was sown on December 10 at Rangpur and the lowest grain yield (5.05 t ha^{-1} was obtained from the same variety i.e., NK 40 was sown on December 20 at Khulna location.

Optimization of sowing window of potato under different agro-climatic regions of Bangladesh

The experiments were conducted at six different locations under different agricultural climatic regions of Bangladesh. Three locations (Rangpur, Pabna and Rajshahi) were drought prone, two locations (Patuakhali and Khulna) were represented as costal (saline) and one location Gazipur was represent plain land ecosystem. Five potato varieties viz. V_1 = BARI Alu 25, V_2 = BARI Alu 53, V_3 = BARI Alu 72, V_4 = BARI Alu 78, V_5 = BARI Alu 7 were used and four sowing dates viz. S_1 = 30 November, S_2 = 10 December, S_3 = 20 December, S_4 = 30 December. Twenty treatments (as combination) were placed in Randomized Complete Block (RCB) factorial design with three replications to find out the optimum sowing window of potato along with varietal performance over the locations. The highest tuber yield (23.76 t/ha) was obtained from Rangpur and the lowest tuber yield (20.21 t ha^{-1}) was obtained from Patuakhali over the six locations. BARI Alu 72 gave the highest tuber yield (24.75 t ha^{-1}) and BARI Alu 25 gave the lowest tuber yield (19.13 t ha^{-1}) among the five potato varieties. December 10 sowing produced the highest tuber yield (23.81 t ha^{-1}) and December 30 sowing produced the lowest tuber yield (19.42 t ha^{-1}) among the four sowing dates. In case of the interaction effect between locations and varieties, BARI Alu 72 variety gave the highest tuber yield (26.82 t ha^{-1}) at Rangpur and BARI Alu 25 gave the lowest tuber yield (17.60 t ha^{-1}) at both Khulna and Patuakhali locations. In respect of the interaction effect between locations and sowing dates, December 10 sowing gave the highest tuber yield (25.75 t ha^{-1}) at Rangpur and December 30 sowing gave the lowest tuber yield (17.87 t ha^{-1}) both at Khulna and Patuakhali locations. Considering the interaction effect between varieties and sowing dates, BARI Alu 72 gave the highest tuber yield (31.13 t ha^{-1}) from December 10 sowing and BARI Alu gave the lowest tuber yield (16.19 t ha^{-1}) from December 30 sowing. Considering the interaction effect among locations, varieties and sowing dates, the highest tuber yield (33.80 t ha^{-1}) was obtained from BARI Alu 72 sown on December 10 at Rangpur and the lowest tuber yield (14.89 t ha^{-1}) was obtained from BARI Alu 25 sown on December 30 both at Khulna and Patuakhali locations.

Simulation on sowing window identification of maize under different climate change scenario in Bangladesh

Teperature rise on maize at Gazipur: With the seasonal run from last 35 years weather data in Decision Support System in Agrotechnology Transfer (DSSAT) crop model, the simulation study shows early winter sowing that is in the month of October found maximum yield in case of BARI Hybrid maize-9 variety at Gazipur. Gazipur is located in the central part of Bangladesh and winter or cooler period stay vary short there for this reason sowing window stay only just for one month that is in the month of October. In normal weather condition yield varied from 7.23 -10.30 t ha^{-1}. The maximum yield was found in case of October sowing and after passage of time yield decline sharply. Thirteen treatment was selected starting from 1 October and every 10 days interval other treatment was setup for simulation study end up to 30 January (Figure 1.1).

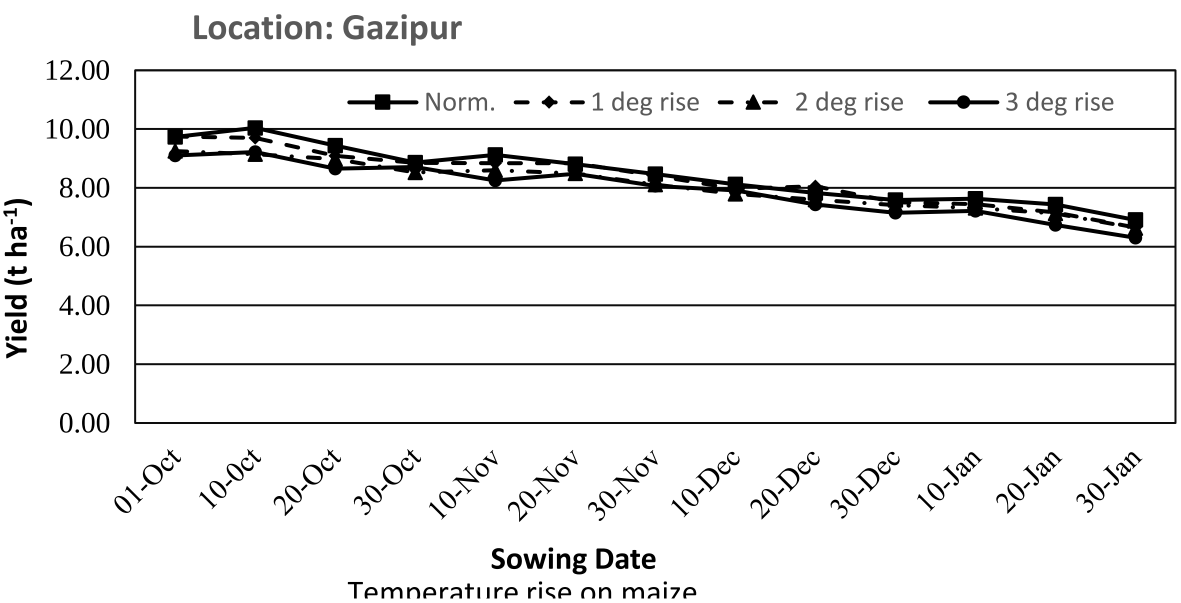
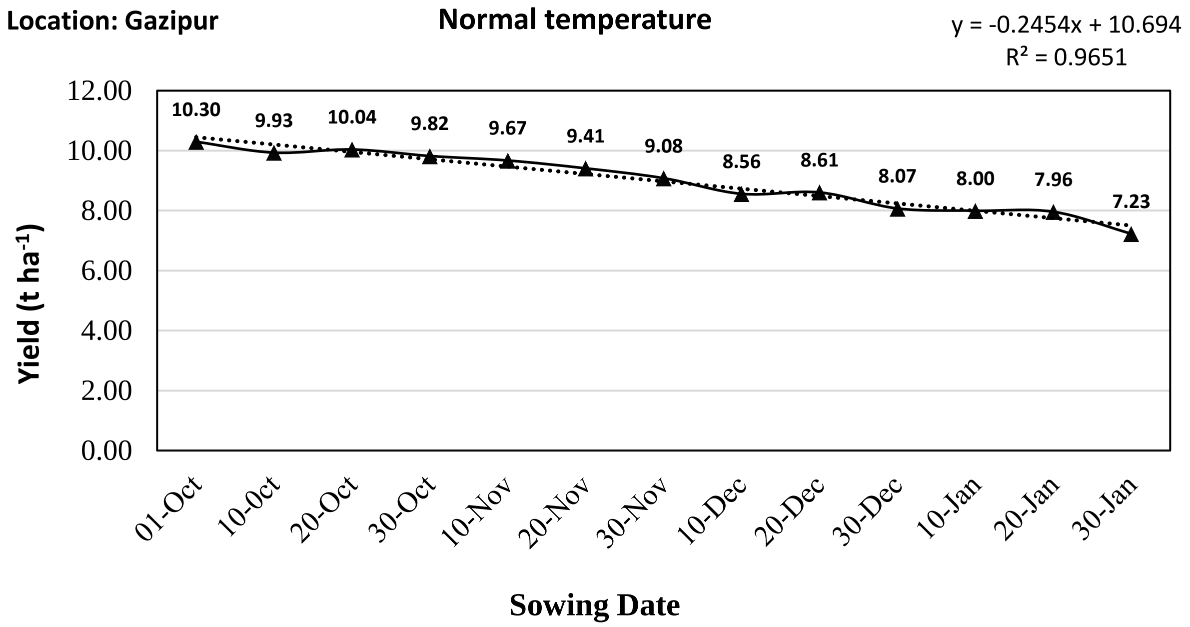


Fig. 1.1: Temperature rise on maize at Gazipur

Maize Production with normal temperature at Gazipur: Maize production with normal temperature at Gazipur yield varied from 7.23-10.30 t ha^{-1}. The maximum yield (10.30 t ha^{-1}) was found from treatment T_1: 1 October. 1 October to 30 October is the best options or optimum sowing window for maize production at Gazipur with normal weather condition (Figure 1.2).



\Fig. 1.2: Maize production with normal temperature at Gazipur

Maize production with 1-degree temperature rise at Gazipur: 1-degree temperatures rise at Gazipur yield varied from 6.65-9.75 t ha^{-1}. The maximum yield was found 1 October sowing followed by 10 October sowing. With the 1-degree temperature rise first two weak gave the higher yield than the last two week of October where as in normal weather condition 3rd week of October gave the second highest yield. That means 1 degree temperature rise narrowing or shorter one weak from the one month of optimum sowing windows of maze at Gazipur (Figure 1.3).

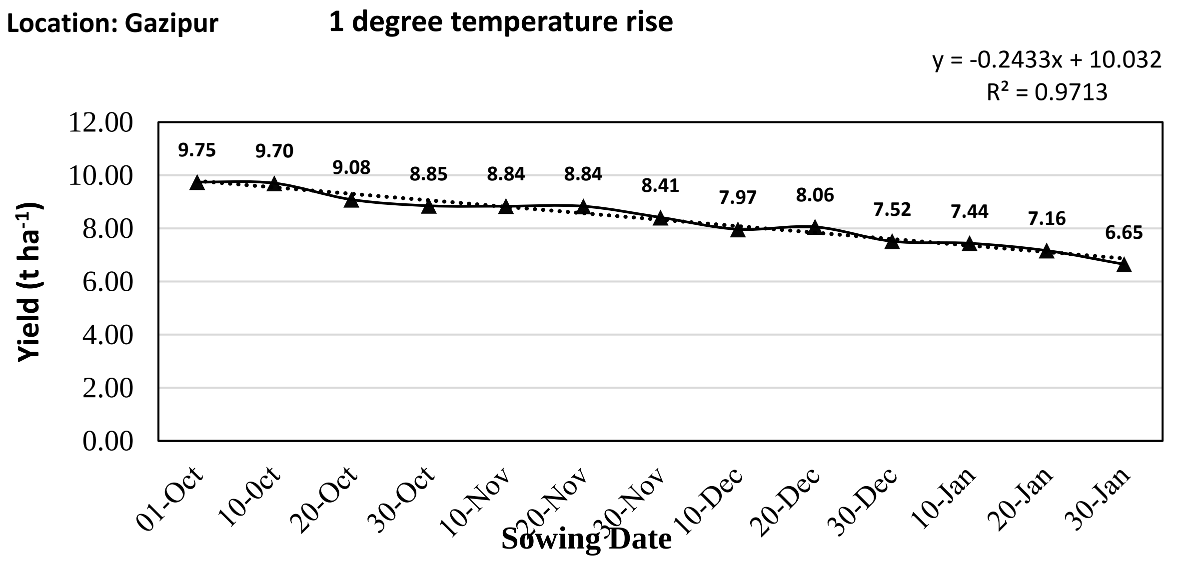


Fig. 1.3: Maize production with 1-degree temperature rise at Gazipur

Maize production with 2-degree temperature rises at Gazipur: In 2-degree temperature rise condition yield varied from 6.63-9.25 t ha^{-1}. The maximum yield (9.25 t ha^{-1}) was found 1 October sowing followed by 10 October (9.15 t ha^{-1}). The lowest yield (6.63 t ha) was found 30 January sowing (Figure 1.4).

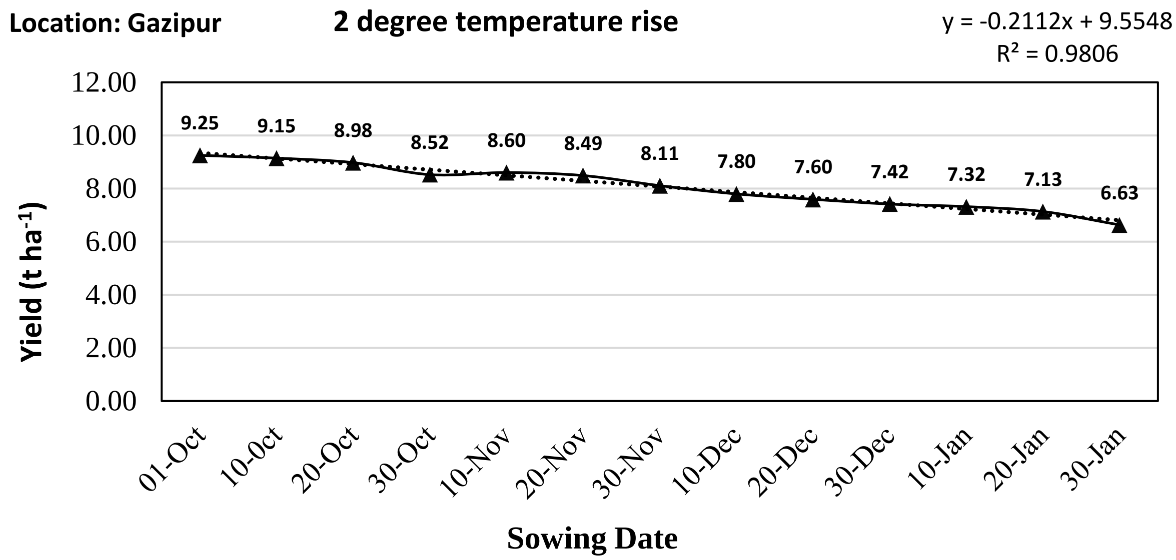


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Fig. 1.4: Maize production with 2-degree temperature rise at Gazipur

Maize production with 3-degree temperature rises at Gazipur: In 3-degree temperature rise condition, situation the yield of maize varied 6.30-9.22 t ha^{-1}. The maximum yield (9.22 t ha^{-1}) was found 10 October sowing. Simulation study shows that with the increase of 3-degree temperature rise condition shifting of one weak forward in optimum sowing window occurred. That means with the 3-degree temperature rise maximum yield of maize shifting 1 October to 10 October in Gazipur Condition (Figure 1.5).

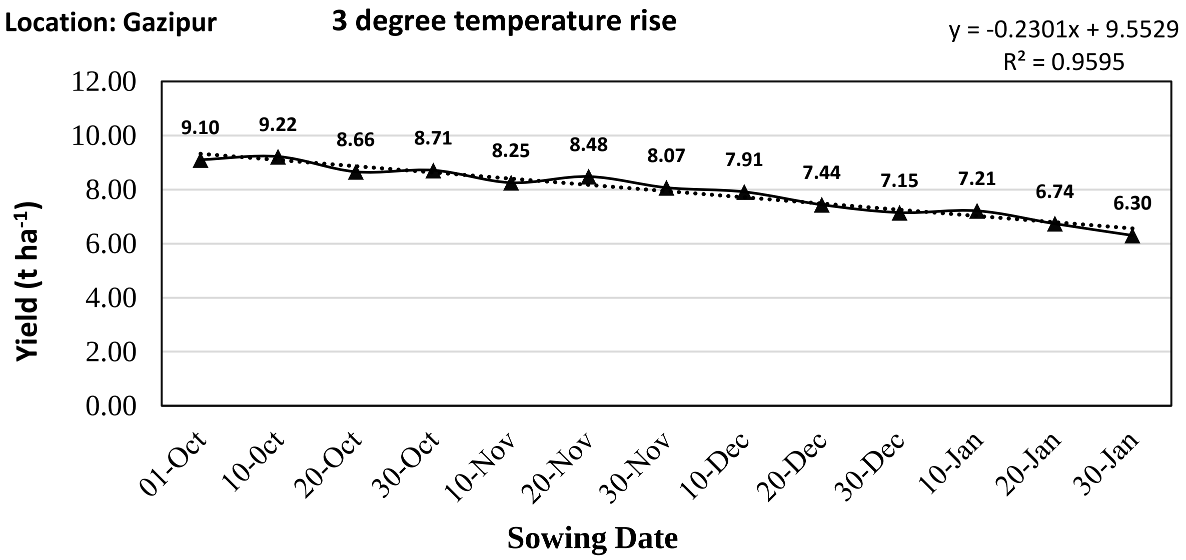

Fig.1.5: Maize production with 3-degree temperature rise at Gazipur

Teperature rise on maize at Pabna: Yield performance of maize is upright up to 1 October to 30 November at Pabna with normal weather condition. In case of Pabna, sowing window stays at least two month that is 1 October to 30 November with normal weather condition. After December sowing ultimate grain yield of maize showed decreasing trend (Figure 2.1).

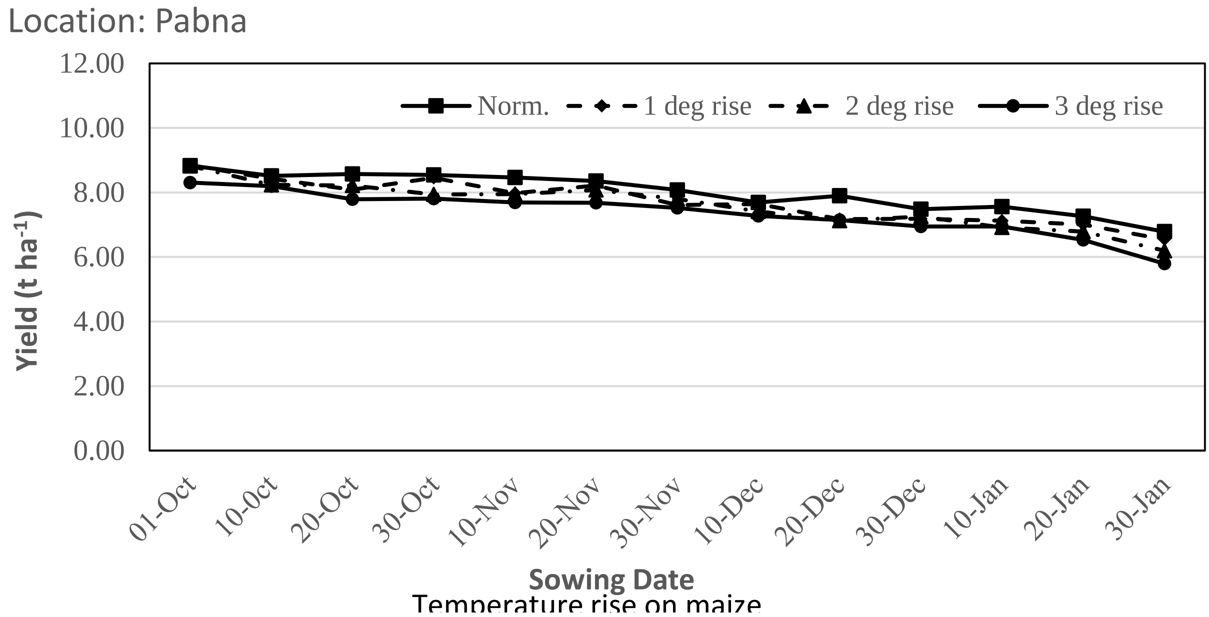

Fig 2.1: Temperature rise on maize at Pabna

Maize production with normal temperature at Pabna: The highest yield was found 1 October sowing and followed by treatment T_3, T_4 and T_2 (Figure 2.2).

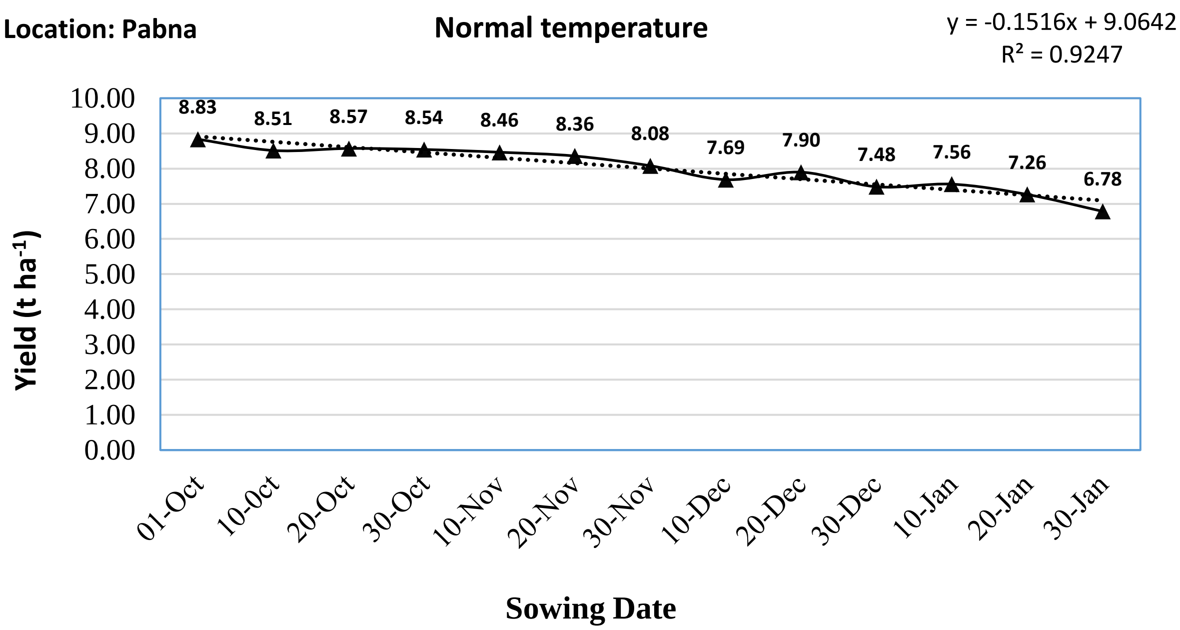

Fig 2.2: Maize production with normal temperature at Pabna

Maize production with 1-degree temperature rise at Pabna: In 1 degree temperature rise condition maize yield varied 6.54-8.85 t ha^{-1}. With the 1-degree temperature rise condition sowing window narrow down up to 1 month then the normal weather condition in maize production at Pabna (Figure 2.3).

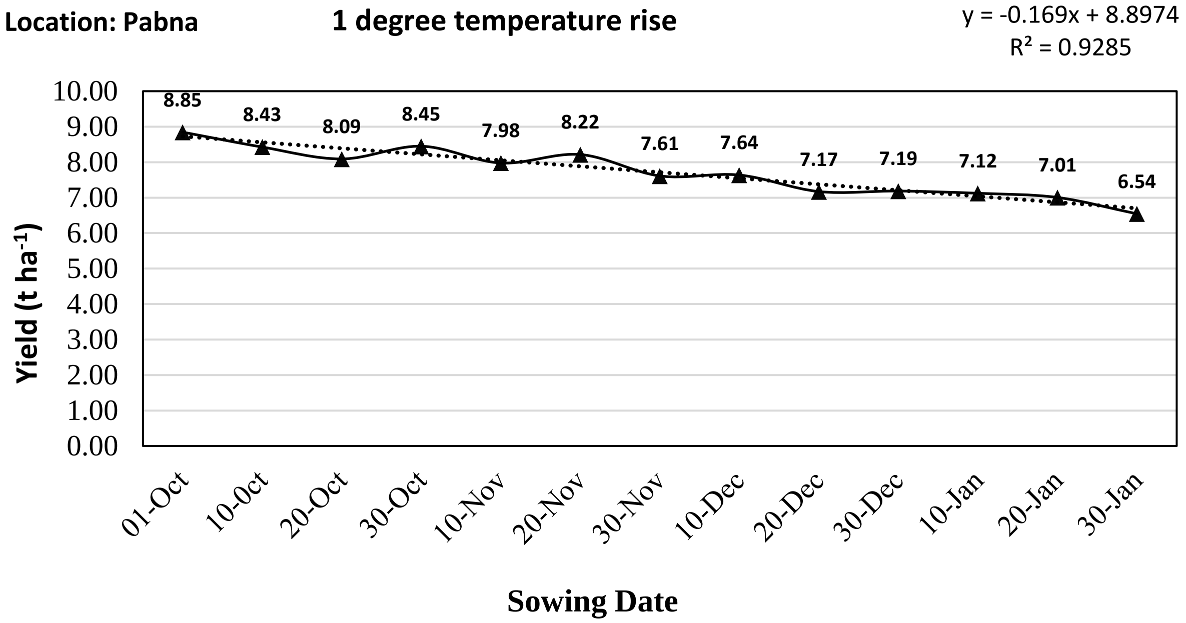

Fig 2.3: Maize production with 1 degree temperature rise at Pabna

Maize production with 2-degree temperature rise at Pabna: In 2-degree temperature rise condition yield of maize varied from 6.20 to 8.82 t ha^{-1}. With 2-degree temperature rise condition sowing windows narrowing down at least 1 weak. rather than the 1-degree temperature rise at Pabna. In case of the 2-degree temperature rise condition, optimum sowing window stay only 3 weeks in maze production at Pabna (Figure 2.3).

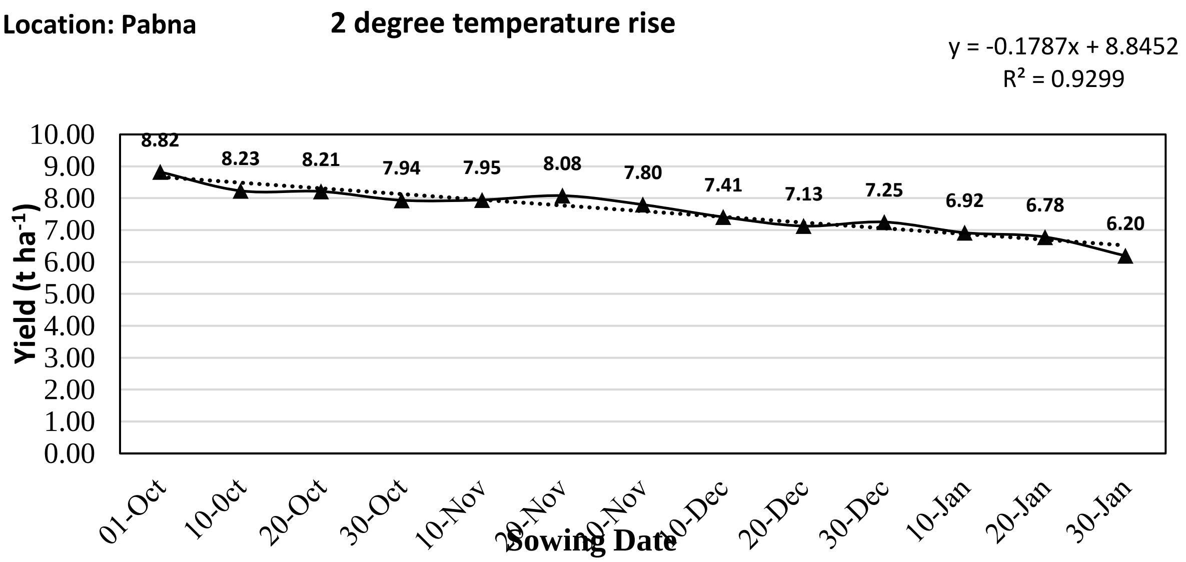

Fig 2.4: Maize production with 2-degree temperature rise at Pabna

Maize production with 3-degree temperature rise at Pabna: In case of 3-degree temperature rise condition, optimum sowing window follow the similar trend of 2-degree temperature rise condition of maize production at Pabna. The yield varied from 5.79-8.31 t ha^{-1}. The optimum sowing window stays three weeks in 3-degree temperate rise condition whereas it belong 2 months with normal weather condition (Figure 2.5).

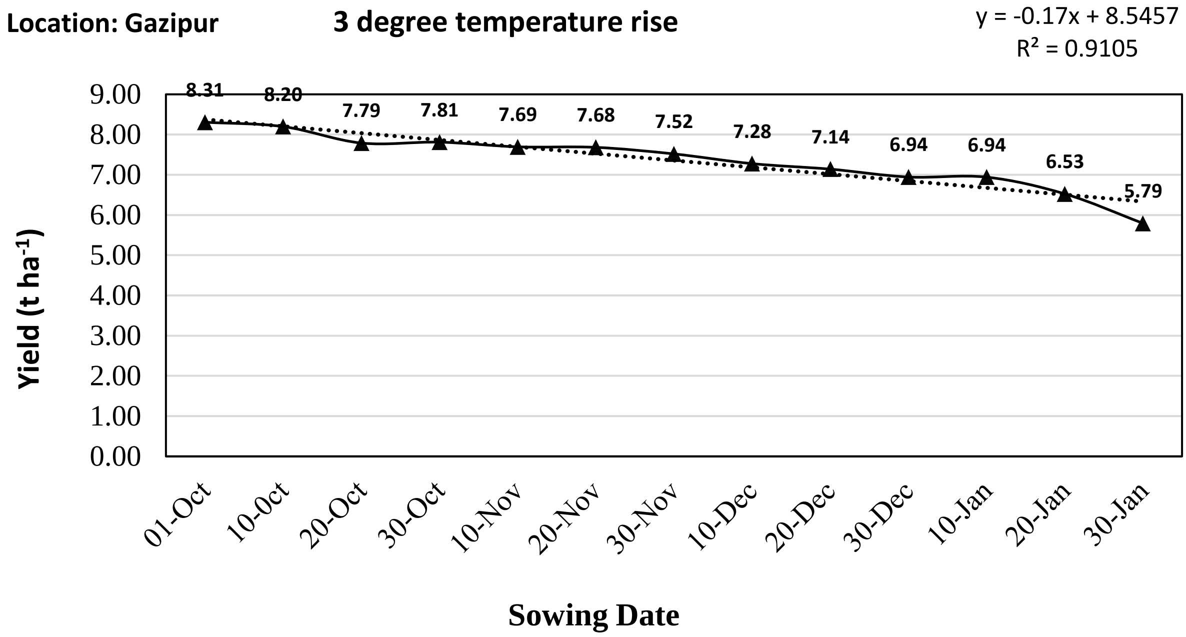

Fig 2.5: Maize production with 3-degree temperature rise at Pabna

FORMULA USED IN THIS REPORT

Cost and return analysis was calculated on the basis of prevailing market price of the produces. Economic analysis involved collection of data on prices and quantities of inputs used and output produced. The inputs used included seed, fertilizer, labour and insecticides. The output and inputs were valued at market prices. The MBCR of the farmer's prevalent pattern and any replacement for it can be computed as the marginal value product ((MVP) over the marginal value cost (MVC). The Marginal of prevalent pattern (F) and any potential replacement (E) for it was computed as (CIMMYT, 1988).

Marginal benefit-cost ratio (MBCR)

The MBCR could be computed as the marginal value product (MVP) over the marginal value cost (MVC). It could be computed as

$$\text{MBCR} = \frac{\text{MVP (over control)}}{\text{MVC (over control)}}$$

$$\text{or} = \frac{\text{Gross return (E) - Gross return (F)}}{\text{TVC (E) - TVC (F)}} = \frac{MVP}{MVC}$$

Where, E= Existing practice or Improve practice, F= Farmers practice

Land use efficiency

It was worked-out by taking total duration of crops in an individual cropping pattern divided by 365 days. It was calculated by the following formula:

$$\text{Land use efficiency (\%)} = \frac{d_2 + d_3 + d_4}{365} \times 100$$

Where, d_2, d_3 and d_4 = duration of relay crop (1^{st}+2^{nd}), 3^{rd} and 4^{th} crop of the pattern, respectively

Production efficiency: It values in terms of kg ha^{-1} day^{-1} was calculated by total main product in a cropping pattern divided by total duration of crops in that pattern. It was calculated by the following formula:

$$\text{Production efficiency (Kg ha}^{-1}\text{Day}^{-1}) = \frac{y_1 + y_2 + y_3 + y_4}{d_2 + d_3 + d_4}$$

Where, y_1, y_2, y_3, and y_4= Equivalent yield per hectare of 1^{st}, 2^{nd}, 3^{rd} and 4^{th} crop of the pattern, respectively

d_2, d_3 and d_4 = duration of relay crop (1^{st}+2^{nd}), 3^{rd} and 4^{th} crop of the pattern, respectively.

Rice Equivalent Yield (REY)

Rice equivalent yield (REY) was calculated to compare system performance by converting the yield of each crop into equivalent rice yield on a price basis, for comparison between crop sequences, the yield of every crop was converted into rice equivalent on the basis of prevailing market price of individual crop (Verma and Modgal, 1983). Rice equivalent yield (REY) was computed as yield of individual crop multiplied by market price of that crop divided by market price of rice by using the following formula:

$$\textbf{REY (of crop}_x\textbf{)} = Y_x (P_x / P_r)$$

where, Y_x is the yield of crop 'x'(tons harvested product ha^{-1}), P_x is the price of crop, 'x' and P_r is the price of rice (Biswas et al., 2006). The price of the rice grain, rice straw, sesame and mustard was 20, 1, 100 and 75 Tk kg^{-1}, respectively.

$$\text{or,} = \frac{\text{Yield of individual crop} \times \text{market price of that crop}}{\text{Market price of rice}}$$

$$\textbf{Weed density}\ (\text{no. m}) = \frac{\text{Total number of weeds}}{\text{Total survey areas}}\text{-2}$$

$$\textbf{Relative weed density} = \frac{\text{Density of each weed species}}{\text{Total density of all weed species}}\ x\ 100$$

Weed persistence index (WPI) was computed using the given formula as suggested by Mishra and Mishra (1997). It indicates the resistance in weeds against the tested treatment.

$$\textbf{WPI} = \frac{\text{Weed population in control plot}}{\text{Weed population in treated plot}} \text{x} \frac{\text{Weed dry weight in treated plot}}{\text{Weed dry weght in control plot}}$$

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LIST OF FARMING SYSTEMS RESEARCH AND DEVELOPMENT (FSRD) AND MULTILOCATION TESTING (MLT) SITES

A. FSRD SITES

1. Ajoddhapur (3), Rangpur
2. Gangarampur (11), Pabna sadar, Pabna
3. Sholakundu (12), Faridpur sadar, Faridpur
4. Atia (8), Delduar, Tangail
5. Tarakandi (8,9), Sherpur sadar, Sherpur
6. Subarnachar (18c, 18f), Noakhali sadar, Noakhali
7. Jamla, (13), Dumki, Patuakhali
8. Basantapur (26), Godagari, Barind, Rajshahi
9. Kamal bazar (20), South Surma, Sylhet
10. Charkharicha (8,9), Mymensingh Sadar, Mymensingh
11. Charpara (4), Sonatola, Bogura
12. Chandradighalia (14), Gopalganj Sadar, Gopalganj
13. Jiakokhi (11), Kushtia Sadar, Kushtia
14. Chandura, Rajshahi

B. MLT SITES

Region-1

Pabna	:	Atghoria (11&12), Sujanagar (10,11&12), Kashinathpur (11&12) of Pabna, Sirajganj (4,5,7&12)
Shyampur, Rajahahi	:	Shibpur, Puthia (11), Paba (11) of Rajshahi
Barind, Rajshahi	:	Aamnura (26) of Chapainawabganj, Sapahar (26) of Naogaon
Rangpur	:	Gobindaganj (3) of Gaibandha, Domar (3) of Nilphamari, Ulipur (3) of Kurigram, Khalashpir (3) of Pirganj, Hatibandha of Lalmonirhat (3)
Bogura	:	Sherpur (4,25), Shibganj (3,4,25),Gabtali (3,4) of Bogura and Joypurhat (3,25)
Rajbari, Dinajpur	:	Raniganj (1), Ghoraghat (1) of Dinajpur, Pirgonj (1) of Thakurgaon,
Thakurgaon	:	Munshirhat (Thakurgaon sadar)

Region-2

Sherpur	:	Melandah(9) of Jamalpur, Nalitabari (8&9), Jhenaigati (8&9) of Sherpur
Tangail	:	Ghatail (9,28), Modhupur (9,28), Bhuyapur (7,8), Mirzapur (8,9), Sadar (7,8) of Tangail
Mymensingh	:	Trishal (8,9), Netrakona (9), Phulpur (9), Muktagaccha (8,9,28)
Kishoreganj	:	Karimganj (8,9), Hossenpur (7,8,9), Nikli (8,19,21), Sadar (8,9)
Narsingdi	:	Shibpur (9&28), Monohordi (9&28) & Raipura (8,9&28)
Gazipur	:	Manikganj (7,8,10,12), Munshiganj (8,10,12,19) and Dhirashram (28)

Region-3

Jashore	:	Tularampur (11),Narail, Seemakhali (11),Magura, Kaliganj (11),Jhenaidah, Jikargacha (11),Jashore
Khulna	:	Satkhira sadar (11,13), Bagherhat sadar (11,13,14), Dumuria (11,13,14), Khulna, Batiaghata (11,13), Khulna, Koyra (13), Khulna
Kushtia	:	Bheramara (11) of Kushtia, Gangni (11), Mujibnagar (11) of Meherpur and Sadar (11) of Chuadanga
Faridpur	:	Rajbari sadar (12), Rajir of Madaripur (10&12)
Patuakhali	:	Aamtali (13), Barguna, Kuakata (13) & Bauphal (13), Patuakhali
Barishal	:	Banaripara (13&19) and Gournadi (12)
Bhola	:	Daulatkhan (18), Charfashion (18)
Gopalganj	:	Pirojpur (12,13,14), Tungipara (10,12,14,19), Muksudpur (10, 14, 19), Gopalganj

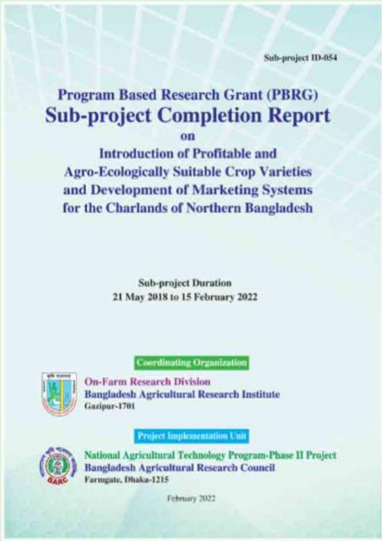
Region-4

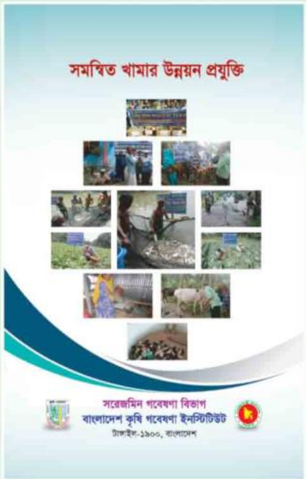
Hathazari	:	Patiya (23,29), Fatikchari (29)
Noakhali	:	Feni (19a), Laxmipur (18f)
Cumilla	:	Barura (19), Debidder (19), Chandina (19), Shaharasti (17,19),Chandpur, Kosba (16,19), Brahmanbaria
Sylhet	:	Moulivibazar (20, 29), Zokiganj (20), Sunamganj (20, 21) and Habiganj (20, 21, 22)
Bandarban	:	Limujiri (29), Buhalong
Cox's Bazar	:	Cox's bazar sadar (23) and Chokoria (23) of Cox's bazar

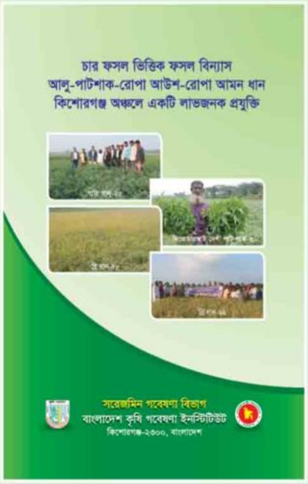
Note: Numerical figure in parenthesis is no. of AEZ

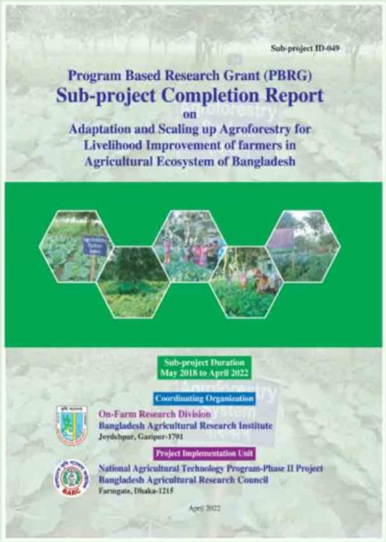
কর্মসম্পাদন সূচক, লক্ষ্যমাত্রা এবং অর্জন: ২০২১-২২ (সেকশন-৩)
সরেজমিন গবেষণা বিভাগ

সূচক	একক	লক্ষ্যমাত্রা	অর্জন
১.১.৩ উদ্ভাবিত অন্যান্য প্রযুক্তি (সেচের দক্ষতা বৃদ্ধি, হাইড্রোপনিক, শারীরতাত্ত্বিক ইত্যাদি)	সংখ্যা	৬	৬
১.২.১ প্রশিক্ষিত কৃষক	সংখ্যা	৫০০	৫০০
১.২.৩ স্থাপিত প্রদর্শনী	সংখ্যা	২০০	২০০
১.২.৪ আয়োজিত সেমিনার/ওয়ার্কশপ	সংখ্যা	৪	৪
১.২.৫ আয়োজিত মাঠ দিবস/র‍্যালী	সংখ্যা	২০	২০
১.২.৬ হস্তান্তরিত জাত	সংখ্যা	৩	৩
১.২.৭ হস্তান্তরিত প্রযুক্তি	সংখ্যা	৫	৫
১.২.৮ বার্ষিক গবেষণা রিপোর্ট প্রকাশিত	সংখ্যা	১	১
১.২.৯ লিফলেট, নিউজলেটার, বুকলেট, জার্নাল ইত্যাদি প্রকাশিত	সংখ্যা	৩	৩
২.২.১ মুজিববর্ষ উপলক্ষ্যে কৃষকের মাঝে বিতরণকৃত বারি আম-৪, বারি আম-১১ এবং অন্যান্য ফলের চারা বিতরণকৃত	সংখ্যা	২৫০	২৫০
২.২.২ মুজিববর্ষ উপলক্ষ্যে কৃষকের বাড়িতে স্থাপিত মিশ্র ফল বাগান	সংখ্যা	৩	৩
২.২.৩ মুজিববর্ষ উপলক্ষ্যে কৃষকের মাঠে প্রদর্শনী স্থাপিত	সংখ্যা	১০	১০
৩.১.৩ জৈবসার (কম্পোস্ট ও ভার্মিকম্পোস্ট) উৎপাদিত	কেজি	১৫০০	১৫০০
৫.২.১ প্রশিক্ষিত জনবল (সরকারি বিধি, প্রশাসনিক ও আর্থিক ব্যবস্থাপনা, আইসিটি, গবেষণা ব্যবস্থাপনা ইত্যাদি বিষয়ে বিজ্ঞানী/ কর্মকর্তা/ এসএসএ/ এসএ/কর্মচারীদের প্রশিক্ষণ/ সমসাময়িক বিষয় নিয়ে লার্নিং সেশন আয়োজিত)	জনঘণ্ট	২৪০	২৪০









Farming Systems and Adaptive Research

- On-Farm Soil Fertility Management
- Improvement of Cropping Systems
- On-Farm Trials with Advanced lines and Technologies
- Integrated Farming
- Socioeconomic Studies
- Transfer of Technologies

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