GROWTH AND YIELD OF SORGHUM AS INFLUENCED BY SPACING AND NUTRIENT MANAGEMENT

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Abstract

A field experiment was conducted at the Research Field of Agronomy Division BARI, Gazipur during *rabi* season of 2021-2022 to find out optimum fertilizer dose and suitable plant spacing and population for better growth and maximum grain yield of sorghum cultivation. Three plant spacing viz., S_1=60 cm × 10 cm (1,66,666 plants/ha), S_2=50 cm × 15 cm (1,33,333 plants/ha) and S_3=40 cm × 20 cm (1,25,000 plants/ha), and four fertilizer doses viz., F_1=N_{120} P_{60} K_{50} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha, F_2=F_1 + 25% NPK (N_{150} P_{75} K_{63} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg /ha), F_3=F_1 + 50% NPK (N_{180} $P_{90}$$K_{75}$ S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) and F_4=Control (Native fertility) were used as treatments in the experiment. Results revealed that, plant spacing and fertilizer levels have great influence on leaf area index (LAI), light interception, chlorophyll content (SPAD value), dry matter production and grain yield of sorghum. Higher LAI was observed with higher population of 1,66,666 /ha receiving higher fertilizer N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha (F_3), which intercepted higher PAR and contributed to higher DM production as well as higher grain yield. Plants grown in 60cm ×10cm spacing (1,66,666 plants/ha) with N_{180} $P_{90}$$K_{75}$ S_{27} $Zn_{2.8}$ $B_{1.4}$ kg /ha (F_3) gave the highest grain yield (4.68 t/ha) followed by same spacing 60 cm × 10 cm (S_1) with N_{150} P_{75} K_{63} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg /ha (F_2) and N_{120} P_{60} K_{50} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha (F_1). Though S_1F_3 combination gave the maximum gross return (Tk. 117000/ha) but maximum benefit cost ratio (2.28) was recorded in S_1F_1 treatment. The results indicated that plant spacing of 60 cm × 10 cm with fertilizer dose N_{120} P_{60} K_{50} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha and N_{150} P_{75} K_{63} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha might be suitable for higher grain yield and economic return of sorghum cultivation.

Introduction

Sorghum (*Sorghum bicolor* L. Moench) is a minor cereal crop but the importance particularly in the arid and semi-arid lands, where many lives depend on the crop as a major source of food (Martin, 1970). Sorghum has the advantage of performing relatively well under stress conditions such as drought and floods (Doggett, 1988). This provides an opportunity to increase production and yield of sorghum where other crops may fail. Food insecurity can be better addressed by increasing sorghum production in marginal areas of barind and char land where majority of the population are starving or malnourished. Sorghum grain is higher in protein lower in fat content than corn and gluten free. Sorghum bran has greater antioxidant and anti-inflammatory properties than well-known foods such as blueberries and pomegranates. Fertilizer is the driving force in the crop production system of the modern agriculture. Inorganic fertilizers today hold the key to the success of crop production systems in Bangladesh Agriculture. But there is no fertilizer recommendation for sorghum production in Bangladesh. There are many reasons of the low yield of sorghum. Among the factors of crop production, balanced fertilizer nutrient elements like NPKSZnB *etc.* is the single most important one that plays a vital role in yield increase (Mahmood *et al*., 2000; Randhawa and Arora, 2000; Iqbal *et al.*, 2015). On the other hand, spacing or number of plant population is also important for successful crop production. Plant population and row spacing are important factors for crop establishment technique that affects the crop stand and other yield parameters in different crops. Maintenance of optimum planting density is always a big problem to the farmers. Lower plant density results in higher weed infestation, poor radiation use efficiency and lower yields. On the other hand, dense plant population may cause lodging, poor light penetration in the canopy, reduction of photosynthesis due to shading of lower leaves and serious yield reduction (Lemerle *et al*., 2004; Lemerle *et al*., 2006). Similarly, plant population, on the basis of row spacing affects the crop stand, agronomic plant characteristics and the yield in sorghum crop (McMurray, 2004; McRae *et al*., 2008). Row spacing affects the crop yield potential (Staggenborg, 1999; Bryant *et al*., 1986). Reducing the distance between rows improves weed control (Walker & Buchanan, 1982) by increasing crop competition and reducing light transmission to the soil (Andrade *et al*., 2002). Narrow row spacing resulting in higher yield is explained by the improved light interception (Steiner, 1986) and decreased plant to plant competition between plants (De Bruin & Pederson, 2008). Johnson *et al.* (2005) reported reduction in total weed density in 30cm apart rows of peanut (*Arachis hypogea*) as compared to the weed density at greater spacing. Grain sorghum is commonly cultivated in rows with 60 to 110 cm spacing, but with the development new production technology and introduction of new herbicides has opened a new window of opportunity to test narrower row spacing for grain production of sorghum. Determining the optimum spacing is essential to get the proper crop stand and maximum yield (Cox, 1996; Widdicombe & Thelen, 2002) of sorghum crop. There is a close relationship between number of plant population and fertilizer dose for crop production. Production of sweet sorghum increases with increased plant densities and nitrogen fertilizer levels (Turgut *et al*., 2005). Negative effect can be shown on crop yield if fertilizer is not increasing with increasing plant population (Kakon *et al*., 2020). Therefore, the appropriate fertilizer input and ideal plant spacing is necessary for getting higher grain yield. Effect of fertilizer and spacing on growth and yield of sorghum is inadequate or sporadic in Bangladesh. Hence, the experiment has been conducted to find out suitable spacing and optimum fertilizer dose for better growth and maximum grain yield of sorghum.

Materials and Methods

The experiment was conducted at the Research Field of Agronomy Division BARI, Gazipur during *rabi* season of 2021-2022. The soil of the research area belongs to the Chhihata series under AEZ-28. Soils of the experimental plots were collected and analyzed. The physical and chemical properties of initial soil of the experimental plot has been presented in Table1.The soil was clay loam with pH 6.23, OM 1.29% (very low), total N 0.112% (very low), exchangeable K 0.098 meq/100g soil (very low), available P 15.23 µg/ml (optimum), available S 24.94 µg/g (optimum), available Zn 0.654 µg/g (low) and available B 0.168 µg/g (very low). Organic matter, N, K and B were under critical level in the soil. Three plant spacing viz., S_1=60 cm × 10 cm (1,66,666 plants/ha), S_2=50 cm × 15 cm (1,33,333 plants/ha) and S_3 =60 cm × 20 cm (1,25,000 plants/ha) and four fertilizer doses viz., F_1 = 120-60-50-27-2.8-1.4 kg/ha of NPKSZnB), F_2=F_1 + 25% NPK, F_3=F_1+ 50% NPK and F_4=Control (Native fertility) were used in the experiment. There were 12 treatment combinations as follows: $S_1\times F_1$, $S_1\times F_2$, $S_1\times F_3$, $S_1\times F_4$, $S_2\times F_1$, $S_2\times F_2$, $S_2\times F_3$, $S_2\times F_4$, $S_3\times F_1$, $S_3\times F_2$, $S_3\times F_3$ and $S_3\times F_4$.The experiment was laid out in a two factor randomized complete block design with three replications. The unit plot size was 8 m × 6 m. Seeds of sorghum (BARI Sorghum-1) were sown on 23 November 2021. Fertilizers were applied as per treatments. One-third of urea and full amount of triple super phosphate (TSP), muriate of potash (MoP), zinc sulphate and boric acid were applied at the time of final land preparation. The remaining urea was side dressed in two equal splits at 30 DAS and 50 DAS and mixed thoroughly with the soil as soon as possible for better utilization. A light irrigation was given after sowing of seeds for uniform germination. Three irrigations were done at 30 and 50 DAS and grain development stage. Thinning was done at 20 DAS and weeding at 25 and 45 DAS. Data on growth parameters like leaf area and dry matter accumulation were measured at different dates with 15 days interval. For recording dry matter weight and leaf area, three plants from each replication were sampled at 30, 45, 60, 90 DAS and at harvest. Different plant parts of the collected samples were separated and then oven dried at 80^0C for 72 hours. Leaf area was measured by an automatic leaf area meter (L13100 c, L1COR, USA). Light interception (LI) by the crop was recorded at five times (30, 45, 60, 90 DAS and at harvest) at around 11:30 am to 13:00 pm by Sunfleck Ceptometer (Model Decagon, Pulman, Washington, USA).Four readings of PARinc and PARt were recorded at different spots of each plot. The proportion of intercepted PAR (PARint) was calculated using the following equation and expressed in percentage (Ahmed *et al.*, 2010):

$$\text{Light interception \{PARint (\%)\}} = \frac{\text{PARinc} - \text{PARt}}{\text{PARinc}} \times 100$$

whrer, PARinc= Incident PAR, PARt= Transmitted PAR, PARint= Intercepted PAR

Soil-Plant-Analysis Development (SPAD) Value of leaf chlorophyll content might be used as an indirect indicator of crop N status. Chlorophyll content measured using a portable SPAD meter (Model SPAD-502, Minolta crop, Ramsey, NJ) at 30, 45, 60, 75 and 90 DAS. The crop was harvested on 7 April 2021 (135 days after sowing). The yield component data was taken from 5 randomly selected hills from each plot. At harvest, the yield data was recorded plot wise from central 10 m^2 area. The collected data were analyzed statistically and means were adjudged by LSD test at 5% level of significance using MSTAT-C package. Cost and return analysis was also done considering local market price of harvested crops. The nutrient status of initial soil of experimental field is given below:

Table 1. Initial soil analytical data of the experimental site at Gazipur

pH	OM (%)	Total N (%)	Exchangeable K (meq/100g soil)	Available P (µg/ml)	Available S (µg/g)	Available Zn (µg/g)	Available B (µg/g)
6.23	1.29	0.112	0.098	15.23	24.94	0.654	0.168
	VL	VL	VL	O	O	L	VL
Critical levels		0.12	0.12	7.0	10.00	0.60	0.20

L= Low, VL= Very low, O= Optimum

Results and Discussion

Light Interception (LI)

Light Interception varied at different plant spacing and fertilizer doses (Fig. 1). Light interception gradually increased and reached the peak at 75 DAS and after reached the peak LI declined up to harvest in all treatments (Fig.1). The reduction of LI after the peak might be reflecting the loss of some older leaves through senescence. Treatment combination of S_1F_3 (1,66,666 plants/ha×N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) followed by S_1×F_2 (1,66,666 plants/ha×N_{150} P_{75} K_{63} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) was favorable for light penetration to the upper of the canopy, which resulted better LI and the lowest LI was found in S_3F_4 (1,25000 plants ×Native fertilizer). Higher light intercepted by the plants of the treatment S_1F_3 was presumably due to larger leaf surface availability for photosynthesis as evident by higher LAI. This indicated that population was the main factor influencing the net radiation absorbed by the plants. It might be due to higher plant population might be caused more light penetration in the canopy, produced higher photosynthesis. The maximum light was intercepted at 75 DAS corresponded to higher LAI. The more the LAI, the greater the light interception. These results are in conformity with the findings of several earlier researchers as Pepper (1974) and Amanullah *et al.* (2010).

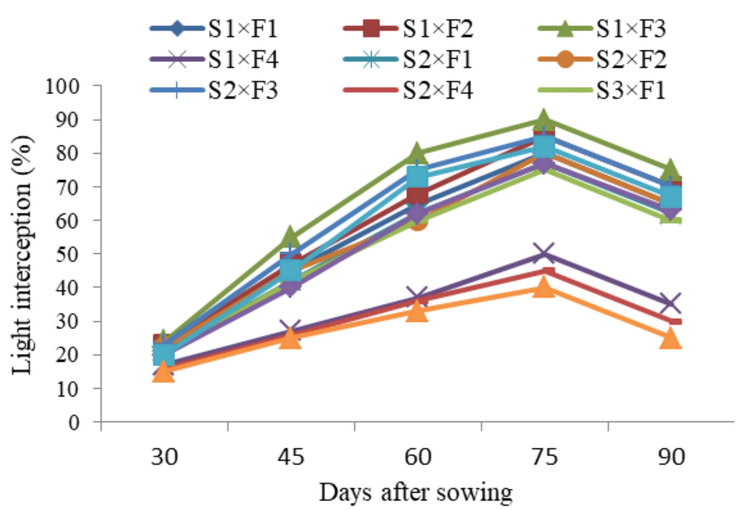

Fig. 1. Light interception of sorghum at different DAS as influenced by spacing and nutrient management.

Chlorophyll content (SPAD value)

SPAD value was influenced by plant spacing and fertilizer level (Fig. 2). The leaf greenness which indicated the leaf chlorophyll content was measured by SPAD meter. The highest SPAD value was observed at 60 DAS which declined progressively reaching the lowest at 90 DAS. The higher SPAD values of sorghum leaves at 60 DAS were probably due to the less sink demand for N from the source (leaf). SPAD value increases with the increase of fertilizer (especially nitrogen). Conversely, SPAD values gradually decreased after 60 DAS, it might have been due to remobilization of N from leaves to reproductive organs as grain formation was started after 60 DAS. SPAD values increased with the increase of fertilizer levels irrespective of lower population with higher LAI. Because, SPAD value of a leaf is counted by individual plant and an individual plant was better in respect of LAI, dry matter accumulation and light interception in lower population with higher fertilizer (S_3×F_3) than higher population with higher fertilizer (S_1×F_3) treatment . So, the highest SPAD value was found in S_3F_3 (1,25,000 plants/ha×N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) followed by S_3×F_2 (1,25,000 plants/ha×N_{150} P_{75} K_{63} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha). The lowest SPAD value was found in all spacing with native fertility.

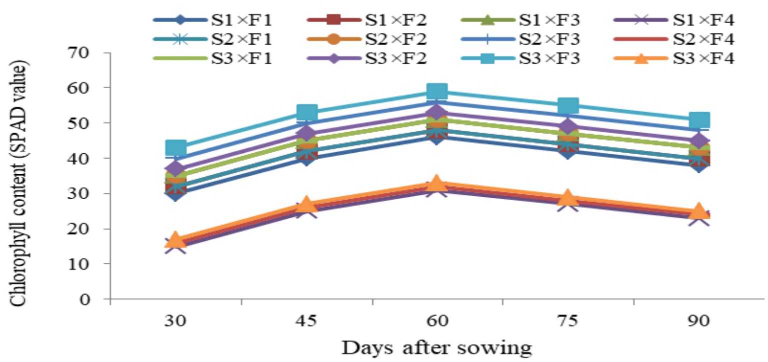

Fig. 2. SPAD value of sorghum at different DAS as influenced by spacing and nutrient management.

Leaf Area Index

Leaf area index (LAI) varied as influenced by different plant spacing and fertilizer doses. The LAI gradually increased and reached the peak at 75 DAS and after reached the peak LAI declined up to harvest in all treatments (Fig.3). The reduction of LAI after the peak might be reflecting the loss of some older leaves through senescence. However, the maximum LAI (3.80) was recorded in S_1 × F_3 (1,66,666 plants/ha×N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) treatment followed by S_1×F_2 (1,66,666 plants/ha×N_{150} P_{75} K_{63} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) treatment and S_2×F_3 (1,33,333 plants/ha×N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) treatment. Higher LAI indicated better leaf area expansion, which might help in solar radiation interception for more dry matter production. The lowest LAI (2.00) was found in S_3×F_4 combination followed by S_2×F_4 and S_3×F_4 treatment combination. Higher LAI in closer spacing was observed due to increased plant density which accommodates more number of plants and can also be ascribed to lesser value of spacing (Wasnik *et al*., 2012).

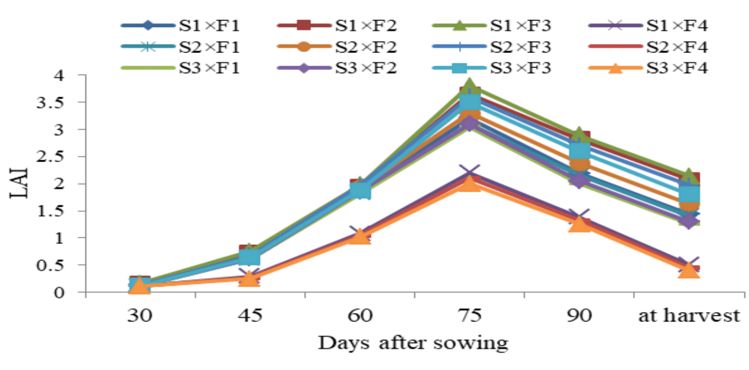

Fig.3. LAI of sorghum at different DAS as influenced by spacing and nutrient management.

Total dry matter production

The yield of a crop is mainly determined by the accumulation of TDM. The pattern of TDM accumulation in sorghum over time was influenced by different plant spacing and fertilizer doses (Fig.4). The TDM accumulation rate was slower up to 45 DAS then increased rapidly up to 90 DAS and then increased slowly up to harvest. The highest TDM was obtained from $S_1\times F_3$ (1,66,666 plants/ha×N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) treatment at harvest followed by $S_1\times F_2$ (1,66,666 plants/ha×N_{150} P_{75} K_{63} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) treatment and $S_2\times F_3$ (133333 plants/ha×N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) treatment and it was higher than other treatments throughout the growing period. The minimum TDM was observed in $S_3\times F_4$ (1,25,000 plants/ha × native fertility) treatment followed by $S_2\times F_4$ and $S_1\times F_4$. Total dry matter was reduced in all spacing with native fertility. Higher population/m^2 (spacing: 60 cm × 10 cm) with higher fertilizer produced higher dry matter accumulation. It might be due to higher plant population may cause more light penetration in the canopy, higher production of photosynthesis due to higher leaf area and ultimately the higher dry matter accumulation resulting higher production of yield (Lemerle *et al*., 2004; Lemerle *et al*., 2006). The treatments (higher population with higher fertilizer) which gave the higher value in leaf area index (LAI) were performed better in total dry matter production resulting higher grain yield. Similar findings were also reported by Tollenaar *et al*. (1997) and Thakur *et al*. (1997).

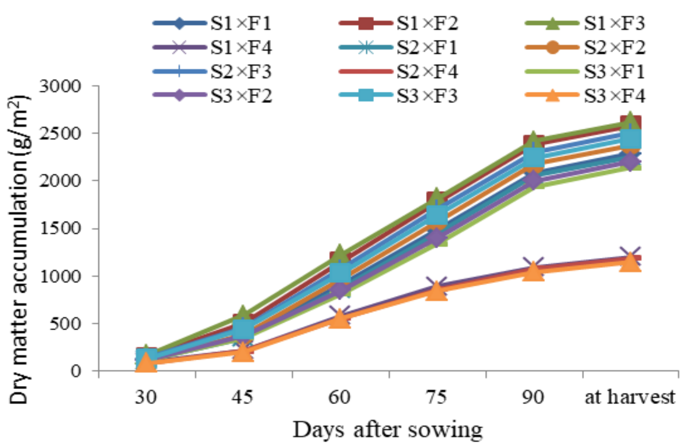

Fig. 4. TDM accumulation of sorghum at different DAS as influenced by spacing and nutrient management.

Plant height, yield component and yield of sorghum

Plant height, number of hill//m^2, yield components and yield of sorghum were significantly influenced by interaction effect of plant spacing and fertilizer doses (Table 2). Wider spacing with higher population produced comparatively taller plant than that of closer spacing with lower population. The tallest plant (174.53 cm) was observed when wider spacing with higher population (S_1) was fertilized with the highest dose F_3 (N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) followed by S_2F_3 and (1,66,666 population with N_{150} P_{75} K_{63} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) and shortest plant (127.33 cm) was found in $S_3\times F_4$ combination followed by $S_2\times F_4$ and $S_1\times F_4$ treatment combination. Similar result was found by Bhuiyan, 2001. The increase in plant height of sorghum in closer spacing with higher population was attributed to the decrease in red to far-red ratio as a result of preferential absorption of red light by the plants (Morgan and Smith, 1981). Such change in spectral balance increased internodes elongation processes (Kretchmer *et al*., 1977) and increased the plant height of sorghum in wider spacing with higher population. The highest number of hill//m^2 (17.5) was recorded in the treatment combination of S_1F_3 followed by S_1F_2 and similarly the highest number of panicle/m^2 (24.2) was recorded in S_1F_3 (higher population with higher fertilizer dose) followed by S_1F_2. It might be due to higher plant population produced higher number of panicle/m^2. On the other hand, the highest number panicle/hill (1.6) was recorded in the treatment combination of S_3F_3 (lower population with higher fertilizer) followed by S_3F_2. It has also been reported that increased in plant population resulted in decrease in number of tillers (Pawlowski *et al.*, 1993; Caliskan *et al.*, 2007). Similar trend was observed in panicle length, number of grains/panicle, 1000-grain weight. Long panicle had higher number of grains /panicle and lower population produced the highest 1000-grain weight and grain yield per plant when the highest dose of fertilizer (N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha) was applied. But lower population failed to produce higher grain yield per unit area (yield/ha). The maximum TDM accumulation due to reducing the distance between plants resulting improved weed control as reported by Walker & Buchanan (1982) by increasing crop competition and reducing light transmission to the soil as reported by Andrade *et al*. (2002). Finally the highest grain yield was obtained from higher population with higher fertilizer dose (Fertilizer dose N_{180} P_{90} K_{75} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha with spacing 60 cm × 10 cm) due to higher population received higher light interception which accumulated higher dry matter and translocation of higher TDM to grain /unit area and higher number of panicles per unit area and produced the higher grain yield followed by same spacing with N_{150} P_{75} K_{63} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha fertilizer level. Similarly, narrow row spacing or higher population with higher fertilizer produced higher grain yield in sorghum (Turgut *et al*., 2005; Patel *et al*., 2013) and in soybean (De Bruin and Pederson, 2008). On the other hand, the lowest grain yield was observed in $S_3 \times F_4$ combination (closer row spacing with lower population with native fertility) produced lower dry matter accumulation per unit area and number of panicles per unit area which reduced grain yield.

Table 2.Yield and yield components of sorghum as influenced by interaction effect of spacing and fertilizer during *rabi* 2021-2022

Spacing × Fertilizer dose	Plant height (cm)	Hill/m^2 (no.)	Panicle/m^2 (no.)	Panicle/hill (no.)	Panicle length (cm)	Grains/ panicle (no.)	1000-grain wt. (g)	Grain yield (t/ha)
$S_1 \times F_1$	154.63	17.3	22.09	1.3	18.23	1435	31.98	4.25
$S_1 \times F_2$	157.54	17.3	23.45	1.4	19.47	1521	32.75	4.49
$S_1 \times F_3$	174.53	17.5	24.18	1.4	20.00	1601	33.17	4.68
$S_1 \times F_4$	137.60	16.6	16.57	1.0	13.80	994	25.00	2.75
$S_2 \times F_1$	152.59	13.7	17.18	1.3	18.80	1452	32.25	3.92
$S_2 \times F_2$	157.07	14.2	19.54	1.4	20.39	1539	33.39	4.00
$S_2 \times F_3$	170.67	14.3	19.95	1.4	20.83	1628	34.89	4.15
$S_2 \times F_4$	130.67	13.6	13.63	1.0	14.07	995	25.42	2.10
$S_3 \times F_1$	151.27	12.8	16.27	1.3	18.80	1457	32.63	3.51
$S_3 \times F_2$	155.93	12.7	18.72	1.5	20.82	1555	33.64	3.75
$S_3 \times F_3$	167.05	12.8	20.82	1.6	21.90	1655	35.03	3.94
$S_3 \times F_4$	127.33	12.9	13.32	1.0	14.53	1000	25.61	1.40
$LSD_{(0.05)}$	12.23	0.83	3.81	0.22	1.88	99.11	2.26	0.62
CV (%)	4.70	3.37	11.97	5.10	5.99	4.17	4.15	4.17

Note: S_1= 60 cm × 10 cm (166666 plants/ha), S_2=50 cm × 15 cm (133333 plants/ha) and S_3 =40 cm × 20 cm (125000 plants/ha); F_1 = 120- 60- 50- 27-2.8-1.4 kg /ha NPKSZnB (Recommended fertilizer dose), $F_2 = F_1$ + 25% NPK and $F_3 = F_1$ + 50% NPK, F_4= Control (Native fertility)

Cost and return analysis

Cost and return analysis is an important tool to evaluate the economic feasibility of crop cultivation. Benefit cost analysis of sorghum production as influenced by interaction of spacing and fertilizer dose has been presented in Table 3. Among the treatments, the maximum gross return (Tk.117000/ha) and gross margin (Tk.62493/ha) was observed in $S_1 \times F_3$ treatment followed by $S_1 \times F_2$. But the maximum BCR (2.28) was recorded in $S_1 \times F_1$. Although treatment $S_1 \times F_3$ gave the maximum gross return but failed to produce maximum BCR due to the maximum total cost of cultivation (Tk.54507/ha) was recorded in S_1F_3 treatment due to involvement of higher fertilizer costs.

Table 3.Cost and return of sorghum cultivation as influenced by interaction effect of spacing and fertilizer during *rabi* 2021-2022

Treatment	Gross return (Tk/ha)	Total cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	BCR
$S_1 \times F_1$	106250	46588	59662	2.28
$S_1 \times F_2$	112250	50548	61702	2.22
$S_1 \times F_3$	117000	54507	62493	2.15
$S_1 \times F_4$	63750	30750	33000	2.07
$S_2 \times F_1$	98000	46438	51562	2.11
$S_2 \times F_2$	100000	50398	49602	1.98
$S_2 \times F_3$	103750	54357	49393	1.91
$S_2 \times F_4$	52500	30600	21900	1.72
$S_3 \times F_1$	87750	46388	41362	1.89
$S_3 \times F_2$	93750	50348	43402	1.86
$S_3 \times F_3$	98500	54307	44193	1.81
$S_3 \times F_4$	35000	30550	4450	1.15

Price (Tk./kg): Sorghum seed:50 and sorghum grain (food and feed): 25

Conclusion

It was concluded that spacing (60 cm × 10 cm) with fertilizer dose N_{120} P_{60} K_{50} S_{27} $Zn_{2.8}$ $B_{1.4}$kg/ha might be suitable for sorghum cultivation. The experiment needs to be repeated next year for confirming the results.

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EFFECT OF NUTRIENT MANAGEMENT AND HARVESTING TIME ON RATOONING OF SORGHUM AS FODDER CROP

A.A. BEGUM, S. S. KAKON, M.R. KARIM, S. T. ZANNAT AND D. A. CHOUDHURY

Abstract

The experiment was conducted at the Research Field of Agronomy Division BARI, Gazipur during *rabi* season of 2021-2022 to find out the optimum fertilizer dose and harvesting time of ratooning sorghum for higher fodder production. Six fertilizer doses viz., F_1= $N_{120}P_{60}K_{50}$kg/ha), F_2= $N_{90}P_{45}K_{37}$kg/ha (75% NPK of F_1), F_3=$N_{60}P_{30}K_{25}$kg/ha (50% NPK of F_1),F_4=$N_{30}P_{15}K_{12}$ kg/ha (25% NPK of F_1), F_5=N_{90} kg/ha, F_6=Control (Native fertility) and three harvesting times viz., H_1=35 days after grain harvest of main crop (DAGH), H_2=45 DAGH and H_3= 55 DAGH were used as treatments in the experiment. Results revealed that, fertilizer dose and harvesting time has greatinfluence on plant height,chlorophyll content (SPAD value), dry matter production (TDM) and green fodder yield of ratoon sorghum. Higherplant height, chlorophyll content (SPAD value), TDM andgreen fodder yield of ratoon sorghum wererecorded when the crop receiving the higher fertilizer like $N_{120}P_{60}K_{50}$ kg/ha, $N_{90}P_{45}K_{37}$ kg/ha and N_{90} kg/ha and harvested at 55 days after grain harvest of main crop.Though F_1H_3 combination gave the maximum gross return (Tk.144722/ha) and gross margin (Tk.121516/ha) but maximum benefit cost ratio (10.24) was recorded in F_5H_3 treatment combination.The results indicated that the fertilizer dose like $N_{120}P_{60}K_{50}$ kg/ha, $N_{90}P_{45}K_{40}$ kg/ha and N_{90} kg/ha produced the higher fodder yield of ratooning sorghum when harvested at 55 days after grain harvest of main crop but the economic point of view fertilizer dose only N_{90} kg/ha gave maximum profit.

Introduction

Now-a-days, cattle production is an important for income generation of the resource poor farmers and to alleviate poverty in Bangladesh. Green fodder can play an important role in rearing milk, meat and draft animals. The shortage of forage crops is about 99% (BBS, 2019) in the country. Rearing of animals is essential for milk production as well as draft power. But it is observed that little care is given to our animals due to shortage of feed. The shortage of animal feed becomes acute during August to November and January to May (OFRD, 1990). There is no scope for the farmers of Bangladesh to use his land for sole fodder production because he has to use his land only for food grain production. However, marginal lands can be used for growing forage crops without affecting areas under food and cash crops. Sorghum (*Sorghum bicolor*) is a dual-purpose crop used for both human food and animal feed in many Asian and African countries (Sarfraz *et al*. 2012; Bean *et al.* 2013), with key characteristics being wide adaptability across environments and tolerance to biotic and abiotic stresses (Krishnamurthy *et al.* 2007; Dahlberg *et al.* 2011; Gill *et al.* 2014). The crop residue is used mainly for feeding livestock by small farmers in the Asian and African continents (Hassan *et al.* 2015). Owing to very high crude fiber and very low crude protein concentrations, sorghum stover left after harvesting grain does not provide quality fodder for milking cattle (Manjunatha *et al.* 2014). The contribution of sorghum as a fodder crop it is fast growing, palatable, nutritious and utilized as silage and hay besides fresh feeding. Recently fodder production is a crucial issue in Bangladesh due to expansion of dairy and livestock farming. In this case, sorghum can mitigate the demand because of its high yielding and high energy value produced with lower number of labour than other forage types. The perennial habit of sorghum in a tropical climate permits the production of successive harvest of seed crops from an initial planting. Cultural treatments involving tillage and fertilization to favor such practice are termed ratooning. Generally, in the plant crop and ratoon crops, more tillers, larger leaf area, larger stalks, larger heads with more and heavier grains, and taller plants, and therefore, increased grain and stover yields were produced with higher N dose (Rodolfo and Plucknett, 1977). Forage sorghum can be grazed (young or as deferredfodder), cut fresh, made into hay or ensiled (Pedersen *et al.*, 2000).Sorghum has good ratooning ability from stubble of the plant crop, which is a desirable trait, as it reduces overall inputs in terms of seed for planting and labor for field preparation (Willey, 1990; Vinutha *et al*., 2017). Nutrient requirement and source especially of nitrogen is the most important for the growth, fodder yield and quality of *kharif* sorghum as fodder crops (Yousif, 1993). On the other hand, cutting or harvesting time is important of ratoon sorghum as fodder due to amount and quality depends on harvesting time.However, research on fertilizer management and harvesting time of ratoon crop of sorghum is inadequate in Bangladesh. So, the experiment has been conducted to find out the optimum fertilizerdose and suitable harvesting time for ratooning of sorghum as fodder crop.

Materials and Methods

The experiment was conducted at the Research Field of Agronomy Division BARI, Gazipur during *rabi* season of 2021-2022. The soil of the research area belongs to the Chhihata series under AEZ-28. The soil was clay loam with pH 6.1. Soil of the experimental plots were collected two times (after harvest of grain sorghum and ratoon sorghum) and analyzed. The physical and chemical properties of experimental soil have been presented in Table1 (after harvest of grain sorghum). The soil of the research area belongs to the Chhiata series under AEZ-28. Soils of the experimental plots were collected and analyzed. The physical and chemical properties of initial soil of the experimental plot has been presented in Table1.The soil was clay loam with pH 6.20, OM 1.20% (very low), total N 0.110% (very low), exchangeable K 0.097 meq/100g soil (very low), available P 14.23 µg/ml (optimum), available S 20.94 µg/g (optimum), available Zn 0.650 µg/g (low) and available B 0.167 µg/g (very low). Organic matter, N, K and B were under critical level in the soil.The 1stor grain crop or main crop experiment was laid out in a piece of land with the area of 32.5 m × 36.4 m. Seeds of sorghum (BARI Sorghum-1) were sown on 16November 2021. Sorghum seeds were sown at a spacing of 60 cm between rows and 10 cm between the plants. Fertilizers were applied at the rate of 120-60-50kg/ha of NPK as urea, triple super phosphate (TSP), muriate of potash (MoP) for grain sorghum. One third of N, whole amount of TSP andMoP were applied as basal. Remaining 2/3 N was top dressed at 25 and 45 days after sowing (DAS) of sorghum. A light irrigation was given after sowing of seeds for uniform germination. Three irrigations were done at 30 DAS,45 DAS and 85 DAS. Thinning was done at 20 DAS and weeding at 35 DAS. Main crop was harvested at 136 DAS on 31 March, 2022. At harvest, plant was cut15 cmabove the ground level to facilitate regeneration forratooning of sorghum as fodder purpose. After harvesting of the main or grain crop, ratooning experiment was laid out in a two factorial randomized complete block design with three replications. The unit plot size was 5 m × 3.6 m.Six fertilizer doses viz., F_1= $N_{120}P_{60}K_{50}$kg/ha), F_2= $N_{90}P_{45}K_{37}$kg/ha (75% NPK of F_1), F_3=$N_{60}P_{30}K_{25}$kg/ha (50% NPK ofF_1),F_4=$N_{30}P_{15}K_{12}$ kg/ha (25% NPK ofF_1),F_5=N_{90} kg/ha and F_6=Control (Native fertility),and three harvesting times viz., H_1=35 days after grain harvest of 1st crop (DAGH), H_2=45 DAGH and H_3=55 DAGH were used in the experiment.One-third of urea and full amount of TSP and MoPwere applied just after harvesting of 1st or grain crop. The remaining urea was side dressed in two equal splits at 15 DAGH and 25 DAH.The fodder was harvested as per time of cutting treatment. For recording dry matter weight and leaf area, three plants from each replication were sampled at harvestfor analysis to determine the quality of ratoon sorghum as a fodder crop. Dry weight of the samples was taken after drying at 80^{0}C in an oven for 72 hours. Soil-Plant-Analysis Development (SPAD) value of leaf chlorophyll content might be used as an indirect indicator of crop N status. Chlorophyll content measured by using a portable SPAD meter (Model SPAD-502, Minolta crop, Ramsey, NJ) at all harvesting times (35, 45 and 55 DAGH). Green biomass weight of fodderwas recorded plot wiseimmediately after harvest. The collected data of the experiment were analyzed statistically and the means were compared using LSD test at 5% level of significance.

Table1. Initial (after harvest of main crop) soil analytical data of the experimental site at Gazipur

pH	OM (%)	Total N (%)	Exchangeable K (meq/100g soil)	Available P (µg/ml)	Available S (µg/g)	Available Zn (µg/g)	Available B (µg/g)
6.20	1.20	0.110	0.097	14.23	20.94	0.650	0.167
	VL	VL	VL	O	O	L	VL
Critical levels	-		0.12	7.0	10.00	0.60	0.20

L= Low, VL= Very low, O= Optimum

Results and Discussion

Yield components and yield of grain sorghum

Plant height, yield and yield components like panicle length, number of grains/panicle, 1000-grain weight of grain sorghum has been presented in Table 2.Plant height was (157.50cm), panicle number/hill (1.20), panicle length (17.87cm), number of grain/panicle (1510), 1000-grain weight (33.05g) and grain yield (4.06t/ha) were observed in grain sorghum.

Table 2. Plant height, yield and yield components of grain sorghum during *rabi* 2021-2022

Plant height (cm)	157.50
Panicle number/hill (no.)	1.20
Panicle length (cm)	17.87
Number of grain/panicle (no.)	1510
1000- grain weight (g)	33.65
Grain yield (t/ha)	4.06

Chlorophyll content (SPAD value)

The leaf greenness which indicated the leaf chlorophyll content was measured by SPAD meter.Chlorophyll content (SPAD value)varied at different fertilizer doses and harvesting time. SPAD value gradually increased up to harvest in all treatments (Fig.1). All fertilizer doses produced higher SPAD value when fodder was harvested 55 days after harvesting of grain crop. On the other hand, SPAD value increases with the increase of fertilizer (especially nitrogen). However, the maximum SPAD value was recorded in $F_1 \times H_3$ ($N_{120}P_{60}K_{50}$ kg/ha × 55 DAGH) treatment followed by $F_2 \times H_3$ ($N_{90}P_{45}K_{37}$ kg/ha× 55 DAGH) and F_5H_3 (N_{90} kg/ha×55 DAGH) treatment. Higher SPAD value indicated higher Chlorophyll content which might be helped to produce higher green fodder yield with good quality. The lowest SPAD value was found in $F_6 \times H_1$ followed by $F_6 \times H_2$ and$F_6 \times H_3$ treatments.

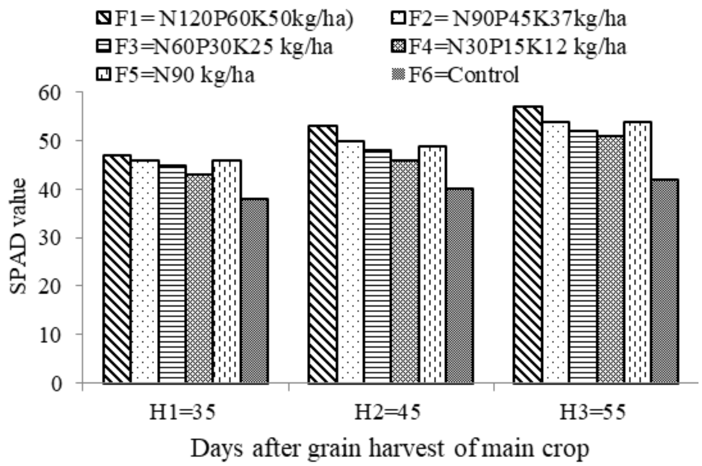

Fig.1. Chlorophyll content (SPAD value) of ratooning sorghum as fodder influenced by nutrient management and harvesting time.

Plant height of ratoon sorghum

Plant height was differed at different fertilizer doses and harvesting times. The plant height gradually increased and reached the peak at harvest in all treatments (Fig.2). Higher plant height was observed in higher fertilizer doses when fodder was harvested at 55 days after harvest of grain crop (H_3) in all the treatments. However, the tallest plant was recorded in $F_1 \times H_3$ ($N_{120}P_{60}K_{50}$ kg/ha × 55 DAH) treatment followed by $F_2 \times H_3$ ($N_{96}P_{48}K_{40}$ kg/ha×55 DAH) treatment and $F_5 \times H_3$ (N_{120} kg/ha× 55 DAH) treatment. The shortestplant was found in $F_6 \times H_1$ followed by $F_6 \times H_2$ and$F_6 \times H_3$ treatments (Control plot).

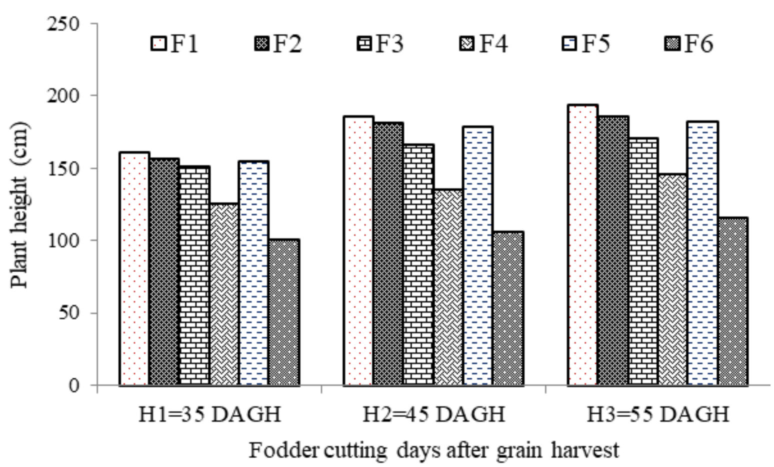

Fig.2.Plant height of ratooning sorghum as fodder influenced by nutrient management and harvesting time.

Total dry matter production

The yield of a crop is mainly determined by the accumulation of TDM. The pattern of TDM accumulation in sorghum was influenced by different fertilizer doses and harvesting time of fodder crop(Fig.3). The TDM accumulation was higher in higher fertilizer dose when harvested at 55 DAGH. However, the maximum TDM was recorded in $F_1 \times H_3$ ($N_{120}P_{60}K_{50}$ kg/ha × 55 DAGH) treatment followed by $F_2 \times H_3$ ($N_{90}P_{45}K_{37}$ kg/ha×55 DAGH) and $F_5 \times H_3$ (N_{90} kg/ha× 55 DAH) treatment. Higher TDM indicated higher production of green fodder yield. The lowest TDM was found in $F_6 \times H_1$ followed by $F_6 \times H_2$ and$F_6 \times H_3$ treatments.

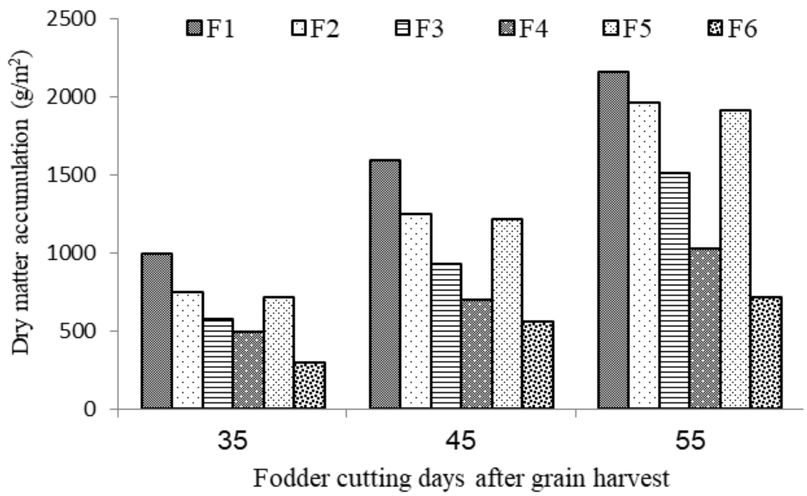

Fig.3.TDM accumulation of ratooning sorghum as fodder crop influenced by nutrient management and harvesting time.

Fodder yield

Fodder yield of ratooning sorghum was significantly influenced by interaction effect of different fertilizer doses and harvesting time (Fig.4). The highest fodder yield (28.94 t/ha) was recorded when cropwas received higher dose of fertilizer F_1($N_{120}P_{60}K_{50}$ kg/ha) and harvested at55 days after grain harvest of main crop (H_3=55 DAGH).It was statistically similar with $F_2 \times H_3$ ($N_{90}P_{45}K_{37}$ kg/ha×55 DAH) treatment and $F_5 \times H_3$ (N_{90} kg/ha× 55 DAGH)treatment. Higher green fodder yield was produced due to higher TDM. The lowest fodder yield (9.54 t/ha) was found in $F_6 \times H_1$ followed by $F_6 \times H_2$ and$F_6 \times H_3$ treatments. Similar result was reported by Azrag and Dagash (2015). They observed that the application of fertilizer 135 kg N/ha resulted in more plant height, more leaves number, more leaf area, more length of head, more weight of seed, more 100-seed weight and more grain yield in both season than the 90 kg N/ha, 45 kg N/ha and 0 kg N/ha, respectively.

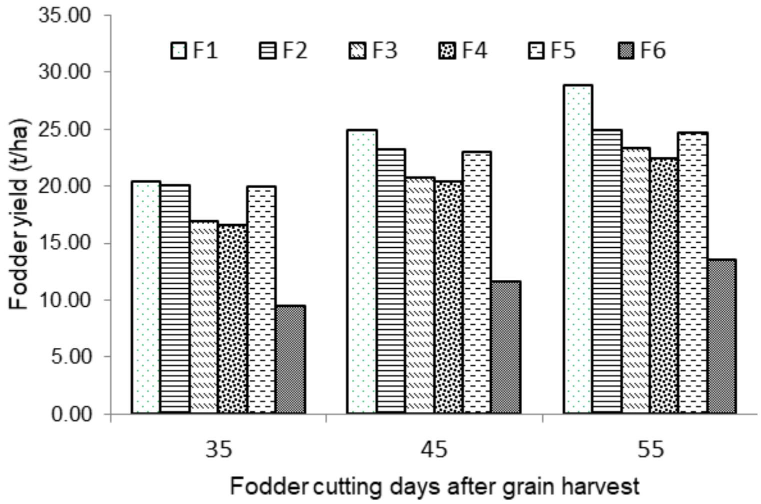

Fig.4. Fodder yield of ratooning sorghum as influenced by interaction effect of fertilizer dose and harvesting time during 2021-2022

Cost and return of ratoon crop of sorghum as fodder

Cost and return analysis is an important tool to evaluate the economic feasibility of crop cultivation. Benefitcost analysis of ratooningsorghum production as fodder crop influenced by interaction effect of fertilizer dose and harvesting time has been presented in Table 3. Among the treatments, the maximum gross return (Tk.144722/ha) and gross margin (Tk.121516/ha)was observed in $F_1{\times}H_3$ treatment followed by $F_2{\times}H_3$,$F_1{\times}H_2$ and$F_5{\times}H_3$. Butthe maximum BCR (10.24) was recorded in $F_5{\times}H_3$, when fodder crop was harvested at 55 days after grain crop receiving fertilizer level only 90 kg/ha (F_5). Although treatment $F_1{\times}H_3$gave the maximum gross return but failed to produce maximum BCR due to the maximum cost of cultivation (Tk.23206/ha) was recorded in $F_1{\times}H_3$ treatment due to involvement of higher fertilizer costs.

Table 3. Cost and return of ratooningsorghum as fodder crop influenced by interaction effect of fertilizer dose and harvesting time during 2021-2022

Treatment	Fodder yield (t/ha)	Gross return (Tk/ha)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR
$F_1{\times}H_1$	20.43	102130	23206	78923	4.40
$F_1{\times}H_2$	24.93	124657	23206	101451	5.37
$F_1{\times}H_3$	28.94	144722	23206	121516	6.24
$F_2{\times}H_1$	20.14	100694	19765	80930	5.09
$F_2{\times}H_2$	23.32	116620	19765	96856	5.90
$F_2{\times}H_3$	25.00	125000	19765	105235	6.32
$F_3{\times}H_1$	17.03	85167	16353	68813	5.21
$F_3{\times}H_2$	20.76	103792	16353	87438	6.35
$F_3{\times}H_3$	23.37	116861	16353	100508	7.15
$F_4{\times}H_1$	16.67	83352	12912	70440	6.46
$F_4{\times}H_2$	20.48	102407	12912	89496	7.93
$F_4{\times}H_3$	22.54	112676	12912	99764	8.73
$F_5{\times}H_1$	19.97	99870	12104	87766	8.25
$F_5{\times}H_2$	23.03	115139	12104	103035	9.51
$F_5{\times}H_3$	24.79	123926	12104	111822	10.24
$F_6{\times}H_1$	9.54	47685	9500	38185	5.02
$F_6{\times}H_2$	11.64	58190	9500	48690	6.13
$F_6{\times}H_3$	13.58	67917	9500	58417	7.15

Price (Tk./kg): Sorghum as fodder: 5

Conclusion

The result revealed that the fertilizer dose like$N_{120}P_{60}K_{50}$ kg/ha, $N_{90}P_{45}K_{37}$ kg/haand N_{90} kg/ha produced the higher fodder yield of ratooning sorghum when harvested at 55 days after grain harvesting of main crop but the economic point of view fertilizer dose only N_{90} kg/ha gave maximum profit.

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GRAIN AND FODDER YIELD OF SORGHUM AS AFFECTED BY CUTTINGTIME

S.S. KAKON, A.A.BEGUM, J.A.CHOWDHURY, M.R.KARIM and D.A.CHOWDHURY

Abstract

The experiment was conducted at the research field of Agronomy Division, BARI,Gazipur, Joydebpur during rabi season of 2021-22 to find out proper cutting time for maximum yield of fodder and grain yield in sorghum and the effect of cutting time on sorghum yield components. There were nine treatments in this study viz. T_1= no cutting ,T_2 =cutting whole plant at 60 DAS for fodder purpose, T_3 = Cutting plant 8″ up from ground level at 70DASfor fodder purpose , T_4=Keeping main tiller then all tiller cut at 70 DAS for fodder purpose, T_5 = Keeping all tiller then main tiller cut at 70 DAS for fodder purpose T_6= Cutting plant 8″ up from ground level at 80DAS for fodder purpose, T_7 = Keeping main tiller then all tiller cut at 80 DAS for fodder purpose and T_8= Keeping all tiller then main tiller cut at 80 DAS for fodder purpose. The results indicated that cutting time significantly affected sorghum fodder yield. Fodder yield increased with increasing cutting time. Cutting sorghum at 60, 70 and 80 DAS resulted in re-growth that eventually produced both fodder and grain. Significantly the highest fodder yield (34.65 t/ha) was recorded in cutting whole plant at 80 DAS for fodder purpose. Significantly the highest seed (4.00 t/ha) yield was recorded in no cutting treatment which was followed by keeping main tiller then all tiller cut at 80 DAS for fodder purpose but seed yield reduction was 3.42% over control. The highest gross return (Tk. 172050/ha) ,gross margin (Tk. 113420/ha) and BCR (2.93) were recorded inT_4 (keeping main tiller then all tiller cut at 70 DAS for fodder purpose)treatment. Though T_1 treatment produced the highest yield but failed to produce the highest BCR but T_4 treatment showed the highest BCR due to producion of higher fodder yield and getting medium grain yield. From the results it could be concluded that keeping main tiller then all tiller cut at 70 DAS may be chosen for fodder purpose and might be harvested at 70 DAS with slight reduction in seed yield for getting dual purpose of fodder yield and seed yield of sorghum in Gazipur region.

Introduction

In Bangladesh, cattle production is an important for income generation of the resource poor farmers and to alleviate poverty. Green fodder can play an important role in rearing milk, meat and draft animals. The shortage of forage crops is about 99% (BBS, 2001) in the country. Rearing of animals is essential for milk production as well as draft power. But it is observed that little care is given to our animals because of shortage of feed. There is no scope for the farmers of Bangladesh to use his land for sole fodder production because he has to use his land only for food grain production. However, marginal lands can be used for growing forage crops without affecting areas under food and cash crops. Rice straw is the main feed source of ruminants in Bangladesh, contributing more than 90% feed energy but it has low quality protein and energy value. Sorghum [*Sorghunz bicolor* (L.) Moench] is a multipurpose plant that ensures grain and stems as raw material for sugar, alcohol, syrup, fuel and paper production, and for animal feeding as grain, pasture, hay and silage (Cothren*et al.,* 2000; Habyarimana*et al.*, 2004). It is extensively grown as a forage crops and becoming increasingly importance in many regions of the world (Miron*et al.*, 2006; Yosef *et al*., 2009; Glamoclija *et al*., 2011). As forage it is fast growing, palatable, nutritious and utilized as silage and hay besides fresh feeding. Recently fodder production is a crucial issue in Bangladesh due to expansion of dairy and livestock farming. In this case, sorghum can mitigate the demand because of its high yielding and high energy value produced with lower labour than other forage types. With this in view, the present experiment was conducted to find out the optimum cutting time for maximum fodder yield as well as grain yield in sorghum.

Materials and Methods

The experiment was conducted at the research field of Agronomy Division, BARI, Joydebpur during *rabi* season of 2021-22. The soil of the experimental field of Joydebpur was silty loam in texture with pH 5.8

belonging to Chhiata series under AEZ-28. The soil was low in organic matter and deficient in total nitrogen, exchangeable potassium and available sulphur. Available phosphours was low in Joydebpur. There were nine treatments T_1= no cutting ,T_2 =cutting whole plant at 60 DAS for fodder purpose, T_3 = Cutting plant 8″ up from ground level at 70DASfor fodder purpose , T_4=Keeping main tiller then all tiller cut at 70 DAS for fodder purpose, T_5 = Keeping all tiller then main tiller cut at 70 DAS for fodder purpose T_6= Cutting plant 8″ up from ground level at 80DAS for fodder purpose, T_7 = Keeping main tiller then all tiller cut at 80 DAS for fodder purpose and T_8= Keeping all tiller then main tiller cut at 80 DAS for fodder purpose. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 3 m x 3 m. Seeds of Sorghum were sown on 07 December 2021.Sorghum seeds were sown at a spacing of 60 cm between rows and 10 cm between the plants. Fertilizers were applied at the rate of 120-48-75-30-3-1kg/ha of N, P, K, S, Zn, B as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid for sorghum. One third of N, whole amount of TSP, MoP, gypsum, zinc sulphate and boric acid were applied as basal. Remaining 2/3 N was top dressed at 25 and 45 days after sowing (DAS) of sorghum. A light irrigation was given after sowing of seeds for uniform germination. Two irrigations were done at 30 and 45 DAS. Thinning was done at 10 DAS and weeding at 15 and 25 DAS.For dry matter estimation, 5 plants were measured at harvest.Dry weight of the samples was taken after drying at 80^0C in an oven for 72 hours.Cutting was done for green fodder leaving the plants 8" above the ground level to facilitate regeneration. The fodder was harvested as per cutting treatment. Green biomass weight of fodder was taken immediately after cutting in the field. T_1 treatment was harvested at 155 DAS and the rest were harvestedon 05 May, 2022. At harvest 10 plants were randomly selected for collecting data on yield components. Grain yields were calculated on whole plot basis and adjusted at 12% moisture content. Local market price of the products at harvest was considered for calculation of gross return and economic performances. The collected data were analyzed statistically and the means were compared using LSD test at 5% level of significance.

Results and Discussion

The plant height (at harvest for fodder purpose) , number of leavesand total leaf and stem weight were influenced by cutting time (Table 1).The longest plant, maximum number of leavesand highest total leaf and stem weight were recorded in T_6 (Cutting whole plant at 80 DAS for fodder purpose) treatment due to the longer cropduration. Sorghum fodder yield significantly differed by cutting time (Fig. 1). Significantly the highest fodder yield (34.65 t/ha) was recorded in T_6 (Cutting whole plant at 80 DAS for fodder purpose) treatment and the lowest (8.10 t/ha) in T_2 treatment due to early cutting.

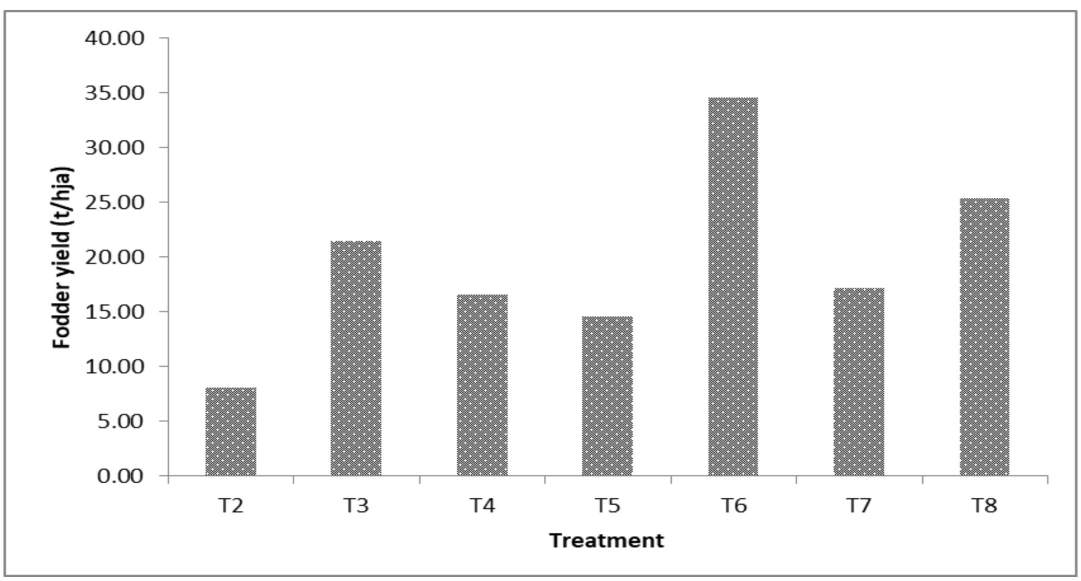

Fig.1 Sorghum fodder yield as affected by cutting time.

Table 1.Growth characters of sorghum as influence by cutting time

Treatment	Plant height (cm)	Leaf no. /plant	Leaf+Stem Fresh wt./plant (g)
T_2	78.47	6.73	53.86
T_3	92.07	7.80	66.80
T_4	92.93	7.80	67.00
T_5	97.73	8.53	93.94
T_6	108.47	7.60	117.47
T_7	103.27	7.87	133.33
T_8	113.27	8.13	145.13
$LSD_{(0.05)}$	14.59	0.83	28.14
CV (%)	8.36	6.03	13.64

Plant height and total dry matter (TDM) production of sorghum plant at harvest significantly influenced by cutting time (Table 2).The TDM (g/m^2) production significantly varied among the treatments.The longest plant was recorded in The highest TDM (1432.53g/m^2) production was obtained from T_1 (no cut) followed by T_4 treatment (1405.0 g/m^2), T_7 and T_8 treatment. The lowest TDM (1033 g/m^2) production was obtained from T_5. Yield and yield contributing characters of sorghum significantly varied by cutting time (Table 2). Significantly the highest number of grain per panicle (1482) was obtained from control (T_1) which was similar with (T_4) keeping main tiller then all tiller cut at 70 DAS (1273) and T_7 (1299) treatment . The lowest number of grain per panicle was obtained from T_2 (558) treatment. The 1000-grain weight also influenced significantly by different treatments. The highest grain weight (35.33 g/1000 grain) was recorded from T_1 which was identical with that of T_4 (35.03 g/1000 grain). Significantly the lowest grain weight was recorded from T_2 (24.57 g/1000 grain). The contribution of all the yield components finally contributed to the seed yield. Significantly the highest seed yield (4.00 t/ha) was obtained from control (T_1). The highest yield in T_1 might be attributed to the maximum source capacity i.e. highest TDM production (g/m^2) and those contributed to maximum number of grain per panicle and the highest 1000-grain weight. Keeping main tiller then all tiller cut at 80 DAS (T_7) gave identical seed yield (3.86 t/ha) with that of T_1 treatment but the yield reduction was 3.42 %. Significantly the lowest grain yield (0.91 t/ha) was obtained from T_2 treatment.These results are in conformity with the findings of Purushotham*et al.* (2001) in guinea grass, Bhattacharya *et al*.(2004) in Stylosanthes, Hooda*et al*. (2004) in pearl millet, Kumar *et al*. (2008) in marvel grass and Patel *et al*. (2013) in oat.

Table 2.Plant height at harvest, total dry matter production and yield and yield components of sorghum as influence by cutting time

Treat	Plant height (cm)	Total dry matter (g/m^2)	Grains /panical (no.)	Panicle length (cm)	1000-grain wt. (g)	Grain yield (t/ha)	Yield decrease over sole sorghum (%)
T_1	135.89	1432.53	1482.44	17.33	35.33	4.00	
T_2	124.66	1060.75	558.67	13.33	24.57	1.10	72.50
T_4	130.89	1405.97	1273.00	17.39	35.03	3.57	10.83
T_5	131.22	1033.39	1005.33	14.89	25.67	2.27	43.33
T_7	134.78	1371.09	1299.67	17.22	33.49	3.86	3.42
T_8	125.89	1427.41	632.67	14.89	27.49	1.57	60.83
$LSD_{(0.05)}$	5.81	126.3	166.4	2.53	5.63	0.28	
CV (%)	6.45	5.39	8.78	8.77	10.23	5.57	

T_1= no cutting ,T_2 =cutting whole plant at 60 DAS for fodder purpose, T_3 = Cutting plant 8″ up from ground level at 70DAS for fodder purpose , T_4=Keeping main tiller then all tiller cut at 70 DAS for fodder purpose, T_5 = Keeping all tiller then main tiller cut at 70 DAS for fodder purpose T_6= Cutting plant 8″ up from ground level at 80DAS for fodder purpose, T_7 = Keeping main tiller then all tiller cut at 80 DAS for fodder purpose and T_8= Keeping all tiller then main tiller cut at 80 DAS for fodder purpose

Cost and return analysis

From the economic analysis it was found that the highest gross return (Tk. 172050/ha) was recorded inT_4 treatmentand the lowest gross return (Tk. 68000/ha) was found in T_2treatment. The highest cost of cultivation was recorded in T_2 treatment (Tk. 58630/ha) due to high labour cost.The highest gross margin (Tk. 113420/ha) was obtained from T_4 treatment. The highest benefit cost ratio (2.93) was obtained from T_4 treatment and the lowest BCR (1.16) was recorded in T_2 treatment (Table 3). Though T_1 treatment produced the highest yield but failed to show the highest BCR whereas T_4 (keeping main tiller then all tiller cut at 70 DAS for fodder purpose) treatment showed the highest BCR due to production of higher fodder yield and moderate grain yield.

Table 3.Cost and return of sorghum cultivation as influenced by cutting time during *rabi* 2021-2022

Treatment	Gross return (Tk/ha)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1	100000	47880	52120	2.09
T_2	68000	58630	9370	1.16
T_3	107550	41200	66350	2.61
T_4	172050	58630	113420	2.93
T_5	129650	58630	71020	2.21
T_6	103950	41200	62750	2.52
T_7	148070	58630	89440	2.53
T_8	115390	58630	56760	1.97

T_1= no cutting ,T_2 =cutting whole plant at 60 DAS for fodder purpose, T_3 = Cutting plant 8″ up from ground level at 70DASfor fodder purpose , T_4=Keeping main tiller then all tiller cut at 70 DAS for fodder purpose, T_5 = Keeping all tiller then main tiller cut at 70 DAS for fodder purpose T_6= Cutting plant 8″ up from ground level at 80DAS for fodder purpose, T_7 = Keeping main tiller then all tiller cut at 80 DAS for fodder purpose and T_8= Keeping all tiller then main tiller cut at 80 DAS for fodder purpose

Price (Tk/kg) Sorghum as fodder when harvested at 70DAS: 5 Sorghum as fodder when harvested at 80DAS: 3

Conclusion

From the results it could be concluded that keeping main tiller then all tiller cut at 70 DAS for fodder purpose may be chosen for fodder purpose and might be harvested at 70 DAS with slight reduction in seed yield for getting dual purpose of fodder yield and seed yield of sorghum in Gazipur region.

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EFFECT OF SAMPLING TECHNIQUE ON YIELD ASSESSMENT OF LENTIL

M.R.KARIM, J. A. CHOWDHURY, A. A. BEGUM, S. S. KAKON AND D.A. CHOUDHURY

Abstract

The field experiment was conducted in agronomy research field, Bangladesh Agricultural Research Institute, Gazipur during rabi 2021-22 to find out whether there is any variation of assessed yield from different sampling technique. Six treatments; T_1 = Linear meter from border line, T_2 = Five random plant yield from border line, T_3 = Linear meter from inner line, T_4 = Five random plant yield from inner line, T_5 = Random unit squre yield, T_6 = Yield component based calculation and T_7 = Whole plot yield. All the treatments showed increased yield than whole plot yield. Maximum yield increase (36.27%) was found in T_6 (Yield component based calculation) treatment and the lowest increase was found in T_3 (6.86%). Whole plot yield sampling is more preferable technique to asses the real yield of crop. For larger plot size, sample collection from inner lines either in the form of linear meter or square meter is better than five plant sampling.

Introduction

Field experiments are conducted to extract in-situ features of interest from complex agricultural phenomena. Attributes of data and information obtained from the field depend on instrumentation tools, data analysis methods and experimental designs. Traditionally, agronomic field research has applied replication, blocking and randomization in experimental design to avoid influences of spatial variability as errors or biases. Yet, conventional experimental designs are characterized by limitations (e.g., small plots, treatments over simplification, and brief duration) and consequently may not represent a realistic cropping system.

In field experiments effects and quantification of variation are measured through sampling. Sampling density depends on several factors (objectives, field variability, costs), and can range from one sample for several hectares to a more detail coverage of the field. Conventionally, samples are obtained for whole fields or parts of fields to provide average values. There are several commonly used sampling methods characterized by destructive sampling (i) Simple random, (ii) Stratified random, (iii) Systematic (grid sampling, (iv) Stratified-systematic etc.

Sample collection involves intensive labor and costs of laboratory analysis, imposing a limitation on the number of samples that can be collected to quantify the experimental error among treatments repetitions. Nevertheless, reducing the number of samples has direct implications on management since it can lead to incorrect decisions. The requirement for improved efficiency has increased the interest in conducting field experiments that take into account spatial variability and reproduce better scenarios for real farm.

Yield is the ultimate target in any agricultural research programme. New varieties or crop production technologies are developed on the basis of yield. Yield potential of a crop sometime may not be expressed due to unfavorable environment. But sometimes, a huge yield gap occurs from the yield potential and it may be due to wrong assessment of yield potential of any variety or production technique. This error may occur due to different sampling method followed.

Lentil is an important and most widely used pulse crop in Bangladesh. It ranks first in terms of area coverage (349109 acre) and production (177354 MT) (BBS, 2020). But, every year huge amount of lentil needs to be imported. Not only lentil, but also most of the food crops except rice showed huge deficit. In this experiment, lentil was used as a model crop from a number of field crops.
So, this experiment is taken to find out whether there is any variation of assessed yield from different sampling technique.

Materials and Methods

The field experiment was conducted in agronomy research field, Gazipur, Bangladesh Agricultural Research Institute during rabi 2021-22. Six treatments; T_1 = Linear meter from border line, T_2 = Five random plant yield from border line, T_3 = Linear meter from inner line, T_4 = Five random plant yield from inner line, T_5 = Random unit squre yield T_6 = Yield component based calculation and T_7 = Whole plot yield, were laid out in randomized complete block design with three repllication. Unit plot size was 3m × 3m. Seeds of BARI masur-6 were treated with Provax-200WP and sown in line with 25 cm row to row distance. Thirty six garm seed were uniformly sown in twelve line in each plot to maintain uniform plant population. The crop was fertilized with 21-39-24-10-1.8 kg/ha of N-P-K-S-B respectively (FRG, 2018). All fertilizers were applied during final land preparation. Irrigation was done as and when necessary in all the treatments. Provax with irrigation water was also applied to control seedling foot rot disease. Data was collected as per treatment. Yield was calculated from yield contributing parameters except T_6.

Results and Discussion

Yield

Yield of lentil found from different treatments are shown in table 1. Maximum yield was found in T_6 (2.78 t/ha) followed by T_3 (2.72 t/ha). Lowest yield was found in T_7 (2.04 t/ha).

Yield comparison

Yield of lentil found from different treatments are compared with yield found from whole plot treatmrnt and are shown in table 1. All the treatments showed increased yield than whole plot yield. Maximum yield increase (36.27%) was found in T_6 (Yield component based calculation) followed by T_2 (Five random plant yield from border line) (34.80%). Lowest increase was found in T_3 (6.86%). The results show that, in case of yield calculation from five random plant, if sampling done with biasness, may misguide the objective of the experiment. Yield calculated from border line sample showed 1-4 % increased yield (Table 2) to the yield calculated from inner line sample following similar sampling technique. This is most probably due to the border effect.

Conclusion

Yield calculation from yield attributes of different collected sample shows increased yield than actual. Whole plot yield sampling is more preferable technique. For larger plot size, whole plot technique seems to be difficult. So, sample collection from inner lines either from linear meter or square meter is better than five plant sampling. Moreover, sampling must be done avoiding biasness.

Table 1. Yield component and yield of lentil from different treatment

Treatments	Pod / plant(no.)	Seed / pot(no.)	1000 SW (g)	Yield (t/ha)
T_1	60.33	18.00	27.00	2.26
T_2	71.33	17.67	26.50	2.75
T_3	55.67	16.33	24.50	2.18
T_4	68.67	16.67	25.00	2.72
T_5	33.67	17.33	26.00	2.21
T_6	71.00	18.00	27.00	2.78
T_7	51.67	16.67	25.77	2.04

Table 2. Yield and yield comparison influenced by different sampling techniques over

Treatments	Yield (t/ha)	Yield comparison (Percent increase or decrease, "+" for increase, "-" for decrease)
T_1 = Linear meter from border line	2.26	+ 10.78
T_2 = Five random plant yield from border line	2.75	+ 34.80
T_3 = Linear meter from inner line	2.18	+ 6.86
T_4 = Five random plant yield from inner line	2.72	+ 33.33
T_5 = Random unit squre yield	2.21	+ 8.33
T_6 = Yield component based calculation	2.78	+ 36.27
T_7 = Whole plot yield	2.04	

Table 2. Yield comparison of lentil calculated from border line sample to the yield of inner line sample following similar sampling technique

Sampling technique	Yield of border line	Yield of inner line	Border line to inner line ratio
Linear meter	2.26	2.18	1.04:1
Five random plant	2.75	2.72	1.01:1

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DETERMINATION OF HARVESTING EFFICIENCY OF MUNGBEAN

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Abstract

A field experiment was conducted at the Agronomy field of BARI, Gazipur and RARS Ishurdi, Pabna during the *kharif I* season of 2021 and 2022. Four harvesting time viz. T_1= Harvesting at 60 DAS (days after sowing), T_2= Harvesting at 65 DAS, T_3= Harvesting at 70 DAS and T_4= Harvesting at 75 DAS were as treatments in the experiment. Later harvesting increased the pods/plant which contributed to higher seed yield. The highest seed yield (859-1002 kg/ha) was noticed in T_3 (harvesting at 70 DAS) at Gazipur and T_4 (harvesting at 75 DAS) at Ishurdi in 2022. In 2021 highest seed yield (814-997 kg/ha) found in T_4 treatment in both locations. In 2022 average harvesting efficiency was computed the highest in T_3 (100%) treatment followed by T_4 (96.92%) treatment and in 2021 the highest harvesting efficiency (100%) found in T_4 treatment in both locations. Harvesting at 70 DAS-75 DAS would be suitable for higher seed yield and harvesting efficiency of mungbean.

Introduction

Mungbean [*Vigna radiata* (L.)Wilczek] is one of the most important pulse crops of Bangladesh. Pulses are being considered as a poor man's meat since they are the cheapest source of protein (Mian, 1976). In Bangladesh mung bean is covering an area of 37635.765 hectares with annual production of 3400 m. tons (BBS, 2019). The demand of mungbean is very high due to its good taste and nutrition. It provides grain for human consumption. The crop can fix atmospheric nitrogen to plant and turns into 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). Eight varieties of mungbean have been developed by Pulses Research Centre, BARI and disseminated with the package of management technologies to the farmers for cultivation. But at the farm level adoption of mungbean varieties, their economics, and harvesting efficiency of the crop at different harvesting time are not well known to the farmers, researchers and policy planners. One of the most serious constraints is the intensive labor requirement during harvesting time for expanding mungbean production. Due to asynchronous flowering and uneven pod-setting, most farmer hand-pick mungbean pods during harvest times. Farmers would not easily change this pract whether sickles can be used for harvest at a time harvesting. Therefore, sequential harvest of individual pods (picking of ripe pods) may be practically undesirable than harvesting the crop at a time by stem cutting in terms of improving/maintaining the yield of mung bean seeds (Islam, 1995). Considering the above facts, the study was undertaken to find out the harvesting efficiency of mungbean at a time. Harvesting Efficiency (HE) according to following formula: $HE\ (\%) = \frac{B}{A} \times 100$

Where, A = Highest seed yield and B = Seed yield in treated plots

Materials and Methods

A field experiment was conducted at Agronomy research field of Bangladesh Agricultural Research Institute, Gazipur and RARS Ishurdi, Pabna, during *kharif I* season 2020-21 and 2021-22. The soil was silty clay loam belonging to Agro Ecological Zone (AEZ) -28 and AEZ-11. The treatments were as, T_1= Harvesting at 60 DAS (days after sowing), T_2= Harvesting at 65 DAS, T_3= Harvesting at 70 DAS and T_4= Harvesting at 75 DAS. The trial was set up in a randomized complete block design with three replications. Sowing was done with spacing of 30 cm × 10 cm at 3 March 2021 on both the locations and in 2022 sowing was done on 1 March on Gazipur and 24 March on Ishurdi, Pabna. Unit plot size was 3 m × 3.6 m. The test crop was BARI Mug-8. The crop was fertilized with cow dung (5t/ha) and 24-24-32-16-3-2 kg/ha of N-P-K-S-Zn-B, respectively in the form of urea-TSP-MoP-gypsum-zinc sulphate and boric acid (FRG' 2018). The whole amount of CD and N-P-K-S-Zn-B fertilizers was applied during final land preparation. A light irrigation was given after sowing for uniform emergence of seeds. Harvesting was done as per treatment. At the time of harvest, yield contributing characters were recorded from one linear meter. Yield data was recorded by harvesting the whole plot were harvested according to the treatments.

Result and Discussion

Yield component and yield

Harvesting time had significant effect on plant height and number of pods/plant other yield components and seed yield of mung bean at BARI, Joydebpur and RARS, Ishurdi (Table 1 and 2). Pods/plant was recorded the highest (19.66-28.20) in T_4 treatment while the lowest in T_2 (15.53) and T_1 (12.40) at Gazipur and Ishurdi (Table 1) in the year 2022. In 2021 highest (18.34 and 18.55) and lowest one (11.00 and 10.80) found in T_4 and T_1 treatment respectively in both locations.Seeds/pod was observed the highest in treatment T_3 at Gazipur (9.80) and in treatment T_4 at Ishurdi (10.67) which found non-significant in 2022 at Gazipur. In year 2021 seeds/pod found highest in T_1 treatment (12.07 and 10.30) and lowest in T_4 treatment (6.97 and 9.40) at both locations. However, the highest seed yield (859-1002 kg/ha) was noticed in T_3 (harvesting at 70 DAS) at Gazipur and T_4 (harvesting at 75 DAS) at Ishurdi (Table 2) in 2022. Seed yield (814-997 kg/ha) found highest in T_4 treatment in both locations in 2021. The highest seed yield was mainly contributed by the higher number of pods/plant (Table 1). The average harvesting efficiency (Table 3) was computed the highest in T_3 (100%) treatment followed by T_4 (96.92%) but the lowest in T_1

(73.42%) in 2022. In 2021 highest average harvesting efficiency found in treatment T_4 (100%). Later harvesting increased higher number of matured pods/plants contributing to higher seed yield as well as higher harvesting efficiency.

Conclusion

Harvesting at 70 DAS-75 DAS would be suitable for higher harvesting efficiency of mung bean (BARI Mung-8).

Table1. Plant height, branches/ Plant (no.) and yield component of mung bean as affected by different harvesting time

Treatment	Plant height (cm)				Branches/ Plant (no.)			
	2020-21		2022-23		2020-21		2022-23	
	Gazipur	Ishurdi	Gazipur	Ishurdi	Gazipur	Ishurdi	Gazipur	Ishurdi
T_1	43	46	34.32	48	1.59	1.53	2.27	1.65
T_2	44	50	36.00	53	1.61	1.60	1.73	1.82
T_3	45	50	39.73	57	1.65	1.60	1.67	1.83
T_4	47	51	49.07	62	1.67	1.62	1.47	1.86
$LSD_{(0.05)}$	2.67	2.92	3.90	10.88	NS	NS	0.19	0.50
CV (%)	8.33	5.65	4.91	9.72	6.31	6.21	5.61	14.03
LS	-	-	-	*	-	-	-	ns

T_1= Harvesting at 60 DAS, T_2= Harvesting at 65 DAS, T_3= Harvesting at 70 DAS, T_4= Harvesting at 75 DAS.

Table1(Contd.)

Treatment	Pods/Plant (no.)				Pod length (cm)			
	2020-21		2022-23		2020-21		2022-23	
	Gazipur	Ishurdi	Gazipur	Ishurdi	Gazipur	Ishurdi	Gazipur	Ishurdi
T_1	11.00	10.80	18.15	12.40	6.36	6.60	6.40	6.8
T_2	12.67	13.67	15.53	14.25	6.77	6.67	7.03	6.8
T_3	14.67	15.53	20.07	16.23	6.87	6.50	6.67	7.1
T_4	18.34	18.55	28.20	19.66	6.84	6.67	6.17	7.3
$LSD_{(0.05)}$	3.59	4.11	3.18	1.47	NS	NS	NS	0.87
CV (%)	5.37	9.34	7.76	4.69	4.37	2.94	4.81	6.23
LS	-		-	***	-	-	-	ns

LS=Level of significance; ns= non-significant; *= Significant at p=0.05; ***= Significant at p=0.001

Table1 (Contd.)

Treatment	Seeds/Pod (no.)				1000-seed weight (g)			
	2020-21		2022-23		2020-21		2022-23	
	Gazipur	Ishurdi	Gazipur	Ishurdi	Gazipur	Ishurdi	Gazipur	Ishurdi
T_1	12.07	10.30	8.67	10.55	32.71	40	31.33	38
T_2	11.88	10.27	9.27	10.61	31.53	41	31.13	43
T_3	11.80	10.27	9.80	10.63	30.71	40	32.16	43
T_4	9.67	9.40	9.47	10.67	29.97	42	29.70	45
$LSD_{(0.05)}$	1.68	NS	NS	0.67	NS	NS	NS	4.43
CV (%)	5.15	6.16	3.75	3.17	3.46	2.86	3.93	5.25
LS	-	-	-	ns	-	-	-	*

Table2. Yield of mung bean as affected by different harvesting time

Treatment	Seed Yield (kg/ha)					
	2020-21			2022-23		
	Gazipur	Ishurdi	Pooled average	Gazipur	Ishurdi	Pooled average
T_1	743	924	834	426.13	926	676.07
T_2	768	951	860	582.93	964	773.47
T_3	791	977	884	859.73	982	920.87
T_4	814	997	906	782.93	1002	892.47
$LSD_{(0.05)}$	62	87	64	17.09	39.81	-
CV (%)	5.65	8.16	6.03	1.29	2.06	-
LS	-	-	-	-	*	-

Table3. Harvesting efficiency of mung bean as affected by different harvesting time

Treatment	Harvesting efficiency (%)					
	2020-21			2022-23		
	Gazipur	Ishurdi	Pooled Average	Gazipur	Ishurdi	Pooled Average
T_1	91.28	92.68	92.05	49.57	92.42	73.42
T_2	94.35	95.39	94.92	67.80	96.21	83.99
T_3	97.57	97.99	97.57	100.00	98.00	100.00
T_4	100.00	100.00	100.00	91.07	100.00	96.92

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ESTIMATION OF OPTIMUM PLANT POPULATION OF MAIZE THROUGH FUNCTIONAL MODEL

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Abstract

A field experiment on hybrid maize with different plant population density was conducted at the Agronomy field of BARI, Joydebpur, Gazipur during the rabi season of 2017-18, 2020-21, 2021-22. Five plant population density, viz. T_1= 66666 plants/ha (75 cm × 20 cm spacing), T_2= 83333 plants/ha (60 cm× 20 cm spacing), T_3=100000 plants/ha (50 cm × 20 cm spacing), T_4=125000 plants/ha (40 cm × 20 cm spacing) and T_5=166666 plants/ha (30 cm × 20 cm spacing) were used in the experiment. LAI and TDM increased with the increase of plant population, those influenced the grain yield. Plant population showed significant influence on grain yield. LAI with the value of 4.77 at 85 DAS and TDM with the value of 6837.87 g/m^2 at harvest were found suitable for the maximum grain yield of maize in T_4 (40 cm × 20 cm spacing: 125000 plants/ha). The highest grain yield (11.22 t/ha) was recorded in 125000 plants/ha (T_4:40 cm × 20 cm spacing) and the lowest (6.69 t/ha) in 166666 plants/ha (T_5:30 cm x 20 cm spacing). The maximum grains/cob, 1000-grain weight were recorded in T_4 and T_3 respectively but the highest grain yield was obtained in T_4 (40 cm × 20 cm spacing: 125000 plants/ha). Functional relationship between plant population and grain yield of maize was established as $Y = 11.33 x-0.19x^2$ ($R^2 = 0.14$); ($R^2 = 0.14$). The result indicated the effect of plant population on the grain yield of maize could be explained 14% by the functional model. The co efficient indicated that increase of one plant/m^2 would increase the grain yield at the rate of 2.77 t/ha. The estimated optimum plant population was 10.75 plants/m^2 through the developed functional model. Then the maximum predicated grain yield would be 9.75 t/ha according to developed model.

Introduction

Maize (*Zea mays* L.) is an important food crop of the world. It is the third most important cereal crop of Bangladesh after rice and wheat. In Bangladesh, grain average yield of maize is very low as compared to other maize growing countries (Tahir *et al*., 2009). There is a number of biotic and abiotic factors those affect maize yield considerably. However, it is more affected by variation in plant density than other member of the grass family (Vega *et al.*, 2001). Maize differs in its responses to plant density (Luque *et al.*, 2006). The use of high population increases interplant competition for light, water and nutrients which may be detrimental to final yield, because it stimulates apical dominance, induces barrenness, and ultimately decreases the number of ears produced per plant and kernels set per ear (Sangoi, 2001). Maize yield model may serve to find out optimal solution for planning or decision making about plant population. Simple yield models have been developed to predict yield of wheat, maize and pea in America by Panye *et al.* (2001). At present, model is widely used to predict to yield potential and to estimate optimum plant population of crop. Recommended plant spacing for maize is 60 cm × 20 cm where plant belongs to 83333 plants/ha in *rabi* season (Ahmed *et al*., 2010). But farmers of our country usually use closer spacing for maize cultivation to get higher yield. Biomass production by crops is related to a number of agronomic management factors. These factors include applied nutrients (such as N, P and K), water availability (by rainfall or irrigation), weed management, plant population etc. The traditional growth analysis describing crop growth over time on some assumptions has certain limitations (Evans, 1972; Causton and Venus, 1981). However, these limitations are to be overcomed with the help of mathematical functions which will smooth the crop growth curve (Richardas, 1969, Hunt, 1982). Yield of maize may be the function of plant population. Therefore, this trial was done to adjust the optimum plant population of maize through assessing functional yield model in relation to LAI and TDM.

Materials and Methods

The experiment was conducted at the Research field of Bangladesh Agricultural Research Institute, Joydebpur, during *rabi* season of 2020-2021. Five plants spacing, viz. T_1= *66666* plants/ha (75 cm×20 cm spacing), T_2= 83333 plants/ha (60 cm×20 cm spacing), T_3=100000 plants/ha (50 cm ×20 cm spacing), T_4=125000 plants/ha (40 cm×20 cm spacing) and T_5=166666 plants/ha (30 cm×20 cm spacing) were used in the experiment. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4.5 m x 5 m. Seeds were sown on 4 November 2020. Nutrients were applied at the rate of 275-76-121-72-5-1 kg/ha of N-P-K-S-Zn-B (FRG, 2018) as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid. One third of urea, whole amount of TSP, MoP, gypsum, zinc sulphate and boric acid will be applied as basal dose. Remaining 2/3 Urea was top dressed at 35 days after sowing (DAS) and 55 DAS followed by irrigation. Three irrigations were given when it was necessary to maintain adequate soil moisture. Plants were sampled at different DAS (days after sowing) for leaf area and dry matter accumulation. Leaf area was measured by an automatic area meter (LI 3100 C, LI-COR, USA). For dry matter, plant samples were dried in an oven at 80 ^oC for 72 hours.

Optimum plant population of maize was estimated through the following functional model like $Y = a + bx - cx^2$,

When optimum plant population for maximum grain yield= $-b/2c$

The crop was harvested on 8 April 2022. The yield components data were collected from 5 randomly selected plants prior to harvest from each plot. At harvest, the yield data was recorded plot wise and analyzed statistically. Model analysis was done using the data of 2021-2022.

Results and Discussion

The variation in LAI was greatly influenced by plant population (Fig.1). LAI increased up to 85 DAS and then it decreased slightly in all the treatments. LAI showed the highest value (4.77) at 85 DAS in the densest population (T_5: 166666 plants/ha) followed by T_4 (125000 plants/ha) while the lowest was in T_1. Higher plant population increased LAI. The leaf area index (LAI) of a crop at a particular growth stage indicates its photosynthetic potential or the level of its dry matter accumulation and it is influenced by plant population (Murphy *et al.*, 1996). The highest physiological growth indices are achieved under high plant density, because of the increased photosynthesis by development of more leaf area (Valadabadi and Farahani, 2010).

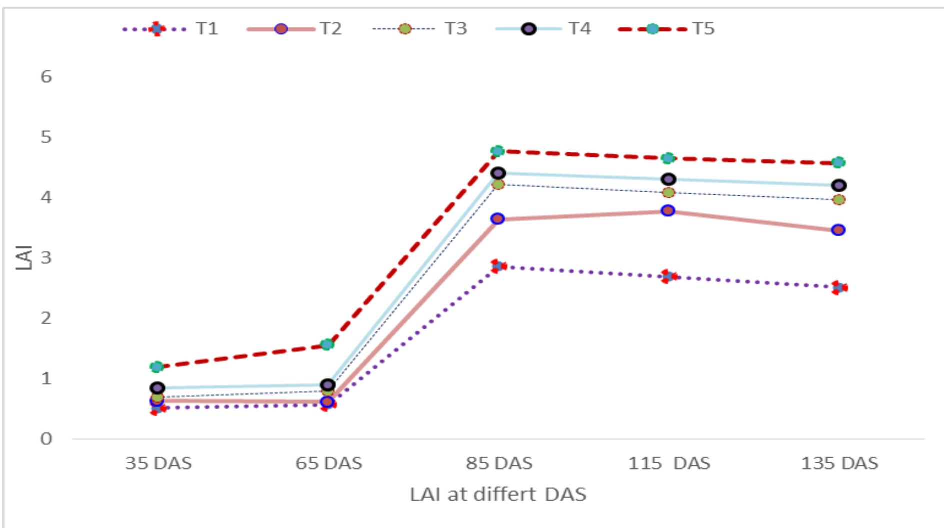


Fig1. Leaf area index (LAI) of maize as influenced by plant population

Dry matter production

Dry matter production was highly influenced by plant population (Fig. 2.) Total dry matter (TDM) was merely invisible at 35 DAS and afterwards it gradually increased, and reached at peak at 135 DAS. The highest TDM was recorded in T_5 followed by T_4 whereas the lowest in T_1 at 60 DAS and subsequent sampling DAS. TDM increased with the increase of plant population. This might be happened due to more plants per unit area. More plants per unit area enhanced to produce more dry matter accumulation per unit area. The maximum TDM (8137.17 g/m^2) was recorded in T_5 (166666 plants/ha) followed by T_4 treatment and the lowest (3389 g/m^2) was found in T_1 treatment at 135 DAS. Generally, more TDM accumulation produced more yield. Previous research findings indicated that high maize density produced higher total dry weight, when crop growth rate increased than that of low maize density throughout crop the growth season (Saberali, 2007).

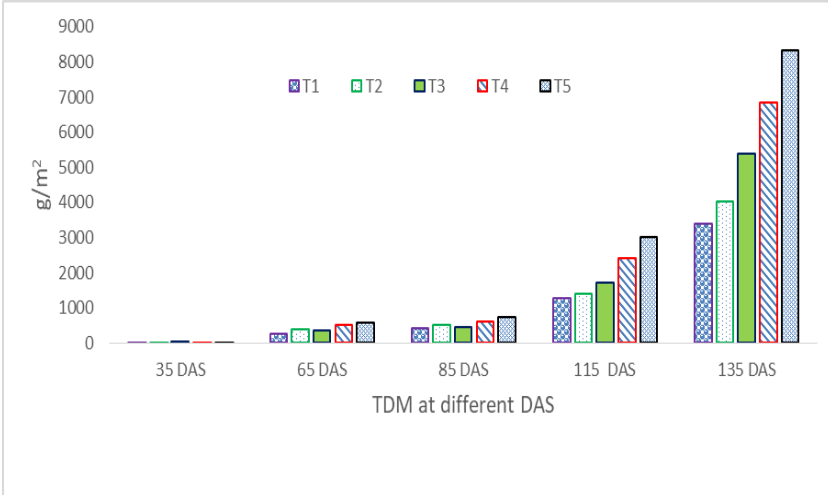


Fig2. Dry matter production in hybrid maize as influenced by plant population

Yield and yield component

Plant population has significant influence on studied crop characters (Table 1). The highest plant height (190.89 cm) was recorded in T_5 (75 cm × 20 cm) treatment and the lowest plant height (177.44 cm) was recorded in T_3 (50 cm×20 cm) treatment. Closer spacing and dense plant population created mutual shading enhancing plant height. Hormonal imbalance due to shading enhanced plant height. Similarly, longer plant was noticed in closer plant spacing (12500 plants/ha) of maize (Greveniotis *et al*., 2019). Number of cobs/m^2 (18.52) was recorded the highest in T_5 (30 cm x 20 cm) while the lowest in T_1 (75 cm x 20 cm). The maximum number of grains/cob (480.00) was recorded in T_4 treatment. Plant population also showed significant influence on grain yield. Grain yield decreased with the increase of plant population. The highest grain yield (10.43 t/ha) was recorded in T_3 (50 cm × 20 cm spacing corresponding to 100000 plants/ha. This was happed due to cumulative effect of higher cobs/m^2 with higher grains/cob and 1000-grain weight (Table 1). The increase in 1000-grain weight in T_3 to T_4 might be due to availability of more resources and nutrient uptake by the plant. On the contrary, the lowest grain yield (6.69 t/ha) were recorded in T_5 (30 cm x 20 cm) treatment having plant population of 166666 plants/ ha. Lower 1000-grain weight in higher plant population density occurred probably due to availability of less photosynthates or grain development on account of high inter-plant competition which resulted in low rate of photosynthesis and high rate of respiration as a result of enhanced mutual shading (Zamir *et al*., 2011). LAI with the value of 4.77 at 85 DAS and 4.30 at 115 DAS were found suitable for the maximum grain yield in T_4 (125000 plants/ha when at 40 cm × 20 cm spacing). Again, the TDM with the value of 6837.87 g/m^2 at harvest was found optimum for the highest grain yield of maize in T_4. The effect of LAI at 85 DAS and TDM at harvest on grain yield of maize was estimated at 95% ($11.33x-0.19x^2$; $R^2 = 0.14$) by functional relationship.

Table1. Effect of plant population on yield component and yield of hybrid maize (2021-2022)

Plant population	Plant height (cm)	Cobs/m^2	Grains /cob	1000-grain wt. (g)	Grain yield (t/ha)
T_1 (66666 plants/ha)	190.00	7.41	401.11	210.12	8.87
T_2 (83333 plants/ha)	188.22	9.26	441.67	237.37	9.42
T_3 (100000 plants/ha)	177.44	11.11	461.89	236.97	10.34
T_4 (125000 plants/ha)	195.22	13.89	480.00	239.98	11.22
T_5 (166666 plants/ha)	190.89	18.52	396.78	189.10	6.69
LSD $_{(0.05)}$	NS	1.42	47.66	29.12	1.82
CV (%)	9.91	6.26	5.80	6.95	10.12

Table2. Effect of plant population on yield component and yield of hybrid maize (2020-2021)

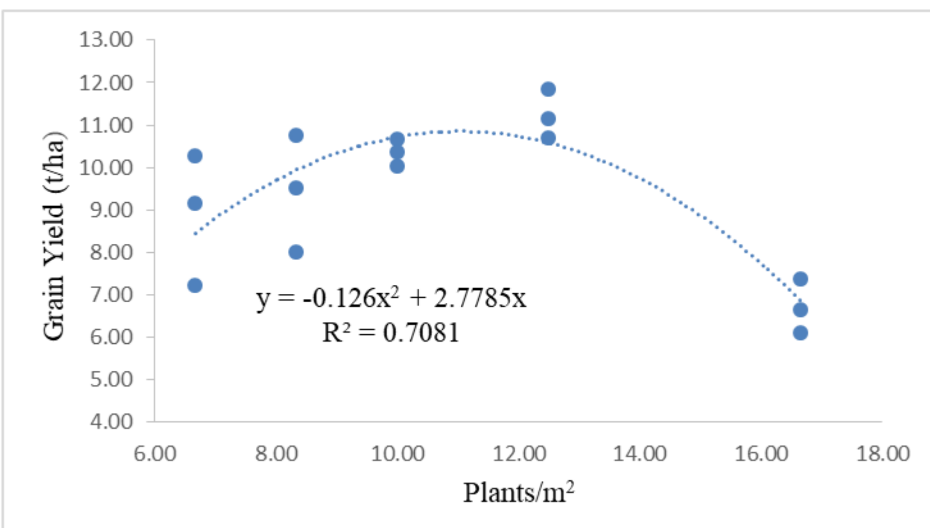
Plant population	Plant height (cm)	Cobs/m^2	Grains /cob	1000-grain wt. (g)	Grain yield (t/ha)
T_1 (66666 plants/ha)	141	6.71	641	275	8.85
T_2 (83333 plants/ha)	144	8.35	631	223	9.71
T_3 (100000 plants/ha)	149	10.03	626	219	10.12
T_4 (125000 plants/ha)	153	11.11	572	211	8.24
T_5 (166666 plants/ha)	157	16.65	533	204	5.02
$LSD_{(0.05)}$	11.59	2.08	67	36.92	4.62
CV (%)	3.78	3.21	5.92	8.67	4.64

Table3. Effect of plant population on yield component and yield of hybrid maize (2017-2018)

Plant population	Cobs/m^2	Grains /cob	1000-grain wt. (g)	Grain yield (t/ha)
T_1 (66666 plants/ha)	5.41	467	337	8.03
T_2 (83333 plants/ha)	6.69	454	336	8.68
T_3 (100000 plants/ha)	8.35	449	328	9.78
T_4 (125000 plants/ha)	11.11	424	289	7.50
T_5 (166666 plants/ha)	16.66	405	277	5.53
$LSD_{(0.05)}$	2.47	31.98	28.05	4.62
CV (%)	3.58	3.85	4.75	5.76

Model analysis

Functional relationship between plant population and grain yield of maize was established as $Y = 11.33x - 0.19x^2$ ($R^2 = 0.14$). The result indicated the effect of plant population on the grain yield of maize could be explained about 14% at by the functional model. The co-efficient indicated that the grain yield would be increased one unit (t/ha) with the increase of one plant/m^2. The co efficient also indicated that increase of one plant/m^2 would increase yield at the rate of 0.19 t/ha. The optimum plant population would be 10.75/m^2 then the predicated grain yield would be 9.75 t/ha as per estimation by the developed model. The functional model can be used to predict maize grain yield at a specific population.



Functional relationship between plant population and grain yield of maize (on the basis of data of 2021-2022).

Conclusion

The optimum plant population of maize would be 10.75 plants/m^2 and the predicted grain yield would be 9.75 t/ha.

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PERFORMANCE OF BARI RELEASED MUSTARD VARIETIES AT MOULVIBAZAR

M. A. M. MIAH, M. SHAHEENUZZAMN, M. SAMSUZZAMAN, M.S.ALAM, AND M.H.HOSSAIN

Abstract

A field experiment was conducted at Regional Agricultural Research Station, BARI,Moulvibazar during the *Rabi* season of 2021-2022 to evaluate the yield performance of BARI developed mustard varieties against local variety at Moulvibazar area. Four mustard variety, viz. BARI Sarisha-14, BARI Sarisha-15,BARI Sarisha-17 and BARI Sarisha-18 were compared to Tori -7. Among the varieties, BARI Sharisha-18 produced the highest yield (1880.67 kg/ha) and it produced 53% higher yield than that of Tori-7. The second highest yield (1738.33 kg/ha) was recorded in BARI Sarisha-17. The results revealed that BARI Sarisha 18 is suitable for cultivation at Moulvibazar area. Alternately, BARI Sarisha-14 may be accomodated for cropping pattern as short duration (75-80 days) variety.

Introduction

Rapeseed-Mustard is the principal oilseed crop, which plays a significant role in the national economy of Bangladesh. It occupies 68% of the area and contributes nearly 34% of the total oilseed production in Bangladesh (BBS, 2019). Bangladesh possesses favorable agro-ecological condition for production of Mustard. The average national seed yield of mustard in this country is only 1143 kg/ha (BBS, 2019) whereas the world average seed yield of mustard is 1575 kg/ha. In Moulvibazar there remains a fallow land during the *Rabi* season. These fallow lands can be utilized by adapting suitable mustard variety. Seed yield of *Brassica* crops in semiarid environment can be increased by minimizing the crop's exposure to high temperature and water stress that often occurs during the growing season (Gan*et al*., 2004). Different levels of irrigation have significant effect on the grain yield of mustard (Mannan and Tarannum, 2016). But, there is little scope of irrigation at Moulvibazar. Residual soil moisture can be utilized for growing mustard. Generally, farmers of Moulvibazar area cultivate local variety of mustard due to lack of availability of high yielding varieties (HYV). The yield level of local variety is very low. It is possible to uplift yield level of mustard through introducing HYV in those areas. Therefore, the experiment was carried out to evaluate the yield performance of BARI developed mustard varieties against local variety at Moulvibazar region for utilizing fallow land.

Materials and Methods

An experiment was conducted at Regional Agricultural Research Station, Akbarpur, Moulvibazar during the Rabi season of 2021-22. The soil belongs to the "Khadimnagar" soil series sandy loam in texture having moderate organic matter content (1.45%), N 0.80%, K 0.07m mol100^{-1}g of soil, P was 25 μgg^{-1} of soil and S was 10μgg^{-1} of soil with pH value 4-5. Five mustard varieties viz. Tori-7, BARI Sharisha-14, BARI Sharisha-15, BARI Sharisha-17, and BARI Sharisha-18, were sown on 16 November, 2021. Seeds were sown in line with 30 cm line spacing. Unit plot size was 3.60 m × 3.00 m. The experiment was laid out RCB Design with 3 replications. Seeds were sown in line with 30 cm line spacing. Unit plot size was 3.90 m × 3.00 m. Fertilizers were applied as basal at 105-32-40-24-2-1-10kg/ha, of NPKSZnB (FRG, 2018) in the form of Urea, TSP, MoP, Zypsum, Zinc sulphate, Boric Acid and 10t/ha well decomposed cowdung, respectively. The field was affected by cutworm. Acimix (cloropyriphos+cypermethrin mixture) was sprayed to control cutworm at every 7 days interval at two times.Rovral wassprayed to control alternaria blight at every 10 days interval. Three irrigations were given at 12 days after sowing (DAS), after top dressing and at 50 DAS. The crop was kept weed free up to 20 DAS by two hand weedings at 10 and 20 DAS. Other yield components like number of siliqua/plant, seeds/ pod and 1000-seeds weight were taken from randomly selected 10 plants from each plot.Data on different parameters were statistically analyzed following MSTAT-C software package and the treatment means were compared by Least Significance Difference (LSD) test at 0.05 level of probability.

Results and Discussion

Days to 50% flowering and days to maturity also varied due to variety. BARI Sharisha-18 showed the longest days to 1st flowering (41), 50% flowering (48) and maturity (99days) followed by BARI Sharisha-17 and BARI Sharisha-15 while Tori-7 showed the lowest value in all three cases (30 days, 36 days and 79 days, respectively) (Table 1). Yield contributing characters and yield of mustard were significantly influenced by variety (Table 1). Significantly the highest number of siliqua /plant (95) was recorded in BARI Sharisha-18 and the lowest (52) in Tori-7.The highest number of seeds /siliqua (30) was in BARI Sharisha -18 and the lowest number of seeds /siliqua was (18) recorded in Tori -7. The highest thousand seed weight (3.44g) was in BARI Sharisha -18 and the lowest thousand seed weight was in (2.75g) Tori-7.Seed yield also differed significantly among mustard varieties . Seed yield of mustard is a function of siliqua/plant, seeds/siliqua and 1000-seeds weight. Significantly the highest yield (1880.67 kg/ha) was observed in BARI Sharisha-18 followed by BARI Sharisha-17 (1738. 33) while Tori-7 produced the lowest yield (880.33 kg/ha) which was 53% higher than Tori-7.

Table1. Yield contributing characters and yield of mustard as affected by variety under rainfed conditions at Moulvibazar

Variety/line	Days to 1st flowering	Days to 50% flowering	Days to maturity	Siliqua/ plant (no.)	Seed/ siliqua (no.)	1000 seed wt. (g)	Seed yield (kg/ha)
Tori-7	30.58	36.04	79.0	52.67	18.33	2.75	880.33
BARI Sarisha-14	31.69	38.07	86.33	85.00	25.33	3.29	1431.33
BARI Sarisha -15	31.00	39.56	90.14	76.33	19.33	3.22	1548.00
BARI Sarisha -17	32.02	26.46	92.16	65.00	27.33	3.30	1738. 33
BARI Sarisha -18	41.27	48.26	99.58	95.00	30.33	3.44	1880.67
LSD $_{(0.05)}$	-	-	-	17.35	5.68	0.15	58.78
CV (%)	-	-	-	12.32	12.50	2.52	4.92

Conclusion

From the result it may be concluded that BARI Sharisha-18 produced higher yield than other variety but this variety required a longer duration for harvesting. On the other hand, BARI Sharisha-14 required small duration for maturity and could be easily accomodated for cropping pattern.

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EFFECT OF SOWING DATES ON SUNFLOWER AT MOULVIBAZAR

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Abstract

A field experiment was conducted at Regional Agricultural Research Station, BARI, Moulvibazar during *rabi* season of 2021-2022 to find out optimum sowing date for BARI Surjomukhi-3 at Moulvibazar. There were four sowing dates viz., 1November, 15November, 30 November and 15 December in the study. Significantly the highest yield (2.27t/ha) was obtained from 30 November sowing followed by 15 November sowing. The results revealed that November sowing performed better for higher seed yield of BARI Surjomukhi-3 at Moulvibazar area.

Introduction

Sunflower is one of the most important oilseed crops in the world. It is a distinctive, flowering the seeds of which contain valuable edible oil that contains more vitamin E than any other vegetable oil (Ahmed, *etal*, 2015).Its oil is a very good choice in terms of healthy oils, being cheaper than olive oil and having a wide range of options for food industry (Dutta, A. 2011).It is an oil seed with good quality (drying oil and low cholesterol) and high oil content (38%), matures within 90 to 120 days (Ogunremi, 1988). Grown as a fodder crop for livestock feeding, the cake of the seed after oil extraction is rich in protein and could supply 50% of protein requirement of laying chicken without significantly reducing egg production (Smith, 1965).Though its production is decreased due to increasing rice area.Sowing date is an important aspect of crop production for maximizing the yield. Planting date exerted significant influence on vegetative traits along with yield and its component (Allam *et al*., 2003).Esechie (1994) observed that late planting delayed emergence, flowering and maturity in Islero and Upsolveraflor hybrid of sunflower. Therefore, the study was undertaken to find out the optimum sowing date for obtaining maximum yield of sunflower at Moulvibazar area.

Materials and Methods

The experiment was conducted at the Regional Agricultural Research Station, Akbarpur, Moulvibazar during the *Rabi* season of 2021-22. The soil belongs to the “Khadimnagar” soil series sandy loam in texture having moderate organic matter content (1.45%), N 0.80%, K 0.07m mol100g^{-1}of soil, P was 25 μgg^{-1} of soil and S was 10μg/g of soil with P^{H} value 4-5. Four sowing dates (15 November, 30 November, and 15 December, 30 December) for BARI Surjomukhi-3 were used in this experiment. Seeds were sown in line with 50 cm × 25cm spacing. Unit plot size was 3.00 m × 3.5 m. The experiment was laid out RCB design with 3 replications. Cow dung @ 5 t/ha was applied and other fertilizers were applied at the rate of 105-36-84-24-2-1.6 kg/ha of NPKSZnB (FRG, 2018), in the form of Urea, TSP, MOP, Zypsum, Zinc sulphate, boric acid, respectively. Half of N and all of triple super phosphate (TSP), muriate of potash (MOP), gypsum, zinc sulphate and boric acid were applied as basal during final land preparation. Remaining half of N was applied as top dress in two equal splits at 25 and 45 DAS. Data on different parameters were subjected to analysis of variance and the treatment means were compared by Least Significance Difference (LSD) test.

Results and Discussion

Days to emergence, days to 1st flowering and days to maturity significantly varied among the sowing time. Late sown crop flowered earlier than those early sown crop which might be due to the fact that higher temperature reduced vegetative growth and enhanced flowering (Nihal, 2010).The highest days to maturity (103) required for 15 December sowing and the lowest (96days) for 30December sowing. Yield and yield contributing characters have been presented in Table 1. Yield contributing characters and yield were also significantly varied by different sowing dates. The highest number (624.33) of grain /head was recorded in 30 November sowing and the lowest number (329.27) of grain per head was recorded in 15 December sowing. Maximum grain weight/head (46.87g) and 1000 grain weight (69.80g) were observed from 30 November sowing. Significantly the highest yield was obtained from 30 November sowing (2.27t/ha) followed by 15 November sowing (2.07 kg/ha) and the lowest(1.58t/ha) yield was recorded in 30 December sowing. Seed yield generally decreased due to delayed sowing which might be attributed to decrease in yield components (Siddique, *et al*., 2002).

Table 1: Yield and yield contributing characters of BARI Surjomukhi-3 on different sowing dates

Date of Sowing	Days to Emer.	Days to 1st Flowering	Days to Maturity	Plant height (cm)	Head diameter (cm)	Grain /head (no.)	Grain wt./ head (g)	1000 grain wt. (g)	Seed yield (t/ha)
15 November	6.00	60.00	99.00	105.67	19.8	612.33	44.22	66.20	2.07
30 November	5.00	60.00	100.00	108.67	20.83	624.33	46.87	69.80	2.27
15 December	5.00	64.00	103.00	106.0	18.86	329.27	38.34	62.46	1.97
30 December	6.00	64.00	96.00	88.07	14.6	465.13	26.04	54.46	1.58
$LSD_{(0.05)}$	0.99	1.74	2.88	4.85	1.84	118.83	13.52	4.35	0.17
CV (%)	8.22	3.33	4.24	5.4	5.12	11.71	17.42	3.45	4.34

Conclusion

From the result it may be concluded that November sowing was found optimum sowing time for higher yield of BARI Surjomukhi-3.

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YIELD PERFORMANCE AND STORAGE QUALITY OF ONION UNDER INTEGRATED NUTRIENT MANAGEMENT AT AEZ-9

M.R.ALI and J. RAHMAN

Abstract

An experiment was conducted at the Regional Agricultural Research Station (RARS), Jamalpur during December 2021 to March 2022 to find out suitable combination of integrated nutrient management for yield performance and storage quality of onion under at AEZ-9. The treatments were; T_1=Recommended fertilizer dose (FRG, 2018): 70-30-60-24-2-1 kg/ha NPKSZnB, T_2=94-38-75-30-2.5-1.25 kg/ha NPKSZnB (125% RFD, T_3= Integrated plant nutrient system (57-20-46-24-2-1 kg/ha NPKSZnB + 3 t/ha poultry manure (PM), T_4= Integrated plant nutrient system (66-28-53-24-2-1 kg/ha NPKSZnB+ 3 t/ha farmyard manure (FYM), $T_{5=}$ Integrated plant nutrient system (30-4-35-24-2-1 kg/ha NPKSZnB+ 3 t/ha vermicompost (VC), T_6= Integrated plant nutrient system (60-27-57-24-2-1 kg/ha NPKSZnB+ 3 t/ha husk ash and T_7=Farmers' practice (69-19.69-40-9 kg/ha NPKS). BARI Piaj-4 was used in the study. The result indicated that onion yield was increased due to integrated nutrient management. The highest onion yield (22.99 t/ha) was found from Integrated Plant Nutrient System IPNS ((57-20-46-24-2-1 kg/ha NPKSZnB) + 3 t/ha poultry manure and lowest onion yield (12.85 t/ha) was found from farmers' practice (69-19.69-40-9 kg/ha NPKS). The highest gross return (Tk. 10,34,550/ha), gross margin (Tk. 7,74,183/ha) and benefit cost ratio(3.97) was found from Integrated plant nutrient system (57-20-46-24-2-1 kg/ha NPKSZnB+ 3 t/ha poultry manure (PM).

Introduction

In Bangladesh, the area under the spices cultivation is 995202 acres with the annual production of 2672826 metric ton and spices cover almost 2.60 percent of total production area in Bangladesh (BBS, 2019). Onion (*Allium cepa* L.) is one of the most vital spices and vegetables in the world (Shigyo and Kik, 2008). It is commonly used as flavorings or as vegetables in stews and salads. It is one of the richest sources of favonoids in the human diet which has been associated with a reduced risk of cancer, heart disease and diabetes. In Bangladesh, onion grows in different agro-climatic regions mainly due to considerably increasing its importance in the daily diet of Bangladeshi. It is also one of the most essential condiments, vegetables and cash crops in Bangladesh. Onion production is affected by different factors among which unbalanced fertilizer application, inappropriate fertilizer rate or lack of proper soil fertility management practices, limited awareness of growers on soil fertility management are the major ones (Gebretsadik and Dechassa, 2016; Negasi *et al*., 2017). Decomposition of organic materials would provide additional nutrients to the growing medium, which may lead to higher uptake of nutrient by the crop and subsequently high yield (Shaheen *et al.* 2007). Moreover, little information is available for suitable combination of integrated nutrient management for yield performance and storage quality of onion under at AEZ-9. With this in view, the present study was under taken to observe the yield performance and storage quality of onion under integrated nutrient management at AEZ-9 for higher yield and economic return.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, Jamalpur during 2021-22. The experiment consisted of seven treatments viz., T_1=Recommended fertilizer dose (FRG, 2018): 70-30-60-24-2-1 kg/ha NPKSZnB , T_2= 94-38-75-30-2.5-1.25 kg/ha NPKSZnB (125% RFD, T_3= Integrated plant nutrient system (57-20-46-24-2-1 kg/ha NPKSZnB+ 3 t/ha poultry manure (PM), T_4= Integrated plant nutrient system (66-28-53-24-2-1 kg/ha NPKSZnB+ 3 t/ha farmyard manure (FYM), $T_{5=}$ Integrated plant nutrient system (30-4-35-24-2-1 kg/ha NPKSZnB+ 3 t/ha t/ha vermicompost (VC), T_6= Integrated plant nutrient system (60-27-57-24-2-1 kg/ha NPKSZnB+3 t/ha husk ash and T_7=Farmers' practice (69-19.69-40-9 kg/ha NPKS). The treatments were tested in randomized complete block design with 3 dispersed replications. The unit plot size was 3 m × 3 m and spacing 15cm × 10cm. BARI Piaz-4 was used. Seedling were transplanted on 12 December 2021 onion harvested on 28 March 2022. FYM and N as per treatment and 45-90-30-3-1.4 kg/ha of P-K-S-Zn-B (FRG, 2018). All of FYM, P, S, Zn, B and ½ of N and K were applied as basal during final land preparation. Remaining N and K were applied in two equal splits at 25 and 50 DAT. Weeding, irrigation and other intercultural operations was done as and when necessary. Yield was calculated in ton per hectare considering the whole plot as harvest area. Ten plants of onion from each plot were selected randomly to collect data on yield components. Collected data were analyzed statistically with the help of STAR programme. Storage data collection was on going.

Results and Discussion

The yield and yield contributing characters of onion have been mentioned in table 1 and economic performance in table 2. From table 1 the result indicated that all the yield attributes were influenced due to integrated plant nutrient management. The tallest plant (60.66 cm) was recorded from IPNS through 3 t/ha poultry manure and the shortest plant (39.17 cm) was found from farmer's practice. Similar trend were found incase of bulb length, bulb breath, number of bulb/m^2, single bulb wt and bulb weight/m^2. The highest yield (22.99 t/ha) was achieved from IPNS through 3 t/ha poultry manure and the lowest yield (12.85 t/ha) was recorded from farmer's practice. The highest yield obtained from integrated plant nutrient system through poultry manure because poultry manure contain higher amount of N, P and K than other component. Farmers' practice gave the lowest yield because they used lower amount nutrient. From table 2 the highest gross return (Tk. 10,34,550/ha), gross margin (Tk. 7,74,183/ha) and benefit cost ratio(3.59) was found from IPNS through 3t/ha poultry manure and the lowest gross return (Tk. 5,78,250/ha), gross margin (Tk. 3,38,227/ha) and benefit cost ratio(2.41) was from farmers' practice.

Table 1. Yield performance and storage quality of onion under integrated nutrient management under AEZ-9 during 2021-22 at RARS, Jamalpur

Treatment	Plant ht (cm.)	Bulb length (cm)	Bulb breath (cm)	Bulb/m^2 (no)	Single bulb wt. (g)	Bulb wt./ m^2 (kg)	Yield (t/ha)
T_1	51.04	4.77	4.63	65.67	30.91	1.91	19.40
T_2	56.02	4.83	4.73	70.67	32.11	2.08	20.76
T_3	60.66	5.09	4.93	72.00	38.71	2.30	22.99
T_4	58.19	4.91	4.88	71.67	33.55	2.11	21.12
T_5	54.99	4.88	4.42	69.33	31.86	2.03	20.28
T_6	52.13	4.83	4.68	66.33	31.28	1.90	19.01
T_7	39.17	3.29	3.02	56.00	19.02	1.29	12.85
LSD $_{(0.05)}$	7.509	1.2124	1.4258	12.8254	7.2722	0.114	3.8431
CV(%)	4.94	6.11	9.19	6.66	6.19	3.56	6.90

Table 2. Economics of performance and storage quality of onion under integrated nutrient management under AEZ-9 during 2021-22 at RARS, Jamalpur

Treatment	Gross return (Tk.ha)	Total variable cost (Tk.ha)	Gross margin (Tk.ha)	Benefit cost ratio
T_1	8,73,00 0	2,47,566	6,25,434	3.53
T_2	9,34,200	2,51,026	6,83,174	3.72
T_3	10,34,550	2,60,367	7,74,183	3.97
T_4	9,50,400	2,61,787	6,88,613	3.63
T_5	9,12,600	2,83,359	6,29,241	3.22
T_6	8,85,450	2,57,388	6,28,062	3.44
T_7	5,78,250	2,40,023	3,38,227	2.41

Note: T_1=Recommended fertilizer dose (FRG, 2018), T_2=125% RFD, T_3= IPNS through 3 t/ha PM, T_4=IPNS through 3 t/ha FYM, T_5=IPNS through 3 t/ha VC, T_6= Recommended fertilizer dose +3 t/ha husk ash, T_7=Farmers' practice Sell price/kg: Onion =Tk. 45.00

Total cost considered seeds, fertilizer, labour, irrigation and additional cost only.

Conclusion

Results reveled that Integrated plant nutrient system (57-20-46-24-2-1 kg/ha NPKSZnB) + 3 t/ha poultry manure (PM) would be optimum for getting higher yield and better economic return at Jamalpur. This is first year data final result may be concluded after complete the second year experiment.

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GROWTH AND YIELD OF BLACK CUMIN INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT

M R ALI AND J. RAHMAN

Abstract

An experiment was conducted at the Regional Agricultural Research Station (RARS), Jamalpur during December during *rabi* season of 2021 to March 2022 to find out the suitable integrated nutrient management for higher yield and economic return of black cumin under at AEZ-9. The treatments were; T_1=Recommended fertilizer dose (RFD): 60-24-45-15-2-1.4kg/ha of NPKSZnB (FRG, 2018), T_2=125% RFD (75-24-4815-2-1.4 kg/ha of NPKSZnB), T_3= Integrated Plant Nutrient System (42-14-45-15-2-1.4 kg/ha of NPKSZnB) + 3 t/ha PM, T_4=Integrated Plant Nutrient System (50-22-40-15-2-1.4 kg/ha of NPKSZnB) + 3 t/ha FYM, T_5= Farmers' practice (69-11.8-15 kg/ha NPK). BARI Kalogira-1 was used in the study. The result indicated that Kologira yield was increased due to integrated nutrient management. Significantly the highest yield (1.57 t/ha) was found from IPNS through 3 t/ha poultry manure and the lowest yield (0.50 t/ha) was found from farmers' practice. The highest gross return (Tk. 3,92,500/ha), gross margin (Tk. 3,06,980/ha) and benefit cost ratio (4.59) were recorded in IPNS through 3t/ha poultry manure .

Introduction

In Bangladesh, the area under the spices cultivation is 995202 acres with the annual production of 2672826 metric ton and spices cover almost 2.60 percent of total production area in Bangladesh (BBS, 2019). Black cumin (*Nigella sativa* L.) is a spice crop in our country that belongs to Ranunculaceae family. The seeds or grains resembling onion seed, are used both as spice and medicine. It is believed to have originated in the Mediterranean region and subsequently spread to Europe, Asia and Africa. Seeds of this plant were used both as spice and medicine since a very long time. The seeds are bitter in taste and consumption of whole seed even in small quantity gives a feeling of constriction of throat. It is appropriately known as seed of blessing (habbatulbarakah). The spice was attributed with numerous medicinal properties and is widely used in unani, ayurveda, siddha and other ethnomedicine systems across the world. The medicinal value of the spice is immense and numerous workers appreciated its unique, varied and powerful pharmacological traits. The popularity of the plant was highly enhanced by the ideological belief in the herb as a cure for multiple diseases. likes anti-tumour anti-diabetic, cardio protective, gastro protective), antiasthmatic, nephroprotective, hepatoprotective, anti-inflmmatory, immunomodulatory, neuroprotective, anticonvulsant, anxiolytic, antioxidant, antinociceptive, antioxytocic, contraceptive, antibacterial antifungal, and anthelmintic activities were immensely appreciated. The major medicinal components are thymoquinone and nigellone (a dimer of thymoquinone). These were attributed to impart anti-tumour, anti-inflammatory and anti-diabetic properties. The crop is presently cultivated in parts of Asia, Africa, Europe and Americas of the globe. The major producing countries are India, Sri Lanka, Bangladesh, Afghanistan, Pakistan, Egypt, Iran, Iraq, Syria, Turkey and Ethiopia (Rana *et al*., 2012; Bhutia *et al*., 2015). In Bangladesh, it covers 14742 hectares of land, with total production of 16526 tons (DAE, 2015), over the Faridpur, Sariatpur, Madaripur, Pabna, Sirajgang, Jessore, Kustia, Bogura, Rangpur, Natore, Jamalpur, Sherpur, Mymensingh, Tangail districts (Ali *et al*., 2015; Noor *et al*., 2008). The major seed spices grown in Bangladesh are coriander, fenugreek, black cumin and Fennel. Black cumin cultivated without proper fertilizer management and agronomic practices. So, the present study was under taken to growth and yield performance of black cumin under integrated nutrient management at AEZ-9 for higher yield and economic return.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, Jamalpur during 2021-22. The experiment consisted of five treatments, viz., T_1=Recommended fertilizer dose (RFD): 60-24-45-15-2-1.4kg/ha of NPKSZnB (FRG, 2018), T_2=125% RFD (75-24-4815-2-1.4 kg/ha of NPKSZnB) , T_3= Integrated Plant Nutrient System (42-14-45-15-2-1.4 kg/ha of NPKSZnB) + 3 t/ha PM, T_4=Integrated Plant Nutrient System (50-22-40-15-2-1.4 kg/ha of NPKSZnB) + 3 t/ha FYM, T_5= Farmers' practice (69-11.8-15 kg/ha NPK). The treatments were tested in randomized complete block design with 3 dispersed replications. The unit plot size was 3 m × 4 m and spacing was 30 cm 5 cm. BARI Kalogira-1 were used. Seeds were sown on 13 November 2021 and harvested on 23 March 2022. FYM and N as per treatment and 60-24-45-15-2-1.4 kg/ha of P-K-S-Zn-B (FRG, 2018). Full amount of cowdung and recommended dose of P, K, S, Zn, B was applied during final land preparation. N was applied into two equal splits at 30 and 55 DAS. Weeding, irrigation and other intercultural operations was done as and when necessary. Yield was calculated in ton per hectare considering the whole plot as harvest area. Ten plants of from each plot were selected randomly to collect data on yield components. Collected data were analyzed statistically with the help of a computer package program STAR and the means were adjusted by Least Significance Difference (LSD) test at 5% level of significance.

Results and Discussion

The yield and yield contributing characters of Kalogira have been mentioned in table 1.and economic performance in Table 2. From Table 1 the result indicated that all the yield attributes were influenced due to integrated plant nutrient management. The tallest plant (78.00 cm) was recorded from IPNS through 3 t/ha poultry manure and the shortest plant (51.00 cm) was found from farmer's practice. Similar trend were found in case of primary branches/plant. The highest number of capsul/plant (29.20) and seed/capsul (95.60) was found from Integrated Plant Nutrient System with 3 t/ha PM and lowest were recorded from farmer's practice. The highest 1000 grain weight (3.40 g) was achieved from Integrated Plant Nutrient System with 3 t/ha PM and lowest (1.00 g) were recorded from farmer's practice. The highest yield (1.57 t/ha) was recorded from IPNS through 3 t/ha poultry manure and the lowest yield (0.50 t/ha) was recorded from farmer's practice. The highest yield obtained from integrated plant nutrient system through poultry manure because poultry manure contain higher amount of N, P and K than other component. Farmers' practice gave the lowest yield because they used lower amount nutrient. The highest gross return (Tk. 3,92,500/ha), gross margin (Tk. 3,06,980/ha) and benefit cost ratio (4.59) were found from IPNS through 3t/ha poultry manure and the lowest gross return (Tk. 1,25,000/ha), gross margin (Tk. 60,545/ha) and benefit cost ratio (1.94) were from farmers' practice.

Table 1. Yield and yield attributes of black cumin influenced by integrated nutrient during 2021-22 at RARS, Jamalpur

Treat.	Plant ht (cm)	Plant/m^2 (no)	branches/ plant (no)	Capsul/ plant (no)	Seed/capsul (no)	1000 seed wt (g)	Yield/m^2 (kg)	Yield (t/ha)
T_1	60.33	73.70	7.20	18.10	72.20	2.50	0.115	1.15
T_2	71.00	73.53	7.40	20.20	76.30	2.80	0.137	1.37
T_3	78.00	75.80	8.53	29.20	95.60	3.40	0.157	1.57
T_4	74.67	72.40	8.20	21.40	87.50	3.10	0.149	1.49
T_5	51.00	71.30	6.20	12.00	40.00	1.00	0.050	0.50
LSD $_{(0.05)}$	9.78	-	0.11	5.05	3.52	0.42	0.01	0.11
CV(%)	7.76	4.76	0.8067	6.33	2.52	0.730	4.09	5.08

Table 2. Economics of black cumin as influenced by integrated nutrient during 2021-22 at RARS, Jamalpur

Treatment	Gross return (Tk.ha)	Total variable cost (Tk.ha)	Gross margin (Tk.ha)	Benefit cost ratioi
T_1	2,87,500	72,363	2,15,137	3.97
T_2	3,42,500	75,458	2,67,042	4.54
T_3	3,92,500	85,520	3,06,980	4.59
T_4	3,72,500	86,576	2,85,924	4.30
T_5	1,25,000	64,455	60,545	1.94

Note: T_1=Recommended fertilizer dose (RFD: 60-24-45-15-2-1.4kg/ha of NPKSZnB (FRG, 2018), T_2=125% RFD, T_3= Integrated Plant Nutrient System (IPNS) with 3 t/ha PM, T_4=Integrated Plant Nutrient System (IPNS) with 3 t/ha FYM, T_5= Farmers' practice

Sell price/kg: Black cumini=Tk. 250.00

Total cost considered seeds, fertilizer, labour, irrigation and additional cost only.

Conclusion

Results reveled that Integrated plant nutrient system (57-20-46-24-2-1 kg/ha NPKSZnB) + 3 t/ha poultry manure (PM) would be optimum for getting higher yield and better economic return at AEZ-9.This is first year data final result may be concluded after complete the second year experiment.

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EFFECT OF MANAGEMENT PRACTICE FOR YEAR ROUND PRODUCTION OF CORIANDER AS CONDIMENT IN RELATION TO WEATHER CONDITION

J RAHMAN, M R ALI, A A BEGUM, S S KAKON, D A CHOUDHURY AND M M KADIR

Abstract

This study was conducted at RARS, Jamalpur between 2021 and 2022 to determine the suitable management practice for year round coriander production as condiment and demand during off season, nutrition supply and higher market price. There are twelve sowing time and two management approaches such as A. Sowing time: January, February, March, April, May, June, July, August, September, October, November and December and B. Management practices: a. Shade net condition and b. Raised bed. Yield of coriander as a condiment was considerably affected by sowing time and management. Significantly highest yield (10.96 t/ha) was recorded in December sowing with shade net and it was found statistically at par December× raised bed (9.93 t/ha) while February×shade net was recorded the lowest (3.44 t/ha) yield due to climatic condition. Different sowing times influenced shade net or raised bed management practices and as a result, this practice may be beneficial for any sort of farmer or homestead area producer due to year-round market price variances.

Introduction

Coriander (*Coriandrum sativum* L.) is an annual plant that belongs to the family Umbelliferae possessing spice, aromatic, nutritional as well as medicinal properties. Leaves of *Coriandrum sativum* displayed stronger antioxidant activity than seeds, and in equal portions of coriander, ethyl acetate extract donated to strongest activity (Ahmad M *et al.*2021). It has usually been stated to as antidiabetic (Izgi., 2020), liver and kidney toxicities (Bindu *et al.*, 2020), anti-inflammatory and lowering cholesterol (Mushtaq UM *et al.* 2020). Coriander is one of the most important leafy vegetable in Bangladesh. It is important to produce coriander throughout the year due to high demand of coriander leaf in daily life. Coriander is a winter crop. During off season (summer) high temperature and heavy rainfall negatively affects the quantity as well as quality of this valuable crop. As a result, the current experiment will be done to determine the best management method for growing coriander as a year-round leafy vegetable in order to maximize yield regardless of weather conditions.

Materials and Methods

The experiment was conducted at the research field of RARS, Jamalpur 24°56´ north latitudes and 89°55´ east longitudes. Treatments included in the experiment were: A. Sowing time: January, February, March, April, May, June, July, August, September, October, November and December and B. Management: a. Shade net condition and b. Raised bed. Design of the experiment was split plot design with 3 replications. Each treatment was sown in unit plot having 2m × 2m with the spacing of 20 cm × 5cm. Fertilizers were applied at the rate of 50-20-32-10 (FRG, 2018) kg/ha of N-P-K-S. All of P, K, S and ½ of N will be applied as basal during final land preparation. Remaining N will be applied at 20 DAS. Weeding was done when necessary. Yield of coriander leaves were calculated from the whole plot area. Yield contributing characters were taken from 5 randomly selected plants from the middle rows of each plot. Weather data (air temperature and rainfall) were collected from the Weather Station, RARS, Jamalpur (Table 1). Data were analyzed with the help of a computer package program, Statistix 8.0 and means were separated following LSD test at 5% level of significance.

Table 1. Fifteen day interval air temperature and rainfall of each month during experimentation

Date	Air temperature (0^{C})			Total rainfall, mm
	Max.	Min.	Ave.	
1-15 November/21	30.93	17.73	24.33	0
16-30 November/21	29.80	15.60	22.70	0
1-15 December/21	27.53	15.66	21.60	0.5
16-31December/21	25.88	12.31	19.63	0
1-15 January/22	25.07	12.40	18.73	6.75
16-31 January/22	24.31	11.63	18.50	0.75
1-15 February/22	24.67	10.47	17.57	28.5
16-28 February/22	28.23	12.38	20.31	0
1-15 March/22	32.47	15.47	23.97	66.56
16-31 March/22	35.00	21.44	28.09	69.9
1-15 April/22	36.00	19.60	28.97	8.75
16-30 April/22	36.87	23.40	30.13	11

Source: Weather Station, RARS,Jamalpur.

Results and Discussion

Combined effect of sowing time and management

Number of plant/m^2, plant height and yield of coriander as influenced by sowing time and management practices have been presented in Table 2. Significantly the highest (242) number of plant/m^2 was obtained from December sowing with shade net and the lowest (137) from January sowing with shade net. The highest plant height (27.90 cm) was recorded in February sowing with raised bed which was followed by January sowing with raised bed and the lowest plant height(21.6 cm)was recorded in November sowing with shade net. Maximum leaf weight /m^2 (2305 g) was recorded in December sowing with shade net and the lowest (428) was in January sowing with shade net. Significantly highest yield (10.96 t/ha) was recorded in December sowing with shade net and it was found statistically at par December× raised bed (9.93 t/ha) while February× shade net was recorded the lowest (3.44 t /ha) yield due to climatic condition.

Table 1. Yield and yield attributes of coriander as condiment as influenced by sowing time and management

Combined effect	No. of plant /m^2	Plant height (cm)	Weight of leaf / m^2 (g)	Yield (t /ha)
November×shade net	195	21.6	1696	9.1
November×raised bed	193	22.6	1210	7.9
December×shade net	242	23	2305	10.96
December× raised bed	202	24.2	2152	9.93
January×shade net	137	23	428	4.42
January×raised bed	233	26.9	1223	9.03
February×shade net	161	22.8	569	3.44
February×raised bed	146	27.9	507	4.78
$LSD_{0.05}$	94.7	8.24	921	3.9
CV (%)	28	19.6	41.7	29.8

Conclusion

From the result it may be concluded that in December sowing with shade net or raised bed would be optimum sowing time and management practice for getting higher yield of farmer or homestead area producer at Jamalpur .

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EFFECT OF PLANTING DATE AND VARIETY ON TARO

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Abstract

This study was conducted at RARS, Jamalpur during 2020 and 2021 to determine the suitable of variety taro and planting date for vegetable production in the lag period shortly after monsoon. Two varieties like BARI PK-1 and BARI PK-2, and five planting dates viz., August, December, January, February and March were used in the experiment. Both the varieties showed better performance in February and March planting than other months. But both the varieties showed good performance and gave better economic return in all the planting dates supplying nutritious vegetables (stolon and rhizome) during the lag period also after monsoon.

Introduction

Taro[Colocasia esculenta (L.) Schott] is an important tropical root crop grown purposely for its starchy corms or underground stem. It is one of the cheapest sources of dietary carbohydrates among the tuber crops (Gerrano *et al.,* 2019). Taro leaves, pseudo stems and corms are rich in vitamins and minerals. Taro is an important cash crop and its petioles, flowers and stems can be used as both foods or medicines with high nutritional or medicinal value (Ribeiro Pereira, P. *et al*; 2021). Edible taro in Bangladesh are known by the common Bengali name '*Kachu*'. Rhizomes (modified stem) (13018 acres) stolon (*lati*) (16738 acres) of land with an annual production of rhizomes (57149 M Ton), stolon (41521 M Ton) in *rabi* and *kharif* seasons, respectively (BBS, 2020). Panikachu is a very much nutritious vegetables. It was neglected for its low price, easy availability and lack of information of its nutritive value. But now-a-days, the utilization of taro is increasing due to increase awareness about nutritional aspect. A large amount of stolons are being exported every year to abroad. We can consume its petiole, leaf, stolon (*lati*) and modified stem. Taro leaf contain highest amount of vitamins and minerals among other vegetables. If anybody consumes 2-3 medium sized leaf daily, then the deficiency of vitamins and minerals will be minimized. Taro can grow in diverse condition, in which any other vegetables could not be grown. Taro mitigates the demand of vegetables in lag period during just after monsoon. The BARI pani kachu-1 or Latiraj and BARI Pani kachu-2 (both stolon-*lati and* modified stem) are improved variety is used primarily for stolons and low yield of rhizomes may be used as by-product. The stolons of latiraj are thick and about one meter long. The highest production and good quality are mostly depends on planting dates. Since climatic conditions suitable planting date may also vary at different locations. Determination of suitable planting dates and varieties for taro cultivation is not yet determined. Stolon and rhizome production is a beneficial programme in contrast of taro can grow in diverse condition, in which any other vegetables could not be grown and mitigate the demand of vegetables in lag period during just after monsoon. Therefore, it would be worthy to identify suitable planting dates and varieties for taro cultivation. In this situation the programme has been undertaken to find out suitable variety and planting date for taro cultivation.

Materials and Methods

The experiment was conducted at the research field of RARS, Jamalpur 24°56´ north latitudes and 89°55´ east longitudes. The site was of medium high land belonging to the agro-ecological zone Old Brahmaputra Flood plain under Agro-Ecological Zone 9. Treatments included in the experiment were: Variety:1. BARI PK-1 and 2. BARI PK-2; planting date: 1. January, 2. February, 3. March, 4. April, 5.August. Design of the experiment was split plot design with 3 replications. Each treatment was sown in unit plot having 4.5m × 3m with the spacing of 60 cm × 45cm. Fertilizers were applied at the rate of 90-30-90-15 kg/ ha NPKS (FRG, 2018) as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, Boron. All of P, K and S were applied as basal during land preparation. N was side dressed in two equal splits at 30 and 60 DAP. Seedlings were transplanted as per treatment. Weeding was done when necessary. Yield of rhizomes and stolon were calculated from the whole plot area. Yield contributing characters were taken from 5 randomly selected plants from the middle rows of each plot. Data were analyzed with the help of a computer package program, Statistix 8.0 and means were separated following LSD test at 5% level of significance.

Results and Discussion

Individual effect of variety and planting date on taro were not significant. The interaction effect of variety and planting date has been discussed here.

Interaction effect of planting date and variety on yield components and yield of taro

Yield components and yield of taro as influenced by interaction effect of planting date and variety have been presented in Table 1.The highest number of stolon/plant (31) was recorded from August × BARI PK-1 and the lowest (13) was recorded from December × BARI PK-2. It might be due to low temperature prevailed in December. The maximum length of stolon (102.4cm) was recorded from January × BARI PK-1 and the minimum (47.1cm) was recorded from August × BARI PK-2.The maximum diameter of stolon (1.33cm) was recorded from March × BARI PK-2 and the minimum (0.71cm) was recorded from August × BARI PK-1.The highest weight of stolon per plant (1196.5g) was recorded from February × BARI PK-1 and the lowest (525.5g) was recorded from December × BARI PK-2.The highest stolon yield (27.6 t/ha) was recorded from February × BARI PK-2 followed by February× BARI PK-1 and the lowest (11.25 t/ha) was recorded from December × BARI PK-2 due diameter and weight of stolon. The highest rhizome yield (38.52 t/ha) was observed under August × BARI PK-2 followed by January × BARI PK-2 and February × BARI PK-2 and the lowest (10.92 t/ha) was observed in January × BARI PK-1 followed by August × BARI PK-1. In different planting date, both the variety of taro performed better in stolon and rhizome production and rhizome yield was better in BARI PK-2 due to its genetic characters.

Table 1.Interaction effect of planting date and variety on yield and yield contributing characters of taro during 2020-2021

Combined effect	Stolon per plant (no.)	Length of stolon (cm)	Diameter of stolon (cm)	Stolon wt./plant (gm)	Stolon yield (t /ha)	Rhizome yield (t/ ha)
August × BARI PK-1	31	78.4	0.71	656.2	13.85	21.51
August × BARI PK-2	30	47.1	0.99	930.3	13.80	41.65
December× BARI PK-1	17	98.7	0.75	614	12.93	27.62
December × BARI PK-2	13	53.2	1.11	525.5	11.25	29.24
January × BARI PK-1	19	102.4	0.91	942.9	20.81	19.92
January × BARI PK-2	16	61.63	1.31	833.8	17.78	38.52
February× BARI PK-1	28	89.47	0.93	1196.5	26.46	28.15
February × BARI PK-2	23	54.33	1.32	1094.3	27.6	38.43
March× BARI PK-1	24	97.9	0.93	815.7	19.34	25.44
March × BARI PK-2	21	65.8	1.33	1111.9	24.52	32.98
$LSD_{0.05}$	3.01	10.12	0.19	21	4.9	11.13
CV (%)	7.92	7.88	10.74	9.6	10.3	8.7

Cost and return analysis of taro

Gross return, cost of cultivation, gross margin and BCR of taro have been presented in Table 2. The highest gross return (Tk.1603590/ha), gross margin (Tk.1486590/ha) and BCR (13.71) were observed in February × BARI PK-2 followed by March × BARI PK-2 and the lowest gross return (Tk. 453800/ha), gross margin (Tk. 337800/ha) and BCR (3.91) were observed in August × BARI PK-1.

Table 2.Cost and return of taro cultivation as influenced by interaction effect of planting dates and varieties during 2020-2021

Interaction effect	Gross return (Tk./ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	BCR
August × BARI PK-1	453800	116000	337800	3.91
August × BARI PK-2	636550	116000	520550	5.49
December× BARI PK-1	581240	116500	464740	4.99
December × BARI PK-2	600660	116500	484160	5.16
January × BARI PK-1	907630	116500	791130	7.79
January × BARI PK-2	1046020	116500	929520	8.98
February× BARI PK-1	1339900	117000	1222900	11.45
February × BARI PK-2	1603590	117000	1486590	13.71
March× BARI PK-1	1175580	117000	1058580	10.05
March × BARI PK-2	1598100	117000	1481100	13.66

Market price (Tk./kg):

Stolon = 25 in August planting, 30 in December planting,35 in January planting, 40 in February planting and 45 InMarch planting

Rhizome (BARI PK-1) = 5 in August planting, 7 in December planting, 9 in January planting, 10 in February planting and 12 in March planting

Rhizome (BARI PK-2) = 7 in August planting, 9in December planting, 11 in January planting, 13 in February planting and 15 in March planting

Conclusion

The results revealed that February and March planting were better than other planting date for both the varieties. But both the varieties showed good performance and gave better economic return in all the planting dates which supplied nutritious vegetables (stolon and rhizome) during the lag period after monsoon.

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TESTING OF FODDER AND SEED YIELDS PERFORMANCES OF BARI RELEASED GRASSPEA VARIETIES

M.A. RAHMAN, M.M. RAHMAN AND M.R. UDDIN

Abstract

The field experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during two consecutive *Rabi* seasons of 2020-21 and 2021-22 after harvesting of previous T.aman rice (cv. BRRI dhan52) to test the dual performances (both fodder and seed yields) of BARI released grasspea varieties. The treatments of the experiment: Factor A: Fodder cutting (C_0 = No fodder cut and C_1 = one cut of fodder at 50 days after emergence); Factor B: Six varieties of grasspea (V_1 = BARI Khesari-1, V_2 = BARI Khesari-2, V_3 = BARI Khesari-3, V_4 = BARI Khesari-5, V_5 = Faridpur local variety were used both the years and V_6 = BARI Khesari-6 used only 2021-22). Significantly the highest fodder yield (3652 kg/ha in 20-21 and 8090 kg/ha in 2021-22) was obtained in C_1V_5 (One cut of shoot at 50 DAE in Faridpur local). Results revealed that yield component and yield of grasspea were influenced significantly by the interaction of shoot cutting and variety. Significantly the highest seed yield (2109 kg/ha in 2020-21) was obtained from C_0V_4 (control in BARI Khesari-5) treatment but in 2021-22, the highest yield was recorded in C_0V_6 (control with BARI Khesari-6) treatment . The lowest yield (1097 kg/ha in 2020-21 and 964 kg/ha in 2021-22) was recorded in C_1V_1 (one cut of shoot at 50 days after emergence in BARI Khesari-1) treatment. The highest BCR was 3.28 in C_1V_6 and also higher values. Although BARI Khesari-6 gave the highest gross margin but BARI Khesari-6, BARI Khesari-5 and Faridpur local variety could be cultivated for both fodder and seed production in southern region of Bangladesh.

Introduction

Grasspea (*Lathyrussativus* L.) is a dual purpose annual legume grown for its seeds for human consumption, and fodder for livestock feeding. It is the most economically important and widely cultivated crop for human consumption. Grasspea seeds are a common staple food in many countries. Immature pods and young plants are cooked and eaten as vegetables. Grass pea foliage and seeds make valuable forage. They can be used fresh, dried as hay or made into silage. Grasspea is a cool season legume and grown as a winter crop in Bangladesh. The area under grasspea cultivation in the country is about 1.12 lakh hectare and production is about 1.19 lakh metric ton (BBS, 2018). The crop can be grown as a sole crop, in inter/relay cropping systems or in mixtures. It can be cultivated with T.*aman* rice as a relay crop. Grasspea forage is grazed at a young stage and then let to re-grow for harvesting seeds. Grasspea is one of the preferred legume seeds in low fertility soils and arid areas because of its outstanding tolerance of dry or flooding conditions. The farmers of Faridpur region (south-western part of Bangladesh) generally cultivate local variety of grasspea only for fodder production for livestock husbandry, which hamper the seed production of the crop. However, the farmers desire to cultivate grasspea as duel purposes (both fodder and seed production) for increasing their income. Bangladesh Agricultural Research Institute (BARI) has developed a good number of high yielding grasspea varieties (like BARI Khesari-1, 2, 3, 4, 5 and 6) that are yet to be tested for duel purposes (both fodder and seed production). Therefore, the experiment has been undertaken to test the dual performances (both fodder and seed yields) of BARI released grasspea varieties for south-western region of Bangladesh.

Materials and Methods

The field experiment was carried out at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during the *Rabi* seasons of 2020-21 and 2021-22 after harvesting of previous T.*aman* rice (cv. BRRI dhan52) to test the dual performances (both fodder and seed yields) of BARI released grasspea varieties. The experimental site is situated in the latitudes and longitudes of $22^o47^/2.5842^{//}$N and $90^o17^/31.96998^{//}$E. The experimental site is located under the agro-ecological zone Ganges Tidal Floodplain (AEZ-13). The soil type is medium high land and soil texture is loamy. The treatments of the experiment were of two factors viz., Factor A: Number of cut for fodder (C_0 = Control or no cut and C_1 = one cut of shoot at 50 days after emergence); Factor B: Number of grasspea variety (V_1 = BARI Khesari-1, V_2 = BARI Khesari-2, V_3 = BARI Khesari-3, V_4 = BARI Khesari-5 and V_5 = Faridpur local variety). Because of available of seeds, V_6 (BARI Khesari-6) was also added as a variety in second year (2021-22). The unit plot size was 4 m × 3 m. Seeds were sown on 17 November 2020 (1st year) and 2 December 2021 (2nd year trial) in row following row to row distance 30 cm and continuous sowing. The experiment was laid out in randomized complete block design (factorial) with three replications. One shoot (fodder) cutting of the grasspea varieties were done at 50 days after emergence (DAE) as per treatment specifications. The experimental plots were fertilized with 35-60-45-45-10 kg/ha urea, TSP, MP, gypsum and boric acid, respectively. Half amount of urea, TSP, MP, gypsum and boric acid were applied as basal during final land preparation (FRG, 2018). The next amount of urea was applied at 50 DAE followed by first shoot (fodder) cutting and irrigation. Other management practices were done as per requirement of the crop following BARI (2020). Data were collected on different parameters in terms of days to flowering, days to maturity, root length, root volume, plant population/m^2, plant height, number of branch/plant, number of pod/plant, number of seed/pod, 1000 seeds weight, seed weight/plot, straw weight/plot, fresh fodder weight/plot and moisture content in fresh fodder. The plot yields were then converted into ton/hectare. Data were analyzed statistically using Statistix 10 software and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) following Gomez and Gomez (1984).

Results and Discussion

Interaction effect of variety and shoot (fodder) cutting of grass pea was found significant, so main factor effect was not discussed here.

Fodder yield varied by the interaction of variety and shoot (fodder) cutting of grasspea (Fig.1). Significantly the highest fodder yield (3652 kg/ha in 20-21 and 8090 kg/ha in 2021-22) was obtained in C_1V_5 (One cut of shoot at 50 DAE in Faridpur local). The lowest fodder yield (1951 kg/ha in 2020-21) was recorded in C_1V_4 (One cut of shoot at 50 DAE in BARI Khesari-5) whereas in 2021-22 , the lowest fodder yield (5038 kg/ha) was recorded in C_1V_2 (One cut of shoot at 50 DAE in BARI Khesari-2)

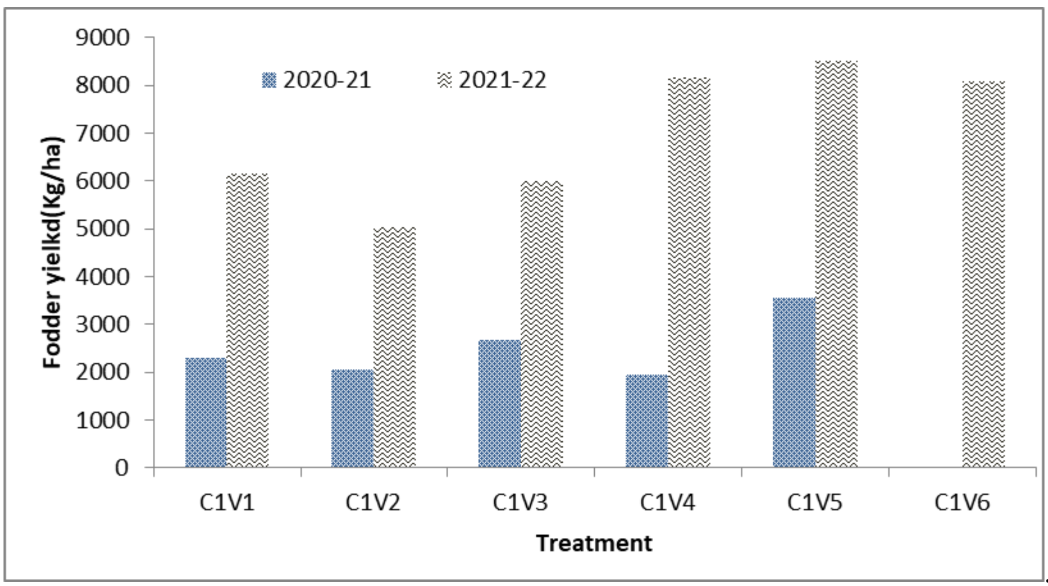

Fig 1. Fodder yield of grass pea as affected by variety and shoot cutting

C_0 = Control or no cut and C_1 = one cut of shoot at 50 days after emergence); Factor B: Number of grasspea variety (V_1 = BARI Khesari-1, V_2 = BARI Khesari-2, V_3 = BARI Khesari-3, V_4 = BARI Khesari-5 V_5 = Faridpur local variety) and V_6 = BARI Khesari-6

From the two years result, it was revealed that maximum days to required for 50 % flowering in one cut of shoot at 50 days after emergence of all the varieties (Table 1). Similar trend was observed in days to maturity. The longest plant was observed in (115.47 cm in 2020-21) C_0V_1(Control with BARI Khesari-1) which was similar to C_0V_2, C_0V_3, C_0V_4, $C_0V_5$and C_1V_2 treatment. On the other hand in 2021-22, the longest plant was observed in (111.44cm) C_1V_1(One cut of shoot at 50 days after emergence with BARI Khesari-1) which was similar to C_0V_4 and C_0V_5 treatment and the shortest plant was recorded in C_1 V_2 treatment..

Table 1. Days to flowering, Days to maturity and Plant height as influenced by shoot cutting and variety during rabi season of 2020-21 and 2021-22

Interaction (Cut X Var.)	Days to flowering		Days to maturity		Plant height (cm)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
C_0V_1	58.00b	61e	117.00c	121g	115.47a	104.45c
C_0V_2	56.00c	61de	115.00c	121g	113.33a	103.61c
C_0V_3	57.00bc	61de	116.00c	122fg	108.73a-c	105.62bc
C_0V_4	58.00b	62de	117.00c	122fg	109.52ab	106.87a-c
C_0V_5	57.00bc	62d	116.00c	123f	110.73ab	110.83ab
C_1V_1	71.33a	62d	128.67b	123f	88.33c	111.44a
C_1V_2	70.67a	66c	129.67ab	128e	101.27a-c	88.09e
C_1V_3	72.00a	68b	131.00a	128de	96.80a-c	89.86de
C_1V_4	71.33a	69b	130.33ab	129cd	90.40bc	90.17de
C_1V_5	71.33a	68b	130.33ab	130bc	99.80a-c	89.83de
F-test	*	70a	*	131ab	*	95.03d

Table 2.Yield component and yield of grasspea as influenced by shoot cutting and variety during *rabi* season of 2020-21 and 2021-22

Interaction (Cut X Var.)	Pod/ plant (no.)		1000 seeds weight (g)		Seed yield (kg/ha)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
C_0V_1	26.33	27.13b-e	56.61	60.33ab	1110cd	1119ab
C_0V_2	19.67	24.33ef	55.58	64.80a	1123cd	1181ab
C_0V_3	23.80	29.07ab	70.34	59.17ab	1212cd	1201ab
C_0V_4	26.87	25.60c-f	38.60	58.39ab	2109a	1312ab
C_0V_5	29.53	27.73a-d	60.14	55.95b	1133cd	1063ab
C_0V_6		28.80a-c		57.60ab		1378a
C_1V_1	22.07	23.20f	60.59	58.10ab	1097d	964b
C_1V_2	27.60	24.60d-f	55.22	60.19ab	1119cd	990b
C_1V_3	28.60	28.00a-c	63.36	53.52b	1438bc	1092ab
C_1V_4	26.40	27.87a-d	38.12	60.08ab	1775ab	1225ab
C_1V_5	25.73	27.73a-d	60.12	54.75b	1213cd	1006ab
C_1 V_6		30.93a		60.67ab		1265ab
F-test	NS	8	NS	*	*	*

C_0 = Control or no cut and C_1 = one cut of shoot at 50 days after emergence); Factor B: Number of grasspea variety (V_1 = BARI Khesari-1, V_2 = BARI Khesari-2, V_3 = BARI Khesari-3, V_4 = BARI Khesari-5 V_5 = Faridpur local variety) and V_6 = BARI Khesari-6

From the two years result, it was revealed that yield contributing characters and yield of grasspea were significantly influenced by the interaction of shoot cutting and variety except pod/plant and 1000-seed wt. in 2020-21 (Table 2). Highest number of pods /plant (30.93) was recorded in C_1V_6 (One cut of shoot at 50 DAE in BARI Khesari-6) which was followed by C_0V_3, C_0V_5, C_1V_5, $C_1V_3$and C_1V_4. The lowest number of pods /plant (23) was recorded in C_1V_1 (One cut of shoot at 50 DAE in BARI Khesari-1). The 1000-grain weight also influenced significantly by shoot cutting and variety. The highest grain weight (64.80 g/1000 grain) was recorded from C_0V_2 which was identical with that of most of treatments. Significantly the lowest grain weight was recorded from C_0V_5 (55.95 g/1000 grain). The contribution of all the yield components finally contributed to the seed yield. Significantly the highest seed yield (2109 kg/ha in 2020-21) was obtained from C_0V_4 (control in BARI Khesari-5) treatment but in 2021-22, the highest yield was recorded in C_0V_6 (control with BARI Khesari-6) treatment . The lowest yield (1097 kg/ha in 2020-21 and 964 kg/ha in 2021-22) was recorded in C_1V_1 (one cut of shoot at 50 days after emergence in BARI Khesari-1) treatment.

Economic performance

Benefit cost analysis of grass pea production as influenced by interaction of shoot cutting and variety has been presented in Table 3. In 2020-21, among the treatments, the maximum gross return (Tk. 104209/ha) , gross margin (Tk. 46476/ha) and BCR (2.21) were observed in C_1V_4 ((one cut of grasspea shoot at 50 DAE in BARI Khesari-5) treatment followed by C_1V_5. In 2021-22, the maximum gross return (Tk. 152249/ha) gross margin (Tk. 105839/ha) and BCR (3.28) were observed in C_1V_6treatment followed by C_1V_4 and C_1V_5 treatment.

Table 3. Cost-return analysis of grasspea as influenced by shoot cutting and variety during *rabi* season of 2020-21 and 2021-22

Interaction (Cut X Var.)	Gross return (Tk/ha)		Gross margin (Tk/ha)		Benefit cost ratio (BCR)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
C_0V_1	49229	49547	7144	8137	1.17	1.20
C_0V_2	49581	51869	7496	10459	1.18	1.25
C_0V_3	55184	52947	13099	11537	1.31	1.28
C_0V_4	91032	57942	48947	16532	2.16	1.40
C_0V_5	50650	48206	8565	6796	1.20	1.16
C_0V_6		60486		19076	-	1.46
C_1V_1	72125	116942	-	70532	1.53	2.52
C_1V_2	74071	103984	25040	57574	1.57	2.24
C_1V_3	93561	120019	26986	73609	1.99	2.59
C_1V_4	104209	151492	46476	105082	2.21	3.26
C_1V_5	95987	146384	57124	99974	2.04	3.15
C_1V_6		152249	48902	105839	-	3.28

Note: C_0 = Control or no cut and C_1 = one cut of grasspea shoot at 50 DAE; V_1 = BARI Khesari-1, V_2 = BARI Khesari-2, V_3 = BARI Khesari-3, V_4 = BARI Khesari-5, V_5 = Faridpur local variety and V_6 = BARI Khesari-6; * and ** Significant at 1% and 5% level of probability, respectively

Conclusion

Although BARI Khesari-6 gave the highest gross margin but BARI Khesari-6 and BARI Khesari-5 and Faridpur local variety could be cultivated for both fodder and seed production in southern region of Bangladesh.

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EFFECT OF TILLAGE AND FERTILIZER DOSES ON SUNFLOWER GROWTH AND YIELD IN SOUTHERN REGION OF BANGLADESH

M.M. RAHMAN, M. A. RAHMAN, M. A. HOUQUE, M.A. RAHMAN AND M. R. UDDIN

Abstract

The field experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during the Rabi season of 2021-2022 to reduce cost of cultivation in Southern region of Bangladesh.The treatments of the experiment were: T_1 F_1= Conventional tillage(Farmers Practice)× Recommended dose, T_1 F_2= Conventional tillage(Farmers Practice)× 75% of RDF, T_1 F_3= Conventional tillage(Farmers Practice)×125% of RDF, T_2 F_1= Power Tiller Operated Seeder× Recommended dose ,T_2 F_2= Power Tiller Operated Seeder× 75% of RDF, T_2 F_3= Power Tiller Operated Seeder ×125% of RDF , T_3 F_1= Strip tillage × Recommended dose , T_3 F_2= Strip tillage × 75% of RDF, T_3 F_3= Strip tillage ×125% of RDF. Results revealed that all the parameters except unfilled seeds/head were significantly varied with interaction of tillage method and fertilizer dose. Highest plant height (90.31 cm) was found from T_2F_1 (PTOS × 75% of RDF) and the lowest(61.54 cm) was fond from T_3F_2 (strip tillage × 75% of RDF). Significantly the highest yield(1.83t/ha) was recorded in (PTOS method× RDF) T_2F_1 treatment which was followed by T_2F_2 (PTOS method×75% of RDF). The highest gross return (Tk. 104530/ha) was observed in T_2F_1 (Power Tiller Operated Seeder× Recommended dose)but the highest (Tk. 39629/ha) gross margin and benefit cost ratio (BCR) were recorded in T_2F_2 (PTOS method× 75% of RDF) treatment. From the economic point of view treatmentT_2F_2 (PTOS method×75% of RDF) might be applied for cultivation of sunflower (BARI Surjomukhi-3) under Ganges Tidal Floodplain

Introduction

Increase of yield and production is the main focusing point in agriculture. Meanwhile, economic production and sustainable agriculture are in getting attention improvement in product quality, reduction in production inputs, conservation the natural resources, and environmental awareness gain importance (Ulusoy, E., 2001). Tillage practices are needed to increase agronomic stability and productivity while enhancing the environment (Hatfield*et al*. 2006). For this reason, sustainable farming and conservation tillage are becoming increasingly attractive to because clearly reduces production cost relative to conventional tillage. In conservation tillage, plants residues remain on the soil surface. They decompose slowly when they are left on the surface. Over the time, a layer of mulch will develop on the soil surface. The mulch layer not only protect the soil from erosion, but will also increase the amount of rainfall that soak into the ground, keeping the water in the soil from evaporating into the atmosphere .Conventional tillage costing more fuel, labor as well as the flora is destructed that forced farmers to minimum tillage which helps both in terms of money and to conserve soil and soil moisture. Also, conservational tillage systems may help less use of fossil fuels and reduced labor requirement; reduce environmental problems, such as soil degradation and decline in biodiversity, related to intensive cropping (Chen, *et al*. 2004). Y .Through conservation tillage the physical and chemical properties remain more or less intact. To increase production and decline production cost in soil tillage operations, reduced tillage and direct seeding system is of great importance. Appropriate tillage and sowing technique can reduce factors that impede seedling emergence reduce energy and labor cost, and control weeds. However, tillage systems are location specific; their success depends on soil, climate and local practices (Ozpinar, S. and Cay, A., 2006).

The objective of this study was to investigate effects of different tillage methods on cost of cultivation, fertilizer rate and yield and yield components sunflower in southern part of Bangladesh. Also, the effect of tillage on protein, oil and ash content were considered to be determined. Reduced and no-tillage methods were compared with conventional tillage systems.

Materials and Methods

The field experiment was carried out at the Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during the *Rabi* and *Late Rabi* season of 2021-22 to reduce cost of cultivation. It also maximize the productivity as well as farmers income. The experimental site is situated in the latitudes and longitudes of $22^{o}47^{/}5.86^{//}$N and $90^{o}17^{/}30.25^{//}$E. The experimental site is located under the agro-ecological zone Ganges Tidal Floodplain (AEZ-13). The soil type is medium high land and soil texture is loamy. The treatments of the experiment were: T_1 F_1= Conventional tillage(Farmers Practice)× Recommended dose, T_1 F_2= Conventional tillage(Farmers Practice)× 75% of RDF, T_1 F_3= Conventional tillage(Farmers Practice)×125% of RDF, T_2 F_1= Power Tiller Operated Seeder× Recommended dose ,T_2 F_2= Power Tiller Operated Seeder× 75% of RDF, T_2 F_3= Power Tiller Operated Seeder ×125% of RDF , T_3 F_1= Strip tillage × Recommended dose , T_3 F_2= Strip tillage × 75% of RDF, T_3 F_3= Strip tillage ×125% of RDF. The whole plot will be sub-divided into twenty seven unit plots. Treatments will be set randomly at each plot. Tillage operations will be done firstly considering tillage unit plots are maintained correctly. Seeds were sown on 27 January, 2022 in line sowing method atseed rate 12 kg/ha. The experiment was laid out in randomized complete block design with three replications. The unit plot size was 5m × 3m The initial soil moisture was 32% on oven dry basis.The experimental plots were fertilized as per recommendation of Fertilizer Recommendation Guide, 2018 (N,P,K,S,Mg,Zn and B @ 70-24-56-16-3-1 and 0.8 respectively). All fertilizers except half of N will be applied during final land preparation.Remaining half N will be applied as two equal split at 20-25 and 40-45 days after planting (before flower initiation stage). Irrigation was applied for two times and other intercultural operations were done as when necessary following the recommended production technologies BARI, 2019).Data were collected on different parameters such as plant population/m^2, days to 50% flowering, days to maturity, plant height, number of head/m^2, number of seeds/head, filled seeds/head, unfilled seeds/head, 1000-seed weight and seed yield/plot, Stover yield/plot. The plot yields were then converted into ton/hectare. Data were analyzed statistically and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) following Gomez and Gomez (1984).

Results and Discussion

Tillage methods and fertilizer doses combined effect

Plant height, yield components and yield of sunflower were significantly influenced by interaction effect of tillage and fertilizer doses (Table 1)except unfilled seed/head.From table 1 it can be explained that the highest plant height was obtained from T_2F_1 meaning PTOS× RDF combination (90.31 cm) which is statistically similar with T_1F_3,T_1F_2,T_2F_3 andT_1F_1. Highest plant population and number of heads/m^2 was found highest in all doses combination of conventional PTOS system (8.00 nos.) and lowest was found in T_3F_3 which denotes as strip tillage in combination with 125% of RDF (7.00 and 6.00 nos. respectively). Largest head was derived from the treatment T_2F_1 meaning PTOS× RDF combination (16.97 cm) and smallest was derived from the treatment T_1F_2 conventional tillage × 75% of RDF combination (9.44 cm).Higher number of seeds/head were found from T_2F_1 meaning PTOS× RDF combination (826.89 nos.) which was similar with treatment T_2F_2,T_1F_3 andT_2F_3. Lower number of seeds/head was found from T_3F_2 meaning strip tillage × 75% of RDF combination (360.22 nos.).Filled seeds/head were found highest in treatment T_2F_2 meaning PTOS× 75% of RDF combination (770.39 nos.) which was statistically similar with treatment T_2F_2,T_1F_3 andT_2F_3 and lowest in treatment T_3F_2 meaning Strip tillage×75% of RDF combination (298.22 nos.). Highest thousand seeds weight were derived from treatment T_2F_2 which was combination of power tiller operated seeder method and 75% of RDF (80.13 gm) which was statistically similar with treatment T_2F_2 andT_2F_3 and lowest was derived from treatment T_3F_2 which was combination of strip tillage method and 75% of RDF (46.90 gm). Significantly the highestyield was observed in treatment interaction of PTOS method× RDF that means T_2F1(1.82 t/ha) and the lowest yield was observed in treatment interaction of strip tillage method×75% of RDF was denoted as T_3F_2 (1.12 t/ha). PTOS in combination with recommended dose of fertilizer which denotes T_2F_1 derived the highest Stover yield (13.03 t/ha) and strip tillage in combination with 75% of RDF which denotes as T_3F_2 derived the lowest Stover yield (12.27t/ha).

Table 1. Yield and yield contributing characters of sunflower were affected by combined effects of tillage and fertilizer dose

Treat.	Plant height (cm)	Pop/m^2 (Nos.)	Head/m^2 (Nos.)	Head dia (cm)	Seed No./Head (Nos.)
T_1F_1	81.20 a	8.00 a	8.00 a	11.96 d	469.89 b
T_1F_2	82.08 a	8.00 a	7.67 a	9.44 g	420.89 bcd
T_1F_3	83.54 a	8.00 a	8.00 a	16.43 c	806.89 a
T_2F_1	90.31 a	8.00 a	8.00 a	16.97 a	826.89 a
T_2F_2	77.31 ab	8.00 a	8.00 a	16.81 b	825.22 a
T_2F_3	82.02 a	8.00 a	8.00 a	16.39 c	795.44 a
T_3F_1	62.93 c	7.67 b	7.33 ab	10.86 f	391.89 cd
T_3F_2	61.54 c	7.00 c	6.67 bc	11.16 e	360.22 d
T_3F_3	65.25 bc	7.00 c	6.00 c	10.75 f	424.89 bc
CV(%)	10.24	2.49	7.30	11.58	6.02
LSD	13.51	0.33	0.95	0.13	61.64

contd.

Treat.	Filled Seed/H (Nos.)	Unfilled Seed/H (Nos.)	1000 Seed Weight (g)	Seed Yield/ Plot (kg)	Yield (t/ha)	Stover Yield (t/ha)
T_1F_1	383.67 b	86.22	53.53 b	6.34 b	1.23 f	12.67 b
T_1F_2	346.33 b	74.56	55.94 b	5.89 d	1.06 i	12.28 d
T_1F_3	760.22 a	46.67	56.58 b	6.09 c	1.78 d	12.28 d
T_2F_1	745.25 a	81.60	80.07 a	7.20 a	1.83 a	13.03 a
T_2F_2	770.39 a	54.83	80.13 a	7.16 a	1.82 b	12.18 e
T_2F_3	724.89 a	70.56	78.62 a	7.08 a	1.80 c	12.62 c
T_3F_1	334.22 b	57.66	50.20 bc	5.37 f	1.21 g	12.67 b
T_3F_2	298.22 b	62.00	46.90 c	5.34f	1.12 h	12.27 d
T_3F_3	370.22 b	54.67	53.07 bc	5.54 e	1.24 e	12.28 d
CV(%)	9.71	47.89	6.19	1.14	0.35	5.69
LSD	88.43	NS	6.61	0.13	0.008	2.22

T_1 F_1= Conventional tillage(Farmers Practice)× Recommended dose, T_1 F_2= Conventional tillage(Farmers Practice) × 75% of RDF, T_1 F_3= Conventional tillage(Farmers Practice) × 125% of RDF, T_2 F_1= Power Tiller Operated Seeder × Recommended dose ,T_2 F_2= Power Tiller Operated Seeder × 75% of RDF, T_2 F_3= Power Tiller Operated Seeder × 125% of RDF , T_3 F_1= Strip tillage × Recommended dose , T_3 F_2= Strip tillage × 75% of RDF, T_3F_3=Striptillage×125%ofRDF

The economic analysis of sunflower as affected by tillage and fertilizer dose has been presented in Table 2. The highest gross return (Tk. 104530/ha) was observed in T_2F_1which was followed by PTOS method× RDF. The lowest gross return (Tk. 65280/ha) was found in treatment T_1F_2 which was of conventional tillage method×75% of RDF. The gross margin was found to be the highest (Tk. 39629/ha) in treatment T_2F_2 which was combination of PTOS method× 75% of RDF. The value of benefit cost ratio (BCR) revealed the highest (1.62) in treatment T_2F_2. The BCR value in treatment T_1F_2(0.95) was found lowest. From economic point of view treatment T_2F_2 which was combination of PTOS method× 75% of RDF might be practiced for getting more income from the sunflower cultivation in Rabi season.

Table 2. Economic return of Effect of tillage and fertilizer doses on Sunflower

Treatment	Yield (t/ha)	Stover Yield (t/ha)	TVC (Tk/ha)	Gross Return(Tk/ha)	Gross Margin(Tk/ha)	Benefit Cost Ratio
T_1F_1	1.23	12.67	70452	74170	3718	1.05
T_1F_2	1.06	12.28	68907	65280	-3627	0.95
T_1F_3	1.78	12.28	69731	101280	31549	1.45
T_2F_1	1.83	13.03	66023	104530	38507	1.58
T_2F_2	1.82	12.18	63551	103180	39629	1.62
T_2F_3	1.8	12.62	64787	102620	37833	1.58
T_3F_1	1.21	12.67	63551	73170	9619	1.15
T_3F_2	1.12	12.27	62109	68270	6161	1.10
T_3F_3	1.24	12.28	64787	74280	9493	1.15

T_1 F_1= Conventional tillage(Farmers Practice)× Recommended dose, T_1 F_2= Conventional tillage(Farmers Practice)× 75% of RDF, T_1 F_3= Conventional tillage(Farmers Practice)×125% of RDF, T_2 F_1= Power Tiller Operated Seeder× Recommended dose ,T_2 F_2= Power Tiller Operated Seeder× 75% of RDF, T_2 F_3= Power Tiller Operated Seeder ×125% of RDF , T_3 F_1= Strip tillage × Recommended dose , T_3 F_2= Strip tillage × 75% of RDF, T_3 F_3= Strip tillage ×125% of RDFNote: Seed and product price: Sunflower seed = 50 Tk/kg, Sunflower Stover = 1 Tk/kg.

Conclusion

From the economic point of view treatment PTOS method× 75% of RDFT_2 might be applied for cultivation of sunflower (BARI Surjomukhi-3) under Ganges Tidal Floodplain. This was the second year experiment and therefore final recommendation will be made by repeating the experimentation in different location of the region.

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EFFECT OF DIFFERENT CONCENTRATION AND APPLICATION TIME OF GIBBERALIC ACID ON GROWTH AND YIELD OF POTATO

M. S. HUDA AND MOST. M. KHANUM

Abstract

The experiment was conducted to find out the appropriate application time and GA_3 concentration for maximizing seed potato production by increasing seed tuber number per plant and yield at the research field of Agricultural Research Station, Rajbari, Dinajpur, during 2021-22. The treatments combinations were as follows; the different application time of GA_3 was used as Factor A: i.e. A_1=Just after desprouting of seed, A_2=At 30 DAP (seedling stage), A_3=At 45 DAP (vegetative growth stage) and A_4=At 60 DAP (maturity stage). The Different concentration of GA_3 were used as factor B; ie. G_{00} = 00 ppm, G_{20} = 20 ppm, G_{40} = 40 ppm and G_{60} = 60 ppm. The application of GA_3 influenced on germination% at 12 DAP, the number of tuber per plant and tuber weight per plant and yield. Application of GA_3 (20 to 40 ppm) in seed tuber or in seedling of potato can increase the number of tuber per plant and also

yield. Significantly the highest yield (51.0 t/ha) was recorded in A_4G_{20} which was statistically followed by A_4G_{40} (50.73ton/ha), A_3G_{20} (45.4 ton/ha), A_3G_{40} (44.5 ton/ha),, A_2G_{40}(44.3 ton/ha), A_4G_{60} (42.17 ton/ha), and A_3G_{60} (41.00 ton/ha).From the above results it may be concluded that application of GA_3 in seed tuber or in seedling of potato can increase the number of tuber per plant and application of GA_3 in vegetative stage of potato can increase the yield of potato.

Introduction

Potato cultivation contributes to meet the increasing need for food created by world population growth (Virtanen, 2014). Seed potato is the starting point in the potato (*Solanum tuberosum* L.) production chain. In order to secure potato production, plant diseases must be controlled and production must be cost effective. The conventional method of bulking seed potatoes is by repeatedly multiplying a set of tubers that have been proven to be disease-free in a process known as clonal multiplication (Bryan, 1981). In addition, continuous field multiplication of the clones exposes the tubers to viruses and soil-borne pathogens especially wilt. This calls for regular disease management through thermotherapy thereby increasing the breeding period and raising the costs even further. This method has a low multiplication rate, about 6-8 daughter tubers per plant (Otazu, 2008). The conventional potted media method that produces approximately 6-8 daughter tubers only in the same period (Hussey and Stacey, 1981; CIP, 2008; Otazu, 2008). But, by treating the tubers with gibberellic acid, the tubers will sprouts faster and the tubers treated with GA_3 produce more number of seed tubers (Rehman *et al.*, 2001). GA_3 treatments significantly increased the number of sprouts and at lower concentration (100 mM) GA_3 increased the number of tubers in the cultivar Fambo (Virtanen *et al.*, (2014). Moreover, foliar application of GA_3 causes significant increase in subsequent germination, stems per plant, leaflets per plant and number of tubers per plant at harvest with increased rate of application in potato. GA_3 enhances vegetative growth; average number of stems, leaflets number and more yields. More sprouts per tuber may result in more stems per plant. Consequently, more stems per plant results more leaves, and the ground cover taking place at a faster rate of ground cover, higher amount of intercepted radiation and assimilation and hence higher total yields .GA_3 increased plant growth and tuber yield but decreased disease incidence considerably and maximum healthy tuber yield was obtained due to application of gibberellicacid .

Lack of good quality seeds among the growers is the major problem adversely affecting the expansion of potato production in many developing countries (Crissman *et al.*, 1993). Due to this, the seeds are highly priced and beyond the reach of many farmers. The widespread use of seed tubers from informal sources, whose health status cannot be guaranteed, has led to low yields, poor quality produce, and spread of pests and diseases. The main bottleneck in this formal seed supply system is the slow multiplication of basic seed into certified seed. To mitigate the bottlenecks caused by this conventional multiplication method, rapid seed potato multiplication techniques have been adopted which include micro-propagation (tissue culture), hydro-phonics and aero-phonics (Muthoni, J. and J. Kabira, 2014) systems, whose are also very cost and in at controlled environment.

It is the crying needs for the seed growers to increase the multiplication rate of seed potato. So, the number of seed tubers per plant at the field of seed multiplication scheme is very important. For these reasons, the experiment was undertaken to find out the suitable method of multiplication of seed potato with ensuring comparatively disease free and quality seed potato and higher seed multiplication rate. Therefore the present experiment was undertaken with the following objectives:

- To find out appropriate concentration and appropriate time of GA_3 application in potato tuber production
- To increase seed tuber number per plant and tuber yield of potato

Materials and Methods

The experiment was carried out during *rabi* season of 2020-21 at Agricultural Research Station, Bangladesh Agricultural Research Institute, Dinajpur to find out the appropriate application time and GA_3 concentration for maximizing seed potato yield in Bangladesh. The treatments combinations were as follows; Factor A: Different Application time of GA_3. A_1= Just after desprouting of seed, A_2= At 30 DAP (seedling stage), A_3= At 45 DAP (vegetative growth stage), A_4= At 60 DAP (maturity stage ,Factor B: Different concentration of GA_3 viz. 1. G_{00}= 00 ppm, 2. G_{20}= 20 ppm 3. G_{40} = 40 ppm and 4. G_{60} = 60 ppm. The 28 to 40 mm size foundation seed tubers of variety “BARI Alu 36” were used in the study with 60 cm × 30 cm spacing planted in RCBD design with three replications. Planting was done on 10 November

2021. The plot size was 3 m × 3 m. Cowdung was used during land preparation at rate of 10 t/ha. Chemical fertilizers were applied with 120-39-75-20 N-P-K-S kg/ha, respectively (FRG,2018). Half of N, K and full dose of P, S were applied at time of final land preparation and remaining N and K were applied as top dress at 25 and 50 days after planting (DAP) followed by irrigation. The crop was haulm pulled at 7 February 2022 of 90 DAS**.** (Days after sawing), and 10 days after haulm pulling the crop was harvested. The five plants were harvested randomly at the first time from each plot and then the rest of the plants will be harvested with help of a country plough and spade. Care was taken to avoid injury in potatoes during harvesting. Collected data were analyzed statistically by using R software packages and mean differences for each character were compared by Least Significant Difference (LSD) test (Gomez and Gomez. 1984).

Stock solution preparation (GA_3)

One gram GA_3 was dissolved in 70% ethyl alcohol (1 to 3 ml) and then make it volume 100 ml by adding distilled water, thus 10000 ppm GA_3 was prepared as stock solution. Then 20, 40 and 60 ppm GA_3 solutions were prepared by adding distilled water and the following formula was used $V_1S_1=V_2S_2$, Where V_1=Volume of Stock solution, S_1=Strength of Stock solution, V_2=Volume of expected solution and S_2=Strength of expected solution.

Preparation of planting materials and GA_3 application

The seed tubers were taken out from the cold storage 8 days before planting. Non sprouted tuber of potato was wetted one time by spraying with different concentrated GA_3 solution and spread over the floor under diffused light for sprouting. The good looking, healthy and well sprouted seed tubers were used for planting.

Results and Discussions

The effect of GA3 on emergence of seed potato:

The effect of different concentration of GA_3 on emergence percentage was varied significantly. The highest emergence percentage (87.3) was recorded from A_1G_{40} and the lowest emergence percentage (72.71) was counted from A_1G_{00} (Fig. 1). The emergence percentage is increased by applying GA_3 on mother seed tuber. This result is supported by Barani *et al.* (2013), where they reported that with increasing the concentration of Gibberellic acid (GA_3) (0, 5, 10 mg/lit, respectively) more and more number of sprouts were observed.

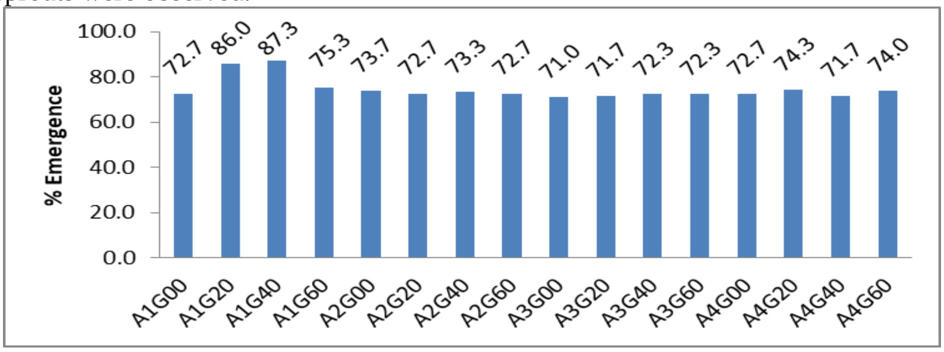

Figure 1: Effect of GA3 on the emergence percentage at 12 DAP in potato field

The effect of different application time and different concentration of GA_3 on the yield and yield component of potato was varied significantly (Table-1). The highest total tuber weight (1.09 kg) per plant was recorded from A_2G_{40} which was statistically similar with A_1G_{40} (0.93 kg), A_2G_{60} (0.95 kg), A3G_{40} (1.0 kg), A4G6_0 (0.99Kg) and A4G_{40} (0.94Kg). The lowest total tuber weight (0.74 Kg) per plant was recorded from A_1G_{60}. The highest total tuber number (16,33) per plant was recorded from A_1G_{40} which was statistically similar with A_2G_{40} (15.6), A_1G_{20} (13.97), A1G_{60} (13.8). The lowest total tuber number (9.87 Kg) per plant was recorded from A_2G_{00}.In case of yield of potato, the highest yield (51.0 t/ha) was recorded from A_4G_{20} which was statistically followed by A_4G_{40} (50.73 t/ha), A_3G_{20} (45.4 t/ha), A_3G_{40} (44.5 ton/ha),, A_2G_{40}(44.3 t/ha), A_4G_{60} (42.17 t/ha), and A_3G_{60} (41.00 t/ha).The lowest yield (33.7 ton/ha) was recorded from $A_4G_{00.}$

These may be due to application of GA_3 increase sprout number / tuber or stem number / plant which increase more number of tuber / plant. These more number of tubers was consumed similar nutrients comparison with G_{00} and the tubers become smaller. Similar findings have also been reported by Akbari *et al.,* (2013), Loretta and Mikitzel (1993) they reported that the production of seed tubers increased by using Gibberellic acid hormone.

Table 1: Effect of different application time and different concentration of GA_3 on yield and yield component of potato

Treatments	LAC% at 75 DAP	Plant height at 75 DAP (cm)	tuber no/ plant	tuber weight /plant (Kg)	Yield (ton/ha)
$A1G_{00}$	95.00	69.13	11.33	0.86	35.79
$A1G_{20}$	97.33	69.80	13.97	0.89	37.88
$A1G_{40}$	100.00	73.67	16.33	0.93	36.67
$A1G_{60}$	99.00	73.53	13.80	0.74	36.73
A_2G_{00}	94.33	73.73	9.87	0.85	38.07
A_2G_{20}	98.67	77.87	10.67	0.88	40.55
A_2G_{40}	98.33	79.40	15.60	1.09	44.03
A_2G_{60}	98.00	82.27	12.63	0.95	45.80
A_3G_{00}	94.00	72.13	10.07	0.79	37.60
A_3G_{20}	99.00	82.60	11.27	0.93	45.43
A_3G_{40}	95.33	79.27	11.20	1.00	44.52
A_3G_{60}	98.33	75.53	9.93	0.79	41.48
A_4G_{00}	93.00	73.53	9.74	0.79	33.70
A_4G_{20}	98.00	84.00	11.13	0.88	51.00
A_4G_{40}	98.00	78.67	11.07	0.94	50.73
A_4G_{60}	98.67	76.53	12.20	0.99	42.17
$LSD_{.05}$	6.85	15.05	3.5072	0.266	13.07
CV%	2.32	7.28	9.66	9.79	10.37

Here, A_1=Just after desprouting of seed, A_2=At 30 DAS (seedling stage), A_3=At 45 DAS (vegetative growth stage) and A_4=At 60 DAS (maturity stage); G_{00} = 00 ppm, G_{20} = 20 ppm, G_{40} = 40 ppm, G_{60} = 60 ppm Means followed by the same letter within same column do not differ significantly at 5% level of DMRT. Figures in parenthesis indicate transformed values.

Conclusion

From the above result it may be con concluded that application of GA_3 in seed tuber or in seedling of potato can increase the number of tuber per plant and application of GA_3 in vegetative stage of potato can increase the yield of potato.

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EFFECT OF DIFFERENT SOWING TIME AND SPACING OF ADVANCED LINSEED LINE (Lin-W-17)

M. S. HUDA AND M. M. KHANUM

Abstract
The trial was carried out at ARS, BARI, Dinajpur during *rabi* season of 2021-22 to find out suitable sowing time and spacing for higher yield of linseed for Dinajpur region. There were four sowing time viz., 15 November,30 November, 15 December and 30 December and four line spacing viz. 15, 20, 25 and 30 cm in the study. The highest yield (2.22 t/ha) was recorded from 15 November with 25 cm spacing which was statically similar with 30 November with 25 cm spacing (2.09 t/ha), 15 Nov with 30 cm spacing (1.98 t/ha) and also 15 November with 20 cm spacing (1.96 t/ha). The resut revealed that November sowing with 25-30 cm line spacing would be the most suitable sowing time at Dinajpur region of advanced linseed line of Lin-W-17.

Introduction
Linseed, *Linumusitatissimum* L., is an oil seed crop in the family Linaceae, appeared as one of the most important oilseed crops for industrial purposes, as well as in terms of being a source of food and feed, and fiber. This aspect of linseed utilization was comprehensively reviewed recently (Singh et al., 2011). Typically, linseed consists of approximately 40% fat, 28% dietary fiber, 21% protein, 4% ash, and 6% carbohydrates (Vaisey-Genser and Morris, 2010). Linseed has wide uses: it is a source of food, feed, fiber, oil, medicine, industrial raw material and export commodity. Linseed possesses a very healthy fatty acids (linoleic-Omega 6 and alpha-linolenic acids or Omega 3). Linseed cake is rich in microelements, vitamins, dietary cellulose, and proteins (up to 38%) (Altai, 2010). Linseed oil has been used as a drying agent for paints, varnishes, linoleum, lacquer, and printing ink. Medicinal uses of linseed include promotes heart health, lowers cholesterol, protects against strokes, lowers blood pressure, used for constipation and helps guard against breast cancer and other cancers (Budwig, 1994; Connor, 2000). Last year, there was an adaptive trail of line of white linseed in Dinajpur which is recently applied for registration as a new variety. Local farmer's are so much interested for producing this oil seed crop. For this reason the experiment was undertaken to find out suitable sowing time and spacing for higher yield of linseed for Dinajpur region.

Materials and Methods

The trial was carried out at ARS, BARI, Dinajpur during rabi season of 2021-22 to find out suitable sowing time and spacing for higher yield of linseed at Dinajpur region. There were four sowing time viz., 15 November, 30 November, 15 December and 30 December and four line spacing were as 15, 20, 25 and 30 cm. The experiment was laid out in RCBD with 3 replications and plot size was 6.0 m × 3 m. The crop was fertilized with at the rate of 45: 15: 25: 10 kg/ha NPKS (FRG, 2018). Chemical fertilizers were used in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid.Half of urea and all the fertilizers were applied during the final land preparation. Remaining urea was applied at flowering initiation (20 days after germination) as top dress.Intercultural operations like watering, weeding and pest control were done as and when required.Yield components of linseed were taken from randomly selected 5 plants from each plot. Seed yield were taken from whole plot. Collected data were analyzed statistically by using R software packages and mean differences for each character were compared by Least Significant Difference (LSD) test (Gomez and Gomez. 1984).

Results and Discussion

Highest crop growth duration was recorded (126 days) in 30 November sowing due to prevailing lower mean air temperature (19.64^{0}C). The second highest crop growth duration was recorded (126 days) in 15 November sowing due to prevailing lower mean air temperature (19.15^{0}C). The minimum duration (112days) was recorded in 30 December sowing due to prevailing higher mean air temperature (21.40^{0}C). Yield and yield contributing characters of linseed as influenced by sowing date and row spacing have been presented Table 1.The highest number of branches per plant was obtained from 30 November with 25 cm line spacing (4.67). The lowest number of branches per plant was obtained from 30 December with 15 cm line spacing (2.23). The highest number of pods per plant was recorded from 15 November with 25 cm line spacing (115) and the lowest was recorded from 30 December with 15 cm line spacing (55). The highest number of seeds / pod was found from 15 November with 25 cm line spacing (9.47), while the lowest was recorded from 30 December with 15 cm line spacing (7.40). The largest number of 1000 seed weight was counted from 15 November with 25 cm line spacing (6.55 g). The lowest number of 1000 seed weight was counted from 30 December with 25 cm line spacing (3.69 g). The maximum seed weight per meter square was counted from 15 November with 25 cm line spacing (276 g). The minimum seed weight per meter square was counted from 30 December with 25 cm line spacing (78.7 g). The highest yield (2.22 t/ha) was recorded from 15 November with 25 cm spacing which was statically similar with 30 November with 25 cm spacing (2.09 t/ha), 15 Nov with 30 cm spacing (1.98 t/ha) and also 15 November with 20 cm spacing (1.96 t/ha). The lowest yield (0.60 t/ha) was recorded from 30 December with 25 cm spacing. Different sowing times and spacing influenced the crop growth, development and yield. These results are consistence with many workers (Thongam *et al.,* (2017), and Alam *et al.,* (2017) reported that different planting dates influenced yield and yield contributing characters.

Table 1. Effect of different sowing time and spacing on yield and yield component of linseed line (Lin-W-17) in dinajpur during *rabi* 2021-22

Treatments	Maturity date	Branch /plant(no.)	Pods/plant (no.)	Seeds/pod (no.)	1000 seed wt. (g)	Yield (t/ha)
15 Nov. ×15cm	126	3.63	100.67	7.70	4.38	1.78
15 Nov.× 20 cm	126	4.07	105.33	8.60	4.93	1.96
15 Nov. ×25cm	126	4.37	115.00	9.47	6.55	2.22
15 Nov.× 30cm	126	4.37	114.67	8.80	6.17	1.98
30 Nov.×15cm	122	4.10	97.33	8.50	4.69	1.64
30 Nov. ×20 cm	122	4.30	99.00	9.00	4.74	1.75
30 Nov.× 25cm	122	4.67	112.67	9.13	4.71	2.09
30 Nov.× 30cm	122	4.60	114.67	8.80	4.82	1.68
15 Dec. ×15cm	120	2.93	76.00	8.00	3.93	1.04
15 Dec.× 20 cm	120	3.17	81.00	8.60	3.87	0.96
15 Dec.× 25cm	120	3.37	87.67	9.00	4.04	0.83
15 Dec.× 30cm	120	3.40	89.67	8.77	4.25	0.76
30 Dec.× 15cm	112	2.23	55.00	7.40	4.45	0.93
30 Dec.× 20 cm	112	2.37	58.33	7.57	4.76	0.66
30 Dec.×25cm	112	2.47	62.67	8.40	3.69	0.60
30 Dec.×30cm	112	2.57	63.00	8.50	4.29	0.62
$LSD_{0.05}$	14.55	1.20	35.04	1.86	1.77	0.38
CV%	6.8	11.11	12.86	7.19	12.55	9.34

DAS= Days after sowing

Conclusion

From the results it may be concluded that November sowing with 25- 30 cm continuous line spacing would be optimum for getting higher yield of linseed in Dinajpur region.

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EFFECTS OF SPACING AND FERTILIZER DOSE ON TRANSPLANTED SUNFLOWER UNDER ZERO TILLAGE CONDITION IN SOUTHERN REGION OF BANGLADESH

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Abstract

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during *Rabi* season of 2021-22 to find out the optimum spacing and fertilizer dose for getting higher yield of transplanted sunflower under zero tillage condition in southern region of Bangladesh. The experimental treatment comprised of two factors viz., Factor A. Three spacing (S_1 = 50 cm × 25 cm, S_2 = 40 cm × 25 cm and S_3 = 30 cm × 25 cm) and Factor B. Four doses of fertilizer (F_1 = Recommended dose (105-36-84-24-2-1.6 kg/ha of NPKSZnB), F_2 = RD (105-36-84-24-2-1.6 kg/ha of NPKSZnB)+ 10% RD; F_3 = RD()105-36-84-24-2-1.6 kg/ha of NPKSZnB) + 20% RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) and F_4 = RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) + 30% RD). Results revealed that plant spacing and fertilizer levels have great influence on yield of sunflower. Significantly the highest yield (2665 kg/ha) was recorded in S_2F_4 {40 cm × 25 cm along with fertilizer dose RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) + 30% RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) } treatment and it was statistically similar to S_2F_2 treatment (2664 kg/ha). The highest gross margin (Tk. 136233/ha) was observed from S_2F_4 treatment. In terms of benefit cost ratio (BCR), S_2F_4 treatment gave the highest value (2.77) which was similar to that of S_2F_3 (2.45). From the results, it may be concluded that seedling (14-day old) transplanting with spacing of 40 cm × 25 cm (S_2) along with 10-20% more fertilizer of recommended dose (105-36-84-24-2-1.6 kg/ha of NPKSZnB) under zero tillage condition just after harvesting of T.*aman* rice might be suitable for higher grain yield and economic return of sunflower cultivation in southern region of Bangladesh.

Introduction

Sunflower (*Helianthus annuus* L.) is an important oilseed crop in Bangladesh. The crop is cultivated in an area of 1290 hectares with an annual production and yield of 1975 tonnes and 1530 kg per hectare, respectively. Of the total production of sunflower, about 59% is produced in southern region t the country (BBS, 2019). Sunflower is inherently a moderately saline tolerant crop species and the area under this crop is increasing day by day and gains popularity among the farmers. Previous research findings showed that sunflower can be cultivated through transplanting of 7-14 days old seedlings under zero tillage condition just after harvesting of T.*aman* rice in southern region (Rahman, 2021). Seedling transplanting of sunflower reduces the plant height and canopy size with increasing the seedling age. The existing recommendation of fertilizer dose and spacing (50 cm x 25 cm) have been made based on the direct seeding of the crop with conventional tillage condition. Sunflower needs a balanced nutrition for its optimum growth and thorough maintenance of soil health (Mukherjee *et al*., 2019). Begum *et al*. (2021) reported that cultivation of dwarf sunflower variety (BARI Sunflower-3) with recommended dose (RD) + 20%RD) gave higher yield and economic return in southern region of Bangladesh. Transplanting of seedling with closer spacing and increased dose of fertilizer may increase the yield of the crop. However, research works regarding the effect of spacing and fertilizer dose on transplanted sunflower have not conducted yet in the country. Therefore, the experiment was undertaken to find out the optimum spacing and fertilizer dose for getting higher yield of transplanted sunflower under zero tillage condition in southern region of Bangladesh.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during *Rabi* season of 2021-22 after T.*aman* rice (cv. BRRI dhan52) to find out the optimum spacing and fertilizer dose for getting higher yield of transplanted sunflower under zero tillage condition in southern region of Bangladesh. The experimental site is situated in the latitudes and longitudes of N22°47′6.33264″N and 90°17′32.64245″E. The experimental site belongs to the agro-ecological zone Ganges Tidal Floodplain (AEZ-13). The soil type is medium high land and soil texture is loamy. The experimental treatment comprised of two factors viz., Factor A. Three spacing (S_1 = 50 cm × 25 cm, S_2 = 40 cm × 25 cm and S_3 = 30 cm × 25 cm) and Factor B. Four doses of fertilizer (F_1 = Recommended dose (105-36-84-24-2-1.6 kg/ha of NPKSZnB), F_2 = RD (105-36-84-24-2-1.6 kg/ha of NPKSZnB)+ 10% RD; F_3 = RD()105-36-84-24-2-1.6 kg/ha of NPKSZnB) + 20% RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) and F_4 = RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) + 30% RD). The sunflower seedlings were transplanted under zero tillage condition just after harvest of T.*aman* rice. The experiment was laid out in randomized complete block design with three replications. The unit plot size was 4 m × 3 m. Seedlings of 14-day old of open pollinated variety namely BARI Surjomukhi-2 were transplanted on 9 December, 2021 as per treatment specifications. Previously, seeds were sown on seed bed on 23 November 2021 to get desirable age of seedlings (14-day old) for this experiment. Fertilizers were also applied as per treatment specifications. Half of urea, all other fertilizers and cowdung were applied as basal at 5 days before seedling transplanting. The rest half amount of urea was applied as side dressing in two equal installments, one at 15-20 days after transplanting (DAT) and the other at 35-40 DAT (before flowering). Data were collected on different parameters such as plant population/m^2, root length/plant, root surface area/plant, root volume/plant, days to 50% flowering, days to maturity, plant height, head diameter, number of filled seed/head, 1000-seed weight, seed weight/plot and stover weight/plot. The parameters (root length, surface area and volume) of plant root systems were measured by using computer based Root Scanner (Model: CI-600, Brand: CID-Bio science, USA). The plot yields were then converted into ton/hectare. Data were analyzed statistically using windows based computer software of Statistix 10 version and then the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) following the protocol as suggested by Gomez and Gomez (1984).

Results and Discussion

Plant population, root length, root volume, days to 50% flowering and maturity were significantly influenced by plant spacing and fertilizer doses (Table1). The highest root length /plant (456.63 cm) was observed when wider spacing with lower population (S_1) was fertilized with the highest dose F_4 (136-46-110-30-11-3 kg/ha of NPKSZnB) followed by S_1F_3, S_2F_3 and S_2F_4 treatment and the shortest root length /plant (288.85 cm) was found in $S_3 \times F_1$ combination. The highest value of root surface area/plant (181.84 cm^2) was recorded in S_2 F_4 {(40 cm × 25 cm) along with higher fertilizer dose(136-46-110-30-11-3 kg/ha of NPKSZnB) treatment that was partially at par to that of S_3F_4, S_1F_4, S_2F_3, S_1F_3 and S_1F_2 treatment combinations. The highest volume of root/plant (5.44 cm^3) was recorded in S_1F_3 treatment which was similar to S_1F_4 (5.17 cm^3), S_2F_2 (4.45 cm^3), S_3F_4 (4.26 cm^3), S_2F_4 (4.25 cm^3) and S_1F_1 (4.23 cm^3). The lowest value of root volume (3.05 cm^3) was recorded in S_3F_1 interaction.The highest duration for 50% flowering was recorded in S_1F_4 interaction (74 days) due to higher fertilizer dose(136-46-110-30-11-3 kg/ha of NPKSZnB). The lowest duration for 50% flowering was recorded (70 days) in S_2F_1due to lower fertilizer dose. Sunflower transplanted with S_1F_4 treatment combination needed the highest number of days (115) to maturity and S_3F_1 treatment took the lowest number of days (110) to become maturity due to lower fertilizer dose.

Yield components and yield of sunflower were significantly influenced by interaction effect of plant spacing and fertilizer doses (Table 2) except Plant height.Highest (17.60 cm) head diameter of sunflower was observed when wider spacing with lower population (S_1) was fertilized with the highest dose F_4 (136-46-110-30-11-3 kg/ha of NPKSZnB) and the lowest diameter was obtained from S_3F_2 interaction. Number of seed/head (filled) was the highest (605.68) in S_3F_2 interaction which was followed by S_2F_1 (599.32), S_2F_2 (517.30) and S_2F_3 (511.59). Interaction of S_3F_4 gave the lowest number of seed/head (355.51). Weight of 1000-seed was found in S_2F_3 (69.64), which was partially at par to that of S_1F_3 (67.19 g), S_1F_4 (65.60 g), S_2F_1 (65.58 g) and S_3F_3 (65.52 g) treatment interaction and the lowest weight was recorded in S_3F_4 (61.60 g). The highest seed yield(2665 kg/ha) was obtained from higher population with higher fertilizer dose (Fertilizer dose (136-46-110-30-11-3 kg/ha of NPKSZnB) with spacing 40 cm × 25 cm) due to higher population produced the higher seed yield followed by S_2F_2 (2664 kg/ha),S_2F_3 (2575 kg/ha), S_3F_3 (2531 kg/ha), S_3F_2 (2476 kg/ha) and S_1F_3 (2400 kg/ha).On the other hand, the lowest seed (1856 kg/ha)yield was observed in $S_1 \times F_1$ combination (lower population with lower fertility) produced lower dry matter accumulation per unit area which reduced seed yield. In case of stover yield, interaction of S_3F_3 showed the highest yield (10.29 t/ha), which was partially identical to that of S_2F_4 (10.13 t/ha), S_2F_2 (10.09 t/ha), S_3F_2 (9.81 t/ha) and S_2F_3 (9.80 t/ha). The lowest yield of stover was found in S_1F_1 (7.53 t/ha).

Table1. Plant pop/m^2, root length/ plant (cm), Root volume/plant days to 50% flowering days to maturity as affected by spacing and fertilizer dose

(Spacing x Fertilizer dose)	Plant pop/m^2 (no.)	Root length/ plant (cm)	Root surface area/ plant (cm^2)	Root volume/ plant (cm^3)	Days to 50% flowering	Days to maturity
S_1F_1	7.47c	296.05d	120.13d	4.23a-c	70.67d-f	112.00c-e
S_1F_2	7.77c	379.27a-c	151.24a-d	4.01bc	72.33a-c	113.00b-d
S_1F_3	7.78c	454.32a	148.59a-d	5.44a	73.00ab	114.33ab
S_1F_4	7.72c	456.63a	158.31a-c	5.17ab	73.67a	115.33a
S_2F_1	9.67b	310.56cd	130.49b-d	3.67c	69.67f	111.33de
S_2F_2	9.70b	357.46b-d	130.44b-d	4.45a-c	70.00ef	112.00c-e
S_2F_3	9.74b	449.99a	150.84a-d	3.97bc	71.33c-e	113.67a-c
S_2F_4	9.48b	445.01a	181.84a	4.25a-c	71.33c-e	113.67a-c
S_3F_1	12.62a	288.85d	122.29cd	3.05c	70.67d-f	110.67e
S_3F_2	12.55a	342.82b-d	120.49d	3.49c	71.00c-f	111.33de
S_3F_3	12.70a	356.01b-d	136.84b-d	3.63c	72.00b-d	113.00b-d
S_3F_4	12.51a	398.64ab	167.17ab	4.26a-c	72.00b-d	114.00a-c
F-test	*	*	*	*	*	*

Table2.Yield component and yield of sunflower as affected by spacing and fertilizer dose

(Spacing x Fertilizer dose)	Plant height (cm)	Head diameter (cm)	Seed/ head (filled)	1000-seed wt. (g)	Seed yield (kg/ha)
S_1F_1	125.47	15.80ab	499.68ab	64.94a-c	1856c
S_1F_2	129.13	15.35ab	482.21ab	65.40a-c	2214bc
S_1F_3	133.80	16.60ab	499.10ab	67.19ab	2400ab
S_1F_4	128.13	17.60a	444.71ab	65.60a-c	2236bc
S_2F_1	131.40	15.37ab	599.32a	65.58a-c	2391ab
S_2F_2	128.47	16.53ab	517.30ab	64.40bc	2664a
S_2F_3	131.53	16.00ab	511.59ab	69.64a	2575ab
S_2F_4	130.20	15.30ab	473.95ab	65.40a-c	2665a
S_3F_1	128.00	15.90ab	430.32ab	63.95bc	2267a-c
S_3F_2	133.87	15.00b	605.68a	65.22a-c	2476ab
S_3F_3	136.93	15.23ab	453.99ab	65.52a-c	2531ab
S_3F_4	134.40	15.40ab	355.51b	61.60c	2277a-c
F-test	NS	*	*	*	*

* Significant at 5% level of probability; NS = Not significant

Three spacing (S_1 = 50 cm × 25 cm, S_2 = 40 cm × 25 cm and S_3 = 30 cm × 25 cm) and Factor B. Four doses of fertilizer (F_1 = Recommended dose (105-36-84-24-2-1.6 kg/ha of NPKSZnB), F_2 = RD (105-36-84-24-2-1.6 kg/ha of NPKSZnB)+ 10% RD; F_3 = RD()105-36-84-24-2-1.6 kg/ha of NPKSZnB) + 20% RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) and F_4 = RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) + 30% RD)

Economic performance

Benefit cost analysis of sunflower production as influenced by interaction of spacing and fertilizer dose has been presented in Table 3. Among the treatment interactions, S_2F_4 gave the highest gross return of Tk. 213205/ha (Table 3) which was similar to S_2F_2 (Tk. 213161), S_2F_3 (Tk. 206005) and S_3F_3 (Tk. 202449/ha). The lowest gross return was found in S_1F_1 (Tk. 148492/ha). The gross margin exhibited the highest value (Tk. 136233/ha) by S_2F_4 interaction which was similar to S_2F_2 (Tk. 122197), S_2F_3 (Tk. 122037) and S_3F_3 (Tk. 118481) but the lowest margin was obtained from S_1F_1 (Tk. 50532/ha). In terms of benefit cost ratio (BCR), treatment interaction of S_2F_4 gave the highest value (2.77), which was similar to that of S_2F_3 (2.45), S_3F_3 (2.41), S_3F_4 (2.37), S_2F_2 (2.34) and S_1F_4 (2.32). The lowest BCR was found in S_1F_1 (1.52). From the economic analysis, it was revealed that sunflower seedling transplanted with the application of S_2F_4, S_2F_2, and S_2F_3 treatment interactions were more profitable than that of S_1F_1.

Table 3.Cost and return of sunflower cultivation as influenced by interaction effect of spacing and fertilizer dose during *rabi* 2021-2022

Treatment	Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)	Benefit cost ratio (BCR)
S_1F_1	148492	97960	50532	1.52
S_1F_2	177160	90964	86196	1.95
S_1F_3	192027	83968	108059	2.29
S_1F_4	178849	76972	101877	2.32
S_2F_1	191249	97960	93289	1.95
S_2F_2	213161	90964	122197	2.34
S_2F_3	206005	83968	122037	2.45
S_2F_4	213205	76972	136233	2.77
S_3F_1	181382	97960	83422	1.85
S_3F_2	198094	90964	107130	2.18
S_3F_3	202449	83968	118481	2.41
S_3F_4	182183	76972	105211	2.37

Three spacing (S_1 = 50 cm × 25 cm, S_2 = 40 cm × 25 cm and S_3 = 30 cm × 25 cm) and Factor B. Four doses of fertilizer (F_1 = Recommended dose (105-36-84-24-2-1.6 kg/ha of NPKSZnB), F_2 = RD (105-36-84-24-2-1.6 kg/ha of NPKSZnB)+ 10% RD; F_3 = RD()105-36-84-24-2-1.6 kg/ha of NPKSZnB) + 20% RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) and F_4 = RD(105-36-84-24-2-1.6 kg/ha of NPKSZnB) + 30% RD)

Sunflower seed price: Tk. 80/kg, stover price: Tk. 0.50/kg

Conclusion

From the above results it may be concluded that sunflower seedling (14-day old) transplanted with spacing of 40 cm x 25 cm ($S_{2)}$ as well as fertilizer dose RD + 10% RD (F_2) or RD + 20% RD (F_3) may produce higher yield of seed in southern region of Bangladesh.. However, the experiment should be repeated in the next cropping year(s) for making final recommendation.

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PERFORMANCE OF GARLIC VARIETIES AT DINAJPUR REGION

M.M. KHANUM, M.S. HUDA AND D.A. CHOUDHURY

Abstract

The experiment was carried out at the research field of Agricultural Research Station, Rajbari, Dinajpur (Latitude: $25^0 38'7.22''$N, Longitude: $88^0 39'6.22''$E) during *rabi* season of 2020-21 and 2021-22 to evaluate the performances of garlic varieties at Dinajpur region. There were five garlic varieties, namely BARI Roshun-1, BARI Roshun-2, BARI Roshun-3, BARI Roshun-4 and a local cultivar. Results revealed that the highest yield (10.77 t/ha) was obtained from BARI Roshun-3, which was followed by BARI Roshun-4 (9.75 t/ha) and BARI Roshun-2. BARI Rashun-3 produced 33, 23, 11 and 58% higher bulb yield than BARI Rashun-1, BARI Rashun-2, BARI Rashun-4 and local cultivar in two consecutive years. The highest gross return (Tk. 430600/ ha) and gross margin (Tk. 288433/ ha) and BCR (3.02) were obtained from BARI Roshun-3. Therefore, the result of this study could be helpful for improving bulb production of garlic under Old Himalayan piedmont plain soil (non-calcareous soils) in Bangladesh.

Introduction

Garlic (*Allium sativum* L.) is one of the most important aromatic herbaceous annual spices under the family Alliaceae (Kurian, 1995), which widely used in the Globe including Bangladesh. It is the second most widely used cultivated Allium, after onion (Bose and Som, 1990), with a characteristic of pungent smell. China is the largest garlic producing country in the world, amounting 21.20 million tons per annum, while Bangladesh produces about 3.12 lakh ton, ranking fourth in the world context (FAOSTAT, 2016). Garlic requires cold, but dry weather, with moderate moisture for proper growth. It also requires well drained soil, with high organic matter content. It is sensitive to high humidity, excessive moisture and high temperature, which limits the growth of the crop (Babaji, 1996). Garlic has been known to have several food and medicinal values. Garlic extracts are generally used in curing whooping cough, lung diseases and stomach pain and child birth disorder. The extract could be used against ear-ache, hypertension, eyesores, an antidote against poisons and antibacterial agent, as well as reduced cholesterol level in human blood. It has been recognized, all over the world as a valuable spice for cooking different dishes. Garlic has higher nutritive value than other bulb crops, as it is rich in proteins, phosphorus, potassium, calcium, magnesium, and carbohydrates and hence also finds medicinal usage, especially in treating intestinal diseases (Rahman and Islam, 2016). It contains about 30- 35% dry matter, 6-7% protein, 0.2% lipid and 23-28% carbohydrates (Khatun *et al*., 2014). In Bangladesh, during 2016- 2017, the estimated area for garlic was about 66,289 hectares, which is 16.08% of total spices and condiments areas and its production was 4.25 lakh metric tons with average yielding of 6.42 t/ha (BBS, 2018). But the production is extremely insufficient in terms of demand and the average yield is quite low, compared to other garlic growing countries. This low yield may be due to the cultivation of the low yielding local varieties, incidence of diseases and insects, lack of technological knowledge of the growers etc. Bangladesh Agricultural Research Institute (BARI) has developed four garlic varieties, namely BARI Roshun-1, BARI Roshun-2, BARI Roshun-3 and BARI Roshun-4, which are high yielding varieties (yield potentiality 6-11 t/ ha) and less susceptible to pests and diseases. These varieties expected to be promising in increasing generation of farmers' income in a very short period of time. However, performance of garlic varieties has not yet been evaluated under different agro-climatic conditions, especially for non-calcareous dark grey Floodplain soils at Northern region of Bangladesh. Considering the above perspectives, the present study was conducted to find out the performances of garlic varieties.

Materials and Methods

The experiment was conducted at the research field of Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI), Rajbari, Dinajpur during *rabi* season of 2020-21 and 2021-22. The experimental site was located at Latitude: $25^0 38'7.22''$N and Longitude: $88^0 39'6.22''$E at an elevation of 37 m above mean sea level and it belongs to the Agro-ecological Zone-1 (Old Himalayan piedmont plain) in Bangladesh (FRG, 2018). The initial soil sample (0-15 cm) was analyzed at the Soil Resources Development Institute (SRDI), Dinajpur, Bangladesh. The soil of the experimental site was medium-high and clay loam texture having 0.96% organic matter, pH 6.10, 0.10% total nitrogen (N), 0.10 meq 100/ g soil potassium (K), 24.67 µg/g phosphorus (P), 8.12 µg/g sulfur (S), 0.88 µg/g zinc (Zn) and 0.39 µg/g boron (B). During crop growth period, Monthly weather data on temperature (maximum and minimum) and total rainfall (mm) were recorded in the both years (Figure 1). The average maximum and minimum temperature in the crop season (November to April) were ranged 22.69°C-33.99°C and 11.15°C-21.76°C during in 2020-21 and 22.25°C-33.43°C and 11.4°C-23.28°C in 2021-22 respectively. The weather of the experimental site is hot sub-humid with total rainfall of 25 mm in 2020-21 and 106 mm in 2021-22 during crop season.The experiment was laid out in randomized completely block design (RCBD) with three replications with the objectives to find out suitable garlic varieties for Dinajpur region. The unit plot size was 1.7m × 1.5 m and spacing 15 cm×10cm were maintained. Five varieties of garlic, viz. BARI Roshun-1, BARI Roshun-2, BARI Roshun-3 BARI Roshun-4 and local (Kacinia) were tested. The seeds (clove) were planted in 09 November, 2020 and 16 November, 2021. The soil was fertilized with $N_{100}P_{54}K_{167}S_{20}B_{1.7}$ kg/ha and cow dung 5 t/ha (Mondal *et al*., 2011). The entire amount of cowdung, P, S, B and ½ of N and ½ of K were applied at the time of final land preparation. The remaining N and K were top dressed in equal two splits, at 25 and 50 days, after planting (DAP). The crops were weeded twotimes, while five times sprayed with Rovral, Ridomil gold, Amistertopfor controlling purple blotch (*Alternaria porri*) as well as Tido plus, confidorand Vertimec were done to control thrips and mite. Irrigation was applied in four times at 15, 30, 45, and 60 days after planting (DAP). The crop was harvested according to maturity of different garlic variety. Yield components of garlic were taken from randomly selected 10 plants from each plot. Bulb yields were taken from whole plot. Collected data were analyzed statistically by using R software packages and mean differences for each character were compared by Least Significant Difference (LSD) test (Gomez and Gomez. 1984).

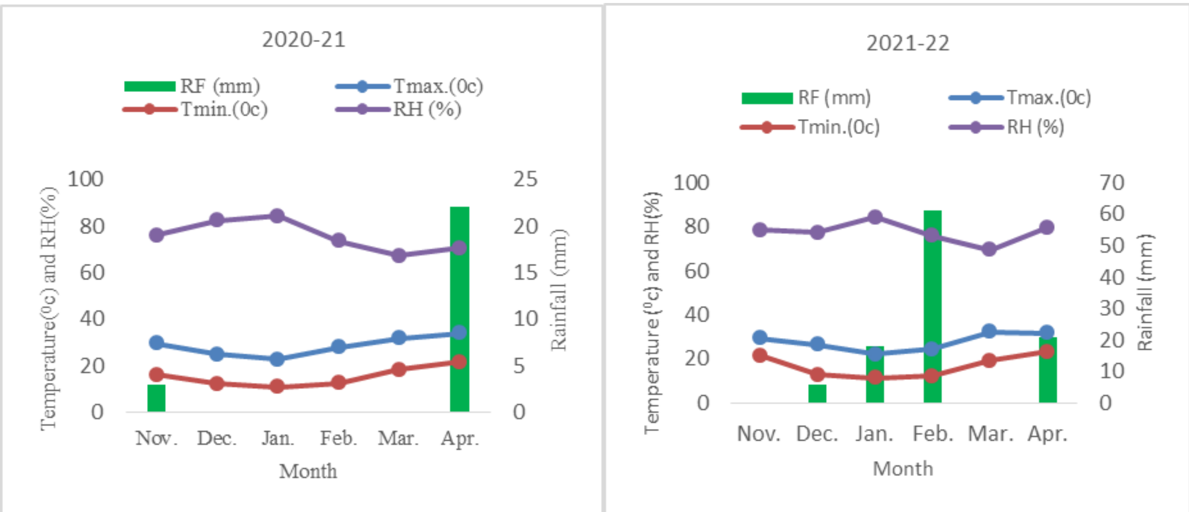

Figure 1. Monthly average maximum & minimum temperature, Relative humidity and rainfall during the growing period of garlic experiment (2020-21 and 2021-22)

Results and Discussion

Yield and yield contributing characters of garlic

Among the varieties, significant variations were observed in yield contributing characters and yield are presented in Table 1 and Table 2. Days to maturity showed no significant variations among the garlic varieties and which was ranged from 137-142 days in two consecutive years. BARI Roshun-1 required maximum period (142 days) for maturity which was followed by BARI Roshun-4 (140 days) in both years. The local cultivar took minimum period (137 days) for maturity in both years. This was followed by BARI Roshun-2 (139 days) and BARI Roshun-3 (139 days). The highest (70.44 cm) plant height was recorded in BARI Roshun-3 and the lowest (61.36 cm) was recorded in Local

(Kacinia) in two consecutive years. The highest number of leaves per plant (8.68) was obtained in BARI Roshun-3 followed by that in BARI Roshun-2, BARI Roshun-4 and the lowest (6.79) in Local cultivar (Kacinia) in both years. The highest neck diameter (1.46cm) and root length (7.85 cm) were found in BARI Roshun-3, while the lowest neck diameter (1.10 cm) and root length (6.16 cm) in Local cultivar in two consecutive years.

The highest bulb length and diameter (5.43 cm×4.51cm) were found in BARI Roshun-3 followed by that in BARI Roshun-4 and BARI Roshun-2, while the lowest (4.29 cm×3.53 cm) in Local cultivar. The highest number of cloves per bulb (24.88) was obtained from BARI Roshun-3 followed by that in BARI Roshun-4 and BARI Roshun-2 and the lowest (18.17) was from local cultivar (kacinia) in both years. The maximum individual bulb weight (19.20 g) was recorded in BARI Roshun-3 followed by that in BARI Roshun-4 and BARI Roshun-2 and the minimum (15.24 g) in Local cultivar in two consecutive years. The highest bulb yield 10.77 t/ha was recorded in BARI Roshun-3 which was statistically at par with BARI Roshun-4 and BARI Roshun-2 in two consecutive years. The lowest bulb yield 6.79 t/ ha was obtained in Local cultivar in both years. BARI Roshun-3 produced 33, 23, 11 and 58% higher bulb yield than BARI Roshun-1, BARI Roshun-2, BARI Roshun-4 and local cultivar in both years. Significantly higher bulb yield potential of BARI Rashun-3 variety might be attributed to higher plant height, number of leaves / plant, neck diameter, root length, bulb length, bulb diameter, number of cloves per bulb and individual bulb weight. Similar findings were reported by Mozumder *et al.* (2015). Islam *et. al.*, (2015) reported that the highest yield was recorded in BARI Roshun-2 and it was followed by BARI Roshun-1 and local.

Table 1. Days to maturity, Plant height, Number of leaves per plant, Neck diameter, Root length of garlic varieties at ARS, Rajbari, Dinajpur (Pooled data of 2 years)

Treatments	Days to maturity (days)	Plant height (cm)	Leaves/Plant (no.)	Neck diameter (cm)	Root length (cm)
T_1	142.49	66.90	7.43	1.32	6.9
T_2	139.33	65.96	7.96	1.33	7.06
T_3	139.50	70.44	8.68	1.46	7.85
T_4	140.16	67.40	8.25	1.4	7.31
T_5	137.83	61.36	6.79	1.1	6.16
$LSD_{(0.05)}$	3.09	4.62	0.92	0.35	0.81
CV (%)	1.18	3.7	6.26	7.20	6.11

T_1=BARI Roshun-1, T_2=BARI Roshun-2, T_3=BARI Roshun-3, T_4=BARI Roshun-4, T_5= Local (Kacinia)

Table 2. Bulb length, Bulb diameter, Number of Cloves per bulb, individual bulb weight and Bulb yield of garlic varieties at ARS, Rajbari, Dinajpur (Pooled data of 2 years)

Treatments	Bulb length (cm)	Bulb Diameter (cm)	Cloves/ Bulb (no.)	Individual bulb wt. (g)	Bulb Yield (t/ha)
T_1	4.60	4.07	20.79	16.72	8.08
T_2	4.79	4.10	22.65	17.23	8.77
T_3	5.43	4.51	24.88	19.20	10.77
T_4	4.97	4.27	23.03	18.53	9.75
T_5	4.29	3.53	18.17	15.24	6.79
$LSD_{(0.05)}$	0.56	0.26	2.27	1.59	0.69
CV (%)	6.34	3.34	5.51	4.84	4.12

T_1=BARI Roshun-1, T_2=BARI Roshun-2, T_3=BARI Roshun-3, T_4=BARI Roshun-4, T_5= Local (Kacinia)

Cost and return

The maximum gross return was obtained from BARI Roshun-3 (Tk. 430400 /ha) followed by BARI Roshun-4 (Tk. 390000 /ha) and BARI Roshun-2 (Tk. 351000/ ha) while the minimum (Tk. 271600 /ha) from Local cultivar (Kacinia) (Table 3). The highest gross margin was also recorded from BARI

Roshun-3 (Tk. 288433 /ha) followed by that in BARI Roshun-4 (Tk. 247833 /ha) and BARI Roshun-2 (Tk. 1208833 /ha) while the lowest from Local (Tk. 129433 /ha). Benefit cost ratio (BCR) was also the highest in BARI Roshun-3 (3.02), followed by BARI Roshun-4 (2.74) and BARI Roshun-2 (2.46) and the local cultivar (1.91). This finding was supported by Khatun *et al.*, (2014).

Table 3. Cost and return of garlic varieties at ARS, Rajbari, Dinajpur

Varieties	Bulb Yield (t/ha)	Gross return (Tk /ha)	TVC (Tk /ha)	Gross margin (Tk /ha)	BCR
BARI Roshun-1	8.08	323200	142167	181033	2.27
BARI Roshun-2	8.77	351000	142167	208833	2.46
BARI Roshun-3	10.77	430600	142167	288433	3.02
BARI Roshun-4	9.75	390000	142167	247833	2.74
Local (Kacinia)	6.79	271600	142167	129433	1.91

Garlic @ Tk. 40/ kg

Conclusion

From the result it may be concluded that BARI Roshun-3 and BARI Roshun-4 perform better compared to BARI Roshun-1, BARI Roshun-2 and local cultivar.

Acknowledgement

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EFFECT OF PLANTING DATE AND NUTRIENT MANAGEMENT ON YIELD OF BROCCOLI

M.M. KHANUM, M.S. HUDA, A. BARMAN, S.S. KAKON AND D.A. CHOUDHURY

Abstract

The experiment was carried out at the research field of Agricultural Research Station, Rajbari, Dinajpur during *rabi* season of 2021-22 to find out optimum planting time and nutrient dose of broccoli in early planting condition when the demand and price of broccoli are high in the market. Three Planting times viz. P_1= 30 October, P_2=15 November, P_3=30 November and four levels of nutrients viz. T_1= STB Recommended chemical fertilizer (RCF) (120-24-60-20-2-1.5 kg/ha NPKSZnB), T_2=T_1+ 25% of NPK (150-30-75-20-2-1.5 kg/ha NPKSZnB), T_3= IPNS with vermicompost 1.5 t/ha, T_4= IPNS with vermicompost 3 t/ha were used in the experiment. Result revealed that the highest yield (18.56 t/ha) was produced by the treatment combination P_1T_4 (when planted grown on 30 October with IPNS + vermicompost 3 t/ha) and the lowest yield (13.31 t/ha) was recorded from the combination P_3T_1{when planted grown on 30 November with STB (120-24-60-20-2-1.5 kg/ha NPKSZnB)}. Maximum gross return (Tk. 556800 /ha) and gross margin (Tk. 379000 /ha) were recorded from P_1T_4(when planted grown on 30 October with IPNS + vermicompost 3 t/ha) treatment but the maximum benefit cost ratio (3.17) was obtained from P_1T_3 (when planted grown on 30 October with IPNS + vermicompost 1.5 t/ha). Although treatment P_1T_4 (when planted grown on 30 October with IPNS + vermicompost 3 t/ha) gave the maximum gross return but failed to produce maximum BCR due to involvement of higher fertilizer costs. From the result it may be concluded that when planted grown on 30 October with IPNS + vermicompost 1.5t/ha (P_1T_3) might be more profitable and economically feasible for broccoli growers in the Dinajpur region.

Introduction

Broccoli (*Brassica oleracea var. italica L.*) belongs to Brassicaceae family is a biennial and herbaceous cole crops. It looks exactly like cauliflower but the color is dark green. The cultivation of broccoli in the country did not start too long ago. As such, the cultivation of broccoli in Dinajpur is completely new. It is rich in vitamins, minerals and antioxidants. It is anti-cancer, anti-inflammatory, anti-gastritis, anti-weight, anti-aging and beautiful skin. So, it plays a great role in meeting the nutritional needs of the people of Dinajpur. Climate of this area is well suited for its production. Several factors for low yield of broccoli. Planting time and nutrient management one of them. Suitable sowing time is one of the basic requirements for obtaining maximum yield and return of any crop. Broccoli is environmentally better adapted and can tolerate comparatively high temperature than cauliflower (Rashid, 1993). For quality production of broccoli, balanced supply of plant nutrients is very much essential. Such requirement of nutrients can be provided by applying inorganic fertilizer or organic manure or both. The combined application of both organic and inorganic fertilizer can increase the yield maintaining sound environmental conditions (Hsieh *et al.*,1996). Organic manure can serve as an alternative practice to chemical fertilizers (Gupta *et al*., 1988) which improves soil structure (Dauda *et al*., 2008) and encourage beneficial microbial population. The use of inorganic fertilizers has increased manifolds in recent years due to shortage or unavailability of organic manures. The increased and imbalance use of chemical fertilizers has negative impacts of soil health due to its effect on soil micro-flora. The judicial application of organic or inorganic fertilizers is an important consideration to improve the yield and quality of the agricultural produce (Bhuma, 2001). Bahadur (2004) suggested that a combined application of manures and fertilizers increased the yield and improved the quality of broccoli. Manures, particularly vermicompost can play an important role in growth and curd yield of broccoli Hence, this study needs to be undertaken to evaluate the effects of inorganic fertilizers and inorganic fertilizers + vermicompost on the growth and yield of broccoli. The present investigation is undertaken to find out the response of broccoli to different levels of nutrient management in early planting condition at Dinajpur region.

Materials and Methods

The experiment was conducted at the research field of Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI), Rajbari, Dinajpur during *rabi* season of 2021-22 to find out optimum planting time and nutrient dose of broccoli in early planting condition when the demand and price of broccoli are high in the market.. The experimental site was located at Latitude: $25^{0}38'10.91''$ N and Longitude: $88^{0}39'.61''$ E at an elevation of 38 m above mean sea level and it belongs to the Agro-ecological Zone-1 (Old Himalayan piedmont plain) in Bangladesh (FRG, 2018). The initial soil sample (0-15 cm) was analyzed at the Soil Resources Development Institute (SRDI), Dinajpur, Bangladesh. The soil of the experimental site was medium-high and clay loam texture having 0.69% organic matter, pH 6.50, 0.038% total nitrogen (N), 0.10 meq 100 g^{-1} soil potassium (K), 22.5 µg/g phosphorus (P), 6.20 µg/g sulfur (S), 0.90 µg/g zinc (Zn) and 0.30 µg/g boron (B). During crop growth period, Monthly weather data on temperature (maximum and minimum) and rainfall (mm) were recorded in the years (Figure 1). The average maximum and minimum temperature in the crop season (October to March) were 32.43°C and 11.4°C during in 2021-22. The weather of the experimental site is hot sub-humid with total rainfall of 517 mm during crop season. The experiment was laid out in a randomized complete block design with three replications.The unit plot size was 7.5 m^2 (3m×2.5m) and spacing 50cm×50cm were maintained. Three Planting times viz. P_1= 30 October, P_2=15 November, P_3=30 November and four levels of nutrients viz. T_1= STB Recommended chemical fertilizer (RCF) (120-24-60-20-2-1.5 kg/ha NPKSZnB), T_2=T_1+ 25% of NPK (150-30-75-20-2-1.5 kg/ha NPKSZnB) T_3= IPNS with vermicompost 1.5 t/ha T_4= IPNS with vermicompost 3 t/ha were used in the study. BARI Broccoli-1 was used in this experiment. Firstly, seeds were sown in seedbed and then thirty days old healthy seedlings were transplanted into the main field according to the treatments. Irrigation was given the first 4-5 days after transplanting of seedlings. Vermicompost was applied at the time of final land preparation. All of phosphorus, sulphur, zinc and boron were applied during final land preparation, while the nitrogen and potassium were applied in three equal splits at 15, 30, and 50 DAT as ring method around the plants and mixed thoroughly with the soil followed by irrigation. Intercultural operation like weeding were done two times at 20 DAT and 35 DAT. Broccoli was harvested several times according to planting date. Insecticide Acimix 55EC 1ml/L water was sprayed at every 15 days interval to control cut worm and Fungicide Rovral 50 WP @ 2gm/L water was sprayed at every 15 days interval to control leaf spot and on broccoli. Yield components of broccoli were taken from randomly selected 5 plants from each plot. Curd yields were taken from whole plot. Collected data were analyzed statistically by using R software packages and mean differences for each character were compared by Least Significant Difference (LSD) test (Gomez and Gomez. 1984). The cost- benefit analysis of broccoli production was calculated based on present market price in Dinajpur.

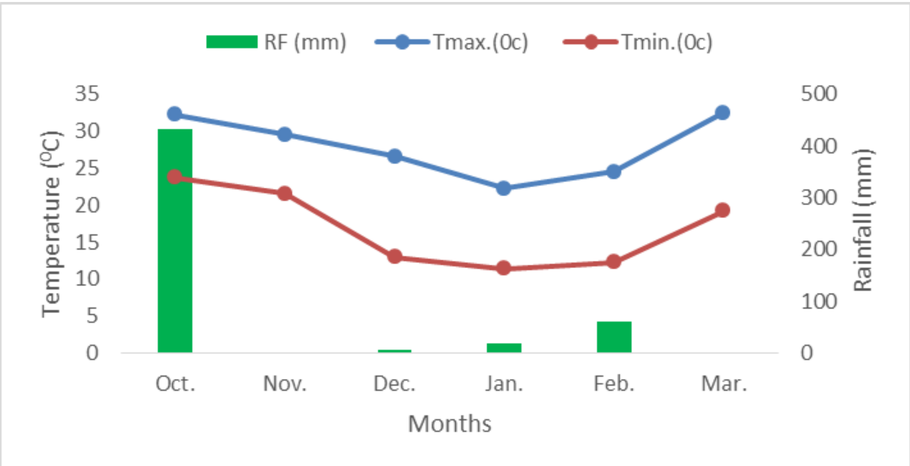

Figure 1. Monthly average maximum temperature, minimum temperature and rainfall during the cropping period from 2020-21 at ARS, BARI, Dinajpur.

Results and Discussion

Yield contributing and yield of broccoli was significantly affected by planting density and fertilizer dose (Table 1). The longest plant (62.06 cm) was recorded from plants grown under P_1T_4(when planted grown on 30 October with IPNS with vermicompost 3 t/ha) treatment combinations and the shortest plant (51.80 cm) was recorded from P_3T_1. Thompson and Kelly (1988) reported that the rate of release of nitrogen is higher from vermicompost than chemical fertilizer which ultimately were reflected in higher plant growth. The maximum number of leaves (20.10) was recorded in the treatment combination P_1T_4 (when planted grown on 30 October with IPNS + vermicompost 3 t/ha) and the lowest number of leaves (15.83) was observed in the treatment combination P_3T_1. In this study, organic manure increased the activity of microorganisms which ultimately made more availability and absorption of essential plant nutrients resulting in increased leaf and plant morphology. The maximum curd diameter and curd length (16.94 cm and 25.16 cm) were obtained from the treatment combination P_1T_4 and the lowest from P_3T_1 treatment combination. The highest (6.40) number of secondary curd was also observed in P_1T_4 (when planted grown on 30 October with IPNS + vermicompost 3 t/ha) treatment combination. The interaction effect of different planting time and nutrient dose were highly significant for secondary curd weight. The highest terminal curd weight (463.93 g) was recorded from the treatment combination P_1T_4 and the lowest (332.80 g) from P_3T_1 treatment combination. The highest yield (18.56 t/ha) was produced by the treatment combination P_1T_4 (when planted grown on 30 October with IPNS + vermicompost 3 t/ha) and the lowest yield (13.31 t/ha) was recorded from the combination P_3T_1{when planted grown on 30 November with STB (120-24-60-20-2-1.5 kg/ha NPKSZnB)}. Vermicompost retains nutrients for long time while the conventional compost fails to deliver the required amount of macro and micronutrient including the vital NPK to plants in shorter time. Euras (2009) reported that the vermicompost is proving to be highly nutritive organic fertilizer and more powerful growth promoter over the conventional composts. It accelerates the rate of decomposition of the organic matter, alters the physical and chemical properties of the material, and lowers the C: N ratio, leading to a rapid humification process in which the unstable organic matter is fully oxidized.

Table 1. Plant height, number of leaf/ plant and yield component and yield of broccoli as affected by planting time and nutrient dose

Treatment Combinations	Plant height (cm)	Leaf/plant (no.)	Terminal curd diameter (cm)	Terminal curd length (cm)	No. of secondary curd	Terminal curd wt.(g)	Secondary curd wt.(g)	Yield (t/ha)
P_1T_1	54.26	17.90	13.76	21.70	4.03	369.77	195.96	14.79
P_1T_2	57.40	18.20	14.43	22.90	4.66	372.57	212.40	14.90
P_1T_3	58.80	19.20	15.41	23.80	5.56	399.98	229.67	15.99
P_1T_4	62.06	20.10	16.94	25.16	6.40	463.93	259.70	18.56
P_2T_1	52.89	16.81	13.70	21.30	3.93	344.73	189.53	13.78
P_2T_2	55.00	17.16	14.06	21.70	4.33	357.10	205.70	14.28
P_2T_3	57.50	17.87	14.60	23.16	5.30	371.42	220.13	14.85
P_2T_4	60.08	19.78	15.93	24.80	6.10	429.50	250.53	17.18
P_3T_1	51.80	15.83	12.00	20.33	3.76	332.80	185.40	13.31
P_3T_2	52.93	16.80	14.26	21.28	4.23	337.20	194.83	13.49
P_3T_3	55.40	16.93	12.86	22.00	4.96	363.08	204.07	14.52
P_3T_4	59.30	19.33	14.87	24.13	5.73	387.93	209.57	15.51
$LSD_{(0.05)}$	2.36	1.28	1.72	1.39	0.97	17.07	7.28	0.97
$CV_{(\%)}$	2.54	3.99	7.06	3.49	7.10	2.83	2.13	2.83

Three Planting times viz. P_1= 30 October, P_2=15 November, P_3=30 November and four levels of nutrients viz. T_1= STB (120-24-60-20-2-1.5 kg/ha NPKSZnB), T_2=T_1+ 25% of NPK (150-30-75-20-2-1.5 kg/ha NPKSZnB) T_3= IPNS with vermicompost 1.5 t/ha T_4= IPNS with vermicompost 3 t/ha

Cost and benefit analysis

Cost and benefit analysis of broccoli curd yield have been presented in Table 2. Result showed that the maximum gross return (Tk. 556800 /ha) and gross margin (Tk. 379000 /ha) were recorded from the treatment combination P_1T_4 (when planted grown on 30 October with IPNS + vermicompost 3 t/ha)but the maximum benefit cost ratio (3.17) was obtained from P_1T_3 (when planted grown on 30 with IPNS + vermicompost 1.5 t/ha) treatment and the lowest gross return (Tk. 199650/ha), gross margin (Tk. 70245 /ha) and benefit cost ratio (1.53) were recorded from the treatment combination P_3T_1. However, the highest benefit cost ratio (3.17) was recorded from IPNS with vermicompost 1.5 t/ha when planted on 30 October (P_1T_3) followed by IPNS with vermicompost 3 t/ha when planted on 30 October (P_1T_4) BCR (3.13) . Although treatment P_1T_4 (IPNS with vermicompost 3 t/ha when planted on 30 October) gave the maximum gross return but failed to produce maximum BCR due to the maximum total cost of cultivation was recorded in P_1T_4 treatment due to involvement of higher fertilizer costs.

Table 2. Cost and benefit analysis of broccoli production as influenced by planting time and nutrient dose

Treatment Combinations	Yield (t/ ha)	Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross Margin (Tk/ha)	BCR
P_1T_1	14.79	369750	129405	240345	2.85
P_1T_2	14.90	372500	131557	240943	2.83
P_1T_3	15.99	479700	150950	328750	3.17
P_1T_4	18.56	556800	177800	379000	3.13
P_2T_1	13.78	275600	129405	146195	2.12
P_2T_2	14.28	285600	131557	154043	2.17
P_2T_3	14.85	371250	150950	220300	2.45
P_2T_4	17.18	429500	173800	255700	2.47
P_3T_1	13.31	199650	129405	70245	1.53
P_3T_2	13.49	202350	131557	70793	1.54
P_3T_3	14.52	290400	150950	139450	1.92
P_3T_4	15.51	310200	173800	136400	1.78

Three Planting times viz. P_1= 30 October, P_2=15 November, P_3=30 November and four levels of nutrients viz. T_1= STB (120-24-60-20-2-1.5 kg/ha NPKSZnB), T_2=T_1+ 25% of NPK (150-30-75-20-2-1.5 kg/ha NPKSZnB) T_3= IPNS with vermicompost 1.5 t/ha T_4= IPNS with vermicompost 3 t/ha

The price rate of fertilizer and vermicompost: urea:16.00 Tk./Kg,TSP:22.00 Tk./Kg,MOP:15 Tk./Kg,Gypsum: 25 Tk./Kg, Zinc Sulphate: 200 Tk./Kg, Boron: 400 Tk.Kg^{-1} and Vermicompost: 20 Tk.Kg^{-1},

Price of broccoli (Tk.Kg^{-1}): 25 (Treat. Comb. P_1T_1 & P_1T_2), 30 (Treat. Comb. P_1T_3 & P_1T_4), 20 (Treat. Comb. P_2T_1 & P_2T_2), 25 (Treat. Comb. P_2T_3 & P_2T_4), 15 (Treat. Comb. P_3T_1 & P_3T_2), 20 (Treat. Comb. P_3T_3 & P_3T_4).

Conclusion

From the study, it may be concluded that when planted grown on 30 October with IPNS + vermicompost 1.5t/ha might be more profitable and economically feasible for broccoli growers in the Dinajpur region. This was the 1st year trial for final conclusion and recommendation the experiment should be repeated next year.

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EFFECT OF PLANT POPULATION AND INTEGRATED NUTRIENT MANAGEMENT ON YIELD OF YARD LONG BEAN (*Vigna unguiculata*)

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Abstract

The experiment was conducted at Agronomy Research Field of BARI, Gazipur and RARS, Jashore, during *kharif* season of 2021-22 to find out the optimum plant population and suitable fertilizer dose for higher yield of yard long bean. Two planting geometry, viz., P_1= 45cm × 30cm (8 plants/m^2) P_2= 40 cm × 20cm (12 plants/m^2) were used at Gazipur whereas at Jashore, three planting geometry viz., P_1=50cm × 25cm, P_2=40cm × 25cm and P_3=40cm × 30cm were used in the study and three nutrient levels viz., F_1=Recommended fertilizer dose RFD)(21-27-33-9-1.2-1.2 kg/ha NPKSZnB), F_2= IPNS + Poultry manure-PM (3 t/ha) and F_3 =IPNS + Vermicompost –VC (3 t/ha) were used in both the location. The better results in terms of vegetable fresh yield were obtained in the following order: PM > VC> NPK. Application of VC is not beneficial due to 15 times higher price than PM. The result indicated that plant spacing of 40 cm × 20 cm with VC added NPK fertilizer combination (F_3) gave the highest pod yield (4.98 t/ha) which was followed by same spacing with PM added NPK fertilizer combination (F_2) but the highest benefit cost ratio (2.00) was recorded in plant spacing of 40 cm × 20 cm with PM added NPK fertilizer combination (F_2) at Gazipur whereas at Jashore, the highest pod yield (3.18 t/ha) was recorded in 40 cm × 25 cm spacing with IPNS (17-21-23-9-1-1 kg/ha NPKSZnB) added poultry manure (3 t/ha). The highest benefit cost ratio (1.50) was obtained from P_2F_2 {40 cm × 25 cm spacing with IPNS (17-21-23-9-1-1 kg/ha NPKSZnB) added poultry manure (3 t/ha)} treatment. The result revealed that spacing 40 cm × 20 cm (1,20,000 plants/ha) or 40 cm × 25 cm (1,00,000 plants/ha) with fertilizer dose IPNS (16-25-30-9-1.2-1.2 kg/ha NPKSZnB at Gazipur and 17-21-23-9-1-1kg/ha NPKSZnB at Jashore) + Poultry manure (3 t/ha) might be suitable for yard long bean cultivation in both the locations.

Introduction

Vigna unguiculata (L.) commonly known as yard long bean or pole type vegetable cowpea is a commercially used leguminous plant with very long pods and climbing growth habit, widely grown in China, South and South East Asia. It belongs to the family Fabaceae and is one of the most popular and remunerative vegetable crop traditionally grown in Bangladesh, cultivated mainly for tender pods that are consumed both fresh and cooked. It is a rich and inexpensive source of vegetable protein and its cultivation enriches soil fertility by fixing atmospheric nitrogen. It has become an essential component of sustainable agriculture in marginal lands of the tropics because of its quick growth habit. But the yield of yard long bean is quite low. It is usually growing during February/March to May/June. Optimum plant spacing and fertilizer dose are important key factors to get maximum yield. In Bangladesh different plant spacing of yard long bean are used by the farmers in different locations.

Moreover, organic matter content in Bangladesh soils is very low (<1.5%) and is being gradually depleted (Ullah *et al*., 2008). Neither the chemical fertilizer nor organic manure alone can help achieve sustainable crop production. The integrated nutrient management is the best approach to restore/ maintain soil fertility and productivity on sustainable basis. Organic manure improves soil structure through aggregation favourably influencing tillage properties, crusting, water infiltration, moisture retention, aeration and temperature. Moreover, organic manures do not create any health hazards and environmental pollution. But in Bangladesh, most soils have less than 1.5%, and some even less than 1% organic matter contents (FAO, 2014). So, to check soil health hazard and environmental pollution, the use of organic fertilizers should be encouraged. Organic fertilizers have been shown to help preserve natural resources and reduce degradation of ecosystem (Mäder *et al*. 2002; Francis and Daniel, 2004). In Bangladesh, now a day, the organic fertilizers like cowdung and chicken manure are available due to increasing dairy and poultry farm. On the other hand, the price of vermicompost is very high (15 times higher) comparable to cowdung and chicken manure. Farmers of Bangladesh are mostly habituated with the use of macro-nutrients, especially nitrogen, phosphorus, sulphur and potassium for crop production. Use of manures is limited. In addition, there are some reports on combined effect of NPKS (25%) and vermicompost (75%) have given higher yield of tomato, cabbage, okra compared to recommended dose of full amount NPKS and control (Islam *et al*. 2017; Farzana *et. al*., 2019; Akhter *et. al*., 2019). However, information on the use of poultry, manure and vermicompost in combination with inorganic fertilizers for yard long bean is scanty in Bangladesh. So, it is imperative to find out the optimum fertilizer dose and appropriate plant spacing for higher yield of yard long bean. Hence, the experiment was undertaken.

Materials and Methods

The experiment was conducted at the research field of Agronomy Division BARI, Gazipur and RARS, Jashore during *kharif* season of 2021-22. The soil of the Gazipur research area belongs to Chhihata series under AEZ-28. Initial soil nutrient status of two locations are given in Table 1.In Gazipur soil pH was 6.28 which indicated the soil was slight acidic whereas in Jashore soil was nutral (pH-7.7). Organic matter percentage was low in both locations. Nitrogen percentage was very low in both locations. Phosphorus level was low in Gazipur but very high in Jashore . Potassium level was low in Gazipur and medium in Jashore. Sulpher status was low in Gazipur location.

Table 1. Initial soil nutrient status of two locations

Location	pH	OM (%)	Total N (%)	Exchangeable K (meq/100g soil)	Available P (µg/ml)	Available S (µg/ml)	Available Zn (µg/ml)	Available B (µg/ml)
Gazipur	6.28	1.41 VL	0.11 L	0.161 L	14.31 L	12.37 L	0.24 VL	0.160 L
Jashore	7.7	1.94 VL	0.113 L	0.24 M	20.79 H			

H=High, M= Medium, L= Low, VL= Very low

The experiment was laid out in a randomaized complete block design with three replications. The unit plot size was 3.6 m × 3.0 m. Two planting geometry, viz., P_1= 45cm × 30cm (8 plants/m^2) P_2= 40 cm × 20cm (12 plants/m^2) were used at Gazipur whereas at Jashore three planting geometry viz., P_1=50cm × 25cm, P_2=40cm × 25cm and P_3=40cm × 30cm were used in the study and three fertility levels viz., F_1=Recommended fertilizer dose RFD)(21-27-33-9-1.2-1.2 kg/ha NPKSZnB), F_2= IPNS + Poultry manure (3 t/ha) and F_3 =IPNS + Vermicompost (3 t/ha) were used in both the locations. Seeds of yard long bean were sown on 18 March, 2022 at Gazipur and 24 March, 2022 at Jashore. Fertilizers were applied as per treatments in the form of urea, TSP, MoP, gysum, zinc sulphate and boric acid. One-third of urea and full amount of all other fertilizers were applied at the time of final land preparation. The remaining urea was top dressed in two equal splits at 35 DAS and 50 DAS. A light irrigation was given after sowing of seeds uniform for germination. Three irrigations were done at 25 and 50 DAS. Intercultural operations like thinning were done at 15 DAS and weeding was done two times at 15 and 25 DAS. For dry matter estimation, 5 plants were sampled at maturity. Yard long bean was harvested several times started on 17 May 2022 at Gazipur and on 27 May, 2022 at Jashore. For dry matter at harvest, 10 plants were randomly collected from each plot and oven dried at 80^o C for 72. The yield component data was taken from 5 randomly selected plants prior to harvest from each plot. At harvest, the yield data was recorded plot wise. The collected data were analyzed statistically using MSTAT-C package and means were adjudged by LSD test at 5% level of probability at Gazipur and Jashore.

Results and Discussion

In Gazipur

Total dry matter

Total dry matter (TDM) production of yard long bean was influenced by plant spacing and fertilizer levels.TDM was higher in P_2F_2 followed by P_2F_1 and P_2F_3 treatments. The lowest TDM was observed from P_1F_1 and P_1F_3 treatments (Fig.1) at Gazipur.

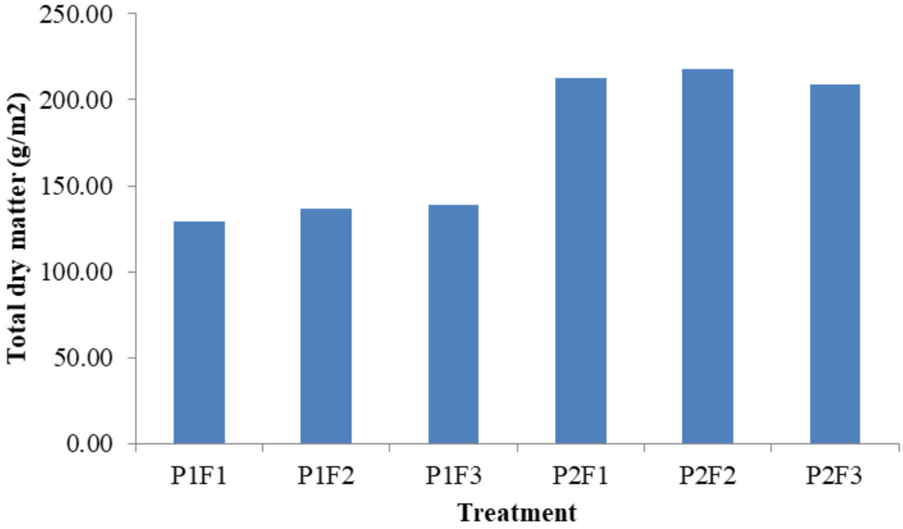

Fig 1: Total dry matter production of yard long bean at harvest as influenced by planting geometry and fertilizer levels

Plant population, plant height, yield attributes and yield

Number of plants/m^2, plant height at harvest, number of pods/plant of yard long bean showed significant variations due to planting geometry and inorganic and organic fertilizer combination (Table 2). Number of plants/m^2 at harvest varied greatly, which ranged between 6 and 11. Plant height at maturity varied from 51.46 to 57.73 cm regardless of treatments. Planting density 12/m^2 under IPNS+3t/ha PM was the tallest (57.51 cm) plant followed by P_2F_1, P_2F_2 and P_1F_2 treatments and the shortest plant (51.46 cm) was recorded from P_1F_3 treatment. The number of pods/plant ranged between 10 and 18 across the fertility level and plant population. The decrease in the number of pods per plant with the increase in plant density could be due to increased intra row competition which eventually might have caused reduction in the number of pods per plant. The highest pods/plant (18) was recorded with 8 plant/m^2 when the crop was fertilized with IPNS+3t/ha PM. Pod yield of yard long bean was also found significantly differed due to spacing and inorganic and organic fertilizer combination (Table 2). The highest pod yield (4.98 t/ha) was recorded from P_2F_3 (Planting density 12/m^2 under IPNS + 3t/ha VC) treatment which was statistically similar with P_2F_2 (4.86 t/ha) treatment. It might be due to higher number of plant population/ha (88888 plants/ha). All the yield contributing characters were higher in P_1 plant spacing but pod yield was higher in P_2 due to higher plant population. These results are in conformity with the findings of Sharma *et al*. (2008), Jakusko *et al*. (2009), Bakry *et al*. (2011), Almaz *et al*. (2016).The lowest pod yield (3.65 t/ha) was obtained from P_1F_1 treatment. Addition of PM or VC greatly improved the yield of yard long bean in this study compared to NPK fertilizers and this confirms the findings of Xu *et al.* (2005) who stated that the yield and quality of leafy vegetables grown with organic fertilizers showed better performance and resulted in a higher total yield than those grown with synthetic fertilizers. The highest pod length (28.77cm) was obtained from P_1F_2 treatment followed by P_1F_3 treatment. The lowest number of pod/plant (10), pod length (20.63 cm) was recorded in P_2F_1 treatment.

Table 2. Plant population, plant height at harvest, yield attributes and yield of yard long bean as influenced by planting geometry and fertilizer dose

Interaction (Spacing × fertility level)	Population/ m^2	Plant height (cm)	Pod/ plant (no.)	Pod length (cm)	Pod yield (t/ ha)
$P_1 \times F_1$	6.00	52.53	17	25.31	3.65
$P_1 \times F_2$	7.00	54.83	18	28.77	4.04
$P_1 \times F_3$	7.00	51.46	17	27.10	4.08
$P_2 \times F_1$	11.00	55.53	10	20.63	4.23
$P_2 \times F_2$	10.00	56.00	12	22.00	4.86
$P_2 \times F_3$	9.00	57.51	14	24.04	4.98
$LSD_{(0.05)}$	1.31	1.29	0.28	0.96	0.06
CV (%)	8.23	3.30	4.20	4.17	4.55

Cost and return Analysis

From the cost-benefit analysis it was found that the highest gross return (Tk. 124417/ha) was obtained from P_2F_3 treatment and the second highest (Tk.121500/ ha) gross return was recorded in P_2F_2 treatment and the lowest gross return (Tk. 91333/ha) was found in P_1F_1 treatment. The highest cost of cultivation was recorded in P_2F_3 treatment (Tk. 87483/ha) due to high labour and fertilizer cost. The highest gross margin (Tk. 61017/ha) was obtained from P_2F_2 treatment. The highest benefit cost ratio (2.00) was obtained from P_2F_2 treatment and the lowest BCR (1.23) was recorded in P_1F_2 treatment (Table 3). Though P_2F_3 treatment produced the highest pod yield but this treatment showed the lowest BCR (1.42) due to higher labour and fertilizer cost. The results were consistent with the earlier reports of lower labour and fertilizer cost which gave the highest fruit yield and returns (Islam *et al*., 2012 and Subrahmaniyan *et al*., 2011).

Table 3. Cost and return of yard long bean as influenced by planting geometry and fertilizer dose

Planting geometry× Fertilizer level	Gross return (Tk/ha)	Cost of production (Tk/ha)	Gross margin (Tk/ha)	Benefit cost ratio
$P_1 \times F_1$	91333	53322	38011	1.71
$P_1 \times F_2$	101000	55483	45517	1.82
$P_1 \times F_3$	101917	82483	19434	1.23
$P_2 \times F_1$	105667	58322	47344	1.81
$P_2 \times F_2$	121500	60483	61017	2.00
$P_2 \times F_3$	124417	87483	36934	1.42

P_1=40 cm× 25 cm, P_2=40 cm × 20cm and three fertilizer doses viz, F_1= RFD (21-27-33-9-1.2-1.2 kg/ha NPKSZnB), F_2= IPNS+ Poultry manure (3 t/ha), F_3 =IPNS + Vermicompost (3 t/ha)
NPK = Nitrogen, Phosphorus, Potassium; PM = Poultry manure, VC=Vermicompost
The price rate of manures and fertilizers: Taka urea: Tk. 16.00 /kg, TSP: Tk. 11.00/ kg, MOP: Tk. 15.00/ kg, PM :Tk. 1.00/kg and VC: Tk. 15/kg. The fresh yard long bean rate was Tk. 25.00 /kg

In Jashore

Treatment: P_1= 50 cm× 25 cm, P_2=40 cm ×25cm, P_3= 40 cm × 30 cm and three fertilizer doses viz, F_1=RFD (21-27-33-9-1.2-1.2 kg/ha NPKSZnB), F_2= IPNS with Poultry manure (3 t/ha),F_3 =IPNS with Vermicompost (3 t/ha); NPK = Nitrogen Phosphorus Potassium; PM = Poultry manure, VC=Vermicompost;

Plant height, total dry matter, yield component and yield

Plant height at harvest, number of pods/plant of yard long bean showed significant variations due to planting geometry and chemical fertilizer and organic manure combination (Table 4). The longest plant height (70.13 cm) was found in $P_3 \times F_1${40 cm × 30 cm along with RFD (21-27-33-9-1.2-1.2 kg/ha NPKSZnB)} treatment and the shortest plant height (62.67 cm) was found in $P_1 \times F_3$ {50 cm× 25 cm along with IPNS with Vermicompost (3 t/ha)}.The highest TDM (652.00 g/m^2) found in $P_2 \times F_2$ {40 cm × 25cm along with IPNS with Poultry manure (3 t/ha) }which was statistically similar to $P_2 \times F_3$ (38.0 %) followed by $P_1 \times F_1$ (34.0 %). The lowest TDM was found in $P_1 \times F_1$ (289.60 g/m^2).

Significantly the highest number of pods/ plant was recorded in $P_2×F_2$ (20) which was statistically similar to $P_1×F_2$ (20) and $P_3×F_2$ (20). The lowest number of pod/plant was recorded in $P_3×F_1$ (16). Significantly the highest pod yield (3.18 t/ha) was obtained from $P_2×F_2$ which was statistically similar to $P_2×F_3$ (2.88 t/ha) and $P_3×F_2$ (2.89 t /ha). The lowest pod yield (2.12 t/ ha) was obtained from $P_1×F_1$ which was statistically similar to $P_1×F_3$ (2.33 t/ha) and $P_3×F_1$ (2.29 t/ha). The result is also supported by Shindhuja *et al*., 2021 who found maximum yield in inorganic and organic combination. This might be due to the low cost of chemical fertilizer and poultry manure than other organic fertilizer. Highest yield was found in closer spacing due to more plant per unit area in closer spacing than wider spacing. Similar findings were obtained by Majumder *et al.(* 2003).

Table 4. Plant height, total dry matter, yield component and yield as affected by planting geometry and fertility levels

Planting geometry × Fertilizer level	Plant height (cm)	Total dry matter (g/m^2)	Pod number/plant (no)	Yield (t/ha)
$P_1×F_1$	67.87	289.60	18	2.12
$P_1×F_2$	64.60	437.87	20	2.52
$P_1×F_3$	62.67	403.73	19	2.33
$P_2×F_1$	65.87	462.00	18	2.57
$P_2×F_2$	64.73	652.00	20	3.18
$P_2×F_3$	65.27	566.67	19	2.88
$P_3×F_1$	70.13	317.10	16	2.29
$P_3×F_2$	67.53	423.16	20	2.89
$P_3×F_3$	64.53	364.30	18	2.67
$LSD_{(0.05)}$	5.86	95.72	1.58	0.34
CV (%)	5.14	12.70	4.87	7.67

Table 5. Cost and return analysis of yard long bean as influenced by planting geometry and fertility levels

Planting geometry× Fertilizer level	Gross return (Tk/ha)	Cost of production (Tk/ha)	Gross margin (Tk/ha)	BCR
$P_1×F_1$	63600	59000	4600	1.08
$P_1×F_2$	100800	70000	30800	1.44
$P_1×F_3$	93200	79000	14200	1.18
$P_2×F_1$	77100	74000	3100	1.04
$P_2×F_2$	127200	85000	42200	1.50
$P_2×F_3$	115200	94000	21200	1.23
$P_3×F_1$	68700	68000	700	1.01
$P_3×F_2$	115600	79000	36600	1.46
$P_3×F_3$	106800	88000	18800	1.21

P_1= 50 cm× 25 cm, P_2=40 cm ×25cm, P_3= 40 cm × 30 cm and three fertilizer doses viz, F_1=Recommended fertilizer dose (RFD)(21-27-33-9-1.2-1.2 kg/ha NPKSZnB), F_2= IPNS with Poultry manure (3 t/ha),F_3 =IPNS with Vermicompost (3 t/ha); NPK = Nitrogen Phosphorus Potassium; PM = Poultry manure, VC=Vermicompost; The price rate of manures and fertilizers: Taka urea: Tk. 16.00 /kg, TSP: Tk. 11.00/ kg, MOP: Tk. 15.00/ kg, PM :Tk. 5.00/kg and VC: Tk. 12/kg. The fresh yard long bean rate was Tk. 30.00 /kg (RFD) and Tk.40.00 /kg (VC and PM)

NPK = Nitrogen Phosphorus, Potassium; PM = Poultry manure, VC=Vermicompost

Cost and return Analysis

From the economic analysis it was found that the highest gross return (Tk. 127200/ha) was obtained from P_2F_2 {40 cm × 25cm along with IPNS + Poultry manure (3 t/ha)} treatment and the lowest gross return (Tk. 63600/ha) was found in P_1F_1 {50 cm× 25 cm along with RFD (21-27-33-9-1.2-1.2 kg/ha NPKSZnB)}treatment. The highest gross margin (Tk. 42200/ha) was obtained from P_2F_2 {40 cm × 25cm along with IPNS + Poultry manure (3 t/ha)} treatment. The highest benefit cost ratio (1.50) was obtained from P_2F_2 {40 cm ×25 cm along with IPNS + Poultry manure (3 t/ha)} treatment which was similar to P_3F_2 {40 cm × 30 cm along with IPNS + Poultry manure (3 t/ha)} treatment (Table 5). It might be due to the low cost of chemical fertilizer and poultry manure than vermicompost. According to the above result, poultry manure and vermicomost incorporation with inorganic fertilizer with 40cm × 25cm spacing provided better result in terms of vegetative growth and yield.

Conclusion

From the result it could be concluded that plant density of 40 cm × 20 cm (1,20,000 plants/ ha) or 40 cm × 25 cm (1,00,000 plants/ha) with fertilizer dose IPNS (16-25-30-9-1.2-1.2 kg/ha NPKSZnB at Gazipur and 17-21-23-9-1-1kg/ha NPKSZnB at Jashore) + Poultry manure (3 t/ha) might be suitable for yard long bean cultivation.

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EVALUATION OF YARDLONG BEAN LINES WITH BARI BORBOTI-1

M.H. RAHMAN, S PAUL, M.S HUDA, M.R. KARIM, S. SULTANA, KU AHAMED AND D.A CHOWDHURY

Abstract

The experiment was conducted at the research field of four (04) BARI stations *viz,* Jashore, Cumilla, Dinajpur and Gazipur during *Rabi* season of 2021-22 to find out the suitable advanced line of yard long bean for winter season in Bangladesh. Two advanced long yard bean lines viz. JSRVU-002, JSRVU-003 were evaluated with the variety BARI Borboti-1 (control). The maximum number of pods per plant (32), pod length (25.49cm) and the highest (27.06 t/ha) were recorded from JSRVU-003 at Dinajpur region.

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Introduction

Vigna unguiculata (L.) commonly known as yard long bean of pole type vegetable. It is a commercially used leguminous plant with very long pods and climbing growth habit, widely grown in China, South and south-East Asia. It belongs to the family Fabaceae and is one of the most popular and remunerative vegetable crop traditionally grown in Bangladesh, cultivated mainly for tender pods that are consumed both fresh and cooked. It is a highly nutritive vegetable containing high percentage of digestible protein (23.52 - 26.27%) (Ano and Ubochi, 2008) along with vitamin A, thiamin, riboflavin, calcium, phosphorus, sodium, potassium, magnesium and a very good source of vitamin C. It is also a good source of micronutrients containing 102.69 - 120.02 mg /kg of iron, 32.58 - 36.66 mg/ kg of inc, 2.92 - 3.34 mg /kg of manganese and 0.33 - 0.57 mg/kg of cobalt (Ano and Ubochi 2008). It's cultivation enriches soil fertility by fixing atmospheric nitrogen.

However, the production of this vegetable in Bangladesh is much lower than any other Asian countries with a national individual of 3.64 M t/ ha (Anon. 2009). Besides, this crop is usually grown during February/March to May/June. If we can find a winter variety of this vegetable, it will be possible to increase the national yield. So, two lines of yard long bean has been evaluated to find out the suitable advanced line of yard long bean for winter season in Bangladesh.

Materials and Methods

The experiment was conducted at four locations viz: Jashore, Cumilla, Dinajpur, and Gazipur during Rabi season of 2021-22. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4.0 m × 3.0 m. Two advanced long yard bean lines viz. JSRVU-002, JSRVU-003 were evaluated with the variety BARI Borboti-1 (control) with 60 cm× 25 cm spacing, and recommended fertilizer dose 21-27-33-9-1.2-1.2 kg/ha NPKSZnB; RFD FRG, 2018. Fertilizer were applied in the form of Urea, TSP, MoP, Gysum, Zinc sulphate and Boric acid. One-third of urea and full amount of all other fertilizers were applied at the time of final land preparation. The remaining Urea was top dressed in two equal splits at 35 DAS and 50 DAS. A light irrigation was given after sowing of seeds uniform for germination. Two irrigations were done at 25 and 50 DAS. Intercultural operations like thinning were done at 15 DAS and weeding were done two times at 15 and 25 DAS. Yard long bean was harvested for several times. and started on 17 May 2021. The yield component data was taken from 5 randomly selected plants prior to harvest from each plot. At harvest, the yield data was recorded plot wise. The collected data were analyzed statistically, and means were adjudged by LSD test at 5% level of probability using R software package.

Results and Discussion

Among the line, the maximum plant height was recorded from JSRVU-003 (228.33cm) at Dinajpur region which was statistically similar to JSRVU-003 at all regions and JSRVU-002 at Cumilla and Dinajpur. Moreover the 1st flowering was recorded from JSRVU-003 (47 DAS). The maximum number of pods / plant was counted from JSRVU-003 (32) at Dinajpur region and the minimum number pod per plant was counted from JSRVU-002 (4.33 no) at Gazipur. Similarly, the maximum pod length (25.49 cm) was recorded from JSRVU-003 at Dinajpur region and the minimum was found in JSRVU-002 (15 cm) at Gazipur. The highest yield was obtained from JSRVU-003 (27.06 ton/ha) at Dinajpur region and the lowest yield was obtained from JSRVU-002 (4.00 ton/ha) at Gazipur. But In case of BARI Borboti -1, There was no flower or pod was found in the field, might be due to it is a summer variety.

Table 1. Performance of Yield and yield component of different Long Yard Bean lines in Jashore, Cumilla, Dinajpur and Gazipur during 2021-22

Location	Treatments	Plant height (cm)	Pod / plant (no.)	Pod length (cm)	Yield (t /ha)
Jashore	JSRVU002	198.00	10.33	25.17	4.33
	JSRVU003	234.00	8.67	18.67	6.63
Cumilla	JSRVU002	226.67	10.23	21.43	4.27
	JSRVU003	221.67	13.783	24.00	6.67
Dinajpur	JSRVU002	227.53	20.09	21.46	7.37
	JSRVU003	228.33	32.00	25.49	27.06
Gazipur	JSRVU002	195.33	4.33	15.00	4.00
	JSRVU003	234.33	8.67	16.00	6.10
CV%		20.68	15.89	14.77	20.68
$LSD_{0.05}$		3.23	4.04	5.81	3.3

Conclusion

From the results, it may be suggested that JSRVU003 is suitable yard long bean line for winter season. In Dinajpur region, the line showed the highest result in case of both yield and yield parameters.

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GROWTH AND YIELD OF BARLEY AS INFLUENCED BY SPACING AND SEED RATE

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Abstract

A field experiment was conducted during rabi seasons of 2021-22 to find out optimum seed rate and plant spacing barley. Two plants spacing viz, R_1= 20 cm row spacing and continuous sowing, R_2= 25cm row spacing and continuous sowing and five seed rates viz; S_1 = 100 kg/ha, S_2 = 120 kg/ha, S_3 = 140 kg/ha, S_4 = 160 kg/ha, S_5 = 180 kg/ha were used as treatments. Results revealed that, spacing and seed rate showed great influence on dry matter production and yield of barley. Dry matter (both in plants and spike) was found the highest with of 25 cm row spacing and continuous sowing with 100 kg/ha seed rate. In the case of yield attributes for most of the parameters like., plant height (76.13 cm), seeds/spike (55.73), 1000-grain weight (45.00 g) were found highest in T_2 (seed rate 100 kg /ha with 25 cm row spacing and continuous sowing) treatment. Significantly the highest grain yield (2.10 t/ha) was recorded in 100 kg/ha seed rate with 25 cm row spacing (T_2) which was followed by 25 com row spacing with 120 kg/ha seed rate. The result revealed that seed rate 100 kg /ha with 25 cm row spacing and continuous sowing gave the highest gross return (Tk.84000/ha) and benefit cost ratio (1.47). The overall results indicated that 25 row spacing with seed rate of 100 kg/ha might be economically profitable for barley production.

Introduction

Barley (Hordeum vulgare) though a minor cereal, it is a valuable crop because it is used for food, processed food and feed for livestock. Besides these conventional uses, it is an important industrial crop. Barley possesses high total biomass, thus the small and marginal farmers of our country used green barley fodder as feed for milch animals. The area under barley cultivation was recorded as 1000 acres in 2011-2012 but it continuously decreased and reached to 460 acres in 2020-2021 (BBS 2022). Though barley is becoming an important crop day by day, its yield is not satisfactory comparing with increasing demand. Better yield of a crop depends on many factors and among many spacing and seed rates has a considerable effect on barley yield. The understanding with conventional tillage management systems is that reduced grain yield can be expected as seed row spacing increases (Doyle 1988; Epplin et al. 1992). The use of 30-cm row spacings in spring cereals under zero tillage did not result in lower yields relative to l0- and 20-cm spacing (Lafond 1994). Seed rate also has considerable effects on crops. Adequate seed rate, cutting schedule and mineral fertilization is considered to be one of the most important pre-requisites for realizing higher green fodder as well as grain yields (Thomson et al., 2009). Hence, the experiment was undertaken to find out the optimum spacing and seed rate of barley.

Materials and Methods

The experiment was conducted at the Research Field of Agronomy Division BARI, Gazipur during rabi season of 2020-2021. The soil of the research area belongs to the Chhihata series under AEZ-28. The soil was clay loam with pH 6.1. Two plants spacing viz, R1= 20 cm row spacing and continuous sowing, R2= 25cm row spacing and continuous sowing and five seed rates viz; S1 = 100 kg/ha, S2 = 120 kg/ha, S3 = 140 kg/ha, S4 = 160 kg/ha, S5 = 180 kg/ha were used. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 3m × 3m. Seeds of BARI Barley-9 were sown on 24 November 2021. The crop was fertilized with 80-28-60-12-3.0 kg/ha (FRG' 2018) of N-P-K-S-Zn, respectively in the form of urea-TSP-MoP-gypsum-zinc sulphate and boric acid. Half N and full dose of other fertilizer was applied as basal dose during land preparation. Remaining N fertilizer was top dressed at 55-60 DAS (days after sowing) after irrigation in two equal splits and mixed thoroughly with the soil as soon as possible for better utilization. A light irrigation was given after sowing of seeds for uniform germination. Four irrigations were done depending on soil moisture. Leaf area was measured by an automatic leaf Area Meter (L13200 C, LICOR, USA). For dry matter estimation, 5 plants were sampled started from 20 DAE at 15 days interval up to maturity. Dry weight of the samples was taken after drying at 800C in an oven for 72 hours. Crop was harvested on 24 March 2022 and. The yield component data was taken from 5 randomly selected plants from each plot. At harvest, yield and yield contributing characters were analyzed statistically using "STAR" software package and means were separated by LSD at 5% level of significance. Economic analysis was performed considering the prevailing market price of applied inputs and output of barley

Results and Discussion

Total dry matter (TDM) and spike dry matter

Dry matter accumulation in spikelets increased gradually with plant growth up to certain level (Fig.1). Dry matter increased up to 45 days after flowering then it doesn't increased considerably because for grain development and maturity more phtosythates accumulated here and then after maturity it doesn't increased noticeably. So, it can be assumed that, up to 45 days after flowering grains attends its physiological maturity. Total dry matter (TDM) production increased gradually with the advancement of plant growth in both the spacing and seed rate (Fig. 2). At harvest TDM of barley was higher in $T_2 = S_1 \times R_2$ treatment at harvest followed by $T_4 = S_2 \times R_2$ treatment. The lowest TDM was observed from $T_{10} = S_5 \times R_2$ treatment. It might be due to higher population for higher seed rate and might reduce the photosynthetic efficiency and ultimately reduced the dry matter accumulation.

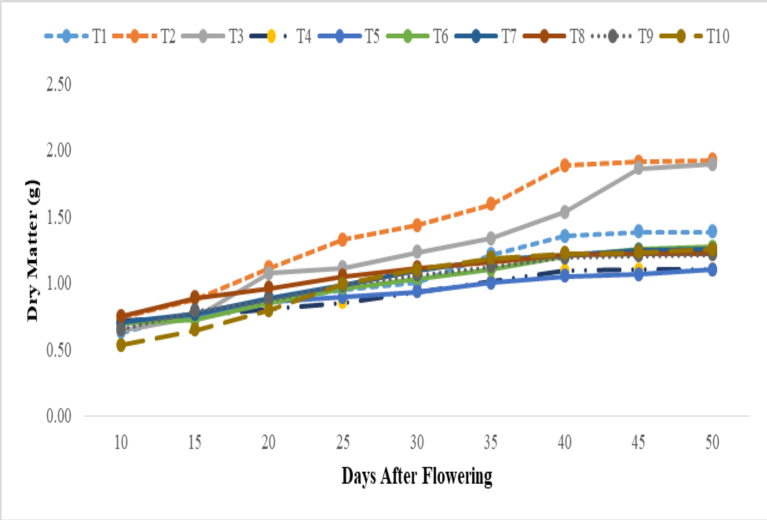

Fig1. Dry matter of spikelets of barley plant as influenced by spacing and seed rate

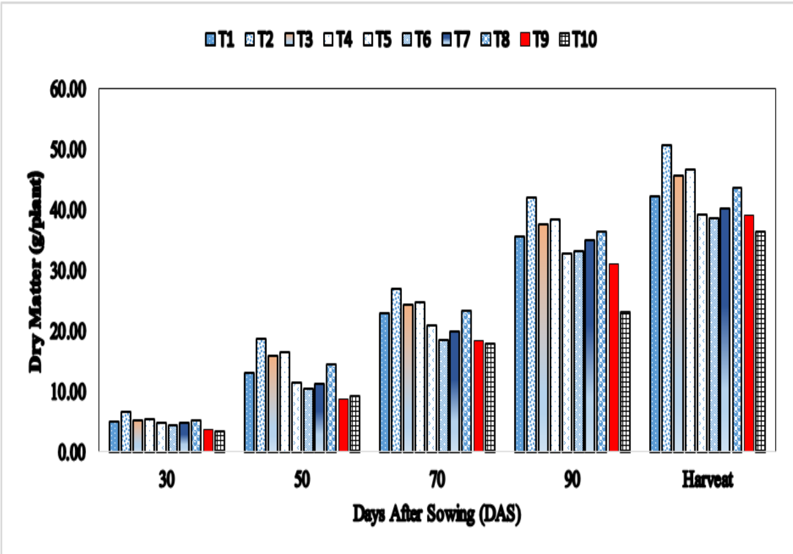

Fig2. Total dry matter (TDM) of barley plant as influenced by spacing and seed rate

Yield and yield component

Yield components and yield of barley were significantly affected by plant spacing and seed rates. Plant height, plants/m^2, tillers/hill, spikes/tillers, spikelets (no.), spike length varied significantly due to variation of treatments (Table 1). Maximum plant height (76.13 cm) was recorded in $T_2 = S_1 \times R_2$ treatment and minimum plant height (61.67 cm) was recorded in $T_6 = S_3 \times R_2$ treatment. Highest plant population i.e., plants/m2 (43.67) found in T_2 ($S_1 \times R_2$) treatment and lowest number of plants (32.33) found in $T_7 = S_4 \times R_1$ treatment. The highest number of tillers/hill (73.67) and spikes/tiller, (68.67) were obtained from $T_2 = S_1 \times R_2$ treatment and for both parameters the lowest one found in $T_{10} = S_5 \times R_2$ and $T_9 = S_5 \times R_1$ treatments respectively. In the case of spikelets and spike length highest value were recorded in $T_6 = S_3 \times R_2$ treatment and lowest one found in $T_2 = S_1 \times R_2$ and $T_9 = S_5 \times R_1$ for spikelets and $T_2 = S_1 \times R_2$ for spike length. Seeds/spike, 1000- grain weight and gain yield were significantly different from each treatment except straw yield (Table 2). The highest seeds/spike (55.73), 1000- grain weight (45.00 g) and grain yield (2.10 t/ha were found in $T_2 = S_1 \times R_2$ treatment. Whereas, maximum straw yield (8.19 t/ha)) were found in $T_7 = S_4 \times R_1$ treatment. The lowest seeds/spike (41.27), 1000- grain weight (40.21 g) was obtained from $T_4 = S_2 \times R_2$ and $T_6 = S_3 \times R_2$ treatments respectively. In $T_{10} = S_5 \times R_2$ treatment lowest straw yield (6.19 t/ha) and grain yield (1.55 t/ha) were found.

Highest value for most of the yield attributes were found in $T_2 = S_1 \times R_2$ treatment i.e., 100kg/ha seed rate and 25 cm row spacing and continuous sowing. This might be due to the fact that greater dry matter accumulation has contributed much as a major source for the development of sink and thereby improved the yield attributes. Significantly the highest yield was recorded in 100kg/ha seed rate and closer spacing indicating a faster growth where low seed rate might have played a significant role in reducing competition for photosynthates and nutrients with other plants resulting in healthy plants.

Cost Benefit Analysis

The highest gross return (Tk. 84000/ha) was obtained from T_2 (seed rate 100 kg /ha with 25 cm row spacing and continuous sowing) treatment and the lowest gross return (Tk. 62000/ha) was found in $T_{10} = S_5 \times R_2$ treatment. The highest gross margin (Tk. 26675/ha) was obtained from T_2 (seed rate 100 kg /ha with 25 cm row spacing and continuous sowing)treatment. The highest benefit cost ratio (1.47) was also obtained from $T_2 = S_1 \times R_2$ treatment (Table 3) and the lowest gross margin (Tk. 4675/ha) and BCR (1.08) was obtained from $T_{10} = S_5 \times R_2$ treatment. Profitability of barley was high in $T_2 = S_1 \times R_2$ for higher yield and gross return which was followed by $T_5 = S_3 \times R_1$ treatment. The lowest profit was earned from $T_{10} = S_5 \times R_2$ due to higher cost of production, low yield, gross margin and BCR.

Conclusion

Results revealed that treatment combination T_2 (seed rate 100 kg /ha with 25 cm row spacing and continuous sowing) would be optimum for getting higher yield and better economic return. This was the first result of the experiment. The experiment needs to be repeated next year for further confirmation.

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Table1. Yield contributing characters of barley influenced by plant spacing and seed rates 2020-21

Treatment	Plant height (cm)	Plants/m^2 (No.)	Tillers/hill	Spikes/tiller	Spikelets (No.)	Spike length (cm)
$T_1 = S_1 \times R_1$	71.20	35.33	69.67	59.67	20.13	7.70
$T_2 = S_1 \times R_2$	76.13	43.67	73.67	68.67	18.67	7.33
$T_3 = S_2 \times R_1$	72.53	34.33	72.67	65.33	22.93	9.33
$T_4 = S_2 \times R_2$	68.53	43.00	68.33	64.33	20.07	7.73
$T_5 = S_3 \times R_1$	70.53	32.67	70.00	67.00	21.35	9.50
$T_6 = S_3 \times R_2$	61.67	43.00	73.33	74.33	23.00	10.13
$T_7 = S_4 \times R_1$	67.13	32.33	68.33	61.67	19.47	8.32
$T_8 = S_4 \times R_2$	71.33	42.00	72.00	61.33	23.40	8.28
$T_9 = S_5 \times R_1$	68.13	34.00	65.67	58.67	18.67	7.60
$T_{10} = S_5 \times R_2$	72. 87	42.67	63.00	56.33	18.93	7.60
LSD $_{(0.05)}$	7.29	4.11	3.77	3.20	1.80	0.74
CV (%)	3.56	3.66	1.83	1.72	2.98	3.03

Table2. Yield attributes and yield of barley influenced by plant spacing and seed rates 2020-21

Treatment	Seeds/spike (No.)	1000- Grain Weight (g)	Straw yield (t/ha)	Grain yield (t/ha)
$T_1 = S_1 \times R_1$	47.73	41.80	6.59	1.89
$T_2 = S_1 \times R_2$	55.73	45.00	7.15	2.10
$T_3 = S_2 \times R_1$	50.60	42.35	6.70	1.92
$T_4 = S_2 \times R_2$	41.27	41.13	6.78	2.00
$T_5 = S_3 \times R_1$	50.27	38.89	6.78	1.80
$T_6 = S_3 \times R_2$	47.33	40.21	6.26	1.69
$T_7 = S_4 \times R_1$	41.40	42.36	8.19	1.78
$T_8 = S_4 \times R_2$	46.60	41.17	6.78	1.90
$T_9 = S_5 \times R_1$	47.73	40.21	7.89	1.59
$T_{10} = S_5 \times R_2$	49.60	41.76	6.19	1.55
$LSD_{(0.05)}$	0.74	1.53	NS	0.11
CV (%)	0.53	1.26	13.06	2.00

Table3. Cost benefit analysis of barley as influenced by spacing and seed rates 2020-21

Treatments	Gross return (Tk./ha)	Cost of production (Tk./ha)	Gross margin (Tk./ha)	BCR
$T_1 = S_1 \times R_1$	75600.00	57325.00	18275.00	1.32
$T_2 = S_1 \times R_2$	84000.00	57325.00	26675.00	1.47
$T_3 = S_2 \times R_1$	76800.00	57325.00	19475.00	1.34
$T_4 = S_2 \times R_2$	80000.00	57325.00	22675.00	1.40
$T_5 = S_3 \times R_1$	72000.00	57325.00	14675.00	1.26
$T_6 = S_3 \times R_2$	67600.00	57325.00	10275.00	1.18
$T_7 = S_4 \times R_1$	71200.00	57325.00	13875.00	1.24
$T_8 = S_4 \times R_2$	76000.00	57325.00	18675.00	1.33
$T_9 = S_5 \times R_1$	63600.00	57325.00	6275.00	1.11
$T_{10} = S_5 \times R_2$	62000.00	57325.00	4675.00	1.08

Price (Tk./kg): Barley (without husk) = 40

Plants spacing viz; R_1= 20 cm row spacing and continuous sowing, R_2= 25 cm row spacing and continuous sowing Seed rates viz; S_1 = 100 kg/ha, S_2 = 120 kg/ha, S_3 = 140 kg/ha, S_4 = 160 kg/ha, S_5 = 180 kg/ha

PERFORMANCES OF MINOR CEREAL CROPS UNDER DIFFERENT TILLAGE CONDITIONS IN RICE BASED CROPPING SYSTEMS IN SOUTHERN REGION OF BANGLADESH

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Abstract

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during two consecutive Rabi seasons of 2020-21 and 2021-22 to evaluate the performances of minor cereals under different tillage conditions in rice based cropping systems in southern region of Bangladesh. The treatments of the experiment were of two factors viz., Factor A: Tillage condition: 3 (T_1 = Zero tillage i.e. relay cropping with T.aman rice, T_2 = Minimum tillage i.e. after harvest of T.aman rice and T_3 = Conventional tillage i.e. power till: 2-3 pass); and Factor B: Number of minor cereal crop: 7 (C_1 = Barley, C_2 = Kaon, C_3 = Cheena, C_4 = Sorghum, C_5 = Oat, C_6 = Buckwheat and C_7 = Chia. An average of two years (2020-21 and 2021-22) experiment, the highest seed yield of barley was 2164 kg/ha in conventional tillage. However, average yield of minimum and zero tillage were 1692 and 1628 kg/ha, respectively. In kaon, conventional, minimum and zero tillage gave the seed yields of 1654, 1222 and 1200 kg/ha, respectively. In respect of cheena, conventional, zero and minimum tillage showed the yields of 1454, 1116 and 1112 kg/ha, respectively. In case of sorghum, average seed yields were 3673, 2640 and 2493 kg/ha in conventional, minimum and zero tillage, respectively. In oat crop, seed yields were 1919, 1466 and 1380 kg/ha in conventional, minimum and zero tillage, respectively. In buckwheat, conventional, zero and minimum tillage produced the yields of 1345, 1046 and 1013 kg/ha, respectively. In case of chia, seed yields of 121, 1047 and 967 kg/ha were found in conventional, minimum and zero tillage, respectively. The experimental results revealed that all the minor cereal crops (chia, barley, kaon, cheena, sorghum, oat and buckwheat) can be cultivated under different tillage conditions in southern region of Bangladesh. However, chia, sorghum, oat, kaon and cheena cultivations were more profitable as compared to other minor cereal crops.

Introduction

The southern region of Bangladesh mainly represents tidal wetland ecosystem of both saline and non-saline types. The crop production is restricted due to salinity in some areas during dry season. In other areas it is affected by daily tide and monsoon tide. Diversified cropping pattern may be the strategic option for the farmers to coping strategy against the risk (Mandal and Bezbaruah, 2013). Rahman (2015) reported that about 29.45% and 55.10% lands remain fallow in *Rabi* and *Kharif*-1 seasons, respectively after harvesting of previous T.*aman* rice mainly due to delaying harvest of T.*aman* rice, soil and water salinity, drought, tidal flooding, lack of suitable adaptation technologies and so on. Traditionally, the farmers in Barishal region practice the relay of Khesari with T.*aman* rice successfully by using residual soil moisture. Relay cropping of different minor cereal crops (like barley, kaon, cheena, sorghum, oat, buckwheat etc.) with previous T.*aman* rice can be alternate cropping approach to bring the fallow lands under crop production particularly in *Rabi* and *Kharif-I* seasons by fitting them into the rice fallows. However, the performances of these minor crops are yet to be examined under different tillage conditions in southern region of Bangladesh. Keeping the above view in mind, an experiment has been undertaken to evaluate the performances of minor cereals under different tillage conditions in rice based cropping systems.

Materials and Method

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during *Rabi* season of 2020-21 to evaluate the performances of minor cereals under different tillage conditions in rice based cropping systems and increase the economic return in southern region of Bangladesh. The experimental site is situated in the latitudes and longitudes of 22°47′5.41406″N and 90°17′30.17557″E. The experimental site is located under the agro-ecological zone Ganges Tidal Floodplain (AEZ-13). The soil type is medium high land and soil texture is loamy. The treatments of the experiment were of two factors viz., Factor A: Tillage condition: 3 (T_1 = Zero tillage i.e. relay cropping with T.*aman* rice, T_2 = Minimum tillage i.e. after harvest of T.*aman* rice and T_3 = Conventional tillage i.e. power till: 2-3 pass); and Factor B: Number of minor cereal crop: 6 (C_1 = Barley (*Hordeumvulgare*), C_2 = Kaon (Foxtail millet) (*Setariaitalica*), C_3 = Cheena (Proso millet) (*Panicummiliaceum*), C_4 = Sorghum (*Sorghum bicolor*), C_5 = Oat (*Avena sativa*) and C_6 = Buckwheat (*Fagopyrumesculentum*) in first year experiment (2020-21). In second year (2021-22), C_7 = Chia (*Salvia hispanica*) was also included under factor B. The experiment was laid out in randomized complete block design with three replications. The unit plot size was 4 m × 3 m. The seeds of the selected minor cereal crops were sown on 8 November 2020 (Zero tillage i.e. relay cropping with previous T.*aman* rice cv. BRRI dhan52), 12 November 2020 (Minimum tillage i.e. after harvest of T.*aman* rice) and 30 November 2020 (Conventional tillage condition) in first year (2020-21). In second year (2021-22), the minor cereal crops were sown on 24 November 2021 (zero tillage), 13 December 2021 (minimum tillage) and 4 January 2022 (conventional tillage). The varieties of these crops were BARI Barley-8 (barley), BARI Kaon-4 (kaon), Tusar (cheena), BARI Sorghum-1 (sorghum), exotic variety (oat), local variety (buckwheat) and exotic variety (chia). Seeds of these minor crops were sown as per treatment specifications. The seed rate of barley was 120 kg/ha, kaon 10 kg/ha, cheena 20 kg/ha, sorghum 10 kg/ha, oat 80 kg/ha, buckwheat 80 kg/ha and chia 6 kg/ha. For minimum or conventional tillage, seeds of minor cereal crops were sown in rows following row to row distance 20 cm for barley, 25 cm for kaon, 25 cm for cheena, 50 cm for sorghum, 20 cm for oat, 10 cm for buckwheat and chia. The plant to plant distance was 10 cm for all the crops. Fertilizer nutrients were applied in the plots of the minor cereal crops as per their respective recommended doses and methods (FRG, 2018), which are described below:

Name of the crops	Nutrient rate (FRG, 2018)	Method of nutrient application
Barley	40-14-34-6-1.0 kg/ha N-P-K-S-Zn, respectively	Half of N and all of P, K, S and Zn were applied as basal 3-5 days before seeding. The N was applied as top dress in two equal splits at 30-35 and 55-60 days after sowing followed by irrigation.
Kaon	40-16-28-6-0.7 kg/ha N-P-K-S-Zn, respectively	Half of N and all of P, K, S and Zn were applied as basal 3-5 days before seeding. The N was applied as top dress in two equal splits at 15-20 and 35-40 days after sowing followed by irrigation
Cheena	40-14-30-6-0.7 kg/ha N-P-K-S-Zn, respectively	Half of N and all of P, K, S and Zn were applied as basal 3-5 days before seeding. The N was applied as top dress in two equal splits at 15-20 and 35-40 days after sowing followed by irrigation.
Sorghum/ Oat/ Buckwheat/ Chia	60-20-35-6-1.0 kg/ha N-P-K-S-Zn, respectively	Half of N and all of P, K, S and Zn were applied as basal 3-5 days before seeding. The N was applied as top dress in two equal splits at 30-35 and 55-60 days after sowing followed by irrigation.

Irrigation was applied for two times and other intercultural operations were done as when necessary following the recommended production technologies of the minor cereal crops (BARI, 2020). The crops were harvested when attained to their respective physiological maturity. Data were collected in relation to phenology, yield attributes and yields of the respective crops. Data were analyzed statistically and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) following Gomez and Gomez (1984).

Results and Discussion

Plant characters of different minor cereal crops under different tillage conditions (2020-21)

In case of barley, number of days to flowering, days to maturity, number of spike/m^2, seed/spike, seed yield and straw yield differed significantly due to different tillage conditions in 2020-21 (Table 1). Days to flowering became the highest in conventional tillage (98 days). Zero tillage (relay cropping) and minimum tillage needed 91 and 89 days, respectively. Similarly, conventional tillage showed the highest number of days to maturity (122 days), where zero and minimum tillage needed 114 and 113 days, respectively to become maturity. Minimum tillage showed the highest number of spike/m^2 (291) that was somewhat identical to conventional tillage (284). Conventional tillage gave the highest number of seed/spike (45.01) and the lowest was observed in minimum tillage (40.01). Seed yield became the highest (2292 kg/ha) in conventional tillage, where the yields of 1956 and 1883 kg/ha were found in minimum and zero tillage, respectively. Likewise, conventional tillage showed the highest yield of straw (4423 kg/ha) and the lowest yield was obtained from zero tillage (3635 kg/ha). In 2021-22, days to flowering, number of spike/m^2, seed yield and straw yield differed significantly by tillage method (Table 2). Zero tillage crop needed the highest number of days to become flowering (97 days) and it was partially at par to minimum tillage (94 days) and the lowest number of days was required in conventional tillage. Crops were sown under conventional tillage condition, which were 40 days after zero tillage. Delay sowing of the crops forced them to become flowering instead of proper vegetative growth and that is why number of days to flowering was the lowest in conventional tillage. The highest number of spike/m^2 (261) was recorded in conventional tillage, whereas spike number of 219.87 and 210.52 were found in minimum and zero tillage, respectively. Similarly, conventional tillage gave the highest yield of seed (2037 kg/ha) and the lowest yield (1401 kg/ha) was obtained from zero tillage. Besides, minimum tillage showed the seed yield of 1457 kg/ha. Straw yield was also the highest (3210 kg/ha) in conventional tillage, while zero and minimum tillage exhibited the yields of 2489 and 2477 kg/ha, respectively. An average of two years (2020-21 and

2021-22), the highest seed and straw yields were 2164 and 3792 kg/ha, respectively in conventional tillage (Table 3). However, average seed and straw yields of minimum tillage were 1692 and 3076 kg/ha, respectively. The lowest average seed and straw yields were 1628 and 3022 kg/ha, respectively in zero tillage.

In case of kaon, the tillage conditions had significant effects only on the number days to flowering, seed and straw yields in 2020-21 (Table 1). Zero tillage crop needed the highest number of days to flowering (104 days) and it was partially similar to that of conventional tillage (97 days). Crop grown with conventional tillage gave the highest yield of seed (1797 kg/ha), while minimum and zero tillage contributed the yields of 1350 and 1319 kg/ha, respectively. Likewise, the highest yield of straw (3352 kg/ha) was found in conventional tillage and the lowest yield (2574 kg/ha) was obtained from minimum tillage. In 2021-22, tillage conditions had significant effect on plant population/m2 and seed yield (Table 2). The plant population became the highest (261.67) in conventional tillage but the population obtained from minimum and zero tillage showed values of 225.82 and 221.00, respectively. Similarly, conventional tillage produced the highest yield of seed (1511 kg/ha) and the lowest yield (1080 kg/ha) was found in zero tillage but minimum tillage gave the yield of 1094 kg/ha. An average of two years (2020-21 and 2021-22), the highest seed and straw yields were 1654 and 3054 kg/ha, respectively in conventional tillage (Table 3). However, average seed and straw yields of minimum tillage were 1222 and 2375 kg/ha, respectively. The lowest average seed and straw yields were 1200 and 2370 kg/ha, respectively in zero tillage.

In respect of cheena, statistically significant differences were found on the studied parameters in terms of number of days to flowering, days to maturity, plant population/m^2, plant height, number of seed/spike, seed and straw yields in 2020-21 (Table 1). Minimum tillage exhibited the highest number of days to flowering (98 days). Conventional tillage needed somewhat reduced number of days (92 days) and zero tillage (relay cropping) showed 81 days to flowering. The longest duration to maturity (130 days) was found in minimum tillage that was statistically identical to that of conventional tillage (129 days). Conventional tillage produced the highest number of plant population/m^2 (251), which was partially at par to that of zero tillage (222). The longest plant (72.73 cm) was observed in minimum tillage, which was statistically at par to that of conventional tillage (72.60 cm) and zero tillage crop gave the shortest plant (67.27 cm). Number of seed/spike became the highest (179.38) in conventional tillage, while zero and minimum tillage showed the values of 162.59 and 151.06, respectively. Conventional tillage gave the highest yield of seed (1547 kg/ha) but the yields provided by zero and minimum tillage were 1289 and 1261 kg/ha, respectively. The highest yield of straw (2956 kg/ha) was obtained from conventional tillage, while zero and minimum tillage provided the yields of 2475 and 2394 kg/ha, respectively. In 2021-22, days to flowering, plant population/m^2, seed and straw yields (Table 2). Conventional and minimum tillage needed statistically similar number of days to flowering (88 days) and the lowest number of days (85 days) was in zero tillage. Plant population/m^2 (263.67) were the highest in conventional tillage but the population in minimum and zero tillage were 215.33 and 206.55, respectively. Conventional tillage also gave the highest yield of seed (1360 kg/ha), while minimum and zero tillage gave the yields of 963 and 944 kg/ha, respectively. The highest yield of straw (2973 kg/ha) was obtained from conventional tillage. Besides, straw yields achieved from zero and minimum tillage were 2340 and 2273 kg/ha, respectively. An average of two years (2020-21 and 2021-22), the highest seed and straw yields were 1454 and 2965 kg/ha, respectively in conventional tillage (Table 3). However, average seed and straw yields of zero tillage were 1116 and 2408 kg/ha, respectively. The lowest average seed and straw yields were 1112 and 2333 kg/ha, respectively in minimum tillage.

In case of sorghum, number of days to physiological maturity, plant height, number of seed/spike, seed and straw yields varied significantly due to different tillage conditions in 2020-21 (Table 1). Conventional tillage showed the highest value (159 days) of number of days to maturity and the lowest duration was found in zero tillage (126 days), while minimum tillage needed 137 days to become maturity. The longest plant (171.80 cm) was obtained from conventional tillage but the shortest plant (125.67 cm) was found in zero tillage. Conventional tillage provided the highest yield of seed (3450 kg/ha), which was partially identical to that of minimum tillage (2619 kg/ha) and the lowest yield (2508 kg/ha) was obtained from zero tillage. Straw yield also the highest (6521 kg/ha) in conventional tillage, while minimum and zero tillage gave the yields of 4982 and 4835 kg/ha, respectively. In 2021-22, tillage condition had significant effects on days to flowering, plant population/m^2, seed and straw yields (Table 2). Crop grown with zero and conventional tillage needed partially similar number of days to flowering (92 and 89 days, respectively). Conventional tillage showed the highest population of plant/m^2 (28.67) and the lowest population (17.85) were recorded in zero tillage. The highest yield of seed (3896 kg/ha) was observed in conventional tillage. However, seed yields obtained from minimum and zero tillage were 2661 and 2477 kg/ha, respectively. Straw yield also was the highest (7749 kg/ha) in conventional tillage that was partially at par to that of minimum tillage (6418 kg/ha) and the lowest yield (5220 kg/ha) was obtained from zero tillage. An average of two years (2020-21 and 2021-22), the highest seed and straw yields were 3673 and 7135 kg/ha, respectively in conventional tillage (Table 3). However, average seed and straw yields of minimum tillage were 2640 and 5700 kg/ha, respectively. The lowest average seed and straw yields were 2493 and 5027 kg/ha, respectively in zero tillage.

In oat crop, statistically significant differences were observed in the parameters of number of days to flowering, days to maturity, spike/m^2, seed/spike, 1000 seeds weight, seed and straw yields in 2020-21 (Table 1). The minimum and conventional tillage needed the higher as well as similar number of days to flowering (99 days) and the lower number of days was shown by zero tillage (94 days). Days to maturity was the highest (136 days) in conventional tillage, where zero tillage and minimum tillage showed the reduced number of days to flowering (130 and 129 days, respectively). The conventional tillage produced the highest number of spike/m^2 (295). Zero tillage and minimum tillage exhibited the lower number of spike/m^2 (240 and 236, respectively). The minimum tillage gave the highest number of seed/spike (29.44) that was partially at par to that of zero tillage (23.19) and the lowest number of seed/spike (20.96) was found in conventional tillage. Weight of thousand seeds exhibited the highest (30.51 g) in minimum tillage, which was statistically similar to that of conventional tillage (30.41 g). The zero tillage oat crop (relay cropping) produced the lowest weight (29.26 g) of 1000 seeds. Seed yield showed the highest value (1978 kg/ha) that was partially identical to that of minimum tillage (1681 kg/ha) and the lowest yield (1564 kg/ha) was found in zero tillage. Similarly, the highest yield of straw (3949 kg/ha) was obtained from conventional tillage, while minimum and zero tillage gave the straw yields of 3216 and 3125 kg/ha, respectively. In 2021-22, tillage conditions created significant variations in relation to plant population/m^2, seed and straw yields (Table 2). The highest population of plant/m^2 (196.00) was found in conventional tillage and it was somewhat at par to that of zero tillage (158.38). Conventional tillage gave the highest yield of seed (1861 kg/ha) but minimum and zero tillage comparatively reduced amount yields (1252 and 1197 kg/ha). The highest yield of straw (3558 kg/ha) was found in conventional tillage that was to some extent identical to minimum tillage (2699 kg/ha) and the lowest yield (2569 kg/ha) was observed in zero tillage. An average of two years (2020-21 and 2021-22), the highest seed and straw yields were 1919 and 3754 kg/ha, respectively in conventional tillage (Table 3). However, average seed and straw yields of minimum tillage were 1466 and 2957 kg/ha, respectively. The lowest average seed and straw yields were 1380 and 2847 kg/ha, respectively in zero tillage.

In case of buckwheat, significant variation was observed in the number of days to flowering and days to maturity, plant population/m^2, number of seed/plant, seed and straw yields of due to different tillage conditions in 2020-21 (Table 1). The longest duration (75 and 98 days) needed to become flowering and maturity, respectively in zero tillage. However minimum tillage and conventional tillage showed reduced durations (62 and 86 days) to attain the stages of flowering and physiological maturity stages, respectively. Plant population/m^2were the highest (130) in zero tillage, which were somewhat identical to conventional tillage (115). Number of seed/plant became the highest (107.39) in conventional tillage and the numbers of 86.22 and 81.56 were produced by minimum and zero tillage, respectively. Conventional tillage gave the highest yield of seed (1425 kg/ha), where zero and minimum tillage produced the yields of 1175 and 1122 kg/ha, respectively. The highest yield of straw (2925 kg/ha) was recorded in conventional tillage. Zero and minimum tillage showed the straw yields of 2327 and 2296 kg/ha, respectively. In 2021-22, tillage conditions created statistically significant effects on the number of days to maturity, plant population/m^2, plant height, seed and straw yields (Table 2). Zero tillage crop needed the highest number of days to become maturity, while minimum and conventional tillage showed 121 and 119 days, respectively. Partially identical population of plant/m^2 were showed by conventional and zero tillage (165.67 and 127.50, respectively). The highest height of plant (91.13 cm) was observed in minimum tillage that was somewhat at par to conventional tillage (87.47 cm) and the lowest height (76.80 cm) was obtained from zero tillage. Conventional tillage gave the highest yield of seed (1264 kg/ha), while zero and minimum tillage showed the yields of 917 and 905 kg/ha, respectively. In terms of straw yield, conventional tillage also exhibited the highest value (2670 kg/ha) but minimum and zero tillage produced the straw yields of 2147 and 1888 kg/ha, respectively. An average of two years (2020-21 and 2021-22), the highest seed and straw yields were 1345 and 2797 kg/ha, respectively in conventional tillage (Table 3). The lowest average seed and straw yields were 1013 and 2107 kg/ha in minimum and zero tillage, respectively.

In case of chia, tillage conditions had statistically significant effects on the number of days to maturity, plant population/m^2, seed and straw yields in 2021-22 (Table 2). Crop grown with zero tillage showed the highest value (126 days) of number of days to maturity and the lowest duration was found in zero tillage (119 days), while minimum tillage needed 137 days to become maturity. Plant population/m^2were the highest (167.33) in conventional tillage and the lowest population (123.25) were recorded in minimum tillage. Seed yield exhibited the highest (121 kg/ha) by conventional tillage, while minimum and zero tillage gave the yields of 1047 and 967 kg/ha, respectively. Statistically somewhat similar yields of straw were obtained from conventional and zero tillage (2628 and 2314 kg/ha, respectively). Minimum tillage crop gave the lowest yield of straw (2114 kg/ha).

Table 1. Plant characters of different minor cereal crops under different tillage conditions at RARS, Rahmatpur, Barishal (2020-21)

Barley								
Tillage condition	Days to flowering	Days to maturity	Spike /m^2 (no.)	Plant height (cm)	Seed/ spike (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
Zero tillage	91b	114b	279b	84.67	41.61b	32.54	1883b	3635b
Min. tillage	89b	113b	291a	93.13	40.01b	32.33	1956b	3774b
Conv. Tillage	98a	122a	284ab	94.40	45.01a	32.27	2292a	4423a
CV (%)	3.42	3.56	10.78	9.19	12.35	3.58	14.10	14.71
F-test	*	*	*	NS	*	NS	*	*
Kaon								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2 (no.)	Plant height (cm)	Seed/ spike (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
Zero tillage	104a	131	289	85.67	207.79	2.50	1319b	2595b
Min. tillage	94b	130	296	83.47	207.46	2.49	1350b	2574b
Conv. tillage	97ab	130	304	84.20	228.60	2.46	1797a	3352a
CV (%)	3.89	3.01	12.10	9.90	14.41	2.63	9.95	10.09
F-test	*	NS	NS	NS	NS	NS	**	*
Cheena								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2 (no.)	Plant height (cm)	Seed/ spike (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
Zero tillage	81c	104b	222ab	67.27b	162.59b	4.17	1289b	2475b
Min. tillage	98a	130a	210b	72.73a	151.06b	4.20	1261b	2394b
Conv. Tillage	92b	129a	251a	72.60a	179.38a	4.18	1547a	2956a
CV (%)	7.68	6.50	15.61	3.54	22.49	1.20	13.46	14.36
F-test	*	*	*	*	*	NS	*	*
Sorghum								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2 (no.)	Plant height (cm)	Seed/ spike (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
Zero tillage	98	126c	8.00	125.67b	605.74	31.14	2508b	4835b
Min. tillage	97	137b	7.00	126.27b	681.95	30.21	2619ab	4982b
Conv. Tillage	98	159a	8.00	171.80a	719.94	30.28	3450a	6521a
CV (%)	0.59	0.47	16.84	10.61	18.05	2.81	14.36	14.87
F-test	NS	*	NS	*	NS	NS	*	*

Oat								
Tillage condition	Days to flowering	Days to maturity	Spike/m^2 (no.)	Plant height (cm)	Seed/ spike (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
Zero tillage	94b	130b	240b	129.47	23.19ab	29.26b	1564b	3125b
Min. tillage	99a	129b	236b	134.13	29.44a	30.51a	1681ab	3216b
Conv. Tillage	99a	136a	295a	144.93	20.96b	30.41a	1978a	3949a
CV (%)	1.45	0.74	7.97	9.46	11.69	1.24	10.27	8.03
F-test	*	*	*	NS	*	*	*	*

Buckwheat								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2 (no.)	Plant height (cm)	Seed/ plant (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
Zero tillage	75a	98a	130a	89.13	81.56b	11.00	1175b	2327b
Min. tillage	62b	86c	108b	86.40	86.22b	11.67	1122b	2296b
Conv. Tillage	61b	90b	115ab	90.47	107.39a	11.17	1425a	2925a
CV (%)	1.59	0.85	13.54	8.27	25.89	12.10	16.02	20.10
F-test	*	*	*	NS	*	NS	*	*

Table 2. Plant characters of different minor cereal crops under different tillage conditions at RARS, Rahmatpur, Barishal (2021-22)

Barley								
Tillage condition	Days to flowering	Days to maturity	Spike/m^2 (no.)	Plant height (cm)	Tiller/ plant (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
ZT	97a	122	210.52b	75.93	8.53	22.96	1401b	2489b
MT	94ab	120	219.87b	80.93	8.37	22.77	1457b	2477b
CT	92b	119	261.00a	66.00	9.27	22.54	2037a	3210a
CV (%)	1.97	1.07	16.66	9.71	9.76	8.08	14.88	16.76
F-test	*	NS	*	NS	NS	NS	*	*
Kaon								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2	Plant height (cm)	Tiller/ plant (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
ZT	100	121	221.00b	108.40	1.10	4.28	1080b	2145
MT	99	121	225.82b	113.53	1.03	4.17	1094b	2176
CT	98	120	261.67a	118.00	1.07	4.04	1511a	2755
CV (%)	1.90	1.50	14.5	7.41	10.83	5.13	10.96	15.29
F-test	NS	NS	*	NS	NS	NS	*	NS
Cheena								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2	Plant height (cm)	Tiller/ plant (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
ZT	85b	121	206.55b	68.67	6.67	4.63	944b	2340ab
MT	88a	122	215.33b	61.07	6.40	4.69	963b	2273b
CT	88a	121	263.67a	76.93	7.63	4.89	1360a	2973a
CV (%)	0.90	1.05	6.50	13.61	20.68	5.67	11.41	12.13
F-test	*	NS	*	NS	NS	NS	*	*
Sorghum								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2	Plant height (cm)	Tiller/ plant (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
ZT	92a	134a	17.85b	147.00	1.03	29.47	2477b	5220b
MT	87b	131b	18.98b	164.20	1.07	30.21	2661b	6418ab
CT	89ab	133ab	28.67a	150.53	1.07	30.70	3896a	7749a
CV (%)	1.71	0.90	16.25	7.09	3.39	5.48	10.89	9.12
F-test	*	NS	*	NS	NS	NS	*	*

Oat								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2	Plant height (cm)	Tiller/ plant (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
ZT	95	126	158.38ab	129.87	6.67	22.80	1197b	2569b
MT	93	122	153.85b	123.93	6.60	21.74	1252b	2699ab
CT	94	120	196.00a	124.60	8.67	22.44	1861a	3558a
CV (%)	1.94	2.50	10.30	14.66	18.88	4.73	12.98	13.19
F-test	NS	NS	*	NS	NS	NS	*	*
Buckwheat								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2	Plant height (cm)	Branch /plant (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
ZT	74	126a	127.50ab	76.80b	6.33	11.92	917b	1888b
MT	76	121b	124.67b	91.13a	6.20	11.06	905b	2147ab
CT	77	119b	165.67a	87.47ab	6.33	11.76	1264a	2670a
CV (%)	5.03	1.14	12.31	6.12	12.21	4.93	9.45	17.74
F-test	NS	*	*	*	NS	NS	**	*
Chia								
Tillage condition	Days to flowering	Days to maturity	Plant pop/m^2	Plant height (cm)	Branch /plant (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
ZT	66	126a	131.47b	87.73	6.27	3.62	967b	2314ab
MT	67	122b	123.25b	82.33	6.47	3.65	1047b	2114b
CT	66	119b	167.33a	84.53	6.80	3.57	1214a	2628a
CV (%)	3.98	0.88	17.39	9.99	10.70	5.68	11.71	6.77
F-test	NS	*	*	NS	NS	NS	*	*

Table 3. Average yields of seed and straw of minor cereal crops under different tillage conditions

Crop name	Tillage condition	Seed yield (kg/ha)			Stover yield (Tk/ha)		
		2020-21	2021-22	Average	2020-21	2021-22	Average
Barley	Zero	1856	1401	1628	3555	2489	3022
	Minimum	1928	1457	1692	3674	2477	3076
	Conventional	2292	2037	2164	4375	3210	3792
Kaon	Zero	1319	1080	1200	2595	2145	2370
	Minimum	1350	1094	1222	2574	2176	2375
	Conventional	1797	1511	1654	3352	2755	3054
Cheena	Zero	1289	944	1116	2475	2340	2408
	Minimum	1261	963	1112	2394	2273	2333
	Conventional	1547	1360	1454	2956	2973	2965
Sorghum	Zero	2508	2477	2493	4835	5220	5027
	Minimum	2619	2661	2640	4982	6418	5700
	Conventional	3450	3896	3673	6521	7749	7135
Oat	Zero	1564	1197	1380	3125	2569	2847
	Minimum	1681	1252	1466	3216	2699	2957
	Conventional	1978	1861	1919	3949	3558	3754
Buckwheat	Zero	1175	917	1046	2327	1888	2107
	Minimum	1122	905	1013	2296	2147	2221
	Conventional	1425	1264	1345	2925	2670	2797
Chia	Zero	-	967	967	-	2314	2314
	Minimum	-	1047	1047	-	2114	2114
	Conventional	-	1214	1214	-	2628	2628

Economic return of minor cereal crops under different tillage conditions (2020-21 and 2021-22)

In case of barley, conventional tillage produced the highest average (2020-21 and 2021-22) gross return as well as gross margin (Tk. 105540 and 40132/ha, respectively) (Table 4). Zero tillage contributed the lowest average gross return (Tk. 80247/ha) but minimum tillage showed the lowest average gross margin (Tk. 27662/ha). Likewise, conventional tillage gave the highest BCR (1.61) and the lowest BCR was found in minimum tillage (1.50).

For kaon, crop grown under conventional tillage showed the highest average gross return and gross margin (Tk. 120644 and 59516/ha, respectively). The lowest average gross return (Tk. 88054/ha) was computed in zero tillage and minimum tillage gave the lowest gross margin of Tk. 38244/ha. Average gross return in minimum tillage was Tk. 89372/ha and gross margin in zero tillage was Tk. 41926/ha. The highest average BCR (1.97) was obtained from conventional tillage and the lowest average BCR (1.75) was computed in minimum tillage.

In cheena, conventional tillage gave the highest average gross return (Tk. 107904/ha) and gross margin (Tk. 46416/ha). Minimum tillage showed the lowest average gross return and gross margin (Tk. 81715 and 30227/ha). Zero tillage gave the gross return of Tk. 81715 and 30227/ha, respectively. Zero tillage exhibited the highest average BCR value (1.76) and the minimum tillage the lowest average BCR (1.59). The average BCR obtained from conventional tillage was 1.75.

In case of sorghum, conventional tillage produced the highest gross return and gross margin (Tk. 128616 and 67129/ha, respectively). The lowest average gross return and gross margin were obtained from zero tillage (Tk. 87379 and 40892/ha, respectively). The average gross return and gross margin of Tk. 94616 and 43129/ha were found in minimum tillage. The highest average BCR value (2.09) was computed in conventional tillage. Zero and minimum tillage contributed the average BCR values of 1.88 and 1.84, respectively.

In oat, conventional tillage gave the highest average gross return (Tk. 142657/ha) and gross margin (Tk. 77670/ha). The lowest average gross return and gross margin were obtained from zero tillage (Tk. 1011197 and 51210/ha, respectively). Minimum tillage contributed the gross return and gross margin of Tk. 106893 and Tk. 51905/ha, respectively. The highest average BCR (2.20) was found in conventional tillage and the lowest average BCR value (1.94) was found in minimum tillage. The average BCR achieved from zero tillage was 2.02.

For buckwheat, conventional tillage gave the highest average gross return and gross margin (Tk. 74097 and 11110/ha, respectively). Minimum tillage contributed the lowest average gross return and gross margin (Tk. 56171 and 3181/ha, respectively). Zero tillage produced the average gross return and gross margin of Tk. 56964 and 8976/ha, respectively. The average BCR values for zero, conventional and minimum tillage were 1.19, 1.18 and 1.06, respectively.

In chia crop, conventional tillage gave the highest gross return (Tk. 256027/ha) and gross margin (Tk. 164939/ha). The lowest gross return and gross margin were found in zero tillage (Tk. 204972 and 128885/ha, respectively). Minimum tillage showed the gross return and gross margin of Tk. 219970 and Tk. 138882/ha, respectively. The highest BCR (2.81) was computed in conventional tillage and the lowest BCR value (2.69) was found in zero tillage. The BCR of minimum tillage was 2.71.

Table 4. Two years average economic return of minor cereal crops under different tillage conditions at RARS, Rahmatpur, Barishal (2020-21 and 2021-22)

Crop name	Tillage type	Gross return (Tk/ha)			Gross margin (Tk/ha)			Benefit cost ratio (BCR)		
		2020-21	2021-22	Average	2020-21	2021-22	Average	2020-21	2021-22	Average
Barley	ZT	91996	68498	80247	41588	18091	29839	1.83	1.36	1.59
	MT	95481	70659	83070	40073	15252	27662	1.72	1.28	1.50
	CT	113541	97539	105540	48134	32131	40132	1.74	1.49	1.61
Kaon	ZT	78948	97160	88054	32821	51032	41926	1.71	2.11	1.91
	MT	80371	98373	89372	29244	47245	38244	1.57	1.92	1.75
	CT	106623	134664	120644	45496	73536	59516	1.74	2.20	1.97
Cheena	ZT	76820	87190	82005	30332	40703	35517	1.65	1.88	1.76
	MT	75025	88404	81715	23538	36916	30227	1.46	1.72	1.59

Crop name	Tillage type	Gross return (Tk/ha)			Gross margin (Tk/ha)			Benefit cost ratio (BCR)		
		2020-21	2021-22	Average	2020-21	2021-22	Average	2020-21	2021-22	Average
	CT	92141	123666	107904	30654	62179	46416	1.50	2.01	1.75
Sorghum	ZT	74340	100418	87379	27853	53930	40892	1.60	2.16	1.88
	MT	77297	111936	94616	25810	60448	43129	1.50	2.17	1.84
	CT	101605	155628	128616	40117	94140	67129	1.65	2.53	2.09
Oat	ZT	93822	108573	101197	43834	58585	51210	1.88	2.17	2.02
	MT	100105	113680	106893	45118	58692	51905	1.82	2.07	1.94
	CT	118635	166680	142657	53647	101693	77670	1.83	2.56	2.20
Buckwheat	ZT	58635	55292	56964	10647	7305	8976	1.22	1.15	1.19
	MT	56369	55972	56171	3381	2985	3183	1.06	1.06	1.06
	CT	71623	76572	74097	8635	13584	11110	1.14	1.22	1.18
Chia	ZT	-	204972	204972	-	128885	128885	-	2.69	2.69
	MT	-	219970	219970	-	138882	138882	-	2.71	2.71
	CT	-	256027	256027	-	164939	164939	-	2.81	2.81

Prices: Barley Tk. 40/kg, kaon Tk. 80/kg, Cheena Tk. 80/kg, sorghum Tk. 30/kg, oat Tk. 80/kg, buckwheat Tk. 50/kg and chia Tk. 300/kg; ZT = Zero tillage, MT = Minimum tillage, CT = Conventional tillage

Conclusion

The experimental results revealed that all the minor cereal crops (barley, kaon, cheena, sorghum, oat and buckwheat) could be cultivated under different tillage conditions in southern region of Bangladesh. However, from the economic point of view chia, sorghum, oat, kaon and cheena cultivations were more profitable as compared to other minor cereal crops.

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EFFECT OF SOWING TIME AND PLANT POPULATION ON GROWTH AND YIELD OF CHIA (*SALVIA HISPANICA)*

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Abstract

The experiment was conductedat Agronomy research field of Bangladesh Agricultural Research Institute (BARI), Gazipur, during *rabi*(winter) season of 2020-22 to study the effect of yield and yield contributing characters of chia seeds as affected by sowing date and spacing. The experiment consisted of three sowing date viz. (15 Nov., 30 Nov.and 15 Dec.) and three spacing viz. (30 cm ×05 cm, 40 cm ×05 cm and 50 cm × 05 cm). Sowing date showed great influence on total dry matter (TDM) production, leaf area index (LAI), yield and yield components of chia. The November sowing produced the maximum TDM and LAI over the years. These parameters finally contributed to higher seed yield than earlier and later sowing date. Early planting took longer time for flowering (66 days) and fruiting while late planting gave early flowering, decreased inflorences number and increased sterile inflorences. It was also found that 15November sowing with 30 cm × 05 cm row spacing produced the higher seed yield (1024kg/ha and) over the years.The results revealed that 15-30 November sowingwith 30 cm × 05 cm produced higher seed yield might be due to favourable air temperature for growth and development of chia. Late sowing after November 30 produced lower seed yield due to high temperature (22^{o}C) prevailed at the later growth stage (February) of chia.Wider spacing gave higher number inflorences but closer spacing gave higher seed yield. Results revealed that November sowing with 30 cm × 05cm performed better and with the advancement of sowing dates the temperature increased, reduced the grain growth duration and decreased the seed yield.

Introduction

The increasing tendency toward herbal medicine for curing diseases makes the necessity of cultivation of various medicinal plants inevitable in world wide level (Rasam *et al*. 2007). Chia (*Salvia hispanica* L.) is an annual plant belonging to the Lamiaceae family native to Mexico and Guatemala (Ixtaina *et al*., 2008). In pre-Columbian times, its seeds were one of the basic foods of Central American civilizations (Ayerza and Coates, 2005). It is cultivated in Argentina, Australia, Bolivia, Colombia, Guatemala, Mexico and Peru. Today, its cultivation is not only limited to America but is also extended to other areas such as Australia and Southeast Asia (Jamboonsri*et al*., 2012).Chia seed is composed of protein (15% –25%), fats (30%–33%), carbohydrates (26%–41%), high dietary fiber (18%–30%), ash (4%–5%), minerals, vitamins, dry matter (90%–93%) and also contains a high amount of antioxidants (Ixtaina *et al*., 2008).Another key characteristic of chia seedis thatitdoes not contain gluten(Bueno *et al*.,2010).In present situation,only cereal crops are included in the cropping pattern but should be included medicinal crops such as chia seeds. In Bangladesh, chia is a new crop, but the economic value of chia in international market and even in Bangladesh market is very high. The use of medicinal food from folk medicine to prevent diseases such as diabetes, obesity and cardiovascular problems is now gaining momentum in the globe. Recently, chia seed has become important for human health and nutrition because its high content of ω-3 fatty acid that promotes beneficial health effects (Vuksan *et al*., 2010). The growth and production of medicinal plants like other types of plants are affected by genetic and agronomic management factors and maximum yield is only obtained when an appropriate combination of these factors are provided for the plants (Rasam*et al*. 2007). Sowing date is an important aspect of crop production for maximizing the yield. Rowspacing is an also important trait of crop production for maximizing the yield. It helps to increase the plant height, number of leaves, branches, healthy foliage and fruit size. Densely planted crop obstruct the proper growth and development and also competed for light. On the other hand, wider spacing ensures the basic requirements but decrease the total number of plants as well as total yield. Proper sowing time and row spacing are very effective to increase yield of Chia crop because it is new crop in Bangladesh environment. Keeping this, the present study was conducted to evaluate the effects of different sowing and row spacing on the growth and yield of chia seed.

Materials and Methods

The experiment was conducted at the Research Field of Agronomy Division BARI, Joydebpur, Gazipurduring*rabi* seasons of 2019-2020 and 2020-21. The experiment site was located Chhiata Series under Agro-Ecological Zone-28 (AEZ-28) latitude23^{0}59/ Nand longitude 90^{0}24/ E.The meteorological data of the experimental site revealed that the highest temperature prevails in March-April and the lowest in December to January.Maximum rainfall was received during the months of December.The crop received 246 mm rain showers from October to March in two successive years. The average maximum (32.78 °C) and minimum (14.27 °C) temperature were found in the month of January during the crop growing season (Figure 1). The experiment consisted of three sowing date viz. (15 Nov., 30 Nov. and 15 Dec.) and three spacing viz. (30 cm×05cm, 40cm ×05cm and 50cm ×05cm)., were used in the study.There were 9 treatment combinations as follows: $D_1{\times}S_1$, $D_1{\times}S_2$, $D_1{\times}S_3$, $D_2{\times}S_1$, $D_2{\times}S_2$, $D_2{\times}S_3$, $D_3{\times}S_1$, $D_3{\times}S_2$and $D_3{\times}S_3$.The experiment was laid out in a RCBD design with three replications. The unit plot size was 3.6 m x 3.0 m. The crop was fertilized with 60-15-30 -5 N-P-K-S kg /ha, respectively (Karim*et al*., 2015). Half of N and full doses of other fertilizers were applied at the time of final land preparation and the rest urea was top dressed 35 days after sowing (DAS). Seeds were treated with vitavax. Hand weeding was done at 25 and 40 days after sowing (DAS).The crops were harvested on 4 March 2021 and 11 March, 2022, 16 March 2021 and 20 March and 24 March 2021 and 27 March, 2022. Data of plant height, yield components and others were recorded from 10 randomly selected plants. Yield was calculated from whole plot. Data on different parameters were subjected to analysis of variance and the treatment means were compared by Least Significant Difference (LSD) test.

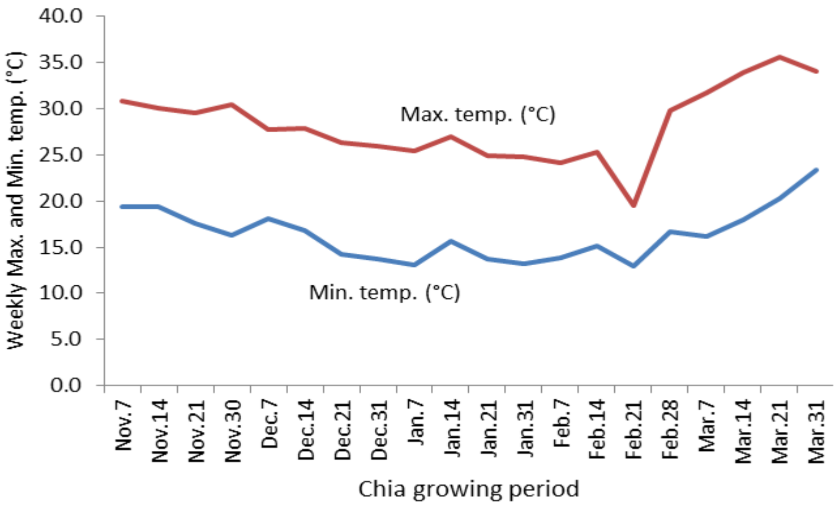

Fig. 1. Mean temperatures prevailed during chia growing periods

Results and Discussion

Crop developmental events and growth duration were influenced by prevailing temperature variations during 2021-22. Emergence of early sown crop occurred 1 to 2 days earlier than those of late sown. The late sown crops flowered earlier with reduced vegetative durations than those of early sown ones. The highest duration for first flowering was recorded in 15 November (63 days) sowingdue to prevailing lower mean air temperature (22.0^{0}C). The second highest duration forfirst flowering was recorded (59 days) in 30November sowingbut due to prevailing higher mean air temperature (23.9^{0}C).Highest crop growth duration was recorded (113 days)in 15November sowingdue to prevailing lower mean air temperature (22.0^{0}C).The second highest crop growth duration was recorded (100 days)in 30November sowingdue to prevailing higher mean air temperature (23.90^{0}C).The minimumduration (94days) was recorded in15 December sowingdue to prevailing higher mean air temperature (21.16^{0}C). The reasons for variation in growth duration might be due to increased day and night temperature at later sowing (Table 1).

Table 1. Crop development events, mean temperature and crop duration of chia seed as affected by sowing date and row spacingdate during *rabi season* of 2021-2022

Sowing date ×raw spacing	Emergence		1st flowering		Crop growth duration	
	Days	Mean air temperature (^{0}C)	Days	Mean air temperature (^{0}C)	Days	Mean air temperature (^{0}C)
$D_1 \times S_1$	6	24.00	63	22.00	113	22.00
$D_1 \times S_2$	6	24.00	63	22.00	113	22.00
$D_1 \times S_3$	6	24.00	63	22.00	113	22.00
$D_2 \times S_1$	7	23.30	59	23.90	100	23.90
$D_2 \times S_2$	7	23.30	59	23.90	100	23.90
$D_2 \times S_3$	7	23.30	59	23.90	100	23.90
$D_3 \times S_1$	8	20.09	55	19.53	94	21.16
$D_3 \times S_2$	8	20.09	55	19.53	94	21.16
$D_3 \times S_3$	8	20.09	55	19.53	94	21.16

$D_{1=}$15November, $D_{2=}$ 30 November, $D_{3=}$ 15December, $S_{1=}$ 30 cm×05cm, $S_{2=}$40cm ×05cm, $S_{3=}$50cm ×05cm

Leaf area index (LAI)

The leaf area index (LAI) of the crop at a particular growth stage indicates its photosynthetic potential or the level of its dry matter accumulation. It is influenced by genotype, plant population (Murphy *et al*., 1996). It is a dimensionless quantity that characterizes plant canopies. The LAI was influenced by different sowing dates over time (Fig. 1)in both the years.In this study, the variation in plant population greatly influenced LAI. LAI increased with the increase in plant population .LAI increased up to 60 DAE and there after it decrease in all the treatments. The higher LAI was recorded in15 November sowing date with 30 cm × 5 cm (66 plants/m^2) row spacing followed by 30 November sowing date with 30 cm × 5 cm (66 plants/m^2)row spacing in all growth period.). Maximum LAI (3.75 in 2020-21 and 3.23 in 2021-22) was recorded at 60 DAEin15 November sowing date with 30 cm ×5 cm (66 plants/m^2) D_1S_1treatment followed by D_2S_2 treatment. LAI was lower with 50 cm ×5 cm (40 plants/m^2) in all the sowing dates over the years.The result of the present study was also supported by (Karim*et al*., 2015).

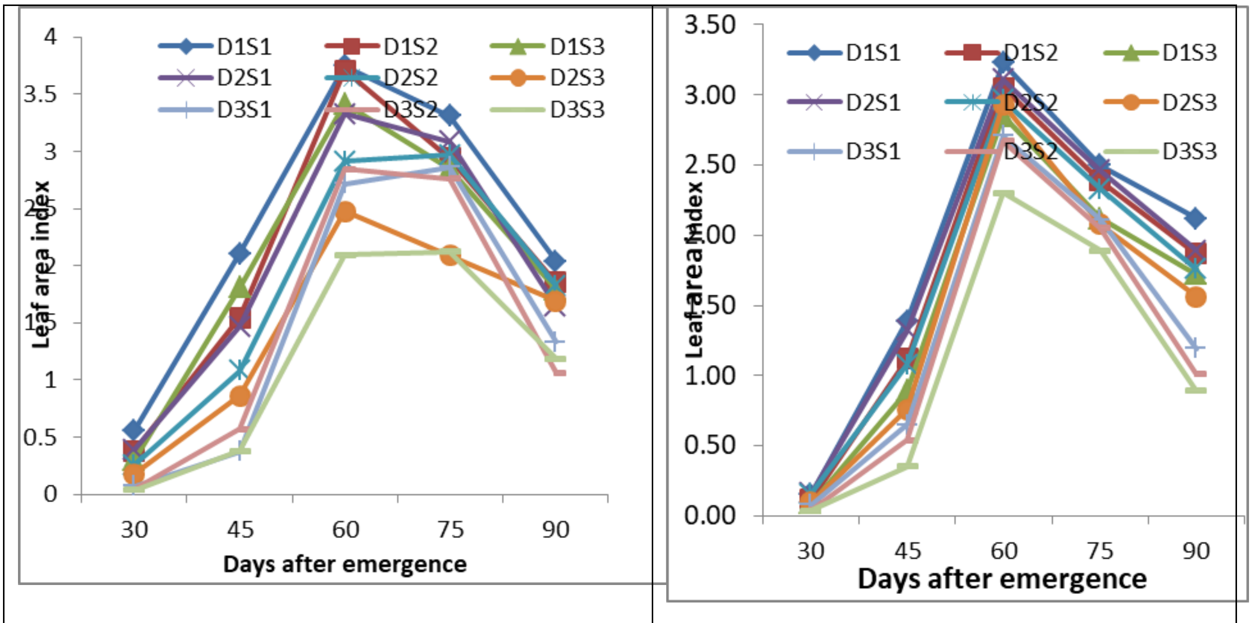

Fig.1.LAI of chia at different DAE as influenced by sowing dates and row spacing during *rabi* seasons of 2020-21 and 2021-22

Effect of sowing date planting spacing onTDM production

The pattern of TDM accumulation in chia over time was influenced by different sowing dates and row spacing (Fig.2)in both the years. The TDM of chia increased slowly up to 45 DAE when the crop sown on 15 and 30 November. After 45 DAE dry matter accumulation rate increased rapidly up to harvest. The highest TDM accumulation/m^2 was obtained from 30 November sowing at harvest. On the other hand, TDM reached the peak at 75 DAE when sown on 15November then declined up to harvest. The reduction of TDM after the peak might be due to leaf senescence. Among the sowing dates, 30 November sowing with 30 cm x 5 cm (66 plants/m^2) row spacing showed the highest TDM (1229g/m^2) at 90 DAE and it was higher throughout the growing period except at 30 and 45 DAEfollowed by 15 November sowing with 30 cm x 5 cm (66 plants/m^2)and it was higher than 15 December sowing throughout the growing period in 2020-21. But in2021-22, 15 November sowing with 30 cm x 5 cm (66 plants/m^2) row spacing showed the highest TDM (956 g/m^2) at 90 DAE due to higher rain fall at early growing period.The crop sown on 30 November got longer duration might be due to favourable temperature for growth and development as compared to other sowing dates and produced the maximum TDM. The results are in agreement with the findings of Karim *et al.* (2015) stated that sowing dates had significant difference on dry matter production.The lowest TDM was observed in 15 December sowing at all over the growing period in both the years.

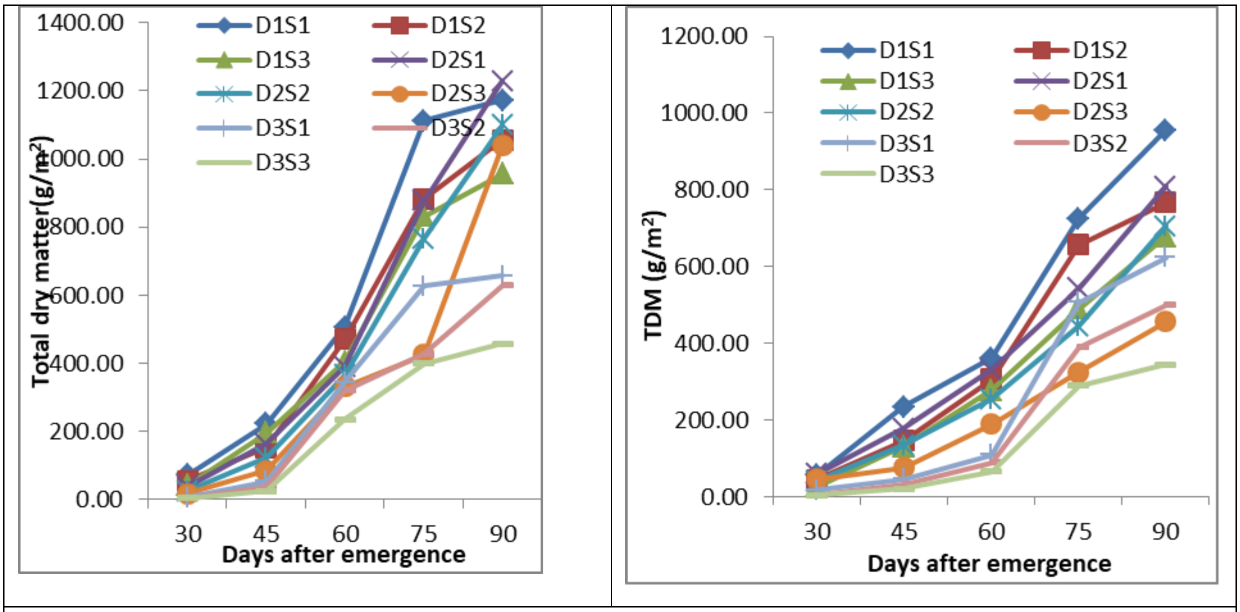

Fig. 2.TDM of chia at different DAE as influenced by sowing dates and row spacing during rabi seasons of 2020-21 and 2021-22

Yield and yield components

Yield and yield attributes of chia seed were significantly affected by different sowing dates and row spacing (Table 2) over the years.Highest (61 in 2020-21 and 58 in 2021-22) no. of plants were recorded in 15 November sowing with 30 cm × 05 cm row spacing and lowest (35 in two years) was recorded in 15 December sowing with 50 cm × 5 cm row spacing.The tallest plant (129.26 cm in 2020-21 and114.0 cm in 2021-22) was recorded in 15 November sowing with 30 cm × 05 cm row spacing which was followed by same sowing date with 40cm × 05 cm row spacing and 30 November sowing with 30 cm × 05 cm row spacing and the shortest plant (86.07 cm in 2020-21 and 81.00 cm in 2021-22) was obtained from 15 December sowing with 50 cm × 5 cm row spacing.Ayerza &Coates(2007) reported that delay in sowing decreased significantly the plant height, leaf area index, total fresh and dry yield in Maize.The maximum number of inflorences/plant(14in 2020-21 and 15in 2021-22), floret/inflorences (15 and 11 in two years) and seed /inflorences(378 and 422 in two years) were obtained from 15 November sowing with 50 cm ×5 cm row spacing which was followed by 30November sowing with 50 cm×5 cm row spacing. The lowest number of inflorences/ plantwas obtained from 15December sowing with 30 cm ×5 cm row spacing. Thousand seed weight is significantly different between sowing times and spacing. The largest size of seed (1000 seed wt.1.26gin 2020-21 and 1.34 g 2021-22g) was produced from November 30 sowing with 50 cm× 5 cm row spacingwhere as the smallest size seed (1000 seed wt1.17g) was produced from December 15 sowing with 30cm × 5 cm row spacing.There are reports of thousand seed weightranging from 1.21 grams to 1.31grams, in field trials in Argentina (Rovati *et al*.,2012). Significantly the highest seed yield (1013.27kg/ ha in 2020-21 874.54kg/ha in 2021-22) was found from November 15 sowing with 30cm ×5cm row spacing due to cumulative effect of better yield components and it was statistically similar to same sowing date with 40 cm ×5 cm row spacing 2020-21 and 30 November sowing with row spacing 30 cm ×5cm and 40 cm ×5cm row spacing(1007-1008 kg /ha) in 2020-21.All the row spacing yielded lower at December 15 sowing might be due to high temperature at flowering stage which ultimately caused lower number of inflorences/plant, seed/inflorences and lower seed size. These findings agree with Wojahn*etal*.,(2018) and Busilachi *et al*.,(2013). 2^{nd} year yield was poorer than 1^{st} year due to heavy shower at initial stage.

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Table 1. Plant /m^2, yield attributes and yield of chia seedas affected by sowing dates and rowspacing during rabi seasons of 2020-21 and 2021-22

Treatment	Plant /m^2 (no.)		Plant height(cm)		Inforences/ plant (no.)		Floret/ inflorences (no.)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
$D_1 \times S_1$	61	57	129.33	114.25	12.86	11.33	11.82	10.73
$D_1 \times S_2$	46	41	117.33	111.87	14.23	13.00	14.86	11.93
$D_1 \times S_3$	37	34	115.53	102.27	14.47	15.00	15.57	11.67
$D_2 \times S_1$	59	56	127.20	105.20	12.83	10.33	13.03	10.25
$D_2 \times S_2$	45	38	112.37	97.00	13.83	12.00	15.53	10.85
$D_2 \times S_3$	36	34	108.83	85.00	13.96	11.67	16.45	10.93
$D_3 \times S_1$	58	55	98.00	100.00	11.83	9.33	9.57	8.77
$D_3 \times S_2$	43	43	87.56	87.93	11.87	10.33	10.73	9.85
$D_3 \times S_3$	35	32	85.37	81.00	12.87	9.00	11.06	9.90
$LSD_{(0.05)}$	2.31	1.78	1.09	1.23	0.53	1.69	0.79	0.21
CV(%)	4.67	5.21	4.03	3.45	4.76	8.64	3.46	5.12

Contd.

Treatment	Inflorences length (cm)		Seeds/Inflorences (no.)		1000-seed weight (g)		Seed yield (kg/ ha)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
$D_1 \times S_1$	15.80	14.50	364.00	387.00	1.20	1.27	1013.27	874.54
$D_1 \times S_2$	16.33	15.78	375.53	422.47	1.23	1.31	1024.38	789.00
$D_1 \times S_3$	18.39	16.55	377.27	429.20	1.24	1.34	945.37	542.47
$D_2 \times S_1$	15.83	12.25	365.27	355.67	1.22	1.22	1007.72	679.33
$D_2 \times S_2$	16.07	13.47	374.27	378.67	1.25	1.24	1008.95	657.33
$D_2 \times S_3$	18.35	13.75	378.73	390.00	1.26	1.26	747.84	465.67
$D_3 \times S_1$	14.33	11.37	335.30	269.67	1.17	1.19	687.04	441.67
$D_3 \times S_2$	14.72	13.13	350.93	336.33	1.20	1.21	622.22	381.65
$D_3 \times S_3$	16.37	13.58	358.70	351.20	1.21	1.23	510.19	288.00
$LSD_{(0.05)}$	0.65	0.094	1.83	3.34	0.04	0.017	17.32	17.92
CV(%)	5.45	3.89	3.29	6.09	4.56	4.56	4.19	4.65

Conclusion

Results revealed that November 15-30 sowing with 30 cm ×5 cm spacing would be optimum for higher yield of chia.

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GROWTH AND YIELD OF CHIA (*SALVIA HISPANICA* L.) UNDER DIFFERENT NUTRIENT MANAGEMENT

S.S. KAKON, S.PAUL, J.A. CHOWDHURY, A.A.BEGUM AND D.A.CHOWDHURY

Abstract

The field experiment was conducted at Agronomy Research Field, Gazipur and Regional Agricultural Research Station, Jashoreof Bangladesh Agricultural Research Institute during *rabi*season of 2021-22 to assess the growth , yield and quality of chia crop under nutrient management.Treatment sincluded in the experiment were: T_1=$N_{30}P_{20}$ $K_{25}S_6Zn_{0.5}$ $B_{0.5}$kg /ha, T_2= N_{60} P_{40} K_{50} S_8 $Zn_{0.5}$ $B_{0.5}$kg/ha, T_3=$N_{90}P_{60}K_{75}S_{10}Zn_{0.5}B_{0.5}$kg/ha, T_4= N_{120} P_{80} K_{100} S_{12} $Zn_{0.5}$ $B_{0.5}$kg/ha and T_5=Control. Different fertilizers level differed in leaf area index (LAI), total dry matter production (TDM), yield and yield components of economic study of chia .Results revealed that, fertilizer levels showed great influence on leaf area index (LAI), dry matter production and yield of chia. The highest LAIwas recorded inT_4(N $_{120}$P $_{80}$K $_{100}Zn_{0.5}B_{0.5}$kg /ha) treatment. Significantly the highest chia yield (792.5kg/ha at Gazipur and 254 kg/ha at Jashore) was observed in T_4 treatment followed by T_3 and T_2 treatments. Cost and return analysis revealed that the highest gross return (225150.00Tk./ha), gross margin (Tk.175706/ha) and cost of cultivation (Tk.49444/ha) were found in T_4treatment.But the highest benefit cost ratio (BCR) of 4.88-4.69 was obtained from T_2 and T_3. The results revealed that among the different fertility levels,T_3 (N_{90} P_{60} $K_{75}S_{10}Zn_{0.5}B_{0.5}$kg/ha) and T_2($N_{60}P_{40}K_{50}S_8Zn_{0.5}B_{0.5}$kg/ha)was found better in respect of yield due to economic returns which saving 12-15% NPKS for chia cultivation.

Introduction

The world population is increasing at an alarming rate and demand- supply curve for food production is not intersecting each other, there is a lacuna for achieving food and nutrition security. Around 795 million people are undernourished around the world and it's about 12.9 per cent for developing countries. In Bangladesh also, the condition is not different. The food habit of the people is also changing across worldwide. The demand for functional food with several health benefits is increasing due to higher public health awareness worldwide. Therefore, there is a need for shifting into more nutritious and energy rich super food crops.

Malnutrition problem in the world is a big threat that has been facing by the humanity and there is a need to adopt nutritionally secured new diet practices for better health of population. Malnourishment problem can be avoided by going in for cultivation and consumption of new super food crops which are rich in protein, Omega-3 fatty acids, minerals, vitamins and dietary fibre.Chia (*Salvia hispanica* L.) is a plant of Mexican and South American origin belonging to Lamiaceae family. It is well known for its nutraceutical value. Seeds contain about 30-35 per cent oil which is the richest source of Omega-3 fatty acid (more than 60 %). This fatty acid is found to be very good for general health. The seeds are also rich source of proteins (20-22%), dietary fiber (around 40%), anti-oxidants and various vitamins and minerals. Chia is becoming very popular as 'super food' all around the world with dramatic increase in cultivation and consumption. With very high demand for it in International and

Indian market, it can be cultivated as a profitable commercial crop. Agronomic management is one of the most important aspects for the success of any crop with efficient use of all the resources.Studies on agronomic management of chia crop are limited as it is a newly introduced crop to Bangladesh. For afarmer to get maximum profit from any crop, study about its growth and responses towards inputs is very much essential. So, the present study was conducted to evaluate the effect of fertility on growth, yield of chia crop.

Materials and Methods

The field experiment was conducted at Agronomy Research Field, Gazipur and Regional Agricultural Research Station, Jashore of Bangladesh Agricultural Research Institute during *rabi* season of 2021-2022. Treatments included in the experiment were: $T_1=N_{30} P_{20} K_{25} S_6 Zn_{0.5} B_{0.5}$ kg/ha,$T_2=N_{60} P_{40} K_{50} S_8 Zn_{0.5} B_{0.5}$kg/ha,$T_3=N_{90}P_{60}K_{75}S_{10}Zn_{0.5}B_{0.5}$kg/ha,$T_4=N_{120}P_{80}K_{100}S_{12}Zn_{0.5}B_{0.5}$kg/ha and T_5=Control.The soil of the research area belongs to the Chhihata series under AEZ-28.The meteorological data of the experimental site revealed that the highest temperature prevails in March-April and the lowest in December to January. Maximum rainfall was received during the months of December.The crop received 246 mm rain showers from October to March. The average maximum (32.78 °C) and minimum (14.27 °C) temperature were found in the month of January during the crop growing season (Figure 1). Soils of the experimental plots were collected and analyzed. The physical and chemical properties of initial soil of the experimental plot has been presented in Table1.The soil was clay loam with pH 6.42, OC 1.09% (very low), total N 0.094% (very low), exchangeable K 0.097meq/100g soil (very low), available P 17.31 µg/mg (optimum), available S 17.57 µg/g (optimum), available Zn 0.629 µg/g (low) and available B 0.166 µg/g (very low). Organic carbon, N, K and B were under critical level in the soil. The experiment was laid out in a randomized complete block design with three replications and the unit plot size was 6m × 3m. Chia line was used in the experiment. Seeds were sown on 24Nomveber, 2021at Gazipur and on 11Novembe, 2021 at Jashore. The seeds were treated with provax @ 3 g/kg seed before sown. Fertilizers were applied as per treatment. Half N and all other fertilizer was applied as basal during final land preparation and rest N was applied at 25DAS. Data on growth parameters like leaf area and dry matter accumulation were measured at different dates with 15 days interval. For recording dry matter weight and leaf area, five plants from each replication were sampled at 30, 45, 60, 75, 90 DAS and at harvest. Different plant parts of the collected samples were separated and then oven dried at 80^0C for 72 hours. Leaf area was measured by an automatic leaf area meter (L13100 c, L1COR, USA).

Table 1. Initial soil analytical data of the experimental site at Gazipur

Soil depth	pH	OC (%)	Total N (%)	Exchangeable K (meq/100g)	µg/g	
					Available P	Available S
0-15 cm	6.42	1.09	0.094	0.097	17.31	17.57
	-	VL	VL	VL	O	O
Critical level			0.12	0.12	7	10

L= Low, VL= Very low, O= Optimum

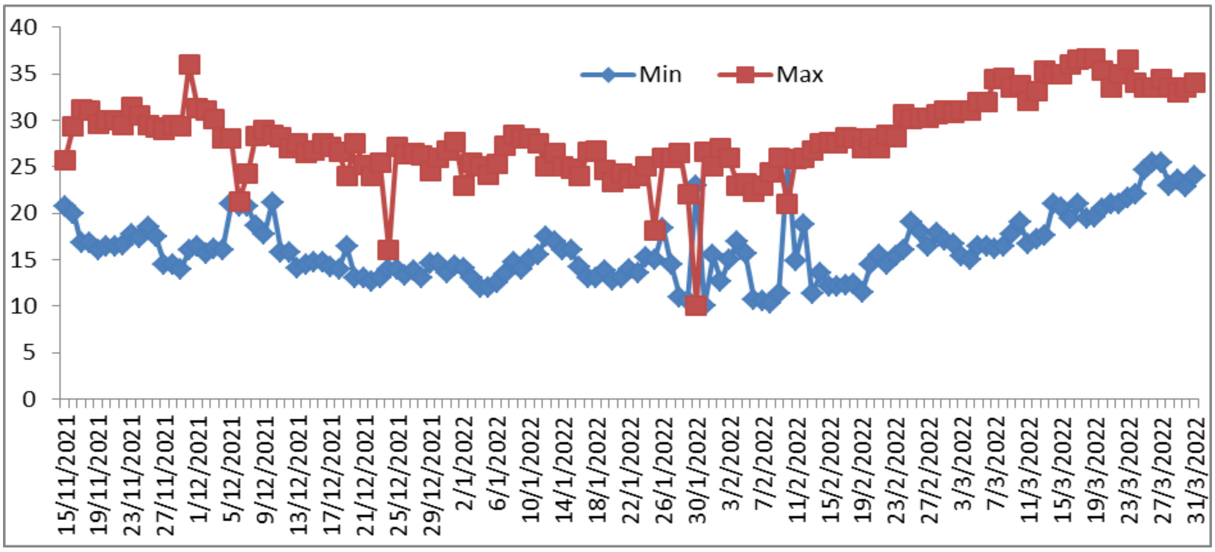

Fig. 1. Mean temperatures prevailed during chia growing periods.

Results and Discussion

Leaf Area Index (LAI)

The LAI was influenced by different fertilizer levels over time has been shown in Fig. 2 at Gazipur.LAI increased up to 60 DAE and thereafter decreased in all treatments. Maximum LAI (3.23) was recorded at 60 DAE in T_4($N_{120}P_{80}K_{100}S_{12}$kg/ha) treatment followed by T_3($N_{90}P_{60}K_{75}S_{10}$kg/ha) and T_2(N_{60} P_{40} K_{50} S_8 N_{120} P_{80} $K_{100}S_{12}$kg/ha) treatment. Higher LAI indicates better leaf area expansion, which might help in solar radiation interception for more dry matter production. The lowest leaf area index(1.5) was found in T_5followed by T_1treatment. Total dry matter (TDM) production increased gradually with the advancement of plant growth in different fertilizer doses (Fig. 3). TDM of chia was higherinT_4($N_{120}P_{80}K_{100}S_{12}$kg/ha) followed by T_3treatment. The lowest TDM was observed from T_5treatment. The treatments which gave the higher value in leaf area index (LAI) were performed better in total dry matter production. Similar findings were also observed with Mary *et al.*, 2018

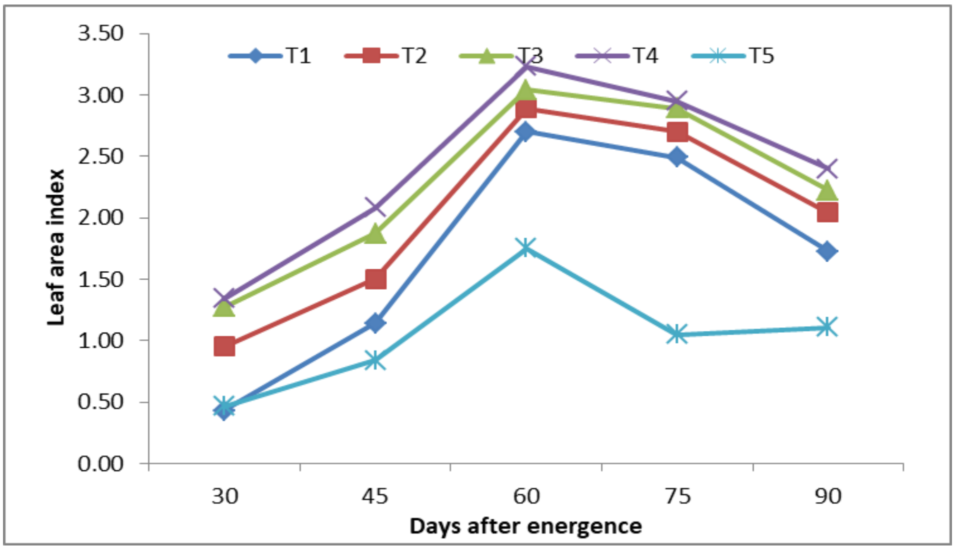

Fig.2. LAI of chia at different days after sowing as influenced by different fertilizer levels at Gazipur

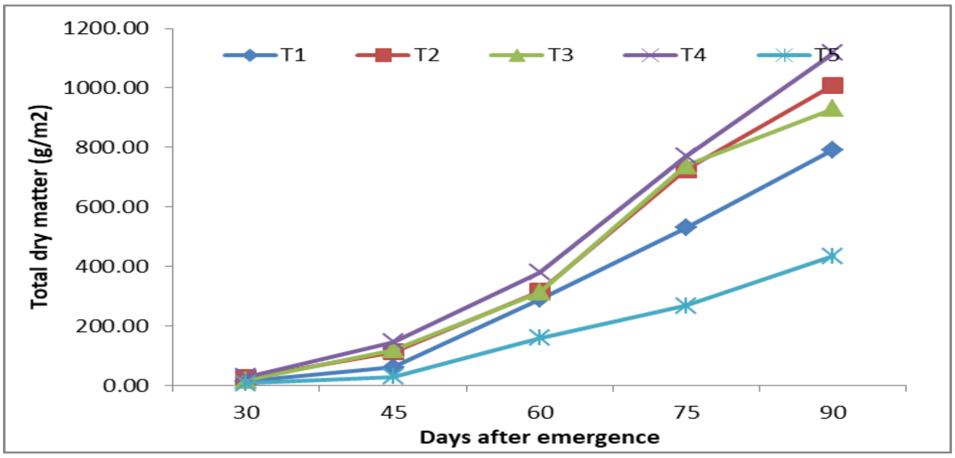

Fig.3. TDM production ofchia at different days after sowing as influenced by different fertilizer levelsat Gazipur

Yield and yield component

Plant height at harvest, yield components and yield of chia were significantly affected by different fertilizer levels (Table 2) at Gazipur and at Jashore. The longest plant (81.00 cm at Gazipur and 81.4 cm at Jashore) was recorded in T_4 ($N_{120}P_{80}K_{100}S_{12}Zn_{0.5}B_{0.5}$kg/ha) treatment which was followed by T_1, T_2 and T_3 treatments and the shortest was in T_5(Control) treatment in both the location. Highest number of branch/plant (9.50 at Gazipur and 5.93 at Jashore) was recorded in T_4 (N_{120} $P_{80}K_{100}$ $S_{12}Zn_{0.5}$ $B_{0.5}$kg/ha) treatment which was followed by T_3($N_{90}P_{60}K_{75}S_{10}Zn_{0.5}B_{0.5}$kg/ha)treatment. Significantly the highest number of inflorences /plant (17) was recorded in T_4 treatment and the lowest (8) in T_5 treatment. The highest inflorence length were observed in T_2 (11.73 cm), T_3(12.07 cm)and T_4(13.73 cm) treatments and the lowest were observed in T_1 and T_5(9.00 cm) treatments. Significantly the highest number of floret/inflorence (18), seed/ inflorence (506) and seed /floret (49.35) were obtained from T_4 treatment and the lowest in T_5 treatment. Treatment T_4 produced the highest 1000-grain wt. (1.37g) which was followed by $T_3$and T_5 treatment produced the lowest 1000-grain wt. (0.96g). Significantly the highest chia yield (792.50 kg/ha at Gazipur and 254 kg/ha at Jashore) were recorded in T_4 which was statistically similar with all other treatments except T_3 and T_2 treatments .Similar results have been reported by Mary *et al.* (2018).Yield attributes increased with increased rates of NPKS might be due to the fact that application of nitrogen to the chia plants maintained greenness of leaves for longer period which in turn helped in greater dry matter accumulation and this might have contributed much as a major source for the development of sink and thereby improved the yield attributes. This year yield of chia drastically reduced due to severe rainfall during cropping season in both the location.

Table 2. Yield components and yield of chia as influenced by different fertilizer levels at Gazipur and Jashore during *rabi* season of 2021-2022

Treatment	Plant height (cm)		Branch /plant(no.)		Inflorences /plant (no.)	Length of inflorence (cm)
	Gaz.	Jash.	Gaz.	Jash.		
T_1	73.80	75.33	7.60	5.60	11.00	10.53
T_2	73.70	72.93	8.10	5.60	13.00	11.73
T_3	76. 00	77.06	9.00	5.20	15.50	12.07
T_4	81.00	81.40	9.50	5.93	17.00	13.73
T_5	50.50	70.36	6.00	4.67	8.00	9.00
$LSD_{(0.05)}$	7.38	6.84	1.29	0.68	1.43	2.34
CV (%)	5.52	6.34	8.57	4.89	5.88	10.90

Contd.

Treatment	Floret/ inflorence (no.)	Seed/ inflorence (no.)	Seed/ floret (no.)	1000 seed wt. (g)	Yield (kg/ha)	
					Gazi.	Jash.
T_1	13	357.50	36.33	1.09	531.94	150.00
T_2	14	409.50	40.00	1.26	671.11	152.33
T_3	15	437.30	44.67	1.29	694.44	189.67
T_4	18	506.30	49.35	1.37	792.50	254.00
T_5	10	318.67	29.00	0.96	272.50	140.67
LSD $_{(0.05)}$	2.35	18.08	6.94	0.103	132.90	97.85
CV (%)	9.10	2.37	9.25	4.51	11.91	9.87

Cost and return analysis

Cost and return analysis is an important tool to evaluate the economic feasibility of crop production. Benefit cost analysis of chia production has been presented in Table 3. Gross return and BCR depends on chia yield. Among the treatments, the highest gross return (Tk. 150100.00/ha) and gross margin (Tk. 105156.00/ha) was observed in T_4 treatment ($N_{120}P_{80}K_{100}S_{12}Zn_{0.5}B_{0.5}$kg/ha) and it was close to T_3($N_{90}P_{60}K_{75}S_{10}Zn_{0.5}B_{0.5}$kg/ha). The highest cost of cultivation (Tk. 44944.00/ha) was recorded in T_4 treatment which was close to T_3($N_{90}P_{60}K_{75}S_{10}Zn_{0.5}B_{0.5}$kg/ha) due to involvement of higher labor and fertilizers cost for cultivation. Among the treatments, the highest benefit cost ratio (3.38) was obtained from T_2 ($N_{60}P_{40}K_{50}S_8Zn_{0.5}B_{0.5}$kg/ha) treatment which was followed by T_3 (N_{90} P_{60} K_{75} S_{10} $Zn_{0.5}$ $B_{0.5}$ kg /ha) treatments (3.32). T_2 and T_3 treatments were found as the most suitable dose for obtaining higher yield and economic benefit in chia cultivation.

Table 3.Cost and return analysis of chia as influenced by different fertility during *rabi* season of 2021-2022 at Gazipur

Treatment	Gross return (Tk./ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	BCR
$N_{30}P_{20}K_{25}S_6Zn_{0.5}B_{0.5}$kg/ha	106388.89	38647.00	67741.89	2.75
$N_{60}P_{40}K_{50}S_8Zn_{0.5}B_{0.5}$kg/ha	134222.22	39746.00	94476.22	3.38
$N_{90}P_{60}K_{75}S_{10}Zn_{0.5}B_{0.5}$kg/ha	138888.89	41845.00	97043.89	3.32
$N_{120}P_{80}K_{100}S_{12}Zn_{0.5}B_{0.5}$kg/ha	150100.00	44944.00	105156.00	3.34
Control	54500.00	35000.00	19500.00	1.56

T_1=$N_{30}P_{20}K_{25}S_6Zn_{0.5}B_{0.5}$kg/ha,$T_2$=$N_{60}P_{40}K_{50}S_8Zn_{0.5}B_{0.5}$kg/ha,$T_3$=$N_{90}P_{60}K_{75}S_{10}Zn_{0.5}B_{0.5}$kg/ha,$T_4$=$N_{120}P_{80}K_{100}S_{12}Zn_{0.5}B_{0.5}$kg/ha and T_5=Control

Conclusion

Results of the experiment revealed that different fertility levels differed distinctly in total dry matter production, leaf area expansion, yield and yield components and economic return. $N_{60}P_{40}K_{50}S_8Zn_{0.5}B_{0.5}$kg/ha and$N_{90}P_{60}K_{75}S_{10}Zn_{0.5}B_{0.5}$kg/ha were found the most suitable dose for obtaining higher yield and economic benefit in chia cultivation.

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DETERMINATION OF SEED RATE AND ROW SPACING FOR POTENTIAL YIELD OF CHIA

J.A. CHOWDHURY, S.S. KAKON, A.A. BEGUM, M.R. KARIM, S.T. ZANNAT AND D.A. CHOUDHURY

Abstract

The field experiment was conducted at Agronomy research field of Bangladesh Agricultural Research Institute, Gazipur, during *rabi* season of 2021-22 to determine optimum seed rate and row spacing for potential yield of chia seeds. The experiment consisted of three seed rate viz. 4, 5 and 6 kg/ha and three spacing viz. 30 cm, 40 cm and 50 cm with continuous sowing. The treatment combinations were, S_1R_1= 4 kg seed/ha with 30 cm spacing, S_1R_2= 4 kg seed/ha with 40 cm spacing, S_1R_3= 4 kg seed/ha with 50 cm spacing, S_2R_1= 5 kg seed/ha with 30 cm spacing, S_2R_2= 5 kg seed/ha with 40 cm spacing, S_2R_3= 5 kg seed/ha with 50 cm spacing, S_3R_1= 6 kg seed/ha with 30 cm spacing, S_3R_2= 6 kg seed/ha with 40 cm spacing, S_3R_3= 6 kg seed/ha with 50 cm spacing. Seed rate and row spacing influenced the LAI, TDM accumulation and chlorophyll content of chia plant. Plant population, yield contributing characters and yield also significantly influenced by seed rate and row spacing. 6 kg/ha seed rate with 30 cm spacing produced the higher LAI and TDM but chlorophyll content was higher when 4 kg/ha seed was sown with 30 cm spacing. When 4 kg/ha seed were sown with 30 cm spacing, it produced the highest inflorences/plant and seed/ inflorences but the highest 1000 seed weight was observed when 5 kg/ha seed sown with 30 cm spacing. Report of the experiment also indicated that, among different treatment combinations 6 kg/ha seed rate with 30 cm row spacing produced the highest seed yield (1055kg/ha) followed by T_4 treatment (5kg seed/ha with 30 cm spacing).

Introduction

The world population is increasing at an alarming rate but the food production cannot meet the demand of increase population. Around 795 million people are undernourished around the world and it's about 12.9 per cent for developing countries including Bangladesh. So, it is necessary to change the food habit towards the food with several health benefits like chia. Already chia seed is gaining popularity day by day world wise. The main edible part of chia is seed (Karim *et al*., 2015). Chia seeds can be a food supplement and are widespread in vegetarian and gluten-free diets. Chia seeds are source of Omega-3 fatty acid (α-linolenic acid), soluble and insoluble fibers and proteins in addition to other important nutritional components, such as vitamins, minerals and natural antioxidants. With very high demand for it in International and Bangladesh market, it can be cultivated as a profitable commercial crop. Chia is a plant characterized by low water requirement and well adapted to arid and semiarid regions (Ayerza, 1995). The cultivation of Chia is gaining popularity in Africa and Asia because it is considered as a good nutritional and healthy food. Standardization of suitable location specific agronomic practices with respect to spacing and seed rate is essentially required to popularize this crop. As chia is a new crop in Bangladesh so, there is a lack of information regarding the growth, phenology, nutritional requirements and management strategies. In order to better manage soil and climatic conditions with the crop needs, studies have been performed in order to adjust row spacing and density of plants and to obtain, therefore, an increase in productivity. Seed rate and row spacing are important factors for crop establishment technique that affects the crop stand and other yield parameters in different crops. Maintenance of optimum planting density is always a big problem to the farmers. Lower plant density results in higher weed infestation, poor radiation use efficiency and lower yields. On the other hand, dense plant population may cause lodging, poor light penetration in the canopy, reduction of photosynthesis due to shading of lower leaves and serious reduction in the yield (Lemerle *et al*., 2004; Lemerle *et al*., 2006). Crop planted with high density competed for growth resources and can obstruct the proper growth and development. On the other hand, low plant density ensures the basic requirements but decrease the total number of plants as well as total yield. Row spacing is also an important trait of crop production for maximizing the yield. It helps to increase the plant height, number of leaves, branches, healthy foliage and fruit size. Similarly, plant population, on the basis of row spacing and seed rate, affects the crop stand, agronomic plant characteristics and the yield in chia crop. Reducing the distance between rows improves weed control by increasing crop competition and reducing light transmission to the soil (Andrade *et al*., 2002). Some studies have shown that the best row spacing range for the culture would be between 30 and 50 cm, with an amount of five kilograms of seed per hectare (Ayerza and Coates, 2005). In a study by Ayerza (1995), it was confirmed that the productivity of chia, as well as many cultures, is dependent on the local climate, However, in the literature, information on cultivation and management pre- and post-harvest of chia are still insufficient. As a new crop in Bangladesh, it is necessary to identify the proper seed rate and row spacing of Chia crop. Keeping this, in mind the experiment was conducted to select optimum seed rate and row spacing for higher yield of chia crop.

Materials and Methods

The field experiment was conducted at the research field of Agronomy Division BARI, Gazipur during *rabi* season of 2021-22 to determine optimum seed rate and row spacing for potential yield of chia seeds. The experimental site was located Chhiata Series under Agro-Ecological Zone-28 (AEZ-28) latitude $23^0 59^/$ N and longitude $90^0 24^/$ E. The experiment consisted of three seed rate viz. 4, 5 and 6 kg/ha and three spacing viz. 30 cm, 40 cm and 50 cm with continuous sowing. There were 9 treatment combinations as follows: S_1R_1= 4 kg seed/ha with 30 cm spacing, S_1R_2= 4 kg seed/ha with 40 cm spacing, S_1R_3= 4 kg seed/ha with 50 cm spacing, S_2R_1= 5 kg seed/ha with 30 cm spacing, S_2R_2= 5 kg seed/ha with 40 cm spacing, S_2R_3= 5 kg seed/ha with 50 cm spacing, S_3R_1= 6 kg seed/ha with 30 cm spacing, S_3R_2= 6 kg seed/ha with 40 cm spacing, S_3R_3= 6 kg seed/ha with 50 cm spacing. The experiment was laid out in a RCB design with three replications. The unit plot size was 4 m × 3 m. The crop was fertilized with 60-15-30 -5 N-P-K-S kg/ha, respectively (Karim *et al*., 2015). Half of N and full doses of other fertilizers were applied at the time of final land preparation and the rest urea was top dressed at 35 days after sowing (DAS). The seeds were sown on 22 November, 2021. Before sowing seeds were treated with provax. Intercultural operations were done when required. The crops were harvested on 15, 20, 23 and 29 March 2022, Data of plant population was recorded from three places of 1 m^2 area of each treatment. plant height and yield components were recorded from 10 randomly selected plants. Yield data was calculated from whole plot. Data on different parameters were subjected to analysis of variance and the treatment means were compared by Least Significant Difference (LSD) test.

Results and Discussion

Plant height of chia plant

Plant height was differed by different treatment. The plant height gradually increased and reached the peak at harvest in all the treatments (Fig. 1). Result showed that plant height increased with increasing seed rate and decreasing row spacing. Higher seeding rate may stimulate plant height due to internode elongation. Data also revealed that plant height decreased with increased row spacing and decreased seed rate that probably due to plant competition for light. Maximum plant height was observed when seeds were sown with 6 kg/ha seed and 30 cm spacing throughout the growing period. The shortest plant was found in S_1R_3 treatment. Gondal *et al.,* 2017, also reported the same in case of sorghum plant.

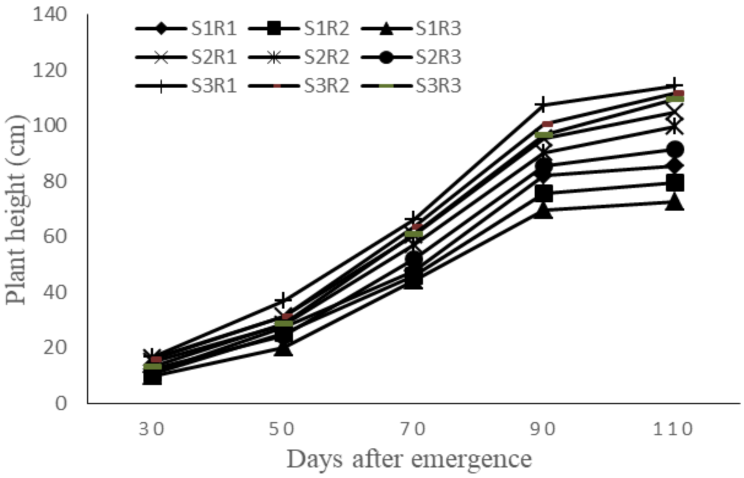

Fig. 1 Plant height of chia crop at different DAE as influenced by seed rates and row spacing

Leaf area index (LAI)

Leaf area index (LAI) is a dimensionless quality that characterized plant canopies which is one of the main driving forces of net primary production, water and nutrient use, carbon balance. LAI was greatly influenced by different seed rate and row spacing over time (Fig. 2). LAI gradually increased and reached the peak at 70 DAE and there after it decreased in all the treatments. The reduction of LAI after the peak reflecting the loss of some older leaves through senescence. Among the treatment combination the higher LAI was recorded in S_3R_1 treatment when 6 kg/ha seed were sown with 30 cm spacing (which have maximum plant population, 124 plants/m^2) followed by S_3R_2 (6 kg/ha seed were sown with 40 cm spacing) and S_3R_3 (6 kg/ha seed were sown with 50 cm spacing) treatment in all sampling period. In this study, the variation in plant population greatly influenced LAI. LAI increased with the increase in plant population. Higher values of LAI with higher planting rates of 6 kg/ha with 30 cm spacing may be ascribed to the more plant stand coupled with taller plants achieving more leaves thus having more LAI. Our results are in line with those of Bilal *et al.* (2009) who reported that the increase in total dry matter accumulation with higher plant density could be attributed to more number of plants per unit area as well as more LAI. LAI was lower in S_1R_3 treatment with 4 kg/ha seed and 50 cm spacing.

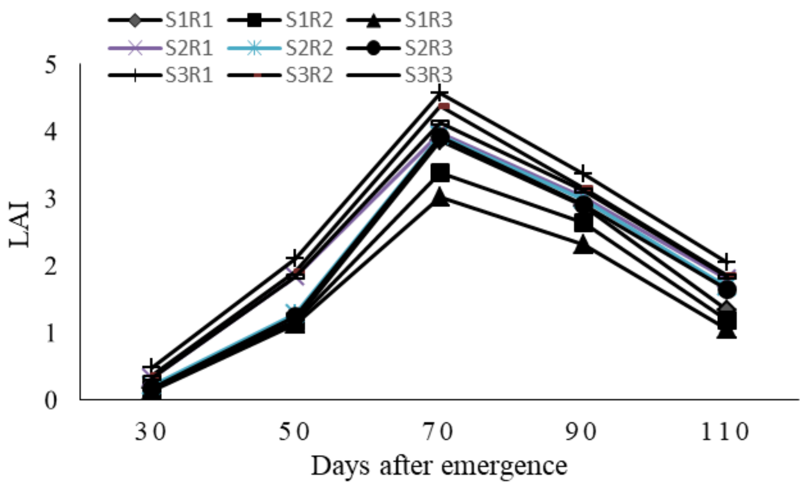

Fig. 2. Leaf area index of chia crop at different DAE as influenced by seed rates and row spacing

Effect of planting spacing on TDM production

The yield of a crop is mainly determined by the accumulation of TDM and its partitioning in to the economic sink. TDM was influenced by seed rate and row spacing. The TDM of chia increased slowly up to 50 DAE then increased rapidly up to 90 DAE and then again increased slowly up to harvest. TDM reached the peak at harvest in all the treatment (Fig. 3). The highest TDM accumulation/m^2 was obtained from S_3R_1 (6 kg/ha seed with 30 cm row spacing) treatment at harvest and it was higher than all other treatments throughout the growing period which followed by S_3R_2 (6 kg/ha seed with 40 cm row spacing) treatment and S_3R_3 (6 kg/ha seed with 50 cm row spacing) treatment. The lowest TDM was observed in S_1R_3 (4 kg/ha seed with 50 cm row spacing) treatment followed by S_1R_2 (4 kg/ha seed with 40 cm row spacing) treatment and S_1R_1 (4 kg/ha seed with 30 cm row spacing) treatment. Total dry matter was lower in seed rate S_1 (4 kg/ha) treatment under all spacing might be due to low plant population. Lower spacing (but higher plant to plant distance) produce higher TDM accumulation. It might be due to dense plant population within a row may cause lodging, poor light penetration in the canopy, reduction of photosynthesis due to shading of lower leaves and ultimately the lower dry matter accumulation resulting serious reduction in the yield (Lemerle *et al*., 2004; Lemerle *et al*., 2006).

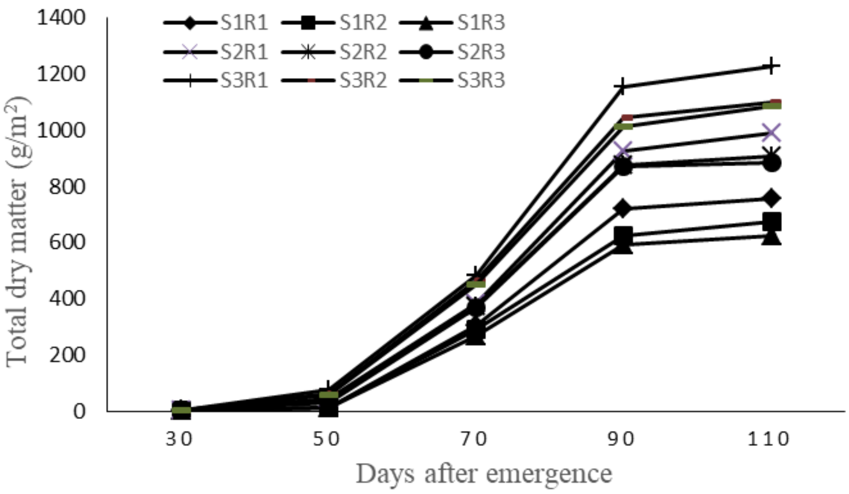

Fig.3. Total dry matter accumulation of chia plant at different DAE as influenced seed rate and row spacing

SPAD

SPAD value was influenced by seed rate and row spacing (Fig. 4). SPAD meter measure the leaf greenness which indirectly indicated the leaf chlorophyll content. Regardless of treatment, at first SPAD values increased with the age of plant and reached peak at 70 DAE there after decreased with the plant age (Fig. 4). Maximum SPAD values were observed at 70 DAE which declined progressively reaching the lowest at 110 DAE in all the treatment. The higher SPAD values of chia leaves at 70 DAE were probably due to the less sink demand for N from the source (leaf). Conversely, SPAD values gradually decreased after 70 DAE, it might have been due to remobilization of N from leaves to reproductive organs as grain formation was started after 70 DAS. The highest SPAD value was found in S_1R_1 (4 kg/ha seed with 30 cm row spacing) treatment followed by S_1R_2 (4 kg/ha seed with 40 cm row spacing) treatment and S_1R_3 (4 kg/ha seed with 50 cm row spacing) treatment. The lowest value was observed in S_3R_3 (6 kg/ha seed with 50 cm row spacing) treatment. The lower SPAD value was found in all spacing with higher seed rate because of higher plant population. Again in case of spacing lower spacing gave the higher SPAD value than higher spacing which might be due to dense plant population within a row

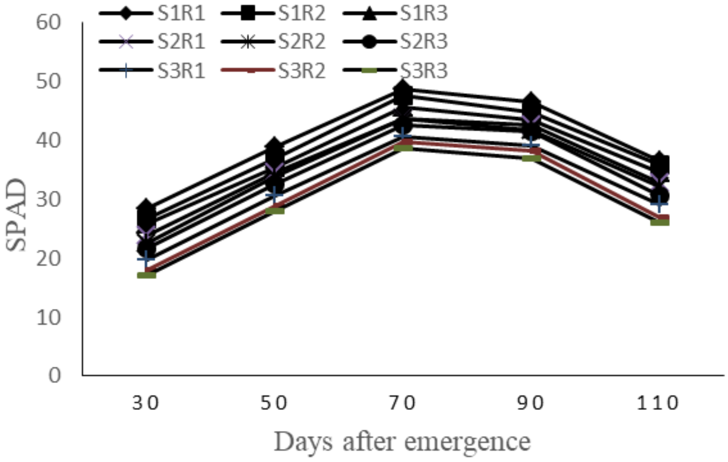

Fig. 4. SPAD value of chia plant at different DAE as influenced seed rate and row spacing

Total chlorophyll content

Total chlorophyll content of chia leaf at different growth stage showed the same trend as SPAD value. Total chlorophyll content was influenced by different seed rate and row spacing (Fig. 5). Regardless of treatment, Total chlorophyll content was also increased with plant growth up to 70 DAE thereafter decreased with the plant age (Fig. 5). Maximum total chlorophyll content were observed at 70 DAE which declined progressively reaching the lowest at 110 DAE in all the treatment. The higher total chlorophyll content of chia leaves at 70 DAE were probably due to the less sink demand for N from the source (leaf). Conversely, Total chlorophyll content gradually decreased after 70 DAE, it might have been due to remobilization of N from leaves to reproductive organs as grain formation was started after 70 DAE. The highest total chlorophyll content was found in S_1R_1 (4 kg/ha seed with 30 cm row spacing) treatment followed by S_1R_2 (4 kg/ha seed with 40 cm row spacing) treatment and S_1R_3 (4 kg/ha seed with 50 cm row spacing) treatment. The lowest value was observed in S_3R_3 (6 kg/ha seed with 50 cm row spacing) treatment. The lower total chlorophyll content was found in all spacing with higher seed rate because of higher plant population. Higher pant population can uptake lower growth resources as well as nitrogen than lower plant population. Again in case of spacing lower spacing gave the higher total chlorophyll content than higher spacing which might be due to dense plant population within a row. In lower spacing plant may receive more growth resources than higher spacing because in lower spacing plant population is relatively lower than higher spacing.

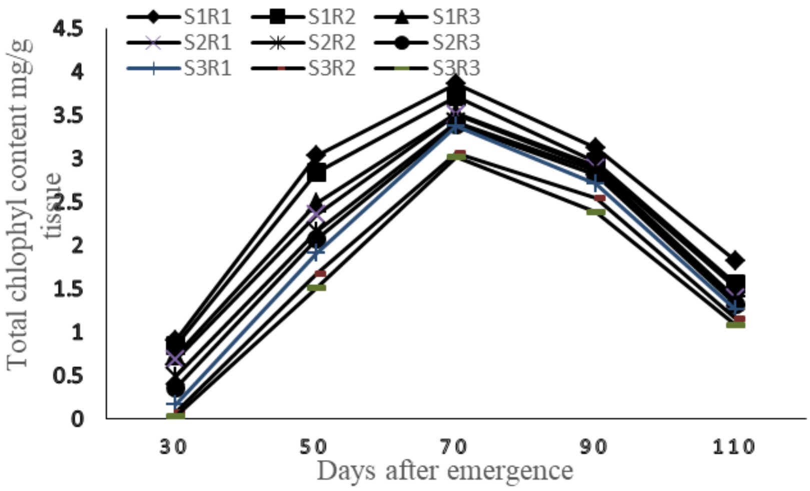

Fig. 5 Total chlorophyll content of chia crop at different DAE as influenced by seed rates and row spacing

Relationship between yield of chia with plant population at harvest

There was a week positive linear correlation between yield of chia with plant population at harvest (Fig. 6). The regression line was y = 3.443x + 603.29 which means the correlation of coefficient (x) was 3.443 stated that chia yield increase at the rate of 3.443 kg/ha for per unit change of plant population at harvest. The contribution of regression (R^2= 0.4606) value indicated that chia yield was 46% dependent on plant population. Thus result showed that increasing plant population increasing the seed yield of chia.

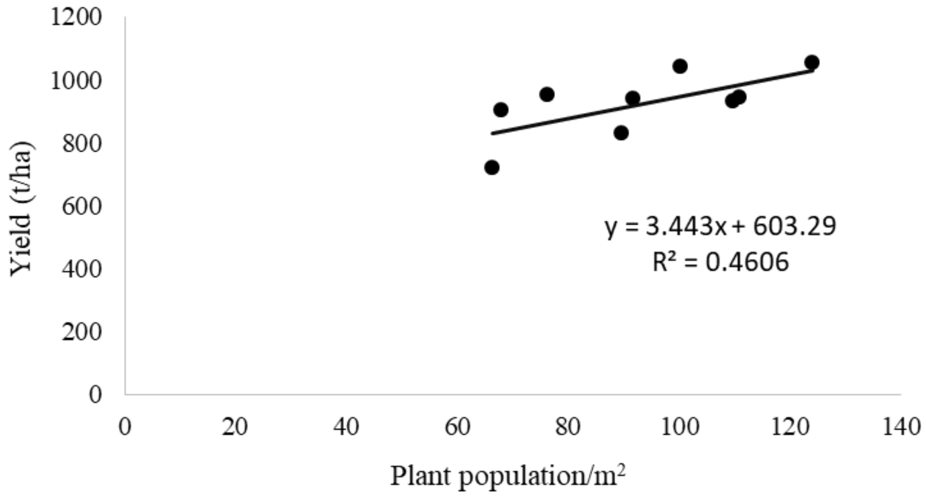

Fig. 6. Relationship between yield of chia with plant population

Yield components and yield

Plant height and inflorences length of chia was not significantly influenced but plant population, yield attributes and yield of chia plant were significantly affected by different seed rate and row spacing (Table 1). The highest plant population was obtained when 6 kg/ha seeds were sown with 30 cm spacing (T_7 treatment) followed by T_8 (6 kg/ha seed with 40 cm spacing) and T_9 (6 kg/ha seed with 50 cm spacing) treatment. Plant population was higher in lower spacing in all seed rate. That means in higher spacing plant population is lower than lower spacing because in higher spacing plant density is relatively higher within a row which caused mortality of some plant than lower spacing. Snider *et al.* (2012) also stating that plant stand establishment may be more favorable under narrow row spacing as compared to wider row spacing owing to more number of seeds per length of row resulting in increased intra-row competition among plants during the early plant establishment. Such observations have been recorded for other crop species as well (De Bruin & Pedersen, 2008) suggesting decrease in the plant population by increasing row spacing caused by the intra-row competition between plants. The maximum number of inflorences/plant (14), floret/inflorences (13) and seed/inflorences (388) were obtained from T_1 treatment (4 kg/ha seed with 30 cm spacing) which was followed by T_4 treatment (5 kg/ha seed with 30 cm spacing). The lowest number of these parameter was obtained from T_9 treatment (6 kg/ha seed with 50 cm spacing).

Thousand seed weight is significantly different between seed rate and row spacing. 1000 seed weight of different treatment ranges from 1.60 to 1.43 gm. The largest size of seed (1000 seed wt. 1.60 g) was produced from T_4 treatment (5 kg/ha seed with 30 cm spacing) whereas the smallest size seed (1000 seed wt1.43g) was produced from T_9 treatment (6 kg/ha seed with 50 cm spacing). There are reports of thousand seed weight ranging from 1.21 grams to 1.31 grams, in field trials in Argentina (Rovati *et al*., 2012).

The highest seed yield (1055kg/ha) was found from T_7 treatment when seed was sown with 6 kg/ha with 30 cm spacing might be due to highest plant population which was statistically similar with t_4 treatment (5 kg/ha seed with 30 cm spacing). The lowest seed yield (719) was recorded with 4 kg seed/ha and 50 cm row spacing might be due to lower number of plant population, inflorences/plant and seed/inflorences. These findings agree with Wojahn *et al.* (2018) and Busilacchi *et al*., (2013). Narrow row spacing results in higher grain yields in soybean (De Bruin & Pederson, 2008). Narrow row spacing resulting in higher yield is explained by the improved light interception and decreased plant to plant competition between plants (De Bruin & Pederson, 2008).

Table 1. Yield components and yield of chia seed as affected by seed rate and row spacing

Treat	Plant population (no.)	Plant height (cm.)	Inflorences length (cm)	Inforences/ plant (no.)	Floret/ inflorences (no.)	Seeds/ Inflorences (no.)	1000-seed weight (g)	Seed yield (kg/ha)
T_1	76	85.33	16.93	14	13	388	1.57	953
T_2	68	79.53	16.93	13	12	360	1.52	902
T_3	66	72.35	14.13	12	11	333	1.50	719
T_4	100	104.61	15.47	13	11	381	1.60	1041
T_5	91	99.73	14.53	13	10	334	1.44	939
T_6	89	95.27	12.4	9	10	326	1.44	830
T_7	124	114.33	13.8	13	12	363	1.51	1055
T_8	111	111.47	16.87	11	11	331	1.44	942
T_9	109	109.27	14.33	9	10	297	1.43	931
$LSD_{(0.05)}$	6.83	NS	NS	1.55	1.20	15.89	0.11	46.09
CV (%)	4.23	8.36	4.98	7.54	6.25	2.65	4.48	2.88

Conclusion

Results revealed that 5 kg/ha and 6 kg/ha seed sown with 30 cm row spacing gave the statistically similar yield of chia. But according to the current studies, 30 cm row spacing and 5 kg seed/ ha , requiring the least inputs, were found to be the optimum, among the tested seed rates and row spacing levels, for better yield of chia. This is first year experiment. So, the experiment needs to be repeated in the next year for confirmation of the results.

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EFFECT OF IRRIGATION ON GROWTH AND YIELD OF CHIA

D.A. CHOUDHURY

Chia (*Salvia hispanica* L.) is an annual plant belonging to the Lamiaceae family native to Mexico and Guatemala. Chia seed is composed of protein (15% –25%), fats (30%–33%), carbohydrates (26%–41%), high dietary fiber (18%–30%), ash (4%–5%), minerals, vitamins, dry matter (90%–93%) and also contains a high amount of antioxidants. In Bangladesh, chia is a new crop, but the economic value of chia in international market and even in Bangladesh is very high. The growth and production of chia are is influenced by agronomic management factors and maximum yield is only obtained when an appropriate combination of these factors are provided for the plants. Irrigation is an important factor of crop production for maximizing the yield. Excess or deficit irrigation decrease plant growth and yield. Crop produce maximum output when optimum soil moisture available in the field. to find out the optimum water requirement of Chia for higher growth and yield. The experiment was conducted at Agronomy Research Field, BARI, Gazipur during 2021-22 to find out the optimum water requirement of Chia for higher growth and yield. Seeds were sown on 2nd week of November. The crop was fertilized with recommended doses of fertilizers and different intercultural operations were done as and when required. Crop was irrigated as per treatments. Chia was harvested in 1st week of March. Effect of irrigation on the yield of chia was noticed. Significantly higher seed yield of chia was found when irrigated at vefetative, flowering and grain filling stage over no irrigation and single irrigation at vegetative stage. On an average, about 30.0% higher yield was obtained in chia when irrigated 3 times over no irrigation.

Table1. Yield of chia influenced by different levels of irrigation at Gazipur during 2021-22

Irrigation Levels	Year (2021-22)
I_0: No Irrigation	480.0
I_1: One irrigation at vegetative stage	800.0
I_2: Two irrigations at Veg. & Flowering stage	1064.0
I_3: Three irrigations at Veg., Flowering & Grain filling stage	1121.6
LSD $_{(0.05)}$	90.2

EFFECT OF PLANTING TIME ON THE YIELD OF CHIA

D.A. CHOUDHURY

In Bangladesh, chia is a new crop, but the economic value of chia in international market and even in Bangladesh is very high. The growth and production of chia are is influenced by agronomic management factors and maximum yield is only obtained when an appropriate combination of these factors are provided for the plants.Optimum planting time is an important factor of crop production for maximizing the yield. Chia is a new crop in Bangladesh. So it is necessary to determine the optimum planting time of Chia for maximum yield. Therefore, the experiment was conducted at Agronomy Research Field, BARI, Gazipur during 2021-22 to determine the optimum planting time of Chia for higher yield. Seeds were sown on 2nd week of November with differenr seed rate to maintain the plant population T_1= 40 plans/sq. m, T_2= 50 plans/sq. m and T_3= 60 plans/sq. m. The crop was fertilized with recommended doses of fertilizers and different intercultural operations were done as and when required. Crop was irrigated as per requirement. Chia was harvested in 1st week of March. Effect of seed rate or plant population on the yield of chia was observed. Significantly higher seed yield of chia was found in 50 plans/sq. m (40 cm x 5 cm) followed by 60 plans/sq. m (30cm x 5 cm) and the lowest seed yield was obtained from 40 plans/sq. m, (50 cm x 5 cm).

Table 2. Yield of chia influenced by plant spacings at Gazipur during 2021-22

Plant Spacings	Year (2021-22)
T_1= 40 plans/sq. m, (50 cm x 5 cm)	945
T_2= 50 plans/sq. m (40 cm x 5 cm)	1050
T_3= 60 plans/sq. m (30cm x 5 cm)	1024
LSD $_{(0.05)}$	15.32

Highlight of Research Findings:

- About 30% higher seed yield of in chia when irrigated 3 times over no irrigation.
- Significantly higher seed yield of chia was found in 50 plans/sq. m (40 cm x 5 cm).

Conclusion

Introduce Chia for its high medicinal value and providing a good source of income to farmers there is a need to evaluate its cultivation as well as to develop appropriate agronomic management practices for higher growth and yield in Bangladesh. Since the cultivation is highly dependent on the environment to express its maximum agronomic potential, studies are needed to determine the factors that really affect the Chia yield. In this context, Agronomy Division of Bangladesh Agricultural Research Institute (BARI) has initiated some agronomic management studies to evaluate the feasibility of Chia cultivation in Bangladesh. Yields of Chia increased significantly due to improved agronomic management practices. Two or three times irrigation at different growth stages produced higher seed yield over no irrigation and single irrigation. Similarly, 40 cm x 5 cm spacing i.e 50 plants/ square meter gave higher yield.

Acknowledgement

We are very grateful to Ministry of Science and Technology for financial assistance and acknowledge their support to execute the research activities during 2021-22.

Weed Management

EFFECT OF INTEGRATED WEED MANAGEMENT ON SORGHUM CULTIVATION

N. AKTHER, S.S. KAKON, A.A. BEGUM, M.Z.ALI AND D.A. CHOUDHURY

Abstract

The field experiment was conducted at Agronomy Research Field, BARI, Gazipur, during Rabi season of 2021-2022 to find out suitable weed management practice in sorghum field. There were six treatment viz., T_1 = Two hand weeding at 25 and 45 DAS, T_2 = Herbicide Atrazine @ 2 L/ha spraying as pre-emergence + one hand weeding at 25 DAS, T_3 =Herbicide Atrazine @ 2 L/ha spraying as pre-emergence + weeding by BARI weeder at 25 DAS, T_4 = Herbicide Atrazine @ 2 L/ha spraying as post-emergence at 25 DAS + one hand weeding at 45 DAS, T_5 = Herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence + one hand weeding at 25 DAS, T_6 = No weeding included in the experiment. Shama (*Echinochloa crusgalli*), Helencha (*Enhydra fluctuans*), Mutha (*Cyperus rotundu*s) and Shetlomi (*Gnaphalium affine*) were the common and dominant weeds in the sorghum field. Results showed that the highest weed population 220 and 192 /m^2 were recorded in control plot at 35 and 55 DAS, respectively. Among the herbicide treated plots, at 35 DAS, the highest WCE (84.52 %) was found in T_5 (Herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence + one hand weeding at 25 DAS) treatment whereas at 55 DAS, the highest WCE (85.32 %) was found in T_4 (Herbicide Atrazine @ 2 L/ha spraying as post-emergence at 25 DAS + one hand weeding at 45 DAS) treatment. The highest grain yield (3.65 t/ha) was obtained from T_1 (Two hand weeding at 25 and 45 DAS) treatment. The maximum gross return (Tk. 91200/ha) was obtained from T_1 (two hand weeding at 25 and 45 DAS) treatment but the highest gross margin of Tk. 46260/ha /ha was observed in T_5 treatment. The highest BCR (2.07) was obtained from T_5 (Herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence + one hand weeding at 25 DAS) treatment. The result revealed that two herbicides (Atrazine @ 2 L/ha spraying, Pendimethylene @ 3 L/ha spraying as pre-emergence +one hand weeding at 25 DAS) and Herbicide Atrazine @ 2 L/ha spraying as post-emergence at 25 DAS + one hand weeding at 45 DAS would be effective for weed control and economically profitable for sorghum cultivation at Gazipur (AEZ 28).

Introduction

Sorghum (*Sorghum bicolor* L.) is considered as king of millets and extensively grown in semi arid tracks of Africa, China and India. The area under sorghum cultivation was recorded as 6316 acres in 1996-1997 but it continuously decreased and reached to 745 acres in 2017-2018 (BBS, 2018).Comparing the production potential of sorghum, the low productivity in India is attributed to several reasons. Among them weed is a major constrains. Weeds are major problems in increasing productivity of the crop. It was reported that yield loss of sorghum due to weeds ranges from 15-97%, depending on the nature and density of weeds (Thakur *et al.* 2016). Weeds germinated fast and grow rapidly at an initial growth period of crops competing with the crops severely for growth resources, viz., nutrients, moisture, sunlight and space. This affects the growth and development of crop and leads to yield losses (Freitas *et al*., 2014). Weed management in grain sorghum is a challenge because of the limited number of herbicides available to growers, rotational crop restrictions following a number of herbicides registered for use in grain sorghum and presence of herbicide resistant weeds. Traditional hand weeding is the most efficient and widely adopted practice of weed management but it is labour intensive, time consuming and not economical due to high wage rates. Mechanical equipment can be time saving during peak operation, resulting in higher output per worker and reduction in the cost of weeding. Chemical weed control is a better supplement to conventional method however the weed emergence pattern, application timing and stage of crop are important in chemical control. Continuous use of herbicides over a prolonged time leads to development of resistance in weeds making them difficult to control. Integrated weed management (IWM), the process of combining several single management strategies together to suppress weeds has been developed. Hence, various components of integrated weed management are to be blended in a systematic way to achieve the acceptable level of weed control. The integration of herbicides with cultural operations and use of pre-emergence and post-emergence herbicides in combination with mechanical methods will makes the crop weed free effectively and thus, improves the crop growth as well as yield. The integrated weed management is, therefore, graining importance in management of weeds for preventing yield losses and higher input-use efficiency (Ishya *et al.*, 2007). Herbicide application in Bangladesh is expected to increase in future due to labour scarce situation. Therefore, this experiment was undertaken to find out the suitable weed control method for sorghum.

Materials and Methods

Field experiment was conducted at the Agronomy Research Field of BARI, Gazipur during *rabi* season of 2021-2022. The soil was silty clay loam with pH 6.3 belonging to ecological zone-28. The experiment was consisted of six treatments viz., T_1 = Two hand weeding at 25 and 45 DAS, T_2 = Herbicide Atrazine @ 2 L/ha spraying as pre-emergence + one hand weeding at 25 DAS T_3 =Herbicide Atrazine @ 2 L/ha spraying as pre-emergence +weeding by BARI weeder at 25 DAS, T_4 = Herbicide Atrazine @ 2 L/ha spraying as post-emergence at 25 DAS + one hand weeding at 45 DAS, T_5 = Herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence +one hand weeding at 25 DAS, T_6 = No weeding. The experiment was laid out in RCBD with three replications. The unit plot size was 3m × 3m. The test variety was BARI sorghum-1. Seeds were sown on 30 December 2021 with maintaining spacing 60 cm × 10 cm. Three times of irrigation were applied in field. The crop was fertilized with N_{120} P_{60} K_{50} S_{27} $Zn_{2.8}$ $B_{1.4}$ kg/ha (FRG, 2018). One third N and all other fertilizers were applied as basal. Rest of N was applied at 20 and 40 DAS. The crop was harvested on 24 April 2022. Weed samples were collected using 50 cm × 50 cm quadrate, from randomly selected four places from each plot at 35 and 55 DAS of sorghum. Number and dry weight of weeds were recorded carefully and dry matter was taken after oven dry. Weed control efficiency (WCE) was calculated according to following formula: $\text{WCE (\%)} = \left(\frac{\text{A - B}}{\text{A}}\right) \times 100$

Where, A = Dry weight of weeds in no weeding plots and B = Dry weight of weeds in treated plots. Data on weed species, weeds/m^2 and weed dry matter were taken at 35 DAS and 55 DAS. The yield component data was taken from 10 randomly selected plants prior to harvest from each plot. At harvest, the yield data was recorded plot wise. The collected data were analyzed statistically using MSTAT-C package and means were adjudged by LSD test at 5% level of probability.

Results and Discussion

Number of weeds/m^2, weed dry weight and weed control efficiency (WCE) were affected by different weed management methods are presented in Table 1. Shama (*Echinochloa crusgalli*), Helencha (*Enhydra fluctuans*), Mutha (*Cyperus rotundu*s) and Shetlomi (*Gnaphalium affine*) were the common and dominant weeds in the sorghum field. The number of weeds /m^2 ranged from 30-84 and 25-44 at 35 and 55 DAS, respectively, in different treated plots. The highest number of weeds /m^2 (220 at 35 DAS and 192 at 55 DAS) was recorded in T_6 (control plot). The lowest number of weed /m^2 (30 at 35 DAS and 25 at 55 DAS) was found in T_1 treatment followed by $T_{5,}$ $T_{2,}$ T_3 at 35 DAS and T_4 at 55 DAS. The number of weeds /m^2 in all the plots at 55 DAS was lower than 35 DAS. It might be due to weeds were suppressed by other weeds and full canopy of crop at later growth stage. The present results are in agreement with the earlier findings of Priya and Kubsad (2013). Dry weight of weed (g/m^2) varied among the treatments (Table 1). The maximum weed dry weight of 24.11 g/m^2 and 66.40 g/m^2 were obtained in T_6 at 35 and 55 DAS, respectively, whereas, the minimum weed dry weight of 7.07 and 9.70 g/m^2 was observed in T_1 treatment followed by T_5 treatment (7.99 and 9.71 g/m^2), T_2, T_4 treatment. Similar result was also reported by Kumar *et al.* (2012).The weed control efficiency was affected by different treatment. At 35 DAS, the highest WCE (86.34 % at 35 DAS and 85.46% at 55 DAS) was found in T_1 treatment followed by T_5 (84.52 % at 35 DAS and 85.32 %). The lowest WCE 69.28% and 63.69% was observed in T_1 treatment at 35 DAS and 55 DAS. Priya and Kubsad (2013) have also obtained similar effect of various weed control treatments on weed control efficiency.

Table 1. Number of weed/m^2, weed dry weight (g/m^2) and weed control efficiency (WCE) at 35DAS and 55 DAS as affected by different treatments

Treatment	Weeds/m^2 (no.)		Dry weight of weed (g/m^2)		Weed control efficiency (%)	
	35 DAS	55 DAS	35 DAS	55 DAS	35 DAS	55 DAS
T_1	30	25	7.05	9.70	86.34	85.46
T_2	40	32	8.41	10.33	83.70	84.44
T_3	44	36	8.91	12.40	82.74	81.33
T_4	84	44	13.87	9.75	73.13	85.32
T_5	40	28	7.99	9.71	84.52	84.88
T_6	220	192	51.60	66.40		

Plant height, yield and yield component of sorghum

Plant height at harvest, yield components and yield of sorghum as affected by different weed management methods (Table 2). The highest plant height (161cm) was found in T_5 (Herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence + one hand weeding at 25 DAS) treatment which was followed by T_1, T_2, T_3 and T_4 and the lowest plant height (136.55 cm) was observed in T_6 treatment. The longest panicle (17.29cm) was observed in T_5 (Herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence + one hand weeding at 25 DAS) treatment which was followed by T_1 and T_4 treatments and the shortest (14.00 cm) was in T_6 treatment. Long panicle had higher number of grains/panicle. The highest number of grain/panicle (1043) was found in T_4 treatment which was followed by T_1, T_3 and T_5 treatments and the lowest number of grain/panicle (768) was observed in T_6 treatment. The highest 1000-grain weight (36.87 g) was obtained in T_5 treatment and the lowest (27.69) was observed in T_6 treatment. The highest grain yield (3.65 t/ha) was found in T_1 (Two hand weeding at 25 and 45 DAS) treatment which was followed by T_5 (Herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence +one hand weeding at 25 DAS), T_2 and T_4 treatments and the lowest grain yield (2.27 t/ha) was observed in T_6 (No weeding) treatment. The highest grain yield was attributed by the highest no. of grains/panicle and 1000- grain weight (Table 2). Similar findings were obtained from Verma *et al. (*2018).

Table 2. Plant height, yield components and yield of sorghum as affected by different treatments

Treatment	Plant height (cm)	Length of panicle (cm)	No. of grains/panicle	1000-grain weight (g)	Grain yield (t/ha)
T_1	158.89	16.50	977.67	35.56	3.65
T_2	157.55	16.14	863.33	33.89	3.54
T_3	153.99	16.39	998.88	33.09	3.07
T_4	154.89	16.89	1043.33	35.36	3.42
T_5	161.55	17.29	996.44	36.87	3.58
T_6	136.55	14.00	768.89	27.69	2.27
LSD $_{(0.05)}$	11.02	0.81	90.01	2.71	0. 26
CV (%)	3.94	4.76	5.31	4.42	4.47

T_1 = Two hand weeding at 25 and 45 DAS, T_2 = Herbicide Atrazine @ 2 L/ha spraying as pre-emergence +one hand weeding at 25 DAS T_3 =Herbicide Atrazine @ 2 L/ha spraying as pre-emergence +weeding by BARI weeder at 25 DAS, T_4 = Herbicide Atrazine @ 2 L/ha spraying as post-emergence at 25 DAS+ one hand weeding at 45 DAS, T_5 = Herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence +one hand weeding at 25 DAS, T_6 = No weeding

Cost and return performance

From the cost-benefit analysis it was found that the maximum gross return (Tk. 91200/ha) was obtained from T_1 (two hand weeding at 25 and 45 DAS) treatment followed by treatments T_2, T_4 and T_5 (Table 3). The highest cost of cultivation was recorded in T_1 treatment (Tk. 50750/ha) due to high labour cost. The highest gross margin of Tk. 46160/ha /ha was observed in T_5 treatment followed by T_2 and T_4 treatments. The highest BCR (2.07) was obtained from T_5 treatment followed by T_2 (2.02) and T_4 treatment due to lower labour cost (Table. 3). The lowest BCR (1.42) was obtained from T_6 (no weeding) treatment.

Table 3. Economic performance of different weed management of sorghum

Treatment	Gross return (Tk./ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1	91200	50750	40450	1.80
T_2	88416	43825	44591	2.02
T_3	76666	45590	31076	1.68
T_4	85408	43230	42178	1.98
T_5	89400	43240	46160	2.07
T_6	56700	39870	16830	1.42

Market price (Tk./kg): Sorghum = 25

T_1 = Two hand weeding at 25 and 45 DAS, T_2 = Herbicide Atrazine @ 2 L/ha spraying as pre-emergence +one hand weeding at 25 DAS T_3 =Herbicide Atrazine @ 2 L/ha spraying as pre-emergence +weeding by BARI weeder at 25 DAS, T_4 = Herbicide Atrazine @ 2 L/ha spraying as post-emergence at 25 DAS+one hand weeding at 45 DAS, T_5 = Herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence +one hand weeding at 25 DAS, T_6 = No weeding

Conclusion

From the Result it might be concluded that two hand weeding at 25 and 45 DAS produced higher seed yield of sorghum but higher benefit cost ratio was obtained from herbicide Pendimethylene @ 3 L/ha spraying as pre-emergence + one hand weeding at 25 DAS, herbicide Atrazine @ 2 L/ha spraying as post-emergence at 25 DAS + one hand weeding at 45 DAS and herbicide Atrazine @ 2 L/ha spraying as pre-emergence + one hand weeding at 25 DAS of sorghum due to lower cost of production. This is the result of first year experiment. The experiment needs to be repeated next year for confirming the results.

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EFFECT OF WEEDING AND NUTRIENT MANAGEMENT PRACTICE ON YIELD OF SWEET GOURD

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Abstract

The field experiment was conducted at the Bangladesh Agricultural Research Institute, Gazipur during *rabi* season of 2021-2022 to find out the optimum fertilizer dose and appropriate weed management method for getting higher sweet gourd fruit yield (Var. BARI sweetgourd-2) and economic return. The experiment was consisted of eight treatments viz.

Note: Note: T_1 = STB: Soil test based fertilizer dose (75-37-82-21-2.0-1.4 kg/ha N-P-K-S-Zn-B, FRG, 2018) + no weeding, T_2 = 125% STB (94-46-103-26-3.0-2 kg/ha N-P-K-S-Zn-B, FRG, 2018) + two hand weeding at 25 and 50 DAT, T_3 = STB + Spading at 25 and 50 DAT, T_4 = 125% STB + Spading at 25 and 50 DAT, T_5 = STB + BARI weeder weeding at 25 and 50 DAT, T_6 = 125% STB + BARI weeder weeding at 25 and 50 DAT, T_7 = STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT, T_8 = 125% STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT were used in the study as treatment variable. Among the treatments the highest weed control efficiency (84% at 25 DAT and 94% at 50 DAT) was found in T_2 (125% STB : 94-46-103-26-3.0-2 kg/ ha of N-P-K-S-Zn-B + two hand weeding at 25 and 50 DAT) treatment followed by T_3 (82% at 25 DAT and 93% at 50 DAT) and T_4 (81% at 25 DAT and 92% at 50 DAT) treatments and the lowest weed control efficiency was obtained from T_8 treatment (77% at 25 DAT and 88% at 50 DAT). Significantly the highest sweet gourd fruit yield 29.38 t/ha was recorded inT_2 treatment (125% STB + two hand weeding at 25 and 50 DAT) but higher benefit cost ratio 2.79 was obtained from T_7 treatment (Soil test basis fertilizer dose + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT) due to lower cost of production. The result revealed that STB (75-36-60-21-2.0-1.4 kg/ha N-P-K-S-Zn-B) + herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT of sweet gourd seedling + one hand weeding at 50 DAT of sweet gourd seedling would be most effective to control weeds for getting higher fruit yield of sweet gourd and economic returns.

Introduction

Production of sweet gourd (*Cucurbita maxima*) belongs to cucurbitaceae family in Bangladesh is increasing day by day. Sweet gourd is creeper type species that covers the maximum areas of land and good source of vitamin and also used as vegetable. Both the production area and production is increasing frequently throughout the recent year (BBS, 2019).The sweet gourd highly nutritious and particularly rich in vitamin A 245%, vitamin C 19%, vitamin B2 11%, vitamin E 10%, fat 0.2 grams, protein 2 grams, potassium 16%, copper 11%, manganese 11%, iron 8% and calories 49 (out of 245 grams of sweet gourd) which can help boost immune system. It’s high in potassium, vitamin c and fiber which have been linked to heart benefits. Crop management factors such as fertilizer and weed management are essential to increase yield and quality of fruit (Harrelson *et al*., 2007, Hossain *et al*., 2010, Madhabilatha *et al*., 1997, Sreenivas *et al*, 2000 and Gupta *et al*., 1976). Weed control reduce potential environmental contamination and will reduce crop weed completion and ultimately increase the yield as well as sweet gourd yield (Nadeem *et al*. 2013). Weeds compute with crops for soil moisture, nutrient, light and thus yield of sweet gourd is reduced considerably (Ciuberkis *et al*., 2004 and Mubeen *et. al*., 2009). The quality of crops is also reduced by weed infestation. Generally farmers are controlling weeds by hand weeding in several times. It takes more times and labour which leads to more cost. Herbicide has the capability to suppress the growth of weed. Herbicide use in Bangladesh is expected to increase dramatically in future due to labour scarcity. Weed and sweet gourd plant competition can severely reduce yields. Its increase the incidence of some plant diseases. Weeds are harbor of insects and diseases. It reduces the spray coverage of pesticide application. The quality of crops is also reduced by variation of fertilizer and hormonal treatment application. Thus, there is a need to study the influence of nutrient management and herbicide on crop performance of sweet gourd. Therefore the experiment was conducted to find out the suitable dose of fertilizer and weed management practice on sweet gourd for getting higher fruit yield and economic returns.

Materials and Methods

The experiment was conducted at the research field of Agronomy Division BARI, Joydebpur, Gazipur during *rabi* season of 2021-22. The soil of the research area belongs to AEZ-28. The soil was clay loam with pH 6.3. Soil samples of the experimental plots were collected and analyzed. The chemical properties of experimental soil are presented in Table 1.

Table 1. Chemical properties of experimental soil (initial)

pH	OM (%)	Total N (%)	Available P (µg/ml)	Exchangeable K (meq/100g soil)	Available S (µg/ml)	Available Zn (µg/ml)	Available B (µg/ml)
6.3	1.910	0.092	7.750	0.079	8.400	1.620	0.175
	VL	L	L	VL	L	O	L
Critical levels		-	7.0	0.12	10.00	0.60	0.20

L= Low, VL= Very low, O = Optimum

Eight treatments viz, Note: T_1 = STB: Soil test based fertilizer dose (75-37-82-21-2.0-1.4 kg/ha N-P-K-S-Zn-B, FRG, 2018) + no weeding, T_2 = 125% STB (94-46-103-26-3.0-2 kg/ha N-P-K-S-Zn-B, FRG, 2018) + two hand weeding at 25 and 50 DAT, T_3 = STB + Spading at 25 and 50 DAT, T_4 = 125% STB + Spading at 25 and 50 DAT, T_5 = STB + BARI weeder weeding at 25 and 50 DAT, T_6 = 125% STB + BARI weeder weeding at 25 and 50 DAT, T_7 = STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT, T_8 = 125% STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT were used in the study as treatment variable. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4 m × 4 m. The chemical fertilizers were used in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. All of organic manure P, K, S, Zn and B were applied in pit 7 days before transplanting of sweet gourd seedling and mixed thoroughly with the soil while urea and MoP were side dressed in four equal split around the plant as at 15, 35, 55 and 75 days after transplanting of seedling under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. In addition 5 t/ha of cow dung were applied before land preparation. Intercultural operation like weeding was done as per treatments. Other intercultural operation was done as and when require. The test variety was BARI sweet gourd-2. Sweet gourd plant was transplanted at 2 m × 2 m spacing on 02 December 2021. Four irrigations were given to crop at 15, 45, 60 and 75 DAE. Weed samples were collected using 50 cm × 50 cm quadrate, from randomly selected four places from each plot at 25 and 50 days after transplanting (DAT) of sweet gourd seedling. Number and dry weight of weeds were recorded carefully. Weed control efficiency (WCE) and relative weed density (RWD) was calculated according to following formulas:

WCE (%) = $\left(\frac{A-B}{A}\right)\times 100$; where, A = Dry weight of weeds in no weeding plots and B = Dry weight of weeds in treated plots.

The Relative Density (RD) was calculated by the following formula:

$$\text{Relative Weed Density (RWD)} = \frac{\text{No. of specific weed species}}{\text{Total no. of weeds}} \times 100$$

BARI sweet gourd- 2 was harvested four times on 25 March 2022, 03 April 2022, 13 April 2022 and 24 April 2022. The yield component data was taken from 2 randomly selected plants prior to harvest from each plot. At harvest, the yield data was recorded plot wise. The collected data were analyzed statistically and means were adjudged by LSD $_{(0.05)}$ test. Economic analysis was also done considering local market price of harvested crops.

Results and Discussion

Weed flora, dry weight of weed and weed control efficiency

Weed species, number of weeds/m^2, weed density (%) and weed control efficiency (WCE) were affected by different fertilizer dose and weed management practices are presented in Table 1 and Table 2. Anguli (*Digitaria* spp), Bothua (*Chenopodium album),* Chapra (*Elusine indica),* Durba (*Cynodon dactylon*), Helencha (*Enhydra fluctuans),* Mutha (*Cyperus rotundus*), Shaknote (*Amaranthus viridis)* and Shama (*Echinochola crusgali)* were the common and dominant weeds in the sweet gourd field (Table 1). The number of weeds/m^2 ranged from 85 to 150 /m^2 and 44 to 211 at 25 DAT and 50 DAT of sweet gourd seedling respectively in different fertilizer dose and weed management practice. Among the treatments the lowest weed /m^2 (85) was found in the treatment T_2 followed by T_3 (91), T_4 (98) and T_5 treatment (104) at 25 DAT of sweet gourd seedling. In case of 50

DAT of sweet gourd seedling the lowest weed was obtained from T_2 treatment (44) followed by T_3 (46), T_4 (70) and T_5 treatment (73). The highest weeds /m^2 (150 at 25 DAT and 211 at 50 DAT) was recorded in T_1 (No weeding plots). It was evident that Anguli *(Digitaria spp)*, Bothua *(Chenopodium album)*, Mutha (*Cyperus rotundus*) and Shama (*Echinochola crusgali*) were found the most dominant weed in the sweet gourd field ranged from 6.82 % -30 %, 3.82% - 10.67, 7.69 - 29.51 and 7.33 % - 32.65 % at 25 DAT of sweet gourd seedling respectively. The number of weeds was decreased in all the plots at 50 DAT than 25 DAT of sweet gourd seedling. The maximum weed dry weight of 42.41g/m^2 and 65.93 g/m^2 was recorded in treatment T_1 treatment (No weeding plots) at 25 DAT and 50 DAT of sweet gourd seedling respectively (Table. 2). The minimum weed dry weight 6.92 and 4.20 g/m^2 was obtained from treatment T_2 at 25 and 50 DAT of sweet gourd seedling. Higher weed density and dry weight decrease the yield of sweet gourd. Similar findings were observed by Sarandon *et al.*, (2002). The variation in weed control efficiency (WCE) was observed among the different treatments. The highest weed control efficiency (WCE) 84 and 94 % was found in treatment T_2 (Two hand weeding at 25 DAT & 50 DAT with 125% of recommended fertilizer dose) respectively followed by $T_{3,}$ T_4 and T_5 treatments (Table 2).

Table 1. Effect of different doses of fertilizer and weed management practice on weed species, weed number/m^2 and weed density (%) over time in sweet gourd field.

Treatment	Local name	Scientific name	No weeding			
			Weed/m^2 (no.)	Weed density (%)	Weed/m^2 (no.)	Weed density (%)
T_1	Anguli	*Digitaria spp*	30	20.00	36	17.06
	Bathua	*Chenopodium album*	16	10.67	28	13.27
	Chapra	*Elusine indica*	22	14.67	22	10.43
	Durba	*Cynodon dactylon*	14	9.33	28	13.27
	Foska begun	*Physalis heterophylla*	8	5.33	9	4.27
	Helencha	*Enhydra fluctuans*	13	8.67	19	9.00
	Kanaibashi	*C0mmelina benghalensis*	4	2.67	11	5.21
	Nunia	*Portulaca oleracea*	12	8.00	21	9.95
	Mutha	*Cyperus rotundus*	12	8.00	15	7.11
	Shama	*Echinochola crusgali*	11	7.33	10	4.74
	Shaknote	*Amaranthus viridis*	8	5.33	12	5.69
		Total	**150**		**211**	
T_2	Local name	Scientific name	25 DAT		50 DAT	
			Weed/m^2 (no.)	Weed density (%)	Weed/m^2 (no.)	Weed density (%)
	Anguli	*Digitaria spp*	12	11.01	6	8.96
	Bathua	*Chenopodium album*	11	10.09	3	4.48
	Chapra	*Elusine indica*	3	2.75	2	2.99
	Durba	*Cynodon dactylon*	7	6.42	3	4.48

	Helencha	*Enhydra fluctuans*	8	7.34	5	7.46
	Kanai bashi	*C0mmelina benghalensis*	1	0.92	3	4.48
	Nunia	*Portulaca oleracea*	8	7.34	4	5.97
	Mutha	*Cyperus rotundus*	14	12.84	3	4.48
	Shama	*Echinochola crusgali*	14	12.84	12	17.91
	Shaknote	*Amaranthus viridis*	7	6.42	3	4.48
		Total	**85**		**44**	
Treatment	Local name	Scientific name	25 DAT		50 DAT	
			Weed/m2 (no.)	Weed density (%)	Weed/m^2 (no.)	Weed density (%)
T_3	Anguli	*Digitaria spp*	28	30.77	3	6.52
	Bothua	*Chenopodium album*	8	8.79	5	10.87
	Durba	*Cynodon dactylon*	3	3.30	4	8.70
	Helencha	*Enhydra fluctuans*	11	12.09	9	19.57
	Mutha	*Cyperus rotundus*	7	7.69	5	10.87
	Nunia	*Portulaca oleracea*	4	4.40	2	4.35
	Shama	*Echinochola crusgali*	23	25.27	13	28.26
	Shaknote	*Paspalum commersonii*	7	7.69	5	10.87
		Total	**91**		**46**	
T_4	Local name	Scientific name	25 DAT		50 DAT	
			Weed/m^2 (no.)	Weed density (%)	Weed/m^2 (no.)	Weed density (%)
	Anguli	*Digitaria spp*	13	13.27	6	8.57
	Bothua	*Chenopodium album*	6	6.12	7	10.00
	Chapra	*Elusine indica*	2	2.04	3	4.29
	Durba	*Cynodon dactylon*	3	3.06	3	4.29
	Foska begun	*Physalis heterophylla*	1	1.02	1	1.43
	Helencha	*Enhydrafluctuans*	9	9.18	8	11.43
	Mutha	*Cyperus rotundus*	15	15.31	11	15.71
	Nunia	*Portulaca oleracea*	4	4.08	2	2.86
	Shaknote	*Paspalum commersonii*	13	13.27	9	12.86
	Shama	*Echinochola crusgali*	32	32.65	20	28.57
		Total	**98**		**70**	
T_5	Local	Scientific name	25 DAT		50 DAT	

	name		Weed/m^2 (no.)	Weed density (%)	Weed/m^2 (no.)	Weed density (%)
	Anguli	*Digitaria spp*	8	7.69	10	13.70
	Bothua	*Chenopodium album*	10	9.62	9	12.33
	Durba	*Cynodon dactylon*	12	11.54	6	8.22
	Foska begun	*Physalis heterophylla*	7	6.73	3	4.11
	Helencha	*Enhydra fluctuans*	9	8.65	5	6.85
	Nunia	*Portulaca oleracea*	11	10.58	4	5.48
	Mutha	*Cyperus rotundus*	14	13.46	17	23.29
	Shama	*Echinochola crusgali*	25	24.04	13	17.81
	Shaknote	*Paspalum commersonii*	8	7.69	6	8.22
		Total	**104**		**73**	
T_6	Local name	Scientific name	25 DAT		50 DAT	
			Weed/m^2 (no.)	Weed density (%)	Weed/m^2 (no.)	Weed density (%)
	Bathua	*Chenopodium album*	4	3.28	5	6.41
	Chapra	*Elusine indica*	14	11.48	5	6.41
	Durba	*Cynodon dactylon*	2	1.64	1	1.28
	Foska begun	*Physalis heterophylla*	9	7.38	5	6.41
	Helencha	*Enhydra fluctuans*	12	9.84	8	10.26
	Mutha	*Cyperus rotundus*	36	29.51	26	33.33
	Nunia	*Portulaca oleracea*	6	4.92	3	3.85
	Shaknote	*Amaranthus viridis*	15	12.30	13	16.67
	Shama	*Echinochola crusgali*	24	19.67	12	15.38
		Total	**122**		**78**	100.00
T_7	Local name	Scientific name	25 DAT		50 DAT	
			Weed/m^2 (no.)	Weed density (%)	Weed/m^2 (no.)	Weed density (%)
	Anguli	*Digitaria spp*	9	7.09	6	6.52
	Bothua	*Chenopodium album*	6	4.72	6	6.52
	Chapra	*Elusine indica*	7	5.51	7	7.61
	Durba	*Cynodon dactylon*	12	9.45	9	9.78
	Foska begun	*Physalis heterophylla*	10	7.87	8	8.70
	Helencha	*Enhydrafluctuans*	10	7.87	11	11.96
	Mutha	*Cyperus rotundus*	17	13.39	16	17.39
	Nunia	*Portulaca oleracea*	15	11.81	5	5.43
	Shaknote	*Amaranthus viridis*	14	11.02	10	10.87
	Shama	*Echinocholacrusgali*	27	21.26	14	15.22
		Total	**127**		**92**	

T8	Local name	Scientific name	25 DAT		50 DAT	
			Weed/m^2 (no.)	Weed density (%)	Weed/m^2 (no.)	Weed density (%)
	Anguli	*Digitaria spp*	9	6.82	6	5.88
	Bothua	*Chenopodium album*	8	6.06	12	11.76
	Chapra	*Elusine indica*	10	7.58	13	12.75
	Durba	*Cynodon dactylon*	12	9.09	9	8.82
	Foska begun	*Physalis heterophylla*	12	9.09	5	4.90
	Helencha	*Enhydrafluctuans*	10	7.58	12	11.76
	Mutha	*Cyperus rotundus*	17	12.88	13	12.75
	Nunia	*Portulaca oleracea*	15	11.36	9	8.82
	Shaknote	*Amaranthus viridis*	12	9.09	9	8.82
	Shama	*Echinocholacrusgali*	27	20.45	14	13.73
		Total	**132**		**102**	

Table 2. Effect of different doses of fertilizer and weed management practice on weed dry weight and weed control efficiency over time in sweet gourd field during *rabi* season of 2021-2022.

Treatment	Weed dry weight (g/m^2)		Weed control efficiency (%)	
	30 DAT	50 DAT	30 DAT	50 DAT
T_1	42.41	65.93		
T_2	6.92	4.20	84	94
T_3	7.45	4.53	82	93
T_4	7.95	5.12	81	92
T_5	8.12	5.80	81	91
T_6	8.32	6.13	80	91
T_7	8.82	6.89	79	90
T_8	9.92	7.90	77	88

Note: T_1 = STB: Soil test based fertilizer dose (75-37-82-21-2.0-1.4 kg/ha N-P-K-S-Zn-B, FRG, 2018) + no weeding, T_2 = 125% STB (94-46-103-26-3.0-2 kg/ha N-P-K-S-Zn-B, FRG, 2018) + two hand weeding at 25 and 50 DAT, T_3 = STB + Spading at 25 and 50 DAT, T_4 = 125% STB + Spading at 25 and 50 DAT, T_5 = STB + BARI weeder weeding at 25 and 50 DAT, T_6 = 125% STB + BARI weeder weeding at 25 and 50 DAT, T_7 = STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT, T_8 = 125% STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT.

The effect of different fertilizer dose on sweet gourd yield:

The effect of different fertilizer dose on sweet gourd fruit yield was varied significantly. The highest sweet gourd fruit yield (29.38 t/ha) was recorded from T_2 treatment (125% STB: 94-46-103-26-3.0-2 kg/ ha of N-P-K-S-Zn-B) + two hand weeding at 25 and 50 DAT) followed by T_4, T_3 treatments and the lowest sweet gourd fruit yield (24.52 t/ha) was obtained from T_1 treatment (Fig.1). The sweet gourd fruit yield was increased by applying higher dose of fertilizer. This result is supported by Barani *et al.* (2013), where they reported that with increasing the fertilizer dose increased the sweet gourd total yield per hectare and more number of sweet gourd fruits was observed.

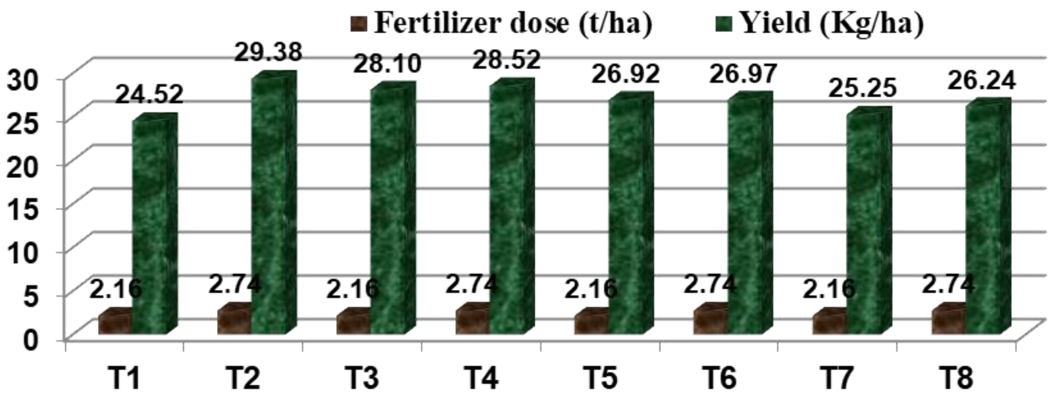

Fig 1. Relationship between applied different fertilizer dose and yield of sweet gourd

Note: T_1 = STB: Soil test based fertilizer dose (75-37-82-21-2.0-1.4 kg/ha N-P-K-S-Zn-B, FRG, 2018) + no weeding, T_2 = 125% STB (94-46-103-26-3.0-2 kg/ha N-P-K-S-Zn-B, FRG, 2018) + two hand weeding at 25 and 50 DAT, T_3 = STB + Spading at 25 and 50 DAT, T_4 = 125% STB + Spading at 25 and 50 DAT, T_5 = STB + BARI weeder weeding at 25 and 50 DAT, T_6 = 125% STB + BARI weeder weeding at 25 and 50 DAT, T_7 = STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT, T_8 = 125% STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT.

Relationship between yields of sweet gourd with weed dry weight at harvest

There was a negative linear correlation between yields of sweet gourd with weed dry weight at harvest (Fig. 2). The regression line ($y = -0.0089x + 28.092$, $R^2 = 0.4253$) that means the correlation of coefficient (x) was -0.0089 stated that sweet gourd yield decrease at the rate of 0.0089 kg/ha for per unit change of weed dry weight at harvest. The contribution of regression (R^2= 0.4253) value indicated that around 43% yield of sweet gourd was attributed due to dry weight of weed. Thus result showed that increasing dry weight of weeds decreasing the fruit yield of sweet gourd. These findings were in agreement with those of Sarandon *et al*., 2002, Ciuberkis *et al*., 2004 and Mubeen *et al.* 2009.

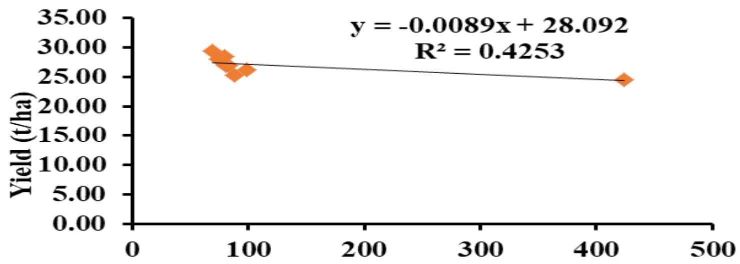

Fig 2. Funtional relationship between yield of sweet gourd and weed dry weight at harvest.

Yield and yield component of sweet gourd

Number of fruit/plant, single fruit weight/plant, fruit breath (cm), fruit length (cm) and fruit yield of sweet gourd as affected by different treatments (Table 3). The highest number of fruit/plant (10.45) was obtained from T_2 treatment which was statistically identical with T_4 treatment (10.14) followed by T_3 (8.79) and T_5 (8.22). The lowest number of fruit/plant was obtained from T_1 (6.95) treatment. Similarly the height number of individual fruit weight (3.40 kg), fruit breath (72.00 cm) and length of fruit (16.71 cm) was recorded in T_2 treatment followed by T_4, T_3 and T_6 treatments (individual fruit weight 3.29 kg, 3.27 kg and 3.19 kg, breath of fruit 69.33 cm, 68.00 cm and 65.67 cm and fruit length of fruit 16.16 cm, 15.70 cm and 15.20 cm). The lowest number of individual fruit weight (2.59 kg), breath of fruit (51.33 cm), length of fruit (13.71 cm) was recorded in T_1 treatment followed by T_7 and T_8 treatments (individual fruit weight

2.87 kg and 2.95 kg, breath of fruit 61.33 cm and 64.33 cm and length of fruit 14.09 cm and 15.02 cm). Highest fruit yield (29.38 t/ha) was obtained from T_2 treatment which was statistically identical with T_4 (28.52 t/ha) and T_3 (28.10 t/ha) treatments. Similarly the lowest fruit yield (24.52 t/ha) was recorded in T_1 treatment followed by T_7 (25.25 t/ha), T_8 (26.24 t/ha), T_5 (26.92 t/ha) and T_6 (26.97t/ha) treatments. The highest fruit yield of sweet gourd in T_2 treatment was attributed by the more numbers of fruit/plant, maximum single fruit weight, fruit length and fruit diameter. Faruque *et al.,* 2006 and Islam *et al.,* 2014, Hossain *et al.,* 2010 also reported similar result.

Table 3. Fruit yield and yield contributing characters of sweet gourd as affected by different treatments.

Treatment	No. of fruit/plant	Single fruit weight (kg)	Breath of fruit (cm)	Length of fruit (cm)	Fruit yield (t/ha)
T_1	6.95	2.59	51.33	13.71	24.52
T_2	10.45	3.40	72.00	16.71	29.38
T_3	8.79	3.27	68.00	15.70	28.10
T_4	10.14	3.29	69.33	16.16	28.52
T_5	8.22	3.09	65.33	15.17	26.92
T_6	8.48	3.19	65.67	15.20	26.97
T_7	7.36	2.87	61.33	14.09	25.25
T_8	7.97	2.95	64.33	15.02	26.24
$LSD_{(0.05)}$	0.91	0.36	5.97	1.21	1.59
CV (%)	6.06	6.57	5.28	4.53	3.37

Table 4. Cost and return analysis of sweet gourd

Treatment	Sweet gourd yield (t/ha)	Gross return (Tk/ha)	Total cost of production (TK/ha)	Gross margin (TK/ha)	MBCR
T_1	24.52	3,67,750	1,44,978	1,66,750	2.54
T_2	29.38	4,40,650	2,01,000	2,78,650	2.19
T_3	28.10	4,21,500	1,62,000	2,43,400	2.60
T_4	28.52	4,27,800	1,78,100	2,79,600	2.40
T_5	26.92	4,03,800	1,48,200	2,50,800	2.72
T_6	26.97	4,04,500	1,53,000	2,68,500	2.64
T_7	25.25	3,78,800	1,36,000	2,35,240	2.79
T_8	26.24	3,93,550	1,43,560	3,93,550	2.74

Price: Sweet gourd: TK. 15/kg, MBCR= Marginal benefit cost ratio.

Note: T_1 = STB: Soil test based fertilizer dose (75-37-82-21-2.0-1.4 kg/ha N-P-K-S-Zn-B, FRG, 2018) + no weeding, T_2 = 125% STB (94-46-103-26-3.0-2 kg/ha N-P-K-S-Zn-B, FRG, 2018) + two hand weeding at 25 and 50 DAT, T_3 = STB + Spading at 25 and 50 DAT, T_4 = 125% STB + Spading at 25 and 50 DAT, T_5 = STB + BARI weeder weeding at 25 and 50 DAT, T_6 = 125% STB + BARI weeder weeding at 25 and 50 DAT, T_7 = STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT, T_8 = 125% STB + Herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha) at 4 DAT + one hand weeding at 50 DAT.

Cost and benefit analysis

The highest gross return (Tk. 4,40,650 /ha) was recorded from T_2 treatment (125% STB 94-46-103-26-3.0-2 kg/ ha of N-P-K-S-Zn-B) + two hand weeding at 25 and 50 DAT) which was 19.82 percent higher than T_1 treatment (No weeding) (Table 4) followed by treatments T_4 (Tk. 4,27,800/ha), T_3 (Tk. 4,21,500/ha) and T_6 (Tk. 4,04,500/ha). The lowest gross return was obtained from T_1 treatment ((Tk. 3,67,750/ha) followed by T_7 (Tk. 3,78,800/ha) and T_8 treatments (Tk. 3,93,550/ha). The highest cost of production was recorded in T_2 treatment (Tk. 2,01,000/ha) due to higher labour and fertilizer cost. The highest gross margin of Tk. 3,93,550/ha was observed in T_8 treatment followed by T_4 (Tk. 2,79,600/ha), T_2 (Tk. 2,78,650/ha) and T_6 (Tk. 2,68,500/ha) treatments. The highest marginal benefit cost ratio (MBCR) (2.79) was obtained from T_7 treatments due to lower labour and fertilizer cost (Table. 3) followed by T_8 (2.74) and T_5 (2.72) .The lowest BCR (2.19) was obtained from T_2 treatment due to higher labour and fertilizer cost though it gave the highest fruit yield. The results were consistent with the earlier reports of lower labour and fertilizer cost which gave the highest fruit yield and returns (Akhteruzzaman *et al*. 1991, Islam *et al*. 2012, Ahmed *et al*. 2013, Subrahmaniyan *et al*., 2011, Weber *et al*., 1995 and Rapp *et al*., 2004).

Conclusion

From the Result it might be concluded that T_2 treatment 125% soil test based fertilizer dose (94-46-103-26-3.0-2 kg/ ha of N-P-K-S-Zn-B) + two hand weeding at 25 and 50 DAT produced the highest sweet gourd fruit yield (29.38 t/ha) but highest marginal benefit cost ratio (MBCR) 2.79 was obtained from T_7 treatment (soil test basis fertilizer dose: 75-37-82-21-2.0-1.4 kg/ha N-P-K-S-Zn-B, FRG, 2018 + herbicide spray Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha at 4 DAT of sweet gourd seedling + one hand weeding at 50 DAT of sweet gourd seedling) due to lower cost of production which would be economically profitable for sweet gourd production at Gazipur region (AEZ 28). This is the result of first year experiment. The experiment should be repeated next year for confirming the results.

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EFFECT OF INTEGRATED WEED MANAGEMENT ON TOMATO CULTIVATION

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Abstract

The field experiment was conducted at the Agronomy Research Field of Bangladesh Agricultural Research Institute (BARI) during *rabi* season of 2020-21 and 2021-22 to find out suitable weed management practices in tomato field. Treatments consist of T_1= Two hand weeding at 25 and 45 DAT, T_2= Magzin 70 WG (Mteribuzin) @ 300-400 gm/ha + One hand weeding at 45 DAT, T_3= G-Penda 33 EC (Pendimethylene) @ 1 L/ha+ One hand weeding 45 DAT, T_4= Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + One hand weeding 45 DAT and T_5= Control (No weeding). Two years results showed that Helencha (Enhydra fluetuans) was observed as a major weed in tomato field. Number of weed/m^2, weed dry weight (g/m^2) and weed control efficiency (WCE) was affected by different treatments. The highest weed populations (78.5/m^2 and 125.5/m^2) were recorded in control plot at 25 and 45 DAT, respectively. The highest WCE (weed control efficiency) was 92.13 and 93.62% at 25 DAT and 45 DAT respectively in T_4 treatment. Single fruit weight (4.39) and yield (74.72 t/ha) of tomato were obtained from T_4 treatment. The highest gross return (Tk. 895200/ ha and Tk. 1120800/ha), gross margin (Tk. 733250/ha and Tk. 865746/ha) and BCR (5.53 and 4.39) was observed in T_4 {spraycing of herbicide i.e., Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + One hand weeding at 45 DAT} treatment. The result revealed that application of herbicide Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at 45 DAT would be effective to control weeds for obtaining higher yield of tomato.

Introduction

Tomato (*Lycopersicon esculentum*) belonging to the family Solanaceae, is a very popular and world's most widely grown vegetable after potato and sweet potato. Tomatoes can be served raw, baked, stewed, fried and soups, conserves, pickles, ketchups, sauces, and other items can be made from it. Tomatoes are a good source of Vitamin A and a fair source of Vitamin C (Norman, 1992) and can be an obstacle during harvesting. Bangladesh has sparse population and availability of labour is very low so in transplanted vegetables weeds can be controlled by herbicide. In 2000 the use of herbicide was 271.10 MT/KL and in 2018 it increased to 6996.60 MT/KL (BBS, 2019). But no one method of weed control can adequately meet the needs of any crop all the time. Integrated weed management is therefore as an integration of effective, environmentally safe and socially acceptable weed control tactics that reduce weed interference below the economic injury level (Thill et al., 1991). Therefore, from the need to develop a cost-effective weed management strategy using the herbicides for control of weeds in tomato the study was conducted.

Materials and Methods

The experiment was conducted at the research field of Agronomy Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during *rabi* season of 2020-21 and 2021-22. The soil was silty clay loam belonging to Agro Ecological Zone (AEZ) 28. There were five (5) treatments viz. T_1= Two hand weeding at 25 and 45 DAT, T_2= Magzin 70 WG (Mteribuzin) @ 300-400 gm/ha + One hand weeding 45 DAT, T_3= G-Penda 33 EC (Pendimethylene) @ 1 L/ha+ One hand weeding 45 DAT, T_4=Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + One hand weeding 45 DAT and T_5= Control (No weeding). The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 3 m× 4 m. The crop was fertilized with cow dung @ 10 t/ha and 123-45-60-24-2-1 kg/ha of N P K S Zn B (FRG, 2018) in the form of urea, triple super phosphate, muriate of potash and gypsum, respectively. Cow dung with other chemical fertilizers along with one third N and one third K were applied as basal dose. Rest of N and K all fertilizers were applied at 25 and 45 DAT in two equal splits. Weeding operation was applied as per treatments. BARI Tomato- 14 was used as test crop. Seedlings 26days old and were transplanted in main field on 05 January 2022. Transplanting was done maintaining 60 cm line to line spacing and 40 cm plant to plant spacing. Weed samples were collected from each plot at 25 and 45 DAT using a quadrate and dry weight was recorded to evaluate the efficacy of different weed control treatments. Tomato was harvested for six times and final harvest was done on 31 March 2021. At the time of harvest, yield contributing characters were recorded from one linear meter and yield data was recorded by harvesting the whole plot. Total Soluble Solids (TSS) or Degrees of Brix (°B) of tomato fruits was measured by a digital refractometer (Model NR151).

$$\text{WCE (\%)} = \left(\frac{A - B}{A}\right) \times 100$$

Where, A = Dry weight of weeds in no weeding plots and B = Dry weight of weeds in treated plots. Yield and yield contributing characters were recorded and analyzed statistically using “STAR” software package and means were separated by LSD at 5% level of significance. Economic analysis was performed considering the prevailing market price of applied inputs and output of tomato.

Results and Discussion

Weed flora, weed dry matter and weed control efficiency

Average over the years number of weeds/m^2, weed dry weights/m^2 and WCE (%) was affected by different weed management methods are presented in Table 1. Helencha (*Enhydra fluetuans),* Durba (*Cynodon dactylon*) and Bathua (*Chenopodium album*) were the common and dominant weeds in the tomato field. The range of number of weeds/m^2 was 29.50-78.50 and 51-125.50 at 25 and 45 DAT, respectively, in different herbicide treated plots (Table 1). The highest number of weeds /m^2 (78.5 at 25 DAT and 125.5 at 45 DAT) was recorded in T_5 (control plot) treatment. The lowest number of weeds/m^2 (29.5 at 25 DAT and 51 at 45 DAT) was found from T_4{Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at45 DAT} treatment followed by T_1 (32 at 25 DAT and 52.5 at 45 DAT). The number of weeds/m^2 in all the plots at 45 DAT was higher than that of at 25 DAT. The maximum weed dry weight (17.80 g/m^2 at 25 DAT and 44.66 g/m^2 at 45 DAT) was obtained in T_5 (control plot), whereas, the minimum weed dry weight (1.40 g/m^2 at 25 DAT and 2.85 g/m^2 at 45 DAT) in T_4 {Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at45 DAT} treatment (Table 1). Weed control efficiency was affected by the different weed management treatments (Table 1). T_4{Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at45 DAT} treatment was the best among the other weed management methods. The highest WCE of 92.13% at 25 DAT and 93.62% at 45 DAT was found in T_4 {Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at45 DAT] treatment followed by T_1 treatment at 25 and 45 DAT (Table 1).

Yield and yield components of tomato

Average over the years, plant height and yield components and yield of tomato were significantly influenced by different weed management methods (Table 2). The highest plant height (111.22 cm), no. of fruits/plant (20.33), single fruit weight (92.13g), fruit length (4.39 cm) and fruit diameter (4.30 cm) of tomato were observed in T_4 {Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at 45 DAT} treatment. The lowest performance of yield contributing characters were found in T_5 treatment.Significantly the highest fruit yield (74.72 t/ha) was recorded in T_4(Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at 45 DAT) treatment which was followed by T_1 treatment which was followed by T_1, $T_3$and T_2while the lowest yield(54.22 t/ha) was found in T_5 treatment. Better weed control method was found in T_4 {Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at 45 DAT} treatment due to the effective control of weeds which resulted in more no. fruits/plant, single fruit weight and finally higher yield.

Total Soluble Solids (TSS) or Degrees of Brix (°B) of tomato fruits

The sweetness of fruits i.e., Total Soluble Solids (TSS) of tomato fruits were significantly influenced by different treatments in both years (Table 3). The amount and types of sugars stored in tomato fruit are a major constituent of postharvest tomato quality by affecting taste and overall fruit quality. What determines the eating experience provided by any tomato at a given place and time, depends on several highly interacting factors, genetic-, agronomic, climactic and various post-harvest handling related issues (Beckles, 2012). The highest TSS was found in treatment T_4 (5.77) and T_1 (5.9) respectively in year 2020-21 and 2021-22 and the lowest one in T_5 (4.63) in 2020-21 and in 2021-22 in T_2 (5.0) treatment.

Economic performance

Benefit cost analysis of tomato in both the years have been presented in Table 4. The highest gross return (Tk. 895200/ ha in 2021and Tk. 1120800/ha in 2022), gross margin (Tk. 733250/ha in 2021and Tk. 865746/ha in 2022) and BCR (5.53 in 2021and 4.39 in 2022) was observed in T_4 {Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at 45 DAT} treatment which was followed by T_3. The lowest BCR (3.49 in 2021and 3.32 in 2022) was obtained from T_5 (Control) treatment.

Conclusion

The result revealed that application of herbicide Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + one hand weeding at 45 DAT would be economically profitable method for controlling weeds as well as higher productivity of tomato.

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Table1. Weeds/m^2, weed dry weight (g/m^2) and weed control efficiency (%) in tomato as affected by different weed control method in 2020-21 and 2021-22 (average and pooled of two years)

Treatment	Weed/m^2 (no.)		Weed dry weight (g/m^2)		Weed control efficiency (%)	
	25 DAT	45 DAT	25 DAT	45 DAT	25 DAT	45 DAT
T_1	32.00	52.50	2.77	4.90	84.49	89.03
T_2	41.00	61.00	4.64	5.76	73.93	87.10
T_3	47.50	66.00	3.37	5.46	81.07	87.77
T_4	29.50	51.00	1.40	2.85	92.13	93.62
T_5	78.50	125.5	17.80	44.66	-	-
$LSD_{(0.05)}$	-	-	0.45	2.82	-	-
CV (%)	-	-	3.17	7.01	-	-

Table2. Effect of different weed control methods on yield component and yield of tomato in 2020-21 and 2021-22 (pooled of two years)

Treat.	Plant height (cm)	Fruits/plant (no.)	Single fruit wt. (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit Yield (t/ha)
T_1	105.67	16.67	88.08	4.19	4.08	72.78
T_2	100.89	14.00	83.87	4.06	4.03	68.94
T_3	98.67	9.67	84.77	4.01	4.06	70.41
T_4	111.22	20.33	92.13	4.39	4.30	74.72
T_5	89.67	8.33	80.05	3.89	3.99	54.22
$LSD_{(0.05)}$	5.23	1.24	1.92	0.11	0.59	3.75
CV (%)	2.83	4.72	1.26	1.50	0.83	3.25

Table3. Effect of different weed control methods on Total Soluble Solids (TSS) of tomato in 2020-21 and 2021-22

Treatments	Average TSS (°B)	
	2020-21	2021-22
T_1	4.87	5.9
T_2	4.70	5.0
T_3	5.53	5.7
T_4	5.77	5.2
T_5	4.63	5.7
Machine/equipment used	Digital Refractometer, Model NR151	

T_1= Two hand weeding at 25 and 45 DAT, T_2= Magzin 70 WG (Mteribuzin) @ 300-400 gm/ha + One hand weeding 40 DAT, T_3= G-Penda 33 EC (Pendimethylene) @ 1 L/ha+ One hand weeding 40 DAT, T_4= Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + One hand weeding 40 DAT and T_5= Control (No weeding)

Table4. Effect of different weed control treatments on yield and economic performance of tomato in two years 2020-21 and 2021-22

Treat.	Gross return (Tk./ ha)		Cost of production (Tk./ ha)		Gross margin (Tk./ha)		BCR	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
T_1	830400	1091700	163050	266071	667350	825629	5.09	4.10
T_2	755160	1034100	153050	255054	596110	779046	4.75	4.05
T_3	814680	1056150	150050	255054	655630	801096	5.12	4.14
T_4	895200	1120800	157950	255054	733250	865746	5.53	4.39
T_5	478560	813300	137050	245054	341510	568246	3.49	3.32

Price: Tomato =Tk.15/kg

T_1= Two hand weeding at 25 and 45 DAT, T_2= Magzin 70 WG (Mteribuzin) @ 300-400 gm/ha + One hand weeding 40 DAT, T_3= G-Penda 33 EC (Pendimethylene) @ 1 L/ha+ One hand weeding 40 DAT, T_4= Shagun 54 WG (Metribuzin 42% + Clodinafop Propargyl 12% WG) @ 400-500 g/ha + One hand weeding 40 DAT and T_5= Control (No weeding)

OPTIMIZATION OF DOSES AND TIME OF APPLICATION OF PENDIMETHALIN ON WEED CONTROL OF ONION

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Abstract

A field experiment was conducted at the Regional Agricultural Research Station, Ishurdi, Pabna during 2020-2021 and 2021-2022 to find out the appropriate dose and time of spray of Pendimethalin (Panida) for weed control of onion. Four doses of Pendimethalin herbicide viz; i) 3 ml /L of water (D_1), ii) 5 ml/ L of water(D_2), iii) 7 ml/ L of water (D_3), iv) Control (D_4), and four spraying time namely, i) Spraying at just after planting and irrigation (T_1), ii)Spraying at 3 days after planting and irrigation (T_2), iii)Spraying at 5 days after planting and irrigation (T_3), iv)Spraying at 7 days after planting and irrigation (T_4) were included in the experiment. Dose and spraying time of Pendimethalin had significant effect of bulb yield. Results obtained that D_3T_1 (Pendimethalin @ 7 ml/ L with spraying just after planting) produced the highest bulb yield (14.78 t/ ha) and the lowest average bulb yield (4.89 t/ ha) was obtained from D_4 with T_1-T_4 treatments. On the basis of economic point of view D_3T_1 combination also superior by getting highest gross margin (TK.201090 /ha) and BCR (2.19), and could be applied for controlling weed in onion field.

Introduction

Onion (*Allium cepa* L.) is a very important spices crop widely grown at the globe including Bangladesh. There are several abiotic and biotic factors responsible for low yielding of this crop. Weed is a very noxious for onion production. As succulent leaf, a considerable amount of leaf is damage during hand weeding, and thereby reduced bulb yield. Such condition, herbicides could be use as an alternative method of weed control. Currently, the use of herbicide becomes popular globally due to unavailability of agricultural laborers and higher wage rates. The effectiveness of a herbicide depends on its optimum does as well as their spray time. However, farmers are use herbicide in scattered doses and spray time. Consequently, they are not getting good result for weed control. Soil health also depends on optimum does of herbicide. Panida (Pendimethalin) is a popular herbicide that recommended for use in wet condition. Therefore, this study is undertaken to find out the appropriate dose, and time of spray of panida for weed control of onion.

Materials and Methods

A field experiment was conducted at the Regional Agricultural Research Station, Ishurdi, Pabna during 2020-2021 and 2021-2022 to find out the appropriate dose, and time of spray of Pendimethalin (panida) for weed control of onion. Four doses of Pendimethalin herbicide viz; i) 3 ml /L of water

(D_1), ii) 5 ml/ L of water(D_2), iii) 7 ml/ L of water (D_3), iv) Control (D_4), and four spraying time namely, i) Spraying at just after planting and irrigation (T_1), ii)Spraying at 3 days after planting and irrigation (T_2), iii)Spraying at 5 days after planting and irrigation (T_3), iv)Spraying at 7 days after planting and irrigation (T_4) were included in the experiment. Herbicides were applied as per treatments. Unit plot size was 3m x 2 m. The crop was fertilized with 240-260-150-110 kg ha^{-1} of Urea-TSP-MOP-Gypsum, and cowdung 5 t /ha (Krishi Projukti Hatboi-2019). Half of Urea and all other fertilizers were applied as basal. Rest half of Urea fertilizers were top dressed at 30 DAP. Onion was planting on 05 and 03 January 2021 and 2022, respectively. The bulb.were harvested on 1 April and 7 april 2021 and 2022, respectively. The crop were irrigated at 20, 35 and 50 DAP. Weed sample was collected at 60 DAP and 80 DAP from every plot. Collected data were analyzed statistically with the help of 'R' program and mean separation was done by LSD at 5% level of significance.

Results and Discussion

Dry weight of weeds

Dry weight of weeds m^{-2} did not statistically vary at different interaction treatments both 60 and 80 DAP (Table 1). In case of herbicide doses, the highest dry weight (26.34 g and 106.43g) was recorded from Control (D_4) and lowest dry weight (18.80 g and 27.61g) was found in D_3 (7 ml /L) at 60 DAP and 80 DAP, respectively. In case of spraying time, the highest dry weight (24.44 g and 58.11g) was recorded from T_4 (Spraying at 7 days after planting and irrigation) and lowest dry weight (17.86 g and 45.90g) was calculated at in T_1 (Spraying at just after planting and irrigation) at 60 DAP and 80 DAP, respectively. The higher weed control efficiency was recorded in D_3T_1 treatment combination both at 60 DAP and 80 DAP (42.37% and 80.10%)

Table 1. Weed dry weight and weed control efficiency affected by different level and spraying time of pendimethalin of onion during 2022

Treatments	Weed dry matter 60 DAE (g/m^2)	WCE (%)	Weed dry matter 80 DAE (g/m^2)	WCE (%)
Dose of pendimethalin (D)				
3 ml/ L (D_1)	20.19	23.35	32.66	69.31
5 ml/ L (D_2)	19.40	26.35	31.24	70.65
7 ml /L (D_3)	18.80	28.63	27.61	74.06
Control (D_4)	26.34	0.00	106.43	0.00
$LSD_{(0.05)}$	5.19	-	6.99	-
CV (%)	24.51	-	14.15	-
LS	*		***	
Spraying time (T)				
Spraying just at planting and irrigation(T_1)	17.86	26.92	45.90	21.01
3 DAP(T_2)	20.47	16.24	46.48	20.01
5 DAP(T_3)	21.96	10.15	47.46	18.33
7 DAP(T_4)	24.44	0.00	58.11	0.00
$LSD_{(0.05)}$	2.46	-	4.24	-
CV (%)	13.76	-	10.16	-
LS	***		***	
Interaction effect of dose and spraying time (D x T)				
D_1T_1	16.19	38.53	27.54	74.12
D_1T_2	20.94	20.50	29.33	72.44
D_1T_3	20.15	23.50	31.26	70.63
D_1T_4	23.48	10.86	42.53	60.04
D_2T_1	15.84	39.86	25.95	75.62
D_2T_2	18.98	27.94	28.39	73.33
D_2T_3	19.64	25.44	28.58	73.15
D_2T_4	23.14	12.15	42.04	60.50
D_3T_1	15.18	42.37	21.18	80.10
D_3T_2	16.10	38.88	22.30	79.05

D_3T_3	19.35	26.54	28.50	73.22
D_3T_4	24.56	6.76	38.45	63.87
D_4T_1	Average weed dry weight in control (D_4) = 26.34	0	Average weed dry weight in control (D_4) = 106.43	0
D_4T_2		0		0
D_4T_3		0		0
D_4T_4		0		0
$LSD_{(0.05)}$	4.91	-	8.48	-
CV (%)	13.76	-	10.16	-
LS	ns		ns	

Where, LS= level of significance; ns= non-significant at P=0.05; *significant at P=0.05; ***significant at P=0.001

Yield and yield component of onion

Plant height had no significant effect on dose of Pendimethalin and spraying time (Table 2). However, numerically higher plant height was found in control (D_4) and spraying at 7 days after planting and irrigation (T_3). On the contrary, higher individual bulb weight/ plant, bulb diameter and bulb yield were obtained in D_3 (7 ml/ L) and T_1 (Spraying just at planting and irrigation) treatment, and the lowest was recorded in D_4 (0 ml/ L) and T_4 (Spraying at 7 days after planting and irrigation) treatment.

Table 2. Yield contributing characters and bulb yield of onion affected by different level and spraying time of pendimethalin during 2022

Dose	Plant height (cm)	Bulb weight/ plant (g)	Bulb diameter (cm)	Bulb yield (t /ha)
Dose of Panida (D)				
3 ml/ L (D_1)	48.26	29.23	3.56	11.13
5 ml/ L (D_2)	49.53	30.00	3.68	12.22
7 ml /L (D_3)	48.60	32.73	3.75	13.16
Control (D_4)	52.22	18.91	3.03	4.88
LSD(0.05)	4.21	2.88	0.53	1.05
CV (%)	8.50	10.39	15.11	10.18
LS	ns	***	ns	***
Spraying time (T)				
Spraying just at planting and irrigation	48.41	30.89	3.64	11.45
3 DAP(T_1)	49.28	28.26	3.47	10.53
5 DAP(T_2)	50.07	26.49	3.44	10.09
7 DAP(T_3)	50.85	25.23	3.48	9.32
LSD(0.05)	2.33	2.22	0.22	1.12
CV (%)	5.58	9.50	7.56	12.90
LS	ns	***	ns	**
Interaction effect of dose and spraying time (D x T)				
D_1T_1	46.64	32.49	3.66	12.84
D_1T_2	47.91	30.26	3.57	11.22
D_1T_3	48.94	28.03	3.49	11.17
D_1T_4	49.54	26.15	3.53	9.28
D_2T_1	47.69	35.98	3.84	13.00
D_2T_2	48.47	30.61	3.70	12.72
D_2T_3	50.54	28.12	3.60	12.00

D_2T_4	51.41	25.30	3.59	11.17
D_3T_1	46.77	36.10	3.93	14.78
D_3T_2	48.67	33.33	3.81	13.63
D_3T_3	48.54	31.19	3.68	12.50
D_3T_4	50.41	30.31	3.60	11.73
D_4T_1	52.52	18.99	3.11	5.16
D_4T_2	52.07	18.86	2.82	4.56
D_4T_3	52.24	18.63	2.97	4.71
D_4T_4	52.04	19.16	3.21	5.11
$LSD_{(0.05)}$	4.67	4.44	0.45	2.25
CV (%)	5.58	9.50	7.56	12.90
LS	ns	ns	ns	ns

Where, LS= level of significance; ns= non-significant at P=0.05; **significant at P=0.01; ***significant at P=0.001

Economics

The highest gross margin and BCR (TK. 201090/ ha and 2.19) were recorded in D_3T_1 (Pendimethalin @ 7 ml/ L with spraying just after planting) combination. However, the negative gross margin (TK. -25410/ ha to TK. -40410/ ha) with lower BCR (0.74 to 0.84) was recorded in D_4 under different spraying times due to weed hampered the bulb yield of onion under D_4 treatment which reflect the negative gross margin.

Table 3. Economic evaluation of onion under using different level and spraying time of pendimethalin during 2022

Treatment	Gross return (TK. /ha)	Total variable cost (TK. /ha)	Gross margin (TK. /ha)	BCR
D_1T_1	321000	160410	160590	2.00
D_1T_2	280500	160410	120090	1.75
D_1T_3	279250	160410	118840	1.74
D_1T_4	232000	160410	71590	1.45
D_2T_1	325000	164410	160590	1.98
D_2T_2	318000	164410	153590	1.93
D_2T_3	300000	164410	135590	1.82
D_2T_4	279250	164410	114840	1.70
D_3T_1	369500	168410	201090	2.19
D_3T_2	340750	168410	172340	2.02
D_3T_3	312500	168410	144090	1.86
D_3T_4	293250	168410	124840	1.74
D_4T_1	129000	154410	-25410	0.84
D_4T_2	114000	154410	-40410	0.74
D_4T_3	117750	154410	-36660	0.76
D_4T_4	127750	154410	-26660	0.83

Price: Urea = TK. 16.00/ kg; TSP = TK. 22 /kg; MOP = TK. 15 /kg; Gypssum= TK. 10 /kg; Labour = TK. 400.00 / 8 hour head, Onion= TK. 25.00 /kg (Non seed)

Conclusion

From the result it may be concluded that D_3T_1 (Pendimethalin @ 7 ml/ L with spraying just after planting) combination performed better for controlling weed in onion field.

WEED MANAGEMENT USING HERBICIDES UNDER ZERO TILLAGE MULCHED CONDITION IN GARLIC FIELD

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Abstract

The experiment was conducted at the Regional Agricultural Research Station, Ishurdi, Pabna during 2020-2021 and 2021-2022 to find out the suitable herbicide for controlling weed in garlic under zero tillage mulched condition. Nine treatments were included as treatments viz; T_1 = Commit (Pretilachlor), T_2 = 2,4-D Amine (2, 4-D), T_3 = Weednil (Quizalofop-p-ethyl), T_4 = Sunrise (Ethoxysulfura), T_5 = Whip Super (Fenoxaprop-p-ethyll), T_6= Ronstar (Oxadiazol), T_7= Panida (Pendimethalin), T_8 = Hand weeding at 25, 45 and 65 DAP, T_9 = Control. The experiment was laid out in a Randomized Complete Block design with three replications. The results showed that the lowest weed dry weight at 120 DAP (42.07/ g m^2) was recorded in T_7 corresponding to 92% weed control efficiency (WCE) which was identical to T_6 (43.30 g m^{-2} with 92 %,WCE) and the highest weed dry weight (541.14 g/ m^2) was obtained from control. Among the herbicides use of Panida (Pendimethalin) and Ronstar (Oxadiazol) produced the significantly higher bulb yield (9.66 t/haand 9.65 t/ha) which was only 2.56% and 2.65..% lower than T_8 (Hand weeding at 25, 45 and 65 DAP), and the lowest in Control (3.94 t ha^{-1}). In economic point of view, the highest gross margin and BCR were obtained from T_7 (Tk. 440900 ha^{-1} and 3.22) and T_6 (Tk. 440550/ ha and 3.22) followed by T_8. Therefore, on the bases of weed control efficiency and economic return Panida (Pendimethalin) and Ronstar (Oxadiazol) both were suitable herbicide for controlling weed in garlic under zero tillage mulched condition.

Introduction

Garlic is one of the most important spice crops in Bangladesh. Many factors are responsible for yield reduction of garlic. Weeds are one of them. Since, garlic is cultivated under zero tillage mulched condition, at that time weeds also emerge and grow vigorously. So, weed is one of the major constraints under zero tillage mulched cultivation. Weed and their subsequent growth is largely governed by the ecological factors like soil moisture, availability of nutrients, temperature, light, rainfall, relative humidity etc. With its competition hampers crop growth and reduces yield. Weeds not only reduce the yield but also deteriorate the quality of crops. Farmers usually follow hand weeding to control weeds in their field. It takes more times and labour which leads to more expenses. In addition in mulched condition weed control is very complex and during weeding many leaves are injured which led to lower growth and bulb yield. Therefore, we should attempt another option that control weed efficiently without any crop injured. Herbicide is one of them. If any herbicide control weeds effectively that will be great achievement under zero tillage mulched cultivation. Therefore, the experiment was undertaken to find out the suitable herbicide(s) for controlling weed in garlic under zero tillage mulched condition.

Materials and Methods

The experiment was conducted at the Regional Agricultural Research Station, Ishurdi, Pabna during 2020-2021 and 2021-2022 to find out the suitable herbicide for controlling weed in garlic under zero tillage mulched condition. Nine treatments were included viz; T_1= Pre-planting application of Commit (Pretilachlor), T_2= Pre-planting application of 2,4-D Amine (2,4-D), T_3= Pre-planting application of Weednil (Quizalofop-p-ethyl), T_4= Pre-planting application of Sunrise (Ethoxysulfura), T_5= Pre-planting application of Whip Super (Fenoxaprop-p-ethyll), T_6= Pre-planting application of Ronstar (Oxadiazol), T_7= Pre-planting application of Panida (Pendimethalin), T_8 = Hand weeding at 25, 45 and 65 DAT, T_9= Control. The doses of different herbicides have been depict in Table 1. The experiment was laid out in a Randomized Complete Block design with three replications. The unit plot size was 3.5 m × 2.5 m. The crop was planted on 09 and 21 November 2020 and 2021, respectively. The bulb.were harvested on 30 March and 3 April 2021 and 2022, respectively, Fertilizer was applied @ 155-35-125-36-2-1.4 kg ha^{-1} of N-P-K-S-Zn-B corresponding to 336-175-250-200-5.6-8 kg ha^{-1} of Urea-TSP-MOP-Gypssum-$ZnSO_4$-Boric acid, respectively. Half of N and all other fertilizer were applied at final land preparation. Remaining half of N was applied as top dressed equally at 25 and 50 days after transplant. Herbicides were applied on muddy soil surface (42% moisture content condition) at 24 hr before planting of garlic. Data on weed growth, yield and yield contributing characters were taken and analyzed statistically. The mean values were adjusted by LSD at 0.05 levels of probability.

Table 1. Doses of different herbicides used in the experiment

Herbicide	Dose (ml/ L of water)
Commit (T_1)	2.5
2,4-D Amine (T_2)	4.0
Weednil (T_3)	2.0
Sunrise (T_4)	6.0
Whip Super (T_5)	2.0
Ronstar (T_6)	2.5
Panida (T_7)	5.0

Results and Discussion

Weed biomass

Weed management using different herbicides and cultural practice (hand weeding) influenced the weed growth significantly (Table 2). The zero (0) weed dry weight was found in T_4 and T_7 treatment at 60 DAP i.e., there were no weed population emerged of those treatment plots., The maximum weed dry weight (45.34 g m^{-2}) was found in T_9 at 60 DAP. At 120 DAP, the lowest weed dry weight (42.07 g m^{-2}) was recorded in T_7 which was statistically identical to T_6 and T_4. The highest weed dry weight (541.14 g m^{-2}) was obtained in control (T_9) treatment (no weeding plot) which was statistically identical to T_6 (532.03 g/ m) treatment where applied Weednil (Quizalofop-p-ethyl) herbicide. The highest weed control efficiency at 120 DAP was found in T_7 and T_6 (92%) whereas the lowest weed control efficiency was found in T_3 (2%) followed by T_5 (5%). Though the treatment T_4 gave the low weed biomass (45.64 g /m) with higher highest weed control efficiency (92%) at 120 DAP, it is discard due to it hampered the emergence as well as growth and development of garlic plant.

Table 2. Weed dry weight and weed control efficiency of garlic under zero tillage mulched condition affected by using different herbicides (pooled average of 2020-2021 and 2021-2022)

Treatment	Weed dry matter 60 DAP (g/ m^2)	WCE at 60 DAP	Weed dry matter 120 DAP (g/ m^2)	WCE at 120 DAP
Commit (T_1)	7.83 (2.82)*	83	119.73 (10.93)	78
2,4-D Amine (T_2)	12.06 (3.52)	73	176.60 (13.30)	67
Weednil (T_3)	19.97 (4.44)	56	532.03 (22.97)	2
Sunrise (T_4)	0.00 (0.71)	100	45.64 (6.79)	92
Whip Super (T_5)	40.08 (6.37)	12	516.07 (22.51)	5
Ronstar (T_6)	2.53 (1.56)	94	43.30 (6.61)	92
Panida (T_7)	0.00 (0.71)	100	42.07 (6.51)	92
Hand weeding (T_8)	14.06 (3.80)	69	105.84 (10.28)	80
Control(T_9)	45.34 (6.73)	0	541.14 (23.26)	0
$LSD_{(0.05)}$	0.69		2.00	
CV (%)	17.27		12.44	
LS	***		***	

Where, LS= level of significance; *Within the parenthesis indicate squire root transform value; ***significant at P=0.001

Table 3. Yield contributing characters and yield of garlic under zero tillage mulched condition affected by using different herbicides (pooled average of 2020-2021 and 2021-2022)

Treatment	Plant population (m^2)	Plant height (cm)	Individual b ulb weight/ plant (g)	Bulb dry weight $plant^{-1}$ (g)/	Bulb diameter (cm)	Leaves dry weight/ 5 plants	Number of clove/ bulb (no.)	100-clove weight (g)	Bulb yield (t /ha)
Commit (T_1)	59	77.42	15.28	6.34	3.20	5.42	18.50	95.17	8.06
2,4-D Amine (T_2)	59	76.87	10.53	5.03	2.86	3.92	18.83	75.17	6.16
Weednil (T_3)	57	81.87	9.30	3.29	2.56	3.07	16.00	66.17	4.49
Sunrise (T_4)	43	50.93	8.90	3.68	2.72	2.64	16.67	78.83	3.10
Whip Super (T_5)	61	85.88	9.96	3.86	2.70	3.76	17.17	79.17	5.09
Ronstar (T_6)	64	72.10	19.35	7.90	3.52	6.47	22.00	111.50	10.66
Panida (T_7)	60	73.70	20.87	8.47	3.65	7.07	22.17	117.67	10.65
Hand weeding (T_8)	60	72.53	19.17	8.25	3.48	6.00	22.17	116.00	10.94
Control(T_9)	58	87.25	8.58	3.03	2.49	2.94	16.50	60.67	3.94
$LSD_{(0.05)}$	5.66	5.63	2.82	1.06	0.31	0.72	2.36	15.31	1.87
CV (%)	8.35	6.36	17.76	16.32	8.87	13.41	10.65	14.68	22.78
LS	***	***	***	***	***	***	***	***	***

Where, LS= Level of significance; ***significant at P=0.001

Yield and yield contributing characters of garlic

Weed management had significant effect on plant population, plant height, bulb weight $plant^{-1}$, number of clove $bulb^{-1}$, clove weight and bulb yield of garlic (Table 3). The plant population ranged from 43-64. However, expect Sunrise (T_4) other herbicidal and cultural weed management treatment gave the statistically similar plant population (59 to 64). Sunrise (T_4) gave the lowest 43 plant population. This means, it inhibits the emergence of garlic plant. Plant height ranged 50.93 cm to 87.25 cm. The maximum plant height (81.87cm, 85.88cm and 87.25cm) was observed with producing higher weedy plots (T_3, T_5 and T_9), and the lowest (50.93 cm) in Sunrise. The higher individual bulb weight, bulb diameter, number of clove/bulb, 100-clove weight and bulb yield were found among the T_6, T_7 and T_8 treatment which values are statistically more or less similar. Pre-planting application of Sunrise (Ethoxysulfura) i.e., T_4 treatment produced significantly lower bulb yield (3.10 tha^{-1}). However, control (T_9) treatment (no weeding) yielded 3.94 t ha^{-1} which was statistically similar to T_3 (4.49 t/ha).

Economic evaluation

The highest gross margin and BCR were obtained from T_7 (Tk. 440900 $ha^{/}$ and 3.22) and T_6 (Tk. 440550/ haand 3.22) treatments where used Ronstar (Oxadiazol) and Panida (Pendimethalin), respectively for weed control followed by T_8. The lowest gross margin (Tk. -11200 /ha) and BCR (0.94) was recorded from Sunrise (Ethoxysulfura) applied treatment (T_4) plot (Table 4).

Table 4. Economic evaluation of garlic under zero tillage mulched condition **affected by using** different herbicides (estimated from pooled average yield data of 2020-2021 and 2021-2022)

Treatments	Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)	BCR
Commit (T_1)	483600	196900	286700	2.46
2,4-D Amine (T_2)	369600	197880	171720	1.87
Weednil (T_3)	269400	196785	72615	1.37
Sunrise (T_4)	186000	197200	-11200	0.94
Whip Super (T_5)	305400	197175	108225	1.55
Ronstar (T_6)	639600	198700	440900	3.22
Panida (T_7)	639000	198450	440550	3.22
Hand weeding (T_8)	656400	226200	430200	2.90
Control(T_9)	236400	196200	40200	1.20

Price: Garlic bulb: Tk 60/kg, labor= Tk. 400, Panida @3 L $ha^{-1}$for 400 ml bottle @ Tk. 400 $bottle^{-1}$

Conclusion

The results revealed that T_8 (Hand weeding at 25, 45 and 65 DAP) treatment gave the maximum bulb yield which was identical to Panida (Pendimethalin) and Ronstar (Oxadiazol) herbicides uses treatment (T_6 and T_7). These two treatment (T_6 and T_7) lower yielded only 2.56% and 2.65..%, respectively than T_8. Based on weed control efficiency and economic return Panida (Pendimethalin) and Ronstar (Oxadiazol) both were suitable for garlic under zero tillage mulched condition.

INTEGRATED WEED MANAGEMENT OF MUKHIKACHU (*Colocasia esculenta*)

S. PAUL, MH RAHMAN, KU AHAMMAD and DA CHOWDHURY

Abstract

An experiment was conducted at Regional Agricultural Research Station, BARI, Jashore during Kharif Season, 2021 to find out the effective weed management practice of Mukhikachu. The nine weed management treatments were as follows: T_1= Mulching (organic mulch: mustard stover),T_2= Mulching (polythene mulch: black color), T_3= Hand weeding (5 times@ 5 DAE, 20 DAE, 35 DAE, 50 DAE, 65 DAE), T_4= Pre-emergence herbicide (Destroy 20 GR: Metalachlor+Bensulfuron Methyl), T_5= Pre-emergence herbicide (Destroy 20 GR)+ Mulching (organic mulch: mustard stover), T_6= Pre-emergence herbicide(Destroy 20 GR)+ Mulching (polythene mulch: : black color), T_7= Pre emergence herbicide (Destroy 20 GR) + Hand weeding (1 time @ 35 DAE), T_8= Hand weeding (3 times @ 20 DAE, 35 DAE, 50 DAE) and T_9= Control (No weeding). Weed species dominating the crop field were *Cyperus rotundus*, *Cynodon dactylon, Amaranthus viridis, Enhydra fluctuans, Eleusine indica, Brassica kaber, Physalis heterophylla*. The lowest weed density was found in T_2= Mulching (polythene mulch) 128.84 no/ m^2 and the lowest total dry weight was found in T_1= Mulching (mustard stover) (82.25 g/m) at 75 DAE. Weed control efficiency (WCE%) was the highest in T_3= Hand weeding (5 times: 5 DAE, 20 DAE, 35 DAE, 50 DAE, 65 DAE) 90% which was statistically similar to T_1= Mulching (organic mulch) (80%). The result revealed that the highest yield (22.73 t/ha) and highest marginal benefit cost ratio (MBCR) 6.49 was found in T_1(organic mulch: mustard stover) treatment. Therefore, organic mulch was the best treatment to manage the crop-weed competition in mukhikachu field.

Introduction

Tropical root and tuber crops are generally cultivated in Africa and Asia for their food and nutrition-rich quality (Owusu-Darko et al., 2014). Taro (*Colocasia esculenta L.)* is an erect herbaceous perennial root crop of tropics and subtropics belongs to the *Araceae* family holding the 9^{th} position among the food crops in world (Rashmi *et al*., 2018). It is cultivated annually in Bangladesh and locally it is called *Mukhikachu, Gati Kachu, and Chhora kachu.* It is largely produced for its underground corms and contains 70–80% starch and has fiber (0.8%), and ash (1.2%). Taro is also a good source of thiamine, riboflavin, iron, phosphorus, and zinc and a very good source of vitamin B6, vitamin C, niacin, potassium, copper, and manganese [Tari *et al*.,2002]. The edible corm *has* Anti-microbial, Anti-cancer, and Antidiabetic effect in human body (Brown et al.,2005; Kumawat et al. 2010 and Kubde *et al*., 2010).

It is reported that tropical root and tuber crops' growth is initially slow and so the crops cannot use resources sufficiently at their early growth stage. At that time weeds grow so fast and so weeds act as a major competitor and limiting factor in the production of root crops (Korieocha, 2014; Labrada *et al*., 1994; Lebot, 2009; Nedunchezhiyan *et al*., 2013). The cultivation time of *C. esculenta* is seven to nine months. However, it is mandatory to keep the crop weed-free in the early one-third period of its' growing time. In our country weeding is predominantly done using manual labor. Weeding constitutes 30% of the total labor input and about 150-200 men days/ ha. Besides, in few areas herbicides are applied. However, herbicides have an adverse effect on the environment and starch content of root crops (Nedunchezhiyan *et al*., 2013). So, frequent uses of herbicides must be decreased. Thus, a single method of weed control is not proven to be completely successful in root crops.

Accordingly, integrated weed management (IWM) has been proposed as a viable method for overcoming weed problem in many crops (Clarence and Stephan, 1991; Donald *et al*., 1991) including root crops (Iyagba, 2010). Cultural, biological, and the least possible level of cost-effective chemical methods are hence, suggested to be applied together in tropical root crops (Clarence and Stephan, 1991; Donald *et al*., 1991). There are few studies on weed control of these root and tuber crops (Lebot, 2009). Therefore, this study was undertaken to find out the effective weed management method of mukhikachu.

Materials and Methods

The experiment was carried out under irrigated condition at the Regional Agricultural Research Station, BARI, Jashore (23°18' latitude and 89°18' longitude with an altitude of 19 m) during Kharif Season, 2021 to find out the effective weed management of Mukhikachu resulting in higher yield. The soil type of the experimental plot was sandy loam under AEZ 11. Nine treatments were tested in randomized complete block design with three replications. Treatments comprised of T_1= Mulching (organic mulch: mustard stover),T_2= Mulching (polythene mulch: black color), T_3= Hand weeding (5 times@ 5 DAE, 20 DAE, 35 DAE, 50 DAE, 65 DAE), T_4= Pre-emergence herbicide (Destroy 20 GR: Metalachlor+Bensulfuron Methyl), T_5= Pre-emergence herbicide (Destroy 20 GR)+ Mulching (organic mulch: mustard stover), T_6= Pre-emergence herbicide(Destroy 20 GR)+ Mulching (polythene mulch: : black color), T_7= Pre emergence herbicide (Destroy 20 GR) + Hand weeding (1 time @ 35 DAE), T_8= Hand weeding (3 times @ 20 DAE, 35 DAE, 50 DAE) and T_9= Control (No weeding) . BARI Mukhikachu-1 (Bilasi) was used as the test crops. In case of organic mulch mustard stover was used and incase of polythene mulch black polythene mulch was used. The unit plot size was 5.0m × 3.0m. Planting was done on 7th April,2021. Row to row spacing was 60 cm and plant to plant spacing 30 cm. *Colocasia* is a heavy feeder and required 10-15 t/ha of well rotten farmyard manure was added in the field before planting. In addition, 80 kg of Nitrogen, 60 kg P_2O_5, and 60 kg of K_2O ha^{-1} were applied. Half N and whole of P and K were added at the time of planting while the remaining half of nitrogen was applied 35- 45 days after planting. Irrigation was applied when required. Treatments were applied accordingly. Weed density (no m^{-2}) and dry weight of weed (gm^{-2}) were taken at 15 DAE,45 DAE and 75 DAE. Rhizome yield was recorded as per plot basis and then converted to t ha^{-1}. The frequency of different weeds was determined and the density of each species was calculated according to Odum (1971).

Weed density (no m^{-2}) = $\frac{\text{Total number of weed}}{\text{Total survey area}}$

Weed Control Efficiency (WCE %) worked out taking into consideration the reduction in weed dry weight in treated plot over weed dry weight in unweeded check (control). It is expressed in %.

WCE (%) = $\frac{WC - WT}{WC} \times 100$

Results and Discussions

Weed species dominating the crop field were *Cyperus rotundus*, *Cynodon dactylon*, *Amaranthus viridis*, *Enhydra fluctuans*, *Eleusine indica*, *Brassica kaber*, *Physalis heterophylla*.

Weed density (no/ m^2) and dry weight of weeds (g/m^2)

Weed density and dry weight of weeds differ significantly among all treatments at all days after emergence (DAE) (Table 1).

At 15 DAE, weed density (no /m^2) and dry weight of weeds (gm^{-2}) were found the highest in control plot T_9 (422.67 no. and 171.86 g/m^2) where no weeding was done was statistically similar to T_4 (337.32 no. and 93.24 g/m^2) where only pre-emergence herbicide was applied followed by T_7 (286.68 no. and 113.4 g/m^2) where pre-emergence herbicide & hand weeding was applied. The lowest weed density (no/ m^2) and dry weight of weeds (g/m^2) were recorded in T_3 treatment (45.32no. and 10.64 g/m^2) which was statistically similar to T_1, T_2, T_5, T_6 and T_8 treatments.

During 45 DAE weed density (no /m^2) and dry weight of weeds (g/m^2) were found the highest in control plot T_9 (622.68 no. and 281.92 g/m^2) where no weeding was done was statistically similar to T_7 (492no. and 170.04 gm^{-2}) followed by T_4 (437.32 no. and 233.2 g/m^2). The lowest weed density (no m^{-2}) and dry weight of weeds (g/m^2) were recorded in T_2 treatment (81.32 no. and 33.68 g/m^2) which was statistically similar to T_1, T_3, T_5, $T_6$and T_8 treatments.

Again at 75 DAE weed density (no m^{-2}) and dry weight of weeds (g/m^2) were found the highest in control plot T_9 (856.64 no. and 455.76 g/m^2) where no weeding was done was statistically similar to T_7 (625.32 no. and 251.72 g/m^2) followed by T_4 (546.68 no. and 313.92 g/m^2). The lowest weed density (no m^{-2}) and dry weight of weeds (g/m^2) were recorded in T_3 treatment (96.68 no. and 44.6 g/m^2) which was statistically similar to T_1, T_2, T_5, $T_6$and T_8 treatments.

The highest weed density (no/ m^2) and dry weight of weeds (g/m^2) in T_9 T_7 and T_4 plots were found at all days after emergence (DAE) (Table 1) because at control plot no weeding was done and pre-emergence herbicide only controlled weed at first few days after planting. The lowest weed density (no m^{-2}) and dry weight of weeds (g/m^2) were recorded in T_3, T_1, T_2, T_5, T_6 and T_8 treatments because mulching (organic and polythene) suppress the weed germination at a large extent. Moreover, hand-weeding for five (5) times decreased weed largely. However, hand weeding for three (3) times removed weed moderately.

Weed Control Efficiency (WCE %) varied considerably among the treatments (Table 1). The highest Weed Control Efficiency (WCE %) was in T_3(90%) treatment which was statistically similar to T_1 and T_5 and T_6. However, Weed Control Efficiency (WCE %) was the lowest in T_9 followed by T_7 and T_4. This result indicated that mulching could decrease weed intensity which help to increase other weed indices. Moreover, exclusive hand weeding also decreased weed intensity. However, only herbicide and combination of herbicide+ one hand weeding could not controlled weed intensity in taro field.

Table 1. Weed density (no/ m^2) and dry weight of weeds **(**g/m^2) at 15 Days After Emergence (DAE), 45 DAE and 75 DAE and Weed Control Efficiency (WCE %)

Treatments	15 DAE		45 DAE		75 DAE		Weed Control Efficiency (WCE %) at 75 DAE
	Weed density (no/ m^2)	Weed dry weight (g/m^2)	Weed density (no /m^2)	Weed dry weight (g/m^2)	Weed density (no/ m^2)	Weed dry weight (g/m^2)	
T_1	70.68	29.04	100	35.48	174.68	82.25	80.92
T_2	53.32	15.8	81.32	33.68	128.84	129.6	70.33
T_3	45.32	10.64	197.32	32.56	96.68	44.6	90
T_4	337.32	93.24	437.32	233.2	546.68	313.92	70.33
T_5	93.32	35	140	66.48	184	87.12	80.28
T_6	53.32	41.88	121.32	75.56	185.36	253.6	43.32
T_7	286.68	113.4	492	170.04	625.32	251.72	39.73
T_8	73.32	29.4	148	34.4	270	120.56	72.82
T_9	422.68	171.44	622.68	281.92	856.64	455.76	0

T_1= Mulching (organic mulch: mustard stover),T_2= Mulching (polythene mulch: black color), T_3= Hand weeding (5 times@ 5 DAE, 20 DAE, 35 DAE, 50 DAE, 65 DAE), T_4= Pre-emergence herbicide (Destroy 20 GR: Metalachlor+Bensulfuron Methyl), T_5= Pre-emergence herbicide (Destroy 20 GR)+ Mulching (organic mulch: mustard stover), T_6= Pre-emergence herbicide(Destroy 20 GR)+ Mulching (polythene mulch: : black color), T_7= Pre emergence herbicide (Destroy 20 GR) + Hand weeding (1 time @ 35 DAE), T_8= Hand weeding (3 times @ 20 DAE, 35 DAE, 50 DAE) and T_9= Control (No weeding)

Yield and Marginal benefit Cost Ratio (MBCR)

Significantly the highest yield (22.73 t/ ha) highest MBCR 6.49) was obtained from T_1 (organic mulch: mustard stover) which was statistically similar to T_5(22 t/ha and 6.15) followed by T_2 (18.92 t/ ha and 4.45) T_3 (17.67 t/ha and 2.08), T_6 (17.6 t/ha and 4.07) treatments (Table 2). This result might be due to mulching and hand weeding (5 times @ 5 DAE, 20 DAE, 35 DAE, 50 DAE, 65 DAE) which resulted in the lowest crop-weed competition. Between two different mulching organic mulch showed the highest result because this straw mulch release nutrients into the taro field (Zhu *et al*., 2022). Among the mulching and pre-herbicide + mulching treatments statistically similar yield was obtained. Moreover, the highest marginal benefit cost ratio (MBCR) 6.49 was obtained from only mulching (organic: mustard stover) treatment. So, during mulching there is no need to use herbicide. In the control (un weeded) plot yield was the lowest (2.7 t /ha and 1.2) which was statistically similar to T_4 (3.4 t/ ha 1.46) followed by T_7 (5.67 t /ha and .77) and T_8 (8.4 t/ ha and 1.16). This result indicated that herbicides controlled weeds for the first few days which was less than critical period of crop- weed competition (Alom, M.S. and Nag, B.L., 2011) and hand weeding for three time could not reduce crop weed competition.

Table 2. Yield and economic analysis of Mukhikachu as influenced by different weed management method during *Kharif* Season, 2021

Treatments	Yield (t/ha)	Total cost of production (Tk./ha)	Gross Return (Tk./ha)	Net Return (Tk.//ha)	MBCR
T_1	22.73	140000	909200	769200	6.49
T_2	18.92	170000	756800	586800	4.45
T_3	17.67	340000	706800	366800	2.08
T_4	3.40	93000	136000	43000	1.46
T_5	22.00	143000	880000	737000	6.15
T_6	17.60	173000	704000	531000	4.07
T_7	5.67	143000	226800	83800	1.59
T_8	8.40	240000	336000	96000	1.4
T_9	2.70	90000	108000	18000	1.2
$LSD_{(0.05)}$	1.82				
CV (5%)	7.93				

T_1= Mulching (organic mulch: mustard stover),T_2= Mulching (polythene mulch: black color), T_3= Hand weeding (5 times@ 5 DAE, 20 DAE, 35 DAE, 50 DAE, 65 DAE), T_4= Pre-emergence herbicide (Destroy 20 GR: Metalachlor+Bensulfuron Methyl), T_5= Pre-emergence herbicide (Destroy 20 GR)+ Mulching (organic mulch: mustard stover), T_6= Pre-emergence herbicide(Destroy 20 GR)+ Mulching (polythene mulch: : black color), T_7= Pre emergence herbicide (Destroy 20 GR) + Hand weeding (1 time @ 35 DAE), T_8= Hand weeding (3 times @ 20 DAE, 35 DAE, 50 DAE) and T_9= Control (No weeding)

Cost of organic matter was 3500Tk/ ton and black polythene mulch 8.85Tk./ m^2 and price of mukhikachu corm 40 Tk./Kg

Conclusion

Results revealed that organic mulch (mustard stover) would be the most effective for controlling weed in mukhikachu field.

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WEED CONTROL MANAGEMENT IN GROUNDNUT CULTIVATION

M. M. RAHMAN, M. A. RAHMAN AND M. R. UDDIN

Abstract

A field experiment was carried out at the Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during the *Rabi* season of 2021-22 to find out the effective and economic weed control method for groundnut cultivation. The treatments of the experiment were: T_1= Control, T_2= One hand weeding at 20 DAE, T_3= Two hand weeding at 20 and 40 DAE, T_4= BARI mechanical weeder at 20 DAE, T_5= One hand weeding at 20 DAE and BARI mechanical weeder at 40 DAE, T_6= Spraying of Weednil at 20 DAE@1.5 ml/L.. Results revealed that, yield and yield contributing characters had differed significantly among different weed management options. Significantly the highest yield was recorede in T_3 (Two hand weeding at 20 and 40 DAE) treatment. T_3 treatment showed the highest gross margin (143852 Tk/ha) and BCR (4.11). The result revealed that two hand weeding at 20 and 40 DAE would be the best option for getting maximum yield of groundnut. But economic point of view (One hand weeding at 20 DAE and BARI mechanical weeder at 40 DAE) may be one of the weed management option in ground nut field

Introduction

The modern groundnut varieties give good yield if the land remains weed free from the early stage of crop growth. But farmers are reluctant to control weed in their field timely due to labor crisis/high cost and hence don't achieve the optimum yield. Moreover, when there is adequate moisture the weed situation becomes worse. But there are many options for weed control- like hand weeding; use of weeder machine, spading and use of herbicide etc. but which one is more effective and economically viable for southern belt is not identified. Among all the crop pests, weeds alone are responsible for about one third loss in crop production. In groundnut, the loss in pod yield ranges from 13 to 100% depending on the season, cultivars, weed composition and duration of crop- weed competition, and the packages of practices adopted (Yaduraju *et al.*, 1980; Kalaiselvan *et al.*, 1994; Rajendran and

Louduraj, 1999; and Devi Dayal and Ghosh, 1999). The extent of yield losses is up to of 62% during the kharif season and up to 47% during the summer season. However, Giri *et al.* (1998) reported an average yield loss of 89% due to weed infestation in irrigated summer groundnut. The crop management practices have a great influence on weed infestation and recorded 34% average yield loss under ordinary management practices and as high as 60% under poor management practices (Devi Dayal and Ghosh, 1999). Under the above circumstances, it is necessary to know the effective and economic weed control method for groundnut cultivation.

Materials and Methods

The field experiment was carried out at the Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during the *Rabi* season of 2021-22 to know the effective and economic weed control method for groundnut cultivation. It also maximizes the productivity as well as farmers income. The experimental site is situated in the latitudes and longitudes of 22^{o}47'5.82''N and 90^{o}17'30.30''E. The experimental site is located under the agro-ecological zone Ganges Tidal Floodplain (AEZ-13). The soil type is medium high land and soil texture is loamy. The treatments of the experiment were: T_1= Control, T_2= One hand weeding at 20 DAE, T_3= Two hand weeding at 20 and 40 DAE, T_4= BARI mechanical weeder at 20 DAE, T_5= One hand weeding at 20 DAE and BARI mechanical weeder at 40 DAE, T_6= Spraying of Weednil at 20 DAE@1.5 ml/L. Treatments were set randomly at each plot. Tillage operations were done firstly considering tillage unit plots are maintained correctly. Seeds were sown on 2nd December, 2021 in line sowing method at 100 kg/ha seed (not shelled). The experiment was laid out in randomized complete block design with three replications. The unit plot size was 3m × 4m. The initial soil moisture was 30% on oven dry basis. Fertilizers were applied at the rate of 60-48-80-48-3-2.1-0.6 kg/ha NPKSZnBMo. Seed (Non-shelled) rate of 100 kg/ha were used. Seeds were sown in line sowing having 30 cm apart. Weeds were removed/ herbicide sprayed as per treatment and plant protection measures were taken as and when required. Data were collected on different parameters such as weed population m^{-2} at 20 DAE, dry matter, relative weed density, yield and yield contributing characters. Data were analyzed statistically and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) following Gomez and Gomez (1984).

Results and Discussion

There are significant differences in all parameter except plant height (Table 1.). In case of plant population/m^2, the highest plant population/m^2 observed in treatment T_3 (23.02 Nos.) was also similar with treatment T_4 (22.68 Nos.) as well as treatment T_2 (22.23 Nos.) and lowest one was in treatment T_1 (14.35 Nos.). Weed population/m^2 significantly varied with treatment where highest was derived from the treatment T_1 (213.87 Nos.) and lowest no. of weeds found in the treatment T_3 (51.83 Nos.). Longest plant was found in treatment T_5 (56.88 cm) and the shortest one was in treatment T_6 (46.87 cm). The highest pod per plant was found in T_3 (26.86 Nos.) and lowest one was T1 (14.92 Nos.). Seed number per pod found greater in T_5 (2.08 Nos.) which was statistically similar with treatment T_3 (2.04 Nos.) and T_5 (2.04 Nos.) and lower was in T_1 (1.85 Nos.).

1000-seed weight was found heavier in T_3 (515.31 g) and lighter in T_1 (456.75g). In case of seed weight per plot, the highest seed weight was found in T_3 (2156.25g) and lowest one was T_1 (679.27g). Highest yield per hectare was generated from treatment T_3 (1798.16 kg) and lowest was from treatment T_1 (562.46 kg). Highest forage yield was found in T_4 (11.13 kg) and lowest one was T_5 (7.98 kg). In case of weed dry weight, the highest weed dry weight was found in T_1 (554.64 g) and lowest one was T_5 (174.24 g). T_5 treatment has significantly higher weed control efficiency (68.58%) than other treatments.

Table 1: Yield and yield attributing character of groundnut as affected by different weed management practices

Treat	P.popl^n/m^2 (Nos)	Weed popl^n/m^2 (Nos)	Plant height (cm)	Pod/plant (Nos)	Seed/pod
T_1	14.35 c	213.87 a	50.08	14.92 f	1.85 d
T_2	22.23 ab	118.16 b	53.62	19.12 e	1.93 cd
T_3	23.02 a	51.83 e	53.43	26.86 a	1.98bc
T_4	22.68 ab	105.89 bc	52.50	19.54 d	2.04 ab
T_5	21.07 b	82.67 d	56.88	23.83 b	2.08 a
T_6	20.28 b	95.66 cd	46.87	21.73 c	2.04 ab
CV (%)	5.65	9.37	8.13	4.72	3.75

Table 1. Cont'd

Treat	1000-seed weight (g)	Seed weight/plot (g)/m^2	Yield/ha (Kg)	Weed dry weight (g)	Weed control efficiency (%)
T_1	456.75 e	679.27 e	562.46 e	554.64 a	-
T_2	468.70 d	1008.15 d	836.56 d	269.83 b	51.35
T_3	515.31 a	2156.25a	1798.16 a	249.84 b	54.95
T_4	486.92 c	1139.25 c	945.66 c	249.74 b	54.97
T_5	507.27 b	1668.34 b	1386.36 b	174.24 b	68.58
T_6	486.89 c	1085.37 cd	900.45 cd	288.85 b	47.92
CV (%)	6.16	9.12	6.12	12.45	-

Cost and return Analysis

Cost and return analysis of groundnut as affected by different weed management options were represented in Table 2. It can be observed that, the highest benefit cost ratio (4.11) obtained from T_3 treatment *e.g.* Two hand weeding at 20 and 40 DAE which was followed by T_5 treatment (3.36).

Table 2. Cost and return analysis of groundnut as affected by different weed management options

Treat	Seed yield/ha (Kg)	GM (Tk./ha)	TVC (Tk./ha)	Net Return (Tk./ha)	BCR
T_1	562.46	44996.8	25000	19996.8	1.79
T_2	836.56	66924.8	30000	36924.8	2.23
T_3	1798.16	143852.8	35000	108852.8	4.11
T_4	945.66	75652.8	27000	48652.8	2.80
T_5	1386.36	110908.8	33000	77908.8	3.36
T_6	900.45	72036	30000	42036	2.40

* Groundnut seed price= 80 Tk/Kg * Groundnut forage price= 5 Tk/kg

N.B: T_1= Control, T_2= One hand weeding at 20 DAE, T_3= Two hand weeding at 20 and 40 DAE, T_4= BARI mechanical weeder at 20 DAE, T_5= One hand weeding at 20 DAE and BARI mechanical weeder at 40 DAE, T_6= Spraying of Weednil at 20 DAE@1.5 ml/L.

Conclusion

The result revealed that two hand weeding at 20 and 40 DAE would be the best option for getting maximum yield of groundnut. But economic point of view (One hand weeding at 20 DAE and BARI mechanical weeder at 40 DAE) may be one of the weed management option in ground nut field.

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EFFECT OF DIFFERENT HERBICIDES FOR CONTROLLING WEEDS IN POTATO FIELD

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Abstract

The experiment was conducted at agronomy research field of Bangladesh Agricultural Research Institute, Gazipur and RARS Cumilla during the period from November 2021 to March 2022 to find out the effectiveness of different herbicides for controlling weed in potato field. The treatments were: T_1 =Fashal Queen 5 EC (Quizalofop-p-ethyl 15%) @ 2.5 L/ha spraying at 4-8 DAP, T_2 =Harvester 30 EC *(*Pendimethalin) @ 2.0 L/ha spraying at 4-8 DAP, T_3 =Rapid Klin 34 EC (Pretilachlor 15% + Oxyfluorfen 12% + Oxadiazon 7%) @ 500 ml/ha spraying at 4-8 ADAP, T_4 =G-Mine 72 SL (2,4-D Amine Salt 72%) @ 2.24 L/ha spraying after emergence of weed, T_5 =SHORT OUT 40 SC (Bispyribac sodium 40% SC) @ 150 ml/ha spraying after emergence of weed, T_6=Sirius Gold 40WP (Bensulfuron methyl 6% + Quinclorac 34%) @ 100 gm/ha spraying after emergence of weed, T_7= Two hand weeding at 25 & 45 DAP, T_8= Control (No weeding and herbicide). Results showed that the highest weed population (128/m^2 at Gazipur, 198/m^2 at Cumilla at 25 DAP and 207/m^2 at Gazipur and 214/m^2 at Cumilla at 45 DAP) were recorded in control plot at 25 and 45 DAP, respectively. The lowest weed population (11/m^2 at Gazipur, 18/m^2 at Cumilla and 16/m^2 at Gazipur, 21/m^2 at Cumilla) was recorded in T_1 (Fashal Queen 5 EC) treatment at 25 DAP and 45 DAP respectively. The highest WCE 94% at Gazipur, 87.9% at Cumilla and 92% at Gazipur, 88.3% at Cumilla was found in T_1 (Fashal Queen 5 EC) treatment at 25 DAP and 45 DAP respectively. The highest tuber yield (24.80 t/ha at Gazipur and 27 t/ha at Cumilla) was obtained from T_1 treatment. All other herbicide treated plot and hand weeded plot gave the statistically identical yield with that of T_1. The results revealed that given six herbicides would be effective for weed control and economically profitable for potato cultivation at Gazipur (AEZ 28).

Introduction

Potato (*Solanum tuberosum*) is one of the major crop cultivated during *rabi* season as popular vegetables in Bangladesh. This location covered an area of 32,170 ha in potato cultivation (Anon., 2007). Potato is the 3rd most important crop of Bangladesh followed by rice and wheat (lllias, 1998). The average yield of potato in Bangladesh is 20.41 t/ha (BBS, 2018) which is too low in comparison to that of some potato growing countries of the world (FAO, 1998). Weed is one of the major constraints of potato production in some potato growing areas of our country. Intense weed competition is one of the constraints in realizing potential yield of potato resulting in substantial reduction in the yield (Singh *et al.*, 1984). Weeds compete with crops for nutrients, water and light, thus yield of potato is reduced considerably. The quality of potato is also reduced by weed infestation (Pandey, 2000). Among the weed species, *Echinochloa crusgalli*, *Chenopodium album*, *Enhydra fluetuans*, *Cyperus rotundus*, *Cynodon dactylon* are the dominant weeds in potato field. However, farmers control weeds by hand weeding in several times. Manual weeding (at least two weeding at 25 and 45 DAP) is costly, time consuming and sometimes not possible due to non-availability of labour. So, herbicidal weed control is essential. Some herbicides have the capability to reduce weed growth.

Pre-emergence herbicide significantly influenced on weed reduction and produced 10% higher tuber yield of potato than the herbicide free plot (Divis, 2002). Khan *et al.*(2008) resulted that, mulching (water hyacinth) with herbicide application (Ronstar 25EC @ l ml/L water) at 7 days after planting as post emergence weed control followed by one time uprooting of weeds by hand at 25 days after planting would be economically profitable for obtaining maximum tuber yield of potato in Munshigonj area. The choice of herbicide, proper application time and proper dose are important considerations for maximizing returns. Research of herbicidal weed control of potato on these aspects is meagre. Hence, the present experiment was conducted to find out the efficacy of different herbicides for controlling weeds in potato field.

Materials and Methods

A field experiment was conducted at Agronomy research field of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur and RARS Cumilla during *rabi* season of 2021-2022. The soil is silty clay loam with p^H 6.3 belonging to Agro Ecological Zone (AEZ) 28. The treatments were: T_1 =Fashal Queen 5 EC ,(Quizalofop-p-ethyl 15%) @ 2.5 L/ha spraying at 4-8 DAP, T_2 =Harvester 30 EC *(*Pendimethalin) @ 2.0 L/ha spraying at 4-8 DAP,T_3 =Rapid Klin 34 EC (Pretilachlor 15% + Oxyfluorfen 12% + Oxadiazon 7%) @ 500 ml/ha spraying at 4-8 ADAP, T_4 =G-Mine 72 SL (2,4-D Amine Salt 72%) @ 2.24 L/ha spraying after emergence of weed, T_5 =Short Out 40 SC (Bispyribac sodium 40% SC) @ 150 ml/ha spraying after emergence of weed, T_6=Sirius Gold 40WP (Bensulfuron methyl 6% + Quinclorac 34%) @ 100 gm/ha spraying after emergence of weed, T_7= Two hand weeding at 25 & 45 DAP, T_8= Control (No weeding and herbicide). The given herbicides were Fashal Queen 5 EC, Harvester 30 EC, Rapid Klin 34 EC, G-Mine 72 SL, Short out 40 SC and Sirius Gold 40WP and the target weeds to control were shama *(Echinochola crusgali)*, chanchi shak (*Alternanthera sessilis)*, dudhia (*Euphorbia hirta)*, durba (*Cynodon dactylon) and bathua (Chenodium album).* The trial was set up in randomized complete block design with three replications. The unit plot size was 3 m × 3 m. The crop was fertilized with cowdung 5 t/ha and 180-40-180-20-4-1 kg/ha of NPKSZnB, respectively (FRG, 2018). Cowdung was applied at the time of land preparation. Two-third of N and full dose of other nutrients were applied at the time of final land preparation and remaining N was applied as top dressed at 30 days after planting (DAP) followed by irrigation. Potato (BARI Alu-7) was planted on 28 December and 20 December 2021 at Gazipur and Cumilla respectively. Crop was harvested on 23 March and 22 March 2022 at Gazipur and Cumilla respectively. A light irrigation was given at 5 DAP for proper emergence. Weed samples were collected from randomly selected four places by using 50 cm × 50 cm quadrate from each plot at 25 and 45 DAP. Number and dry weight of weeds were recorded carefully. Weed control efficiency (WCE) was calculated according to following formula of Mani et al. (1973): WCE (%) = $\left(\frac{A-B}{A}\right)\times 100$ where, A = Dry weight of weeds in no weeding plot and B = Dry weight of weeds in treated plot. Data on yield and yield contributing characters were taken and statistically analyzed following MSTAT-C software package. Means were adjusted by LSD test at 5% level of significance.

Results and Discussion

Weed species and density

Number of weeds/m^2 was affected by different herbicides and hand weeding (Table 1). It was observed that Shyama (*Echinochloa crusgalli)*, Bathua (*Chenopodium album)*, Mutha (*Cyperus rotundus*), Helencha (*Enhydra fluetuans),* Durba (*Cynodon dactylon)* were the common and dominant weeds in the potato field at both the location. At 25 DAP the number of weeds /m^2 ranged from 11 to 18 at Gazipur and 18 to 30 at Cumilla in different herbicide treated plots and 16 to 28 at Gazipur and 21 to 35/m^2 at Cumilla at 45 DAP. The highest weed /m^2 (128 at Gazipur, 198 at Cumilla at 25 DAP and 207 at Gazipur and 214 at Cumilla at 45 DAE) was recorded in T_8 (control plots). The lowest number of weeds/m^2 (11 at Gazipur, 18 at Cumilla at 25 DAP and 16 at Gazipur, 21 at Cumilla at 50 DAP) was found in T_1 (Fashal Queen 5 EC) which was more or less similar with other herbicide treated plot. At 45 DAP the number of weeds/m^2 was increased all the plots than 25 DAP.

Weed dry weight and Weed Control Efficiency (WCE)

The maximum dry weight of 23.98 g/m^2 at Gazipur, 28.1 g/m^2 at Cumilla and 26.14 g/m^2 g/m^2 at Gazipur, 30.2 g/m^2 at Cumilla were obtained in T_8 at 25 and 45 DAP respectively, whereas the minimum dry weight of 1.41 g/m^2 at Gazipur, 3.40 g/m^2 at Cumilla and 2.10 g/m^2 at Gazipur, 3.52 g/m^2 at Cumilla at 25 and 45 DAP respectively were found in T_1 treatment (Table 2). The variation of weed control efficiency (WCE) was observed among different herbicides. The highest WCE 94% at Gazipur, 87.9% at Cumilla and 92% at Gazipur, 88.3% at Cumilla was found in T_1 treatment at 25 DAP and 45 DAP respectively (Table 2).

Yield and Yield components of potato

Plant height, number of tuber/hill, tuber weight/plant and yield of potato were significantly influenced by applying different types of herbicides in both the location (Table 3). The tallest plant (58.8 cm at Gazipur and 61.3cm at Cumilla) was found in T_7 (Two hand weeding at 25 & 45 DAP respectively) treatment followed by T_3 (Rapid Klin 34 EC) treatment and the shortest plant (47.80 cm at Gazipur and 40.2 cm at Cumilla) was found from control (T_8) plot at both the location. The highest number of tuber/hill (12.30 at Gazipur and 12.90 at Cumilla) was found in T_7 (Two hand weeding at 25 & 45 DAP) which was statistically similar to T_2 (Harvester 30 EC) and T_3 (Rapid Klin 34 EC) treatment and the lowest (7.00 at Gazipur and 8.9 at Cumilla) was observed in T_8 (Control) treatment. The highest tuber weight /plant (389.06 g at Gazipur and 414.0 g at Cumilla) was observed in T_7 (Two hand weeding at 25 & 45 DAP) treatment which was statistically similar to T_1 (Fasal Queen 5 EC). The highest tuber yield (24.80 t/ha at Gazipur and 27.0 t ha^{-1} at Cumilla) was found in T_1 (Fashal Queen 5 EC) which was statistically similar to all other treatments (T_2, T_3, T_4 T_5 T_6, T_7) except T_8 Control (No weeding and herbicide). Control plot gave the statistically lowest tuber yield.

Economic Performance

Cost of cultivation varied among the treatments due to variation of weeding cost (Table 4). From the economic analysis it was found that the maximum cost of cultivation was recorded in T_8 treatment (Tk. 140530/ha at Gazipur and Tk. 150500/ha at cumilla). Among the treatments the maximum gross return (Tk.248000/- at gazipur and Tk. 2,70,000/- at Cumilla) was found in T_1 (Fashal Queen 5 EC) treatment. Which was followed by other all herbicidal treatment. These could be attributed to lower cost of cultivation in these herbicide treatments as compared to weed free treatment. The highest gross margin (Tk.123900/- at Gazipur and Tk.1,36,600/- at Cumilla) was recorded in T_1 (Fashal Queen 5 EC) and the lowest (Tk.33960 at Gazipur and Tk. 81,800/- at Cumilla) was in T_8 (Control) treatment. The maximum BCR (2.00 at Gazipur and 2.02 at Cumilla) was also obtained from T_1 (Fashal Queen 5 EC) treatment. T_7 produced the statistically similar yield but BCR is lower than herbicidal treatment because of higher cost involvement for a greater number of manual weeding. It increased the cost of manual weeding thus corresponding towards total out put cost.

Conclusion

The result revealed that all herbicides used in this trial were found effective for controlling weed in potato field at both Gazipur (AEZ 28) and Cumilla location.

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Table 1 Weed number/m^2 at 25 and 45 days after emergence of potato as influenced by different weed management treatments at Gazipur and Cumilla

Treat.	25 DAP		45 DAP	
	Gazipur	Cumilla	Gazipur	Cumilla
T1	11	18	16	21
T2	11	28	23	32
T3	15	25	28	32
T4	15	20	25	22
T5	15	20	24	22
T6	18	19	27	24
T7	116	130	25	35
T8	128	198	207	214

Table 2. Weed dry weight and Weed Control Efficiency at 25 and 45 days after emergence of potato as influenced by different weed management treatments at Gazipur and Cumilla

Treatments	Weed dry weight (g/m^2)				Weed Control Efficiency (%)			
	25 DAP		45 DAP		25 DAP		45 DAP	
	Gazipur	Cumilla	Gazipur	Cumilla	Gazipur	Cumilla	Gazipur	Cumilla
T_1	1.41	3.40	2.10	3.52	94	87.9	92	88.3
T_2	1.43	3.92	3.05	3.66	94	86.0	88	87.9
T_3	2.34	3.58	2.83	3.64	90	87.2	89	87.9
T_4	2.45	3.50	2.91	3.54	89	87.5	88	87.8
T_5	2.07	3.49	2.76	3.55	91	87.6	89	88.2
T_6	2.16	3.45	2.98	3.58	91	87.7	88	88.1
T_7	22.83	23.98	3.66	4.20	4.8	14.7	86	86.1
T_8	23.98	28.1	26.14	30.20	-	-	-	-

Table 3. Effect of different herbicides on yield components and yield of potato during 2021-22

Treat	Plant height (cm)		Tuber/Hill (no.)		Tuber wt./Plant (g)		Tuber yield (t/ha)	
	Gazipur	Cumilla	Gazipur	Cumilla	Gazipur	Cumilla	Gazipur	Cumilla
T_1	51.20	56.3	9.90	9.70	376.03	413.7	24.80	27.0
T_2	54.40	49.4	11.80	12.0	304.63	355.0	23.32	24.8
T_3	57.20	57.0	11.80	11.3	310.76	400.3	23.36	26.1
T_4	48.10	49.9	11.60	10.8	318.2	352.7	24.10	23.1
T_5	49.10	48.7	10.00	10.1	312.13	376.0	22.97	26.9
T_6	57.10	48.6	9.60	9.60	330.65	360.7	23.32	23.1
T_7	58.80	61.3	12.30	12.9	389.06	414.0	23.21	26.4
T_8	47.80	40.2	7.00	8.9	202.03	319.0	12.88	20.7
CV(%)	8.01	13.9	4.78	9.5	5.35	16.9	9.25	10.6
LSD	7.43	12.78	0.88	1.84	29.81	52.5	3.59	4.62

T_1 = Fashal Queen 5 EC (Quizalofop-p-ethyl 15%), T_2 =Harvester 30 EC *(*Pendimethalin), T_3 =Rapid Klin 34 EC (Pretilachlor 15% + Oxyfluorfen 12% + Oxadiazon 7%), T_4 =G-Mine 72 SL (2,4-D Amine Salt 72%), T_5 =SHORT OUT 40 SC (Bispyribac sodium 40% SC), T_6=Sirius Gold 40WP (Bensulfuron methyl 6%+ Quinclorac 34%) T_7= Two hand weeding at 25 & 45 DAE, T_8= Control (No weeding and herbicide)

Table 4. Economic performance of different treatments on potato cultivation during 2021-22

Treat	Tuber yield (t/ha)		Gross return (Tk./ha)		Total cost of production (Tk./ha)		Gross margin (Tk./ha)		BCR	
	Gazipur	Cumilla	Gazipur	Cumilla	Gazipur	Cumilla	Gazipur	Cumilla	Gazipur	Cumilla
T_1	24.80	27.0	248000	270000	124100	133400	123900	136600	2.00	2.02
T_2	23.32	24.8	233200	248000	124100	133400	109100	114600	1.88	1.85
T_3	23.36	26.1	233600	261000	124100	133400	109500	127600	1.88	1.96
T_4	24.10	23.1	241000	231000	124100	133400	116900	97600	1.94	1.73
T_5	22.97	26.9	229700	269000	124100	133400	105600	135600	1.85	2.01
T_6	23.32	23.1	233200	231000	124100	133400	109100	97600	1.88	1.73
T_7	23.21	26.4	232100	264000	140530	150500	91570	113500	1.65	1.75
T_8	12.88	20.7	128800	207000	94840	125200	33960	81800	1.36	1.65

Price; Potato-10 Tk../kg

T_1 = Fashal Queen 5 EC (Quizalofop-p-ethyl 15%), T_2 =Harvester 30 EC *(*Pendimethalin), T_3 =Rapid Klin 34 EC (Pretilachlor 15% + Oxyfluorfen 12% + Oxadiazon 7%), T_4 =G-Mine 72 SL (2,4-D Amine Salt 72%), T_5 =SHORT OUT 40 SC (Bispyribac sodium 40% SC), T_6=Sirius Gold 40WP (Bensulfuron methyl 6%+ Quinclorac 34%) T_7= Two hand weeding at 25 & 45 DAE, T_8= Control (No weeding and herbicide)

EFFICACY OF DIFFERENT HERBICIDES FOR CONTROLLING WEEDS IN BARE PLACE

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Abstract

A field experiment was conducted at Agronomy Research Field of Bangladesh Agricultural Research Institute, Gazipur, during *rabi* season of 2021-2022 to find out the efficacy and suitable herbicide to control weeds in bare place. The treatments were: T_1= Raisonate 20 SL (Glufosinate 20% SL) @ 5.25L/ha spraying at 20 days after land preparation (DALP), T_2 = Raisonate 20 SL (Glufosinate 20% SL) @ 5.25L/ha spraying at 20 DALP + 1 HW at 20 days after herbicide spraying (DAHS), T_3 = Raiquat 20 SL (Diquat 20 SL) @ 3.75L/ha spraying at 20 DALP, T_4 = Raiquat 20 SL (Diquat 20 SL) @ 3.75 L/ha spraying at 20 DALP + 1 HW at 20 DAHS, T_5 = Two HW at 20 and 40 days after land preparation and T_6 = Control (No weeding and no herbicide). The target weed to control by Raisonate were Shyama (Echinochloa crusgalli), Khude shyama (Echinochloa colonum), Mutha (Cyperus rotundus), Durba (Cynodon dactylon), Lajjaboti (Mimosa pudica), Ulu (Imperata cylindrica) and Chapra (Eleusine indica). On the other hand, the target weed to control by Raiquat were Mutha (Cyperus rotundus), Nakphuli (Cyperus difformis), Manayona (Commelina diffusa), Chechra (Scirpus maritimus), Arrow leaf pondweed (Monochorea vaginalis). The highest number of weed population 280/m^2 and 315/m^2 were recorded in control plot at 30 and 50 DALP, respectively. The lowest number of weed population 15/m^2 and 12/ m^2 were recorded in T_2 treatment followed by T_4. Weed control efficiency (83%-97%) was found at 30 and 50 DALP in herbicide treated plots. So the results revealed that both Raisonate 20 SL (Glufosinate 20% SL) and Raiquat (Diaquat 20% SL) post emergence herbicide would be effective herbicide for controlling weeds in bare place at Gazipur (AEZ 28*)*.

Introduction

In a fallow land and after recession of water in charland area, grow a large number of weed spontaneously. It would be costly for weeding these lands by manually. Besides this, bare place surrounding the home, both sides of road and rail line, large number of weed grow which breaks the beautification of these places, infestation of venomous insects including snakes increases and sometimes illegal activities takes place in the deep weedy areas. So, it is necessary to clean the weeds. Herbicidal weed control is well established in the developed countries, but in Bangladesh the farmers are still practice manual weeding. It takes more time, labour and costly. In Bangladesh very small scale farmers use chemicals to control weeds. It is assumed that in comparison to manual weeding, herbicide may provide more effective, economic and easier solution for weed management. Moreover, their excessive and indiscriminate use has resulted in the development of herbicidal resistance and environmental pollution (Phokela *et al.*, 1990). Therefore, the present experiment has been undertaken to find out the suitable herbicide and their efficacy for controlling weeds in bare place.

Materials and Methods

An experiment was conducted at Agronomy Research Field of Bangladesh Agricultural Research Institute, Gazipur during *rabi* season of 2021-2022. The soil is silty clay loam with p^H 6.3 belonging to Agro Ecological Zone (AEZ) 28. The treatments were: T_1= Raisonate 20 SL (Glufosinate 20% SL) @ 5.25L/ha spraying at 20 days after land preparation (DALP), T_2 = Raisonate 20 SL (Glufosinate 20% SL) @ 5.25L/ha spraying at 20 DALP + 1 HW at 20 days after herbicide spraying (DAHS), T_3 = Raiquat 20 SL (Diquat 20 SL) @ 3.75L/ha spraying at 20 DALP, T_4 = Raiquat 20 SL (Diquat 20 SL) @ 3.75 L/ha spraying at 20 DALP + 1 HW at 20 DAHS, T_5 = Two HW at 20 and 40 days after land preparation and T_6 = Control (No weeding and no herbicide). The trial was set up in a randomized complete block design with three replications. The unit plot size was 5m × 3m. To make the land in sufficient moist conditioned, irrigation was applied before spraying herbicide. Herbicide was applied at 20 DALP on 10 December, 2021. Weed samples were collected from randomly selected four places by using 50cm × 50cm quadrate from each plot at 30 and 50 DALP (10 and 40 days after herbicide application). Number and dry weight of weeds were recorded carefully. Weed control efficiency (WCE) was calculated according to following formula: WCE (%) = $\left(\frac{A-B}{A}\right)100$; where A= Dry weight of weeds in no weeding plots and B = Dry weight of weeds in treated plots.

Results and Discussion

Weed flora, dry matter of weeds and weed control efficiency

Weed species, number of weeds/m^2 and weed control efficiency (WCE) were affected by different herbicides and hand weeding (Table1). Bathua *(Chenopodium album),* Maloncha *(Alternanthera philoxeroides),* Mutha *(Cyperus rotundus),* Shyama *(Echinochloa crusgalli),* Khude shyama *(Echinochloa colonum),* Bon palong *(Rumex maritimus),* Shetlomy (*Gnaphalium affine)*, bon mula (*Raphanus rahanistrum*), Kanaibanshi (*Commelina benghalensis*) and Ulu (*Imperata cylindrica*) were the common and dominant weed species in the experimental field. Target weed namely Lajjaboti (*Mimosa pudica),* Manayona *(Commelina diffusa) and* Arrow leaf pondweed *(Monochorea vaginalis)* were not found in experimental field. The number of weeds/m^2 ranged from 15-20 and 12-42 at 30 and 50 DALP, respectively, in herbicide treated plots (Table 1). The highest number of weeds /m^2 (280 at 30 DALP and 315 at 50 DALP) was recorded in T_6 (control plot). The lowest number of weeds/m^2 (15 at 30 DALP and 12 at 50 DALP) was found in the treatment T_2 followed by T_1 (16 at 30 DALP) and T_5 (13 at 50 DALP). The number of weeds /m^2 at 30 DALP was lower than 50 DALP in all treatments except T_2 and T_4 and in these two treatments weed population was higher at 30 DALP than 50 DALP due to one hand weeding was done at 40 DALP in T_2 and T_4. The maximum weed dry weight of 107.15 g/m^2 and 180.20 g/m^2 were obtained from T_6 (control) at 30 and 50 DALP, respectively, whereas, the minimum weed dry weight of 5.10 g/m^2 and 5.05 g/m^2 were found in T_1 and T_2 treatment at 30 and 50 DALP, respectively, followed by T_2 treatment at 30 DALP and T_5 at 50 DALP (Table 3). The variation in weed control efficiency (WCE) was observed among different herbicides. The highest WCE (95%) at 30 DALP was found in T_1 and T_2 treatment followed by all treatments except control and at 50 DALP, the highest WCE (97%) was found in T_2 treatment followed by T_4 and T_5. The target weeds of $T_{1,}$ T_2, T_3 and T_4 treatments were controlled 83-97% both at 30 and 50 DALP (Table 4).

Conclusion

Results revealed that both herbicides Raisonate 20 SL (Glufosinate 20% SL) @ 5.25L/ha and Raiquat 20 SL (Diquat 20 SL) @ 3.75L/ha would be suitable for controlling weeds in bare place at Gazipur (AEZ 28).

Table 1. Effect of different herbicides on weed species, weed number/m^2 and weed density (%) over time in bare place during *rabi* 2021-2022

Treat	Local name	Scientific name	30 DALP/10 DAHS		50 DALP/40 DAHS	
			Weed/ m^2 (no.)	Weed density (%)	Weed/ m^2 (no.)	Weed density (%)
T_1	Durba	*Cynodon dactylon*	2	13	2	5
	Mutha	*Cyperus rotundus*	4	25	4	11
	Shyama	*Echinochloa crusgalli*	2	13	4	11
	Maloncha	*Alternanthera philoxeroides*	5	31	10	26
	Khude shyama	*Echinochloa colonum*	-	-	3	8
	Bathua	*Chenopodium album*	1	6	4	11
	Bon palong	*Rumex maritimus*	4	25	6	18
	Chapra	*Eleusine indica*	-	-	3	8
	Ulu	*Imperata cylindrica*	-	-	2	5
		Total	**16**	**-**	**38**	**-**
T_2	Durba	*Cynodon dactylon*	2	13	1	8
	Mutha	*Cyperus rotundus*	-	-	1	8
	Shyama	*Echinochloa crusgalli*	6	40	2	17
	Khude shyama	*Echinochloa colonum*	-	-	1	8
	Ulu	*Imperata cylindrica*	1	7	3	25
	Maloncha	*Alternanthera philoxeroides*	3	20	3	25
	Khude shyama	*Echinochloa colonum*	2	13	1	8
	Chapra	*Eleusine indica*	1	7	1	8
		Total	**15**	-	**12**	
T_3	Maloncha	*Alternanthera philoxeroides*	2	11	5	12
	Kanaibashi	*Commelina benghalensis*	4	21	4	10
	Nakphuli	*Cyperus difformis*	2	11	4	10
	Mutha	*Cyperus rotundus*	2	11	4	10
	Chechra	*Scirpus maritimus*	2	11	5	12
	Bathua	*Chenopodium album*	1	5	5	12
	Bon palong	*Rumex maritimus*	2	11	5	12
	Shetlomy	*Gnaphalium affine*	2	11	4	10
	Durba	*Cynodon dactylon*	2	11	6	14
		Total	**19**	-	**42**	-
T_4	Mutha	*Cyperus rotundus*	3	17	-	-
	Bathua	*Chenopodium album*	2	11	2	17
	Maloncha	*Alternanthera philoxeroides*	2	11	4	33
	Chechra	*Scirpus maritimus*	3	17	2	17
	Nakphuli	*Cyperus difformis*	1	6	1	8
	Durba	*Cynodon dactylon*	2	11	1	8
	Shetlomy	*Gnaphalium affine*	3	17	-	-
	Bon palong	*Rumex maritimus*	2	11	2	17
		Total	**18**	**-**	**12**	**-**
T_5	Bathua	*Chenopodium album*	-	-	2	15
	Maloncha	*Alternanthera philoxeroides*	5	25	4	31
	Kanaibashi	*Commelina benghalensis*	2	10	1	8
	Chechra	*Scirpus maritimus*	3	15	-	-
	Bonmasur	*Vicia sativa*	2	10	-	-

	Mutha	*Cyperus rotundus*	2	10	-	-
	Shetlomi	*Gnaphalium affine*	4	20	4	31
	Bon palong	*Rumex maritimus*	2	10	2	15
		Total	**20**	**-**	**13**	
T_6	Maloncha	*Alternanthera philoxeroides*	23	8	24	8
	Shayma	*Echinochloa crusgalli*	34	12	38	12
	Khude shyama	*Echinochloa colonum*	12	4	15	5
	Bathua	*Chenopodium album*	32	11	38	12
	Kanaibashi	*Commelina benghalensis*	8	3	9	3
	Nakphuli	*Cyperus difformis*	10	4	11	3
	Anguli	*Digitaria sanguinalis*	8	3	9	3
	Mutha	*Cyperus rotundus*	50	18	56	18
	Chapra	*Eleusine indica*	20	7	25	8
	Shetlomi	*Gnaphalium affine*	8	3	12	4
	Durba	*Cynodon dactylon*	14	5	12	4
	Chechra	*Scirpus maritimus*	20	7	22	7
	Ulu	*Imperata cylindrica*	21	8	22	7
	Bon palong	*Rumex maritimus*	20	7	22	7
		Total	**280**	**-**	**315**	**-**

Table 2. Effect of different herbicides on number of weeds/m^2 over time in experimental field during *rabi* season of 2021-2022

Treatment	30 DALP/10 DAHS	50 DALP/40 DAHS
T_1= Raisonate 20 SL at 20 DALP	16	38
T_2= T_1 + 1 HW at 40 DALP/20 DAHS	15	12
T_3= Raiquat 20 SL at 20 DALP	19	42
T_4= T_3 + 1 HW at 40 DALP/20 DAHS	18	12
T_5= Two HW at 20 and 40 DALP	20	13
T_6= Control	280	315

Table 3. Effect of different herbicide on weed dry weight of weed and weed control efficiency in experimental field during *rabi* season of 2021-2022

Treatments	Weed dry weight (g/m^2)		Weed control efficiency (%)	
	30 DALP /10 DAHS	50 DALP /40 DAHS	30 DALP /10 DAHS	50 DALP /40 DAHS
T_1= Raisonate 20 SL at 20 DALP	5.10	25.75	95	86
T_2= T_1 + 1 HW at 40 DALP/20 DAHS	5.70	5.05	95	97
T_3= Raiquat 20 SL at 20 DALP	7.20	30.30	93	83
T_4= T_3 + 1 HW at 40 DALP/20 DAHS	7.10	6.20	93	96
T_5= Two HW at 20 and 40 DALP	7.80	6.70	93	96
T_6= Control	107.15	180.20	-	-

Table 4. Effect of different herbicides on target weeds and weed control efficiency in experimental field during *rabi* season of 2021-2022

Treatments	Name of weed	Weed control efficiency (%)	
		30 DALP	40 DAHP
T_1-T_2= Raisonate 20 SL	Shyama (*Echinochloa crusgalli)*	82-84	89-95
	Khude shyama (*Echinochloa colonum)*	100	80-93
	Mutha (*Cyperus rotundus*)	92-100	93-98
	Durba (*Cynodon dactylon*)	81-85	83-92
	Lajjaboti (*Mimosa pudica*)	Absent in field	Absent in field
	Ulu (*Imparata cylindrica*)	95-100	86-91
	Chapra (*Eleusine indica*)	95-100	88-96
T_3-T_4=Raiquat 20 SL	Mutha (*Cyperus rotundus*)	94-96	93-100
	Chechra (*Scirpus maritimus)*	85-90	77-91
	Nakphuli *(Cyperus difformis)*	80-90	64-91
	Manayona (*Commelina diffusa*)	Absent in field	Absent in field
	Arrow leaf pond weed *(Monochorea vaginalis)*	Absent in field	Absent in field

EFFICACY OF DIFFERENT HERBICIDES FOR CONTROLING WEEDS IN ONION FIELD

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Abstract

A field experiment was conducted at Agronomy Research Field of Bangladesh Agricultural Research Institute, Gazipur and Regional Agricultural Research Station (RARS), Jashore during rabi season of 2021-2022 to find out the suitable herbicide for controlling weed in onion field. Eight treatments viz., T_1 = Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha spraying at 2-3 days after transplanting of onion seedling, T_2 = Nirzash 46 SL (Bentazone 40% + MCPA 6%) @ 9 ml/L spraying at 2-4 leaf stage of weed, T_3= Citro-55 SC (Atrazine 50% + Mesotrione 5%) @ 1 L/ha spraying at 2-3 days after transplanting of onion seedling, T_4 = Cutter 50 EC (Quizalofop- P-Ethyl 50%) @ 300 ml/ha spraying at 2-4 leaf stage of weed, T_5 = Raxil 50 EC (Quizalofop-P-Ethyl 50%) @ 300 ml/ha spraying at 2-4 leaf stage of weed,T_6 = Bay 30 WP (Bensulfuron-methyl 12% + Bispyribac sodium 18%)) @ 75 gm/ha spraying at 2-4 leaf stage of weed, T_7= Two hand weeding at 25 & 50 DAT and T_8 = Control (No weeding and herbicide) were in the experiment. Results showed that number of weed/m^2, weed controp efficiency (WCE) and yield of onion were significantly influenced by the six herbicides. The highest weed population (78 and 150/m^2) was recorded in T_8 at 25 DAT in both locations and similar results found at 50 DAT (155 and 205/m^2) in both locations. The lowest weed number (7 and 13/m^2) was found in T1 at 25 DAT in both locations and at 50 DAT also similar trend was found. In both locations (Gazipur and Jashore) the highest weed control efficiency (WCE) at 25 DAT (84.94% and 85.62%) was found in T1 treatment and at 50 DAT the highest WCE (84.24% and 87.17%) was also found in same treatment. Among the herbicide treated plots highest onion bulb yield (18.25t/ha at Gazipur and 18.86t/ha at Jashore) was obtained from T1treatment. All herbicide treated plot and hand weeded plot gave the statistically identical yield with T1. Among the herbicide treated the highest gross return Tk. 6,38,685/ha at Gazipur and Tk. 6,60,269/ha at Jashore, gross margin Tk. 4,42,838/ha at Gazipur and Tk. 4,72,422/ha at Jashore followed by T_3, T_4, T_5, and T_6 treatments. The highest BCR (3.26 at Gazipur and 3.51 at Jashore) was obtained from T1 treatment followed by T3 (3.19 at Gazipur and 3.44 at Jashore), T_4 (3.16 at Gazipur and 3.41 at Jashore), T5 (3.00 at Gazipur and 3.24 at Jashore), T6 (2.67 at Gazipur and 2.90 at Jashore) and T_2 (2.40 at Gazipur and 2.62 at Jashore) treatments. So, the result revealed that six herbicides would be effective for weed control and economically profitable for onion cultivation at Gazipue (AEZ 28) and Jashore (AEZ 11).

Introduction

Onion (Allium cepa L) is one of the most popular spices in Bangladesh for its pungent bulbs and flavorful leaves. Its use in mainly condiment for food. It is also source of important vitamin C, B6 and folic acid. It is widely cultivated during winter season. It ranks first among the spices crops grown in Bangladesh. It is widely cultivated during winter season.However, the average yield of this crop in Bangladesh is low due to improper use of fertilizers, inadequate irrigation, poor weed control etc. Weeds compete with crops for soil moisture, nutrient, light and thus yield of onion is reduced considerably. Weed emerges with crops and competes with crops for nutrients, water and sunlight. Yield loss due to weeds in onion varies from 28-93%, depending on the type of weed flora, weed intensity and duration of crop-weed competition (Pandey *et al.,* 2001 and Kumar *et al.,* 2012 Karim *et al.,*2008). Among the weeds different types of grasses and sedges are the major problem (Khan *et al.* 2011). Weeds usually grow faster than crop plants and absorb available nutrients and space for growth (Rahman and Krishnamoorthy, 2005 and Karim *et al.,*1998)thereby causing poor growth and development of the maincrops, resulting in yield reduction. The quality of crop is also reduced by weed infestation. Onion production might be increased with good variety and changing existing management practices (Ashrafuzzamanet al., 2009). However, the lack of weed control can result in the total loss of marketable onions (Wicks et al., 1973). Onions do not compete well with weeds due to their slow growth rate, short height, non-branching plant structure, low leaf area and shallow root system (Singh *et al.,* 1992; Wicks *et al.,* 1973; Bell and Boutwell. 2001). Generally farmers controlling weeds by hand weeding in several times. It takes more times and labor which leads to more expenses. In Bangladesh very small scale farmers use different chemicals to control the weeds. It is assumed that in comparison to manual weeding, herbicide may provide more effective, economic and easier solution for weed management in onion field. Therefore, the present experiment has been undertaken to find out the efficacy of different herbicidesPendicare 33 EC (Pendimethalin 33%) , Nirzash 46 SL (Bentazone 40% + MCPA 6%) , Citro-55 SC (Atrazine 50% + Mesotrione 5%) , Cutter 50 EC (Quizalofop-P-Ethyl 50%) , Raxil 50 EC (Quizalofop- P- Ethyl 50%) , Bay 30 WP (Bensulfuron-methyl 12% + Bispyribac sodium 18%) for controlling weed in onion field and their weed control efficiency for getting maximum yield and to compare with conventional method as well as to increase the overall onion production of the country.

Materials and Methods

A field experiment was conducted at Agronomy research field of Bangladesh Agricultural Research Institute, Gazipur and Regional Agricultural Research Station, Jashore, during the period from December 2021 to March 2022. The soil of Gazipur and RARS, Jashore were silty clay loam in texture with pH 6.3 and 8.3 belonging to Agro Ecological Zone (AEZ) 28 and 11, respectively. The treatments were as follows: T1 = Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha spraying at 2-3 days after transplanting of onion seedling, T2 = Nirzash 46 SL (Bentazone 40% + MCPA 6%) @ 9 ml/L spraying at 2-4 leaf stage of weed, T3 = Citro-55 SC (Atrazine 50% + Mesotrione 5%) @ 1 L/ha spraying at 2-3 days after transplanting of onion seedling, T4 = Cutter 50 EC (Quizalofop – P – Ethyl 50%) @ 300 ml/ha spraying at 2-4 leaf stage of weed, T5 = Raxil 50 EC (Quizalofop – P – Ethyl 50%) @ 300 ml/ha spraying at 2-4 leaf stage of weed,T6 = Bay 30 WP (Bensulfuron-methyl 12% + Bispyribac sodium 18%) @ 75 gm/ha spraying at 2-4 leaf stage of weed, T7= Two hand weeding at 25 & 50 DAT,T8 = Control (No weeding and herbicide). The trial was set up in randomized complete block design with three replications. The unit plot size was 3 m × 3 m. The crop was fertilized with cowdung 10 t/ha and 140-60-120-40-4.5-2.1 kg/ha of N-P-K-S-Zn-B (FRG 2018) respectively. Cowdung was applied at the time of land preparation. All of P, S, Zn, B and ½ of N and K were applied as basal during final land preparation. Remaining N and K were applied in two equal splits at 25 and 50 days after transplanting followed by irrigation and mixed thoroughly with soil as soon as possible for better utilization followed by irrigation. Seedlings of onion variety (BARI Piaj-4) were transplanted at Gazipur on 27 December 2021 and 13 December 2021 at Jashore. A light irrigation was given after transplanting. Weed samples were collected using 50cm × 50cm quadrate, from randomly selected four places from each plot as per treatment. Number and dry weight of weeds were recorded carefully. The Relative Density (RD) and weed control Efficiency (WEC) were calculated by the following formula.

Relative Density (RD) = $\frac{\text{No of specific weed species}}{\text{Total no. of weeds}} \times 100$

WCE (%) = $\left(\frac{A - B}{A}\right)$ X100

Where, A = Dry weight of weeds in no weeding plots and B = Dry weight of weeds in treated plots. The crop was harvested on 05 April 2022 at Gazipur 26March, 2022 at Jashore. Yield and yield contributing characters were recorded and analyzed statistically and mean separations were done by LSD test at 5% level of significance.

Results and Discussion

Weed flora and dry matter of weeds: Weed species, number of weeds/m2, weed density (%) and weed control efficiency (WCE) were affected by different herbicides are presented in Table 1.The given herbicides were Pendicare 33 EC, Nirzash 46 SL, Citro-55 SC, Cutter 50 EC, Raxil 50 EC and Bay 30 WP and the target weeds to control wereChapra (Elusine indica), Bathua (Chenopodium album), Durba (Cynodon dactylon), Mutha (Cyperus rotundus), Shama (Echinochloa crusgalli), Nunia (Portulaca oleraceae), Helencha (Enhydra fluctuans)and Shaknote (Amaranthus viridis) givenby herbicide companiesin the onion field at Gazipur and Jashore.Target weed namely Bon sharisha (Brassica hispida), Holdae mutha (Cyperus esculentu), Bonkopi (Gnaphalium affine), Sonali bon palong (Rumex marutums) and Pani kachu (Monochoria vaninalis)were not found in onion experimental field in the both locations.The range of number of weeds/m2 was 7-14 and 14-27 at 25 and 50 DAT, respectively, in different herbicide treated plots at Gazipur and 13-28 at 25 DAT and 25-50 at 50 DAT at Jashore (Table 1).The highest number of weeds/m2 (78 at 25 DAT and 155 at 50 DAT) at Gazipur and (150 at 25 DAT and 205 at 50 DAT) at Jashore were recorded in T6 (control plot). The lowest number of weeds/m2 (7 at 25 DAT and 14 at 50 DAT) was found in the treatment T1 followed by T3 (8 at 25 DAT and 16 at 50 DAT) at Gazipur. On the other hand, the lowest number of weeds/m2 (13 at 25 DAT and 25 at 50 DAT) was found in the same treatment (T1) followed by T3 (15 at 25 DAT and 30 at 50 DAT) at Jashore. The number of weeds/m2 in all the plots at 50 DAT was higher than that of at 25 DAT in both locations.The maximum weed dry weight (16.27 g/m2 at Gazipur, 19.75 g/m2 at Jashore at 25 DAT and 33.51 g/m2 at Gazipur, 48.26 g/m2 at Jashore at 50 DAT) was obtained in T8 (control plot), whereas, the minimum weed dry weight (2.45 g/m2 at Gazipur, 2.84 g/m2 at Jashore at 25 DAT and 5.28 g/m2 at Gazipur, 6.19 g/m2 at Jashore at 50 DAT) was found in T1 treatment followed by T3, T4, T5, T6 and T2 treatments (Table 2). The variation in WCE was observed among different herbicides in both locations. The highest WCE (84.94% and 84.24%) was found both at 25 and 50 DAT in T1treatment followed by T3, T4, T5, T6 and T2treatments at Gazipur (Table 2). Similar trend also observed in case of Jashore. The highest WCE (85.62% at 25 DAT and 87.17% at 50 DAT) was found in the same treatment (T1) followed by T3, T4, T5, T6 and T2 treatments at Jashore (Table 2). The target weeds of all herbicides were controlled 80-95% at 25-50 DAT in both the locations (Table 2).In case of Pendicare 33 EC,Bathua88-90% at Gazipur and 83-85% at Jashore was controlled 25 and 50 DAT, Bon sharisha100% at Gazipur and 83% at Jashorewas controlled at 25 and 50 DAT, Holdaemuthawere absent in both the location (Gazipur and Jashore), Mutha94% at Gazipur and 89-92% at Jashore was controlled at 25 and 50 DAT, Nakfully 80% at Gazipur and 85-86% at Jashorewas controlled at 25 and 50 DAT,Shama89 to 90% at Gazipur and 90-94% at Jashorewas controlled 25 and 50 respectively (Table 3). In case of Nirzash 46 SL,Bathua80-82 % at Gazipur and 80-83% at Jashore was controlled 25 and 50 DAT, Bonkopi were absent in both the location, Mutha 84-88% at Gazipur and 83-84% at Jashore was controlled at 25 and 50 DAT, Shama 89 to 90% at Gazipur and 86-90% at Jashore was controlled 25 and 50 respectively (Table 3).In case of Citro-55 SC,Bathua80-82 % at Gazipur and 80-83% at Jashore was controlled 25 and 50 DAT, Bon palong80-83% at Gazipur and Jashore was controlled at 25 and 50 DAT, Mutha 88% at Gazipur and 84-86% at Jashore was controlled at 25 and 50 DAT, Sonali bon palongwas absent in Gazipur and 89-100% at Jashore was controlled 25 and 50 respectively (Table 3).In case of Cutter 50 EC,Chapra89-90 % at Gazipur and 80-88% at Jashore was controlled 25 and 50 DAT, Foska begun 80-81% at Gazipur and 83-86% at Jashore was controlled at 25 and 50 DAT, Khude shama 80% at Gazipur and 82-83% at Jashore was controlled at 25 and 50

DAT respectively (Table 3). In case of Raxil 50 EC,Chapra80-89% at Gazipur and 80-83% at Jashore was controlled 25 and 50 DAT, Foska begun 80-88% at Gazipur and 83-86% at Jashore was controlled at 25 and 50 DAT, Khude shama 90% at Gazipur and 82-83% at Jashore was controlled at 25 and 50 DAT respectively (Table 3).In case of Bay 30 WP,Anguli 80-87% at Gazipur and 82-85% at Jashore was controlled 25 and 50 DAT, Bathua 80-88% at Gazipur and 83-85% at Jashore was controlled at 25 and 50 DAT, Mutha 88-94% at Gazipur and 83-95% at Jashore was controlled at 25 and 50 DAT.Panikachuwere absent in both the location (Gazipur and Jashore) at 25 and 50 DAT respectively (Table 3). Better weed management indices in treated plots (T1, T2, T3, T4, T5, T6) where due to lowest weed infestation. Similar results were recorded by Tewari *et. al.,* (1999) and Bell *et. al.,* (2001) in onion.

Table 1. Effect of herbicide on number of weed in onion during rabi season of 2021-2022 (Gazipur and Jashore)

Treatment	Number of weeds /m^2			
	25 DAT		50 DAT	
	Gazipur	Jashore	Gazipur	Jashore
T1	7	13	14	25
T2	14	28	27	50
T3	8	15	16	30
T4	9	17	20	32
T5	10	19	21	35
T6	12	25	23	40
T7	10	17	22	28
T8	78	150	155	205

Table 2. Effect of herbicide on weed dry weight (g/m^2) and weed control efficiency in onion field during *rabi* season of 2021-2022 (Gazipur and Jashore)

Treatment	Gazipur				Jashore			
	Weed dry weight (g/m2)		Weed control efficiency (%)		Weed dry weight (g/m2)		Weed control efficiency (%)	
	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT
T_1	2.45	5.28	84.94	84.24	2.84	6.19	85.62	87.17
T_2	3.25	6.25	80.02	81.35	3.51	8.92	82.23	81.52
T_3	2.72	5.79	83.28	82.72	2.84	6.87	85.62	85.76
T_4	2.79	6.12	82.85	81.74	2.92	7.68	85.22	84.09
T_5	2.92	6.23	82.05	81.41	3.02	7.93	84.71	83.58
T_6	2.95	6.15	81.87	81.65	3.34	8.23	83.09	82.95
T_7	2.56	3.52	84.27	89.50	3.17	5.67	83.95	88.25
T_8	16.27	33.51			19.75	48.26		

Note: T1 = Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha spraying at 2-3 days after transplanting of onion seedling, T2 = Nirzash 46 SL (Bentazone 40% + MCPA 6%) @ 9 ml/L spraying at 2-4 leaf stage of weed, T3 = Citro-55 SC (Atrazine 50% + Mesotrione 5%) @ 1 L/ha spraying at 2-3 days after transplanting of onion seedling, T4 = Cutter 50 EC (Quizalofop – P – Ethyl 50%) @ 300 ml/ha spraying at 2-4 leaf stage of weed, T5 = Raxil 50 EC (Quizalofop – P – Ethyl 50%) @ 300 ml/ha spraying at 2-4 leaf stage of weed,T6 = Bay 30 WP (Bensulfuron-methyl 12% + Bispyribac sodium 18%)) @ 75 gm/ha spraying at 2-4 leaf stage of weed, T7= Two hand weeding at 25 & 50 DAT,T8 = Control (No weeding and herbicide)

Table 3. Effect of herbicide on target weed and weed control efficiency over time in onion field during rabi season of 2021-2022 (Gazipur and Jashore)

Treat ment	Local name	Scientific name	WDW (g/m^2)		WCE (%)		WDW (g/m^2)		WCE (%)	
			Gazipur				Jashore			
			25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT

T1	Bathua	*Chenopodium album*	1	2	90	88	2	3	83	85
	Bon sharisha	*Brassica hispida*	0	0	100	100	1	2	83	83
	Holdae mutha	*Cyperus esculentus*	0	0	100	100	0	0	100	100
	Mutha	*Cyperus rotundus*	1	2	94	94	2	3	89	92
	Nakfully	*Cyperus difformis*	1	2	80	80	1	2	86	85
	Shama	*Echinochola crusgali*	1	3	89	90	3	2	90	94
	Local name	*Scientific name*	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT
T2	Bothua	*Chenopodium album*	2	3	80	82	2	4	83	80
	Bonkopi	*Gnaphalium affine*	0	0	100	100	0	0	100	100
	Mutha	*Cyperus rotundus*	2	5	88	84	3	6	84	83
	Shama	*Echinochloa crusgalli*	1	3	89	90	3	5	90	86
	Local name	*Scientific name*	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT
T3	Bothua	*Chenopodium album*	2	3	80	82	2	4	83	80
	Bon palong	*Rumex maritimus*	1	2	80	83	1	3	83	80
	Mutha	*Cyperus rotundus*	2	4	88	88	3	5	84	86
	Sonali bon palong	*Rumex marutums*	0	0	100	100	0	1	100	89
Treat ment	Local name	Scientific name	WDW (g/m^2)		WCE (%)		WDW (g/m^2)		WCE (%)	
			Gazipur				Jashore			
			25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT
T_4	Chapra	*Elusine indica*	1	2	89	90	2	3	80	88
	Foska begun	*Physalis heterophylla*	1	3	80	81	1	3	86	83
	Khude shama	*Echinochloa colonum*	2	3	80	80	2	3	83	82
	Local name	*Scientific name*								
T_5	Chapra	*Elusine indica*	1	4	89	80	2	4	80	83
	Foska begun	*Physalis heterophylla*	1	2	80	88	1	3	86	83

	Kude shama	*Echinochloa colonum*	1	2	90	90	2	3	83	82
	Local name	*Scientific name*								
T_6	Anguli	*Digiraria sanguinalis*	2	2	80	87	2	3	85	82
	Bathua	*Chenopodium album*	2	2	80	88	2	3	83	85
	Mutha	*Cyperus rotundus*	1	4	94	88	1	6	95	83
	Pani kachu	*Monochoria vaninalis*	0	0	100	100	0	0	100	100

Treatment	Local name	Scientific name	WDW (g/m^2)		WCE (%)		WDW (g/m^2)		WCE (%)	
			Gazipur				Jashore			
			25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT
T_8	Anguli	*Digitaria spp*	10	15			13	17		
	Bathua	*Chenopodium album*	10	17			12	20		
	Bon palong	*Rumex maritimus*	5	12			6	15		
	Chapra	*Elusine indica*	9	20			10	24		
	Durba	*Cynodon dactylon*	10	25			11	29		
	Foska begun	*Physalis heterophylla*	5	16			7	18		
	Helencha	*Enhydr afluctuans*	4	16			5	19		
	Kanai bashi	*Commelina benghalensis*	2	5			3	8		
	Khude shama	*Echinochloa colonum*	10	15			12	17		
	Mutha	*Cyperus rotundus*	17	32			19	36		
	Nunia	*Portulaca oleracea*	4	12			5	15		
	Nakfully	*Cyperus difformis*	5	10			7	13		
	Shama	*Echinochola crusgali*	9	29			30	35		
	Shaknote	*Amaranthus viridis*	6	16			8	20		
	Sonali bon palong	*Rumex marutums*	1	6			2	9		
	Bon sharisha	*Brassica kaber*	0	0			6	12		

Yield and yield components of onion

The height of pseudo stem, single bulb weight and yield of onion were significantly influenced at both locations by applying different type of herbicides (Table 4). The tallest pseudo stem (58.69 cm at Gazipur and 60.79 cm at Jashore), the highest single bulb weight (69.64 g at Gazipur and 70.48 g at Jashore) and bulb yield (18.36 t/ha at Gazipur and 19.42 t/ha at Jashore) were observed in T7 treatment (Two hand weeding at 25 and 50 DAT). Among the herbicides the tallest pseudo stem (57.23 cm at Gazipur and 59.33 cm at Jashore), the highest single bulb weight (66.29 g at Gazipur and 66.18 g at Jashore) and bulb yield (18.25 t/ha at Gazipur and 18.86 t/ha at Jashore) was obtained from T1 treatment (Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha spraying at 2-3 days after transplanting of onion seedling) which statistically identical with T3, T4, T5 and T6 and T2 treaments except control (no weeding and no herbicide) in both the locations. Significantly the smallest pseudo stem (31.30 cm at Gazipur and 33.40 cm at Jashore), the lowest single bulb weight (23.06 g at Gazipur and 23.91 g at Jashore) and bulb yield (5.82 t/ha at Gazipur and 6.43 t/ha at Jashore) was obtained from T_8 treatment in control treatment (No weeding).This may be due to low chlorophyll content and photosynthetic rates due to unchecked weed growth there by reducing availability of moisture, light and nutrients to the crop and resulted in loss of onion bulb yield in control plot. These results are in according with Mahmood *et al.*,2002, Mehamood *et al.*,2007, Turk and Tawaha. 2002, Ramani and Khanpara.2010, Sable *et al.*,2013, Anarase.2014, Verma and Singh. 1996 and Karim *et. al.*,1998 in onion crop.

Table 4. Effect of herbicide on yield and yield components of onion during rabi season of 2021-2022 (Gazipur and Jashore)

Treatmment	Height of pseudo stem (cm)		Single bulb weight (g)		Bulb yield (t/ha)	
	Gazipur	Jashore	Gazipur	Jashore	Gazipur	Jashore
T_1	57.23	59.33	66.29	66.18	18.25	18.86
T_2	49.50	51.60	54.36	55.20	13.43	14.05
T_3	56.80	58.90	63.01	63.86	17.85	18.47
T_4	53.69	55.79	60.79	61.64	17.67	18.29
T_5	51.68	53.78	59.78	60.62	16.79	17.40
T_6	54.62	56.72	56.40	57.25	14.94	15.55
T_7	58.69	60.79	69.64	70.48	18.36	19.42
T_8	31.30	33.40	23.06	23.91	5.82	6.43
LSD $_{(0.05)}$	9.46	9.45	6.28	6.08	2.93	3.05
CV (%)	10.45	10.04	6.33	6.05	10.87	10.85

Cost and return analysis

Cost-benefit analysis of onion in both locations have been presented in Table 5. The maximum cost of cultivation Tk. 2,86,978/ha and Tk. 2,46,978/ha was calculated in T_7 treatment (Two hand weeding at 25 & 50 DAT) at both locations Gazipur and Jashore. The highest gross return (Tk. 6,42,717/ha at Gazipur and Tk. 6,79,583/ha at Jashore was also observed in T_7 treatment (Two hand weeding at 25 & 50 DAT).Among the herbicide treated the highest gross return Tk. 6,38,685/ha at Gazipur and Tk. 6,60,269/ha at Jashore, gross margin Tk. 4,42,838/ha at Gazipur and Tk. 4,72,422/ha at Jashore followed by T_3, T_4, T_5, and T_6 treatments. Among the herbicide treated the lowest gross return Tk. 4,70,024/ha at Gazipur and Tk. 4,91,607/ha at Jashore, gross margin Tk. 2,74,177/ha at Gazipur and Tk. 3,03,760/ha at Jashore was recorded in T_2 treatment.The highest BCR (3.26 at Gazipur and 3.51 at Jashore) was obtained from T_1 treatment that means Pendicare 33 EC (Pendimethalin 33% @ 2 L/ ha spraying at 2-3 days after transplanting of onion seedling)herbicide treated followed by T3 (3.19 at Gazipur and 3.44 at Jashore), T_4 (3.16 at Gazipur and 3.41 at Jashore), T_5 (3.00 at Gazipur and 3.24 at Jashore), T_6(2.67 at Gazipur and 2.90 at Jashore) and T_2(2.40 at Gazipur and 2.62 at Jashore) (Table 5).The lowest BCR (2.24 at Gazipur and 2.75 at Jashore) was obtained from T6 (control, No weeding) treatment.Although treatment T7produced the highest bulb yield (18.36 t/ha at Gazipur and 19.42 t/ha at Jashore) did not show the highest BCR due to higher weeding cost by hand weeding.

Table 5 .Cost and return analysis of different herbicides in onion cultivation during rabi season of 2021-2022 (Gazipur and Jashore)

Treatments	Gross return (Tk./ha)		Cost of production (Tk./ha)		Gross margin (Tk./ha)		BCR	
	Gazipur	Jashore	Gazipur	Jashore	Gazipur	Jashore	Gazipur	Jashore
T_1	6,38,685	6,60,269	1,95,847	1,87,847	4,42,838	4,72,422	3.26	3.51
T_2	4,70,024	4,91,607	1,95,847	1,87,847	2,74,177	3,03,760	2.40	2.62
T_3	6,24,867	6,46,450	1,95,847	1,87,847	4,29,020	4,58,603	3.19	3.44
T_4	6,18,619	6,40,202	1,95,847	1,87,847	4,22,772	4,52,355	3.16	3.41
T_5	5,87,546	6,09,130	1,95,847	1,87,847	3,91,699	4,21,283	3.00	3.24
T_6	5,22,822	5,44,406	1,95,847	1,87,847	3,26,975	3,56,559	2.67	2.90
T_7	6,42,717	6,79,583	2,86,978	2,46,978	3,55,739	4,32,605	2.24	2.75
T_8	2,03,596	2,25,180	1,50,985	1,50,985	52,611	74,195	1.35	1.49

Note: Onion price: Tk. 35/kg;

T1 = Pendicare 33 EC (Pendimethalin 33%) @ 2 L/ ha spraying at 2-3 days after transplanting of onion seedling, T2 = Nirzash 46 SL (Bentazone 40% + MCPA 6%) @ 9 ml/L spraying at 2-4 leaf stage of weed, T3 = Citro-55 SC (Atrazine 50% + Mesotrione 5%) @ 1 L/ha spraying at 2-3 days after transplanting of onion seedling, T4 = Cutter 50 EC (Quizalofop – P – Ethyl 50%) @ 300 ml/ha spraying at 2-4 leaf stage of weed, T5 = Raxil 50 EC (Quizalofop – P – Ethyl 50%) @ 300 ml/ha spraying at 2-4 leaf stage of weed,T6 = Bay 30 WP (Bensulfuron-methyl 12% + Bispyribac sodium 18%)) @ 75 gm/ha spraying at 2-4 leaf stage of weed, T7= Two hand weeding at 25 & 50 DAT,T8 = Control (No weeding and herbicide)

Conclusion

The results revealed that herbicides,Pendicare 33 EC (Pendimethalin 33%), Nirzash 46 SL (Bentazone 40%+MCPA 6%), Citro-55 SC (Atrazine 50% + Mesotrione 5, Cutter 50 EC (Quizalofop-P-Ethyl 50%), Raxil 50 EC (Quizalofop-P-Ethyl 50%) , Bay 30 WP (Bensulfuron-methyl 12% + Bispyribac sodium 18%) spraying at 2-3 days after transplanting were found effective for controlling weeds in onion field and economically profitable for onion cultivation at Gazipur (AEZ-28) and Jashore (AEZ-11) region.

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PERFORMANCE OF DIFFERENT HERBICIDES FOR CONTROLLING WEEDS IN GARLIC

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Abstract

A field experiment was conducted at Agronomy Research Field of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur and RARS, Jamalpur in 2021-22 to find out the performanceof two herbicides for controlling weeds in garlic field. The treatments were: ; T_1= Tabala 50 EC (Oxyflurofen 5% + Metolachlor 30% + Pendimethalin 25%) @ 2-3 L/ha spraying at 3 DBP + one hand weeding (HW) at 25 DAP; T_2 = Tabala 50 EC (Oxyflurofen 5% + Metolachlor 30% + Pendimethalin 25%) @ 2-3 L/ha spraying at 3 DAP; T_3 = Unirazine 50 SC (Atrazine) @ 600-700 ml/ ha spraying at 3 DBP + one hand weeding (HW) at 25 DAP; T_4 = Unirazine 50 SC (Atrazine) @ 600-700 ml/ ha spraying at 15 DAP + one hand weeding (HW) at 25 DAP; T_5= Two HW at 25 & 45 DAP and T_6 = Control (No weeding and herbicide). Results showed that number of weed/m^2, weed control efficiency (WCE) and yield of garlic were significantly influenced by the two herbicides. The highest weed population (77.33 and 179.00/m^2) was recorded in T_6 at 45 DAP in both locations and similar results found at 45 DAP (136.67 and 190.67/m^2) in both locations. The lowest weed number (21 and 38/m^2) was found in T_5 at 25 DAP in both locations and at 45 DAP (666666) also similar trend was found. At 25 DAP the highest WCE (90.76% and 90.82%) was found in T_5 treatment and at 45 DAP the highest WCE (86.64% and 86.56%) was also found in same treatment. The result showed that, spraying of Tabala 50 EC (Oxyflurofen 5% + Metolachlor 30% + Pendimethalin 25%) @ 2-3 L/ha 3 days before planting with one hand weeding (HW) at 25 days after planting; and Unirazine 50 SC (Atrazine) @ 600-700 ml/ ha at 15 days after planting with one hand weeding at 25 days after planting would be effective for controlling weed in garlic field.

Introduction

Garlic (*Allium sativum* L.) is one of the most popular spices in Bangladesh for its pungent bulbs and flavorful leaves. Fresh or crushed garlic yields the sulfur-containing compounds allicin, ajoene, diallylpolysulfides, vinyldithiins, and S-allylcysteine; as well as enzymes, saponins, flavonoids, and Maillard reaction products, which are not sulfur-containing compounds. It is widely cultivated during winter season. However, the average yield of this crop in Bangladesh is low due to improper use of fertilizers, inadequate irrigation, poor weed control etc. Weeds compete with crops for soil moisture, nutrient, light and thus yield of onion is reduced considerably. The quality of crop is also reduced by weed infestation. Weeds compete with garlic for nutrients, soil moisture, space, and light and considerably reduce the yield, quality and value of the crop through increased production and harvesting costs (Hussain, 1983). Generally, farmers controlling weeds by hand weeding in several times. It takes more times and labour which leads to more expenses. In Bangladesh very small-scale farmers use different chemicals to control the weeds. It is assumed that in comparison to manual weeding, herbicide may provide more effective, economic and easier solution for weed management in garlic. Most of the studies conducted on weeds control in Allium. family by chemicals showed significant effect on bulb yield (Sandhu *et al*., 1997; Vora and Mehta, 1998 and 1999; Tewari *et al*., 1998; Mahmood *et al*., 2002). Similarly, Khan *et al*., (2002) and Khan *et al*., (2010). Therefore, the present experiment was undertaken to find out performance and efficacy of two chemical herbicides with appropriate spraying time for controlling weed in garlic for getting maximum yield and to compare with conventional method.

Materials and Methods

A field experiment was conducted at Agronomy research field of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur and Regional Agricultural Research Institute (RARS), Jamalpur, during *rabi* season 2021-22. The treatments were; T_1= Tabala 50 EC (Oxyflurofen 5% + Metolachlor 30% + Pendimethalin 25%) @2-3 L/ha spraying at 3 DBP + one hand weeding (HW) at 25 DAP; T_2 = Tabala 50 EC (Oxyflurofen 5% + Metolachlor 30% + Pendimethalin 25%) @ 2-3 L/ha spraying at 3 DAP; T_3 = Unirazine 50 SC (Atrazine) @ 600-700 ml/ ha spraying at 3 DBP + one hand weeding (HW) at 25 DAP; T_4 = Unirazine 50 SC (Atrazine)@ 600-700 ml/ ha spraying at 15 DAP + one hand weeding (HW) at 25 DAP; T_5 = Two HW at 25 & 45 DAP and T_6 = Control (No weeding and herbicide). The trial was set up in randomized complete block design with three replications. Sowing was done from 19-28, November 09, 2021 in both locations. The unit plot size was 3 m × 3 m. Test crop was BARI hybrid garlic-4. The crop was fertilized with cow dung (5 t/ha), 115-48-90-30-3.0-2.1 kg/ha (FRG' 2018) of N-P-K-S-Zn-B, respectively in the form of urea-TSP-MoP-gypsum-zinc sulphate and boric acid. All of P, S, Zn, B and half of N and K was applied as basal dose during final land preparation. Remaining N and K was applied in two equal splits at 25 and 45 DAP under moist soil condition and mixed thoroughly with soil as soon as possible for better utilization A light irrigation was given after sowing for uniform emergence of seeds. Weed samples were collected from randomly selected four places from each plot at 25 and 45 days after planting. Number and dry weight of weeds were recorded carefully. Harvesting was done from 29 March to April 04, 2022 and yield data were collected. The Relative Density (RD) of weed and weed control efficiency (WCE) were calculated according to following formulae:

$$\text{Relative Density (RD)} = \left[\frac{\text{No of specific weed species}}{\text{Total no. of weeds}}\right]\times 100$$

$$\text{WCE (\%)} = \left(\frac{\text{A} - \text{B}}{\text{A}}\right)\times 100$$

Where, A = Dry weight of weeds in no weeding plots and B = Dry weight of weeds in treated plots. Yield and yield contributing characters were recorded and analyzed statistically using "STAR" software package and means were separated by LSD at 5% level of significance. Economic analysis was performed considering the prevailing market price of applied inputs and output of garlic.

Results and Discussion

Weed flora and dry matter of weeds

Weed species, number of weeds/m^2 and weed density (%) were affected by different herbicides are presented in Table 1 Shaknote (*Amaranthus viridis*), Bonmoshur (*Vicia sativa*), Helencha (*Enhydra fluetuans*), Bathua (*Chenopodium album*), Bon Palong (*Rumex maritimus*), Shama (*Echinochola crusgali*), Bonmula (*Raphanus rahanistrum*), Mutha (*Cyperus rotundus*), Shetlomi (*Gnaphalium affine*), Durba (*Cynodon dactylon)*, Chapra (*Eleusine indica*), Anguli (*Digitaria spp*) were prominent in garlic field.

At 25 DAP, weeds ranged from 25.33 to 77.33/m^2 in Gazipur and 76.67 to 179.00/m^2 in Jamalpur. At 45 DAP, weeds ranged from 33.33 to 136.67/m^2 in Gazipur and 90.00 to 190.67/m^2 in Jamalpur. The highest weeds/m^2 was recorded in T_6 (No Weeding) treatment and the lowest (38) from T_5(Hand Weeding) treatment (Table 1). The number of weeds was increased in all the treated plots at 45 DAP than 25 DAP in both locations.

At 25 DAP the highest weed dry weights of 11.68g/m^2 and 98.09 g/m^2 were recorded in T_6 (Control) at Gazipur and Jamalpur respectively. At 45 DAP the highest weed dry weights of 70.51g/m^2 and 75.86 g/m^2 were recorded in T_6 at Gazipur and Jamalpur respectively. The minimum weed dry weights at 25 DAP (1.23 and 12.78g/m^2) were found in T_5 (Two HW at 25 & 45 DAP) at both locations. At 45 DAP minimum weed dry weights (5.49and 11.27g/m^2) was also found in T_5 in both locations. This was followed by T_1(Tabala 50 EC @2-3 L/ha spraying at 3 DBP + one hand weeding at 25 DAP) and then T_4 (Unirazine 50 SC @ 600-700 ml/ ha spraying at 15 DAP + one hand weeding at 25 DAP) treatments at 25 DAP and 45 DAP respectively in both locations. The highest WCE of 89.46% and 86.97% was found in T_5 Followed by T_1 and T_4 treatments at 25 DAP, respectively in both locations. At 45 DAP in both locations, the highest WCE of 92.21% and 85.14% were also found in T_5 then T_4 and followed by T_4 treatments, respectively (Table 2).

Yield and Yield Components

Some yield component data were taken at RARS, Jamalpur. The height of stem and yield of garlic were significantly influenced by different weed control method (Table 3). The tallest stem (73.53 cm at Jamalpur) and the highest single bulb weight (977 g at Jamalpur) found in Treatment T_1. Highest yield (8.44 t/ha at Gazipur and 7.60 t/ha at Jamalpur) were observed in T_1 treatment in both locations followed by T_5 then T_4 in Gazipur and T_4 then T_5 in Jamalpur. Significantly the lowest bulb yield (1.37 t/ha at Gazipur and 4.65 t/ha at Jamalpur) was recorded in control (no weeding and herbicide) treatment due to higher no of weeds/m^2 and weed dry weight.

Economic performance

Economic performance of different herbicide treatments on garlic profitability described in Table 4. The highest gross margin of Tk. 271359/ha and Tk. 231879/ha with BCR 3.2 and 2.9 was obtained from T_1 in both locations followed by T_4 treatment, while the lowest was found in T_6 (gross margin Tk. 3823 and BCR 1.1 in Gazipur and gross margin Tk. 88750 and BCR 1.7) treatment. Profitability of garlic was high in T_1 for higher yield and gross margin which was followed by T_4 treatment. Whereas, in case of hand weeding (T_5) due to higher cost of production BCR and gross margin was low

Conclusion

The result revealed that although hand weeding treatment gave higher yield, but due higher cost of production BCR is low whereas herbicide with hand weeding reduced the cost of production and ultimately increased the BCR. So, herbicide Tabala 50 EC (Oxyflurofen 5% + Metolachlor 30% + Pendimethalin 25%) should be sprayed @ 2-3 L/ha 3 days before planting with one hand weeding (HW) at 25 days after planting. Whereas, herbicide Unirazine 50 SC (Atrazine) should be sprayed @ 600-700 ml/ ha at 15 days after planting with one hand weeding at 25 days after planting for controlling weeds in garlic field.

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Table1. Effect of different herbicide on number of weeds m^{-2} in garlic during *rabi* season of 2021-2022 (Gazipur and Jamalpur)

Treatments	Number of weeds/m^2			
	Gazipur		Jamalpur	
	25 DAP	45 DAP	25 DAP	45 DAP
T_1	36.67	36.33	125.67	112.33
T_2	58.33	58.00	135.00	129.00
T_3	56.00	79.33	149.33	145.00
T_4	40.00	44.33	129.00	115.33
T_5	25.33	33.33	76.67	90.00
T_6	77.33	136.67	179.00	190.67

Table2. Effect of different herbicide on weed dry weight and weed control efficiency in garlic during rabi season of 2021-22 (Gazipur and Jamalpur)

Treat.	Weed dry weight (g/m^2)				Weed control efficiency (%)			
	Gazipur		Jamalpur		Gazipur		Jamalpur	
	25 DAP	45 DAP	25 DAP	45 DAP	25 DAP	45 DAP	25 DAP	45 DAP
T_1	1.34	4.39	11.78	12.26	88.52	93.78	87.38	83.39
T_2	2.68	8.22	66.12	36.34	77.05	88.34	32.59	75.09
T_3	3.78	9.12	60.27	40.16	67.64	87.07	38.56	47.06
T_4	1.41	8.17	14.26	14.66	87.93	88.42	85.46	80.67
T_5	1.23	5.49	12.78	11.27	89.46	92.21	86.97	85.14
T_6	11.68	70.51	98.09	75.86	-	-	-	-
LSD $_{(0.05)}$	0.18	0.74	6.09	1.72	-	-	-	-
CV (%)	1.69	1.48	4.90	1.91	-	-	-	-

Table3. Effect of herbicide on yield components of garlic during *rabi* season of 2021-2022

Treatment	Height of stem (cm) (Jamalpur)	Single bulb weight (g) (Jamalpur)	Yield (t/ha)	
			Gazipur	Jamalpur
T_1	72.36	835.00	8.44	7.60
T_2	66.42	533.33	5.14	5.18
T_3	69.10	424.01	2.78	5.25
T_4	65.47	746.67	6.67	7.30
T_5	73.53	977.00	7.89	7.14
T_6	65.07	457.00	1.37	4.65
LSD $_{(0.05)}$	5.75	NS	0.46	0.57
CV (%)	2.78	4.34	3.04	3.24

Table 4. Cost and return analysis of different herbicides in garlic cultivation during *rabi* season of 2021-2022 (Gazipur and Jamalpur)

Treatments	Gross return (Tk./ha)		Cost of production (Tk./ha)		Gross margin (Tk./ha)		BCR	
	Gazipur	Jamalpur	Gazipur	Jamalpur	Gazipur	Jamalpur	Gazipur	Jamalpur
T_1	396680	357200	125321	125321	271359	231879	3.2	2.9
T_2	241580	243460	125321	125321	116259	118139	1.9	1.9
T_3	130660	246750	125321	125321	5339	121429	1.0	2
T_4	313490	343100	125321	125321	188169	217779	2.5	2.7
T_5	370830	335580	157325	145321	213505	190259	2.4	2.3
T_6	64390	218550	60567	129800	3823	88750	1.1	1.7

Price: Garlic =Tk.47/kg

T_1= Tabala 50 EC (Oxyflurofen 5% + Metolachlor 30% + Pendimethalin 25%) @2-3 L/ha spraying at 3 DBP + one hand weeding (HW) at 25 DAP; **T_2** = Tabala 50 EC (Oxyflurofen 5% + Metolachlor 30% + Pendimethalin 25%) @ 2-3 L/ha spraying at 3 DAP; **T_3** = Unirazine 50 SC (Atrazine) @ 600-700 ml/ ha spraying at 3 DBP + one hand weeding (HW) at 25 DAP; **T_4** = Unirazine 50 SC (Atrazine)@ 600-700 ml/ ha spraying at 15 DAP + one hand weeding (HW) at 25 DAP; **T_5** = Two HW at 25 & 45 DAP and **T_6** = Control (No weeding and herbicide)

YIELD AND CROP COMPETITION OF LEAFY VEGETABLES INTERCROPPING SYSTEM WITH CHILLI

J.A. CHOWDHURY, A.A. BEGUM, S.S. KAKON, M.R. KARIM AND D.A. CHOUDHURY

Abstract

The field experiment was carried out on chilli + leafy vegetables intercropping system at the Agronomy Research Field of Bangladesh Agricultural Research Institute (BARI), Gazipur during *rabi* season of 2021-2022. The study was conducted to find out the suitable intercrop combination of these crops for higher productivity and economic return. The treatments were viz., T_1=Two row spinach (66%) in between two row of chilli (100%), T_2= Two row red amaranth (66%) in between two row of chilli (100%), T_3= Two row raddish (66%) in between two row of chilli (100%), T_4= Two row coriander (66%) in between two row of chilli (100%), T_5 = Sole chilli (60 cm × 50 cm). Significantly the highest chilli yield (7.19 t/ha) was obtained in sole chilli. Chilli equivalent yield ware higher in all the intercrops (28.92 -33.85t/ha) than that of sole crop of chilli. The highest chilli equivalent yield (33.85 t/ha) was recorded when two row spinch (66%) intercropped in between two row of chilli (100%) (T_1). The highest gross margin (Tk. 265120/ha) and BCR (4.61) were also obtained from the same treatment. The result expressed that the intercrop combination of two row spinach (66%) in between two row of chilli (100%) could be agronomically feasible and economically profitable.

Introduction

Intercropping is a traditional practice in Bangladesh and it increases total productivity per unit area through maximum utilization of land, labour and growth resources (Crauford, 2000; Mahfuza *et al*., 2012). It is a cropping system which integrates crop production with soil conservation. One of the advantages of this system is that it gives an assurance against crop failure which is common in developing countries. Another advantage of mixing crop is the yield and quality improvement compared with sole cropping. By judicious choice of compatible crops and adopting appropriate planting geometry, inter/intra specific competition may be minimized resulting higher total productivity (Umrani *et al.*, 1984). Canopy architecture of tall stature crop regulates the availability of light on under storied crop (Faruque *et al.*, 2000). Leafy vegetables such as spinach, red amaranth, radish, coriander, mustard etc. are short duration and short stature vegetable. On the other hand, chilli is comparatively tall and long duration crop. Chilli is one of the major spices crop in Bangladesh cultivated in 2, 49,748 acres of land (both winter and summer) with a production of 1,41,177 metric tons (BBS, 2018). It is usually grown as sole and in some cases intercrop at farmer's field in different parts of Bangladesh. Chilli is generally grown with wide row spacing of 60 cm which makes it suitable for intercropping. So, there is a great scope to cultivate short durated (30-45 days) leafy vegetable like red amaranth, spinach, radish and coriander in the inter row space of chilli as intercrop. Leafy vegetable like red amaranth, spinach, radish and coriander being short structure quick growing crops can be easily intercropped between two rows of chilli at early growth stage for getting higher economic return. Therefore, this experiment was conducted to find out suitable crop combination for higher productivity and economic return.

Materials and Methods

A field experiment was conducted under irrigated condition during *rabi* season, 2021-2022 at the Agronomy Research Field of BARI, Gazipur. The experiment consisted of five different treatments viz., T_1= Two row spinach (66%) in between two row of chilli (100%), T_2= Two row red amaranth (66%) in between two row of chilli (100%), T_3= Two row radish (66%) in between two row of chilli (100%), T_4= Two row coriander (66%) in between two row of chilli (100%), T_5 = Sole chilli (60 cm × 50 cm). The experiment was laid out in a randomized complete block design with three replications and each plot size was 3.6 m × 3.0 m. BARI Morich-3, BARI Palongshak- 1, BARI Lalshak-1, BARI Mula-1 and BARI Dhonia-1 were used as test crops. Chilli was transplanted with 2 seedlings per hill and later maintained one seedling per hill. The inter row spacing was 60 cm and intra row spacing was 50 cm. Intercrops were sown between the rows. Five tons of cowdung/ha was applied to the crop before transplanting. Before chilli seedling transplanting, the land was fertilized with 96-45-75-15-1.5-1.4 kg/ha N-P-K-S-Zn-B (FRG, 2018). Half of N and full amount of all other fertilizers were applied as basal during final land preparation. Remaining N was applied in three equal splits at 25, 50 and 70 DAT. Inter cultural operation and plant protection measures were taken up as and when required. In case of chilli, five randomly selected plants were taken for plant height, number of fruit, fruit length, single plant fruit weight and yield. Yield of leafy vegetable were taken from whole plot. For economic analysis, gross income, total operational cost, gross margin and BCR were used. Photosynthetic measurements were carried out by using portable photosynthesis equipment (LI-6800, Li-COR, USA) at fruiting stages of chilli growth with steady light intensity (1,200 μmol m^{-2} s^{-1}) at a CO_2 concentration of 400 μmol/mol and all of the measurements were made between 8:00 and 9:00 on cloudless days. Data on yield and yield contributing characters were taken and statistically analyzed following MSTAT-C software package. Means were adjusted by LSD test at 5% level of significance.

Results and Discussion

Plant height of chilli plant

Plant height was differed by different intercropping treatment. The plant height gradually increased and reached the peak at harvest in all the treatments (Fig. 1). Higher plant height was observed in sole chilli treatment this might be due to more availability of growth resources than intercrop chilli. Among the intercropping combination the higher plant height of chilli was observed when chilli intercropped with coriander. This might be due to because of coriander took more time for germination than other intercrop which allow the chilli crop more initial free time for growth than other intercrop combination. The shortest plant was observed when chilli intercropped with spinach.

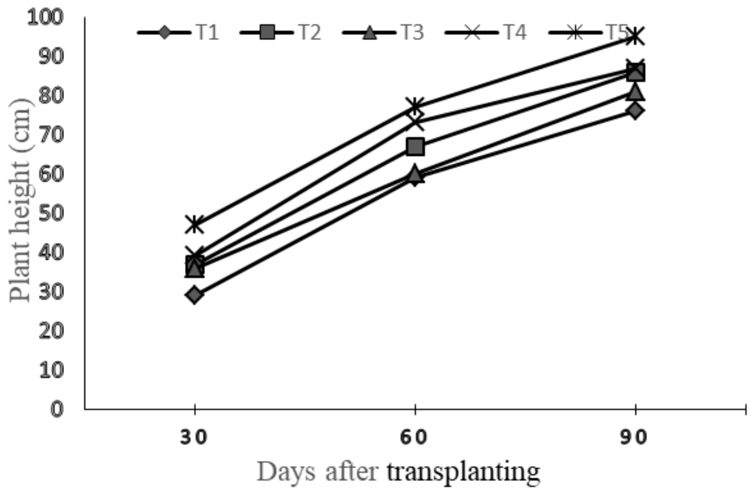

Fig. 1. Plant height of chilli plant in different intercropping combination

Leaf area (LA)

The leaf area (LA) of the crop at a particular growth stage indicates its photosynthetic potentiality or the level of its dry matter accumulation. It is influenced by genotype, plant population (Murphy *et al*., 1996). The LA was influenced by different intercropping system (Fig. 2). LAI increased up to 90 DAP in all the treatments. The higher LA was recorded in sole chilli treatment in all three growth stages. Among the intercropping system, the maximum LA was recorded in T_4 treatment when chilli was intercropped with coriander because coriander took more time to germinate which allow the chilli crop more free time in initial growth stage than other combination so plant can utilize more growth resources. Minimum LA was observed when chilli intercropped with spinach.

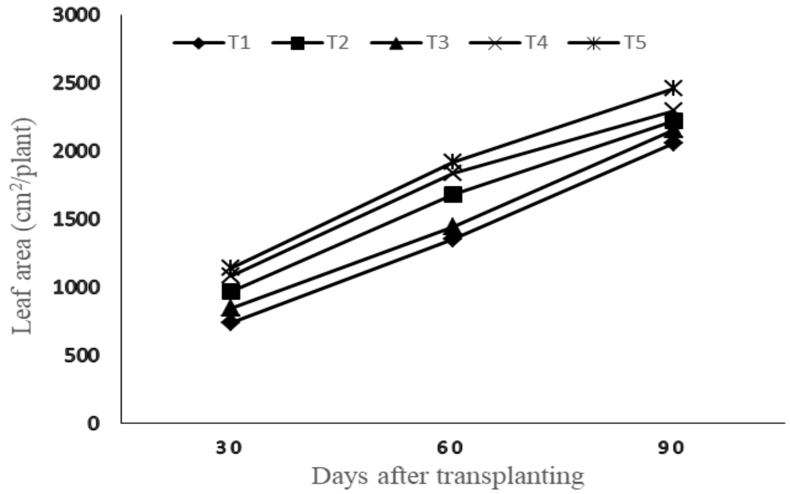

Fig. 2. Leaf area of chilli plant in different intercropping combination

Effect of intercropping on TDM production of chilli

The pattern of TDM accumulation of chilli plant over time was influenced by different intercropping combination (Fig.3). The TDM of chilli increased slowly up to 90 DAP in all the treatment combination. The highest TDM accumulation/m^2 was obtained in sole chilli plant in all three sampling date. In case of intercropping combination highest TDM was obtained by chilli when chilli intercropped with coriander and lowest from T_1 (chilli +spinach intercropping system) treatment.

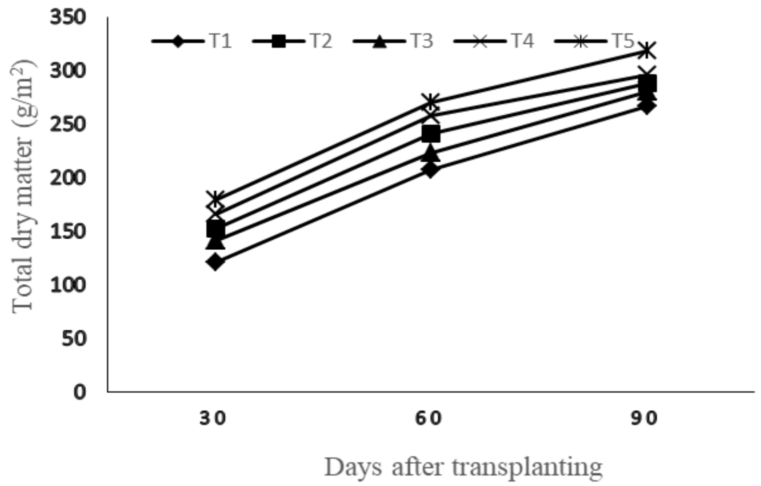

Fig. 3. Total dry matter of chilli plant in different intercropping combination

Photosynthetic characteristics

The photosynthetic characteristics, including net photosynthetic rate (P_n), stomatal conductance (G_s), intercellular CO_2 concentration (C_i), and transpiration rate (T_r), of functional leaves were measured to explain the chilli leaf responses to different intercropping systems. Compared with sole cropping of chilli, P_n, C_i, G_s, and T_r decreased significantly under different intercropping system (Table 1). P_n of T_1, T_2, T_3 and T_4 respectively decreased by 26.28% 15.29%. 16.96% and 2.48% compared with those of the sole cropping system. The highest Photosynthetic rate was observed in sole treatment. In case of inter cropping highest and lowest in T_4 (coriender intercropped with chilli) and T_1 (spinach intercropped with chilli) treatment.

Table 1. Chilli leaf photosynthetic characteristics in chilli-leafy vegetable intercropping system

Treat.	Photosynthetic rate (µmol CO_2 $m^{-2}s^{-1}$)	Intercelular CO_2 (µmol CO_2 $m^{-2}s^{-1}$)	Stomatal Conductance (µmol H_2O $m^{-2}s^{-1}$)	Transpiration (mol H_2O $m^{-2}s^{-1}$)	Decrease in photosynthetic rate over sole (%)
T_1	12.48	360.97	0.46300	0.00331	26.28
T_2	14.34	335.33	0.42033	0.00457	15.29
T_3	13.55	341.98	0.43733	0.00568	16.96
T_4	16.51	313.91	0.40033	0.00614	2,48
T_5	16.93	307.80	0.36433	0.00650	-
$LSD_{(0.05)}$	1.01729	21.892	0.04408	0.00050	
CV (%)	3.66	3.50	5.61	4.56	

Fruit yield and yield contributing characters of chilli

Crop characters of chilli affected by intercropping have been presented in Table 2. Fruit yield and yield contributing characters of chilli was not significantly influenced by intercropping. Sole chilli produced the numerically highest plant height (87.67 cm), fruit number/plant (225), fruit weight/plant (351.36 g) and green chilli fruit yield (7.19 t/ha). Among the intercropping combinations numerically the maximum plant height (86.67 cm), number of fruit/plant (223) and weight of fruit/plant (349.65 g) were observed when two row coriander intercropped with chilli (T_4 treatment), while the lowest plant height (81.15 cm), number of fruit/plant (212), weight of fruit/plant (346.06 g) and green chilli fruit yield (7.05 t/ha) was observed in treatment when two row spinach intercropped with chilli (T_1 treatment). Yield of green chilli fruit varied from 7.05 t/ha to 7.19 t/ha due to influence exerted by different treatments. In different intercropping treatment chilli fruit yield varied from 7.05 t/ha to 7.18 t/ha. The chilli without intercrop (sole chilli) gave the highest fruit yield of 7.19 t/ha was attributed due to more number of fruit/plant and higher fruit weight/plant. Islam *et al.* (2014) also reported similar result and the lowest (7.05 t/ha) in T_1 treatment (two inter row spinach intercropped with chilli).

Table 2. Crop characters and fruit yield of chilli as influenced by intercropping (2021-2022)

Treatment	Plant height (cm)	Fruits/plant (no.)	Fruit weight/ plant (g)	Green Chilli Fruit Yield (t/ha)
T_1	81.15	212	346.06	7.05
T_2	86.33	222	348.98	7.15
T_3	83.07	217	347.37	7.14
T_4	86.67	223	349.65	7.18
T_5	87.67	225	351.36	7.19
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	4.30	5.22	3.35	4.57

Note: T_1= Two row spinach (66%) in between two row of chilli (100%), T_2= Two row red amaranth (66%) in between two row of chilli (100%), T_3= Two row raddish (66%) in between two row of chilli (100%), T_4= Two row coriander (66%) in between two row of chilli (100%), T_5 = Sole chilli (60 cm × 50 cm)

Biomass yield of leafy vegetable

The biomass yield of different leafy vegetable was significantly influenced by intercrop with chilli (Table 3). Among the intercropping combinations the highest leafy vegetable yield (17.87 t/ha) was recorded in T_1 treatment (Two row spinach (66%) in between two row of chilli (100%)) and the lowest yield (14.96 t/ha) from T_4 treatment (Two row coriander (66%) in between two row of chilli (100%)).

Table 3. Biomass yield of leafy vegetable in chilli + leafy vegetable intercropping (2021-2022)

Treatment	Biomass yield (t/ha)
T_1 = Two row Spinach (66%) in between two row of chilli (100%)	17.87
T_2 = Two row red amaranth (66%) in between two row of chilli (100%)	15.64
T_3 = Two row raddish (66%) in between two row of chilli (100%)	16.20
T_4 = Two row coriander (66%) in between two row of chilli (100%)	14.96
LSD $_{(0.05)}$	1.76
CV (%)	5.44

Chilli equivalent yield (CEY)

Equivalent yield expressed the total productivity of system. Chilli equivalent yield was higher in all the intercrops (33.85- 28.92 t/ha) than the sole crop of chilli (7.19 t/ha) (Table 4). Among the intercrop combinations, the highest CEY (33.85 t/ha) was recorded in T_1 treatment which was followed by T_3 treatment (31.44 t/ha). The lowest CEY (28.92 t/ha) was obtained from T_4 treatment. Ahmed *et al.* (2013) also reported that intercrop combination increased the equivalent yield.

Cost and return analysis

Economics of different chilli intercropping system was analyzed taking into account the prices prevailed at local market. Intercropping combination of different leafy vegetable with chilli showed higher monetary return than sole crop (Table 4). Among the intercropping situation the highest gross return (Tk. 338500/ha) was recorded from T_1 treatment (Two row spinach (66%) in between two row of chilli (100%)). This intercropping combination also gave the highest gross margin (Tk. 265120/ha) and benefit cost ratio (4.61). The results of increased productivity and returns were consistent with the yield advantage of crop mixture compared to monoculture (Akhteruzzaman *et al*., 1991; Islam *et al*., 2012 and Ahmed *et al*., 2013).

Table 4. Cost and return of different chilli-leafy vegetable intercropping system (2020- 2021)

Treatment	CEY (t/ha)	Gross return (Tk./ha)	Cost of production (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1	33.85	338500	73380	265120	4.61
T_2	30.61	306200	73276	232924	4.18
T_3	31.44	314400	73304	241096	4.29
T_4	28.92	289200	73290	215910	3.95
T_5	7.19	71900	63000	8900	1.14

Market price (Tk./kg): Chilli= 10, Red amaranth= 15, Spinach= 15, Raddish shak= 15, Criander= 15

BCR=Benefit cost ratio

Note: T_1= Two row spinach (66%) in between two row of chilli (100%), T_2= Two row red amaranth (66%) in between two row of chilli (100%), T_3= Two row raddish (66%) in between two row of chilli (100%), T_4= Two row coriander (66%) in between two row of chilli (100%), T_5 = Sole chilli (60 cm × 50 cm)

Conclusion

From the experimental findings it can be concluded that all intercropping treatments were found productive and profitable as compared to sole crop. Different leafy vegetable intercropped with chilli produced higher equivalent yield than sole chilli. Two row spinach (66%) in between two row of chilli (100%) intercrop combination showed the highest BCR but all other combinations was also found agronomically productive and economically profitable.

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MAIZE- LEGUME STRIP CROPPING FOR RESOURCE CONSERVATION

J.A. CHOWDHURY, A.A. BEGUM, S.S. KAKON, M.R. KARIM AND D.A. CHOUDHURY

Abstract

A field experiment was conducted under irrigated condition during *rabi* season, 2021-2022 at the Agronomy Research Field of Bangladesh Agricultural Research Institute to maintain sustainable productivity and to conserve soil health and soil moisture. The experiment consisted of four treatments viz., T_1= Maize (4 row) alternate with lentil (8 row), T_2= Maize (4 row) alternate with pea (8 row), T_3= Maize (4 row) alternate with grass pea (6 row) and T_4= Sole Maize (8 row). The grain yield of maize **(**6.69 t/ha**)** was higher in sole maize plot than all strip cropping plot. The maize equivalent yield (6.69 t/ha) was also highest in sole maize because heavy rainfall severely affects all legume strip.

Introduction

Intercropping system involve two or more crop species or genotypes growing together and co existing for a time. As compared to monocrop, they can take part in pest control, similar yields with reduced inputs, population mitigation and greater or more stable aggregate food or forage yields per unit area (Brooker *et al*., 2015 and Lithourgidis *et al*., 2011). Strip cropping can be regarded as an adaptation of the more traditional intercropping system with strips. Strip intercropping is de-fined as the production of two or more crops within the same field in strips wide enough that each can be managed independently by existing machinery; yet narrow enough that the strip components can interact. Strip cropping is expected to enhance the resilience of the production system, to reduce the risk of income loss during inclement weather (such as long dry spell, heavy rainfall, typhoon, etc.), to increase the biodiversity and to diversify the family's nutrition and food security. Strip cropping is like any other intercropping strategy based on the management of plant interactions to maximize growth and productivity caused by efficient use of plant growth resources such as light, water and nutrients (Hauggaard *et al.,* 2001). Strip cropping helps to maintain or improve the status of organic content in the soil, thereby enriching the soil fertility and enabling to develop more stable aggregates in the soil, increase in soil nitrogen, resulting from nitrogen fixation, associated to the legume crops. Again, large uniform areas of one crop make the agricultural system more vulnerable only one pest insect and fungus needs to 'land' and the whole field will be infested unless measures are rapidly taken. This is caused by the fact that natural enemies find it difficult to survive on such a large field: there is too little (alternative) food and there is no shelter. More diversity in a field offers beneficial organism's sufficient food and shelter throughout the year. And this in turn makes life difficult for harmful organisms, resulting these findings it difficult to cause damage to the crops. Strip cultivation can increase the biodiversity in the field. The selection of plants with different developmental cycles and morphological structures enables more efficient utilization of nutrients, water, and light in strip cropping than in sole cropping. Moreover, interaction between species in the rhizosphere can influence nutrient availability and uptake (Zhang *et al*., 2013; Ngwira *et al*., 2012; Tilman *et al*., 2015). Thus, the experiment was undertaken to evaluate the effect of strip cropping on maintain sustainable productivity and conserve soil health, and soil moisture.

Materials and Methods

A field experiment was conducted under irrigated condition during *rabi* season, 2021-2022 at the Agronomy Research Field of Bangladesh Agricultural Research Institute. The experiment consisted of four different treatments viz., T_1= Maize (4 row) alternate with lentil (8 row), T_2= Maize (4 row) alternate with pea (8 row), T_3= Maize (4 row) alternate with grass pea (6 row), T_4= Sole Maize (8 row). Experiment was laid out in a RCB design with three replications and each gross plot of 9.6m × 7.0m. Maize (var. BARI Hybrid maize-9), lentil (var. BARI Masur-6, pea (var. BARI Motorsuti-3) and grass pea (var. BARI Khasari-1) were used as test crops. All crops were sown on 17 November 2021. 5 t/ha of cowdung was applied to the crop before sowing. Recommended dose of fertilizer was applied to all crops (for maize: 225-60-120-45-4-1.6kg/ha N- P- K- S- Zn- B; for lentil: 21-18-21-9-2-1.2 kg/ha N- P- K- S- Zn- B; for pea 45-24-30-12-1.4 kg/ha N- P- K- S- Zn and for grass pea 15-15-18-9 kg/ha N- P- K- S) (FRG, 2018) in the form of urea, TSP ,MoP, Gypsum, Zinc sulphate and Boric acid. For maize one third of N and all of other fertilizer was applied during final land preparation and rest N was applied in two equal splits at 30 days after sowing and 50 days after sowing. For other three crops all fertilizer were applied during final land preparation. Cultural and plant protection measures were taken up as and when required. Observations were taken on the five randomly selected plants in each plot in respect to plant height, yield component and yield.

Result and Discussion

Rainfall

Rainfall data during crop growth period of maize legume strip cropping have been presented in figure 1. The crop received total 386 mm rainfall during crop growth period. Maximum rainfall occurred during month of December mainly within 1 December to 15 December. Out of total rainfall, 249 mm rainfall occurred from1 to 15 December

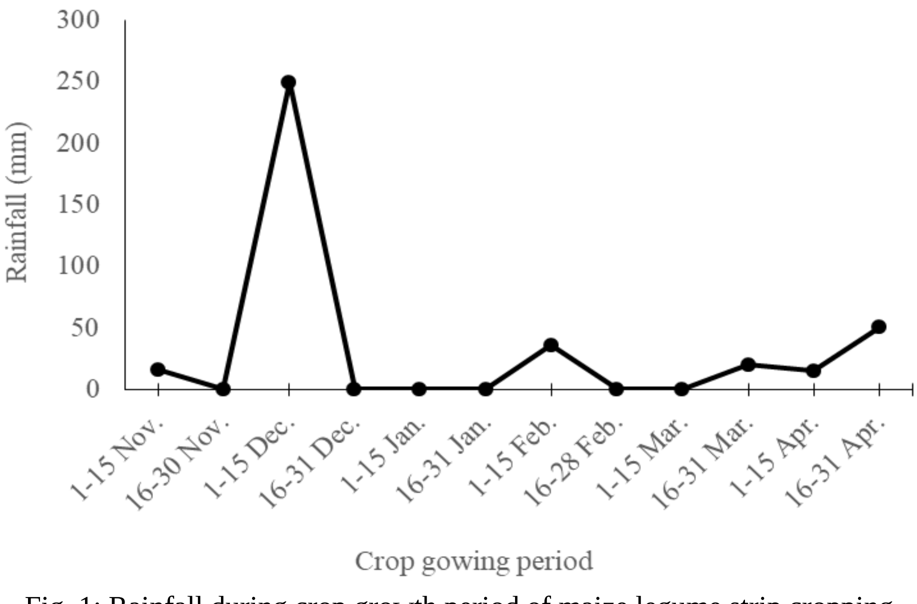

Fig. 1: Rainfall during crop growth period of maize legume strip cropping

Yield and yield contributing characters

Yield and yield contributing characters Maize

Strip cropping significantly influenced yield contributing characters and grain yield of maize (Table 1). Plant height, cob length, cob diameter, grains no./cob and 1000-grain weight of all strip maize is higher than sole maize. The tallest plant (187 cm) was observed in T_2 (Maize alternate with Pea strip) treatment. The highest cob length (20.35 cm), cob diameter (4.78), grains no./cob (612) and 1000 grain weight (304.45 gm) was also obtained from maize strip adjacent to the pea strip and lowest in sole maize. This might be due to effect of legume strip from previous year.

Strip cropping also influenced the grain yield of maize (Table 2). Grain yield of maize varied from 4.44 to 6.69 t/ha due to influence exerted by different treatments. Highest maize grain yield was obtained from sole maize cropping system which was 6.69 t/ha. Maize of all strip cropping produced lower grain yield than sole cropping and T_1 (maize strip adjacent to the lentil strip) produced the lowest maize yield.

Yield of Legume crop

yield of legume crops severely affected by heavy rainfall occurred in early growth stage (1-15 December). Crop of pea strip could not produce any pod. Seed yield of lentil and grass pea was very low which was only 0.27 t/ha and 0.48 t/ha, respectively (Table 2).

Maize equivalent yield (MEY)

Equivalent yield expressed the total productivity of intercropping system. MEY of all strip cropping was lower than sole maize cropping because heavy rainfall (249 mm) completely damage the pea strip and severely damage the lentil and grass pea strip. So pea completely fail to produced pod and lentil, grass pea produced very small amount of pod. Maize equivalent yield (MEY) of sole maize was 6.69 t/ha whereas MEY of strip cropping was ranges from 4.44 to 6.01 t/ha (Table 2).

Table 1. Yield components of maize in maize-legume strip cropping during 2021-2022

Treatments	Plant height (cm)	Cob length (cm)	Cob diameter (cm)	Grains/cob (no.)	1000grain wt. (g)
T_1	183	18.80	4.70	567	291.92
T_2	187	20.35	4.78	612	304.45
T_3	181	19.50	4.75	592	297.02
T_4	152	16.00	4.03	473	260.53
$LSD_{(0.05)}$	9.37	2.00	0.505	81.65	30.05
CV(%)	2.67	5.37	5.54	7.29	5.21

Table 2. Yield of maize and component crop in maize legume strip cropping during 2021-2022

Treatments	Grain yield of Maize (t/ha)	Seed yield of legume crop (t/ha)	Maize equivalent yield (t/ha)
T_1	4.00	0.27	4.44
T_2	4.45	-	4.45
T_3	4.09	0.48	6.01
T_4	6.69	-	6.69
$LSD_{(0.05)}$	0.99	-	-
CV (%)	6.25	-	-

T_1= Maize (4 row) alternate with lentil (8 row). T_2= Maize (4 row) alternate with Pea (8 row). T_3= Maize (4 row) alternate with grass pea (6 row). T_4= Sole Maize (8 row)

Conclusion

Adverse weather condition (heavy rainfall) effect the result of this year. So for Authentic result the experiment should be repeated for next year

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PERFORMANCE OF INTERCROPPING BUSHBEAN WITH SORGHUM

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Abstract

The experiment was conducted at the Agronomy Research Field of Bangladesh Agricultural Research Institute, Gazipur during rabi season of 2021 to 2022 to find out the suitable crop combination of bush bean with sorghumfor increasing total productivity, economic return, maximize land utilization through intercropping system. Six treatments viz., T_1= Sorghum normal row 100% (60 cm × 20 cm) + 1 row bush bean in between two rows of sorghum 43.75% (30 cm × 5 cm), T_2= Sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean in between two rows of sorghum 87.50% (30 cm × 5 cm), T_3= Sorghum paired row 100% (30 cm/120 cm/30 cm× 20 cm) + 2 row bush bean in between two paired rows of sorghum 37.50% (30 cm × 5 cm), T_4= Sorghum paired row 100% (30 cm/120 cm/30 cm× 20 cm) + 3 row bush bean in between two paired rows of sorghum 56.25% (30 cm × 5 cm), T_5= Sole sorghum (60 cm × 20 cm) and T_6= Sole bush bean (30 cm × 5 cm) were used. Light availability on bush bean decreased with the increase of shade produced by sorghum canopy over the time up to 65 DAS. The lowest light availability on bush bean in T_2 treatment sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean in between two rows of sorghum 87.50% (30 cm × 5 cm). The maximum grain yield of sorghum was observed in sole crop 4.52 t/ha and it was decreased by 4.20-18.81 % among the intercrop combination. The highest Sorghum equivalent yield (SEY) of 9.13 t/ha, gross return (Tk. 1,82,600/ha), gross margin (Tk. 1,36,600/ha) and benefit cost ratio (BCR) of 3.97 were obtained from T_2 treatment sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean in between two rows of sorghum 87.50% (30 cm × 5 cm). The highest Land equivalent ratio (LER) of 1.75 was also found in the same treatment. The results revealed that sorghum normal row 100% (60 cm × 20 cm) + 2 rows bush bean 87.50% (30 cm × 5 cm) might be agronomically feasible and economically profitable.

Introduction

Intercropping is a traditional practice in Bangladesh and it increases total productivity per unit area through maximum utilization of land, labour and growth resources (Ahmed *et al*., 2013; Islam *et al*., 2006; Mahfuza *et al*., 2012). By judicious choice of compatible crops and adopting appropriate planting geometry, inter/intra specific competition may be minimized resulting higher total productivity (Alom *et al*., 2013). Canopy architecture of tall stature crop regulates the availability of light on under storied crop (Faruque *et al.,* 2006). Sorghum [(*Sorghunz bicolor* L. Moench) is an unbranched and erect cereal crop grown with wide spacing. Several short duration and short stature vegetable like bush bean may be grown in association with sorghum. Sorghum grain is as nutritious as other cereal grains; contains about 11% water, 340 k/cal of energy, 11.6% protein, 73% carbohydrate and 3% fat by weight (Thimmaiah, 2002; Taylor *et al*., 2006; Yan *et al*., 2012). Sorghum is used as food, feed, fodder and fuel. This crop is of great importance in conservation agricultural production system, ensuring food security, minimizing input cost for farmers and protection from soil erosion. On a field basis, sorghum yields have exceeded 11 t/ha with above average yields ranging from 7-9 t/ha where moisture is not a limiting factor (Mohamed, 2011). Bush bean (*Phaseolus vulgaris*. L) is an important high yielding legume crop and can be used as vegetable and soup and it contains vitamin A (23%), vitamin C (27%), vitamin K (12%) carbohydrates (5.5%), and protein (3%) (Davis *et al.*, 2001). Generally legumes in association with non-legumes not only helps in utilization of the nitrogen being fixed in the current growing season, but also helps in residual nutrients build up of the soil (Islam *et al.,* 2006). Farmers often demand for quick return from their crops, so they can get quick return by growing short duration vegetable crops with sorghum. But literature is meager regarding sorghum + bush bean intercropping under different planting systems in Bangladesh condition. By adopting appropriate planting geometry in the intercropping system, the total productivity of the crops can be enhanced (Umrani *et al.,* 1984). So, this experiment was conducted to find out suitable planting systems of sorghum and bush bean (short duration crop) intercropping for higher productivity and economic return.

Materials and Methods

The experiment was conducted at the research field of Agronomy Division BARI, Gazipur during *rabi* season of 2020-21. The soil of the research area belongs to AEZ-28. The soil was clay loam with pH 6.3. Treatments included in the experiment were: T_1= Sorghum normal row 100% (60 cm × 20 cm) + 1 row bush bean in between two rows of sorghum 43.75% (30 cm × 5 cm), T_2= Sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean in between two rows of sorghum 87.50% (30 cm × 5cm), T_3= Sorghum paired row 100% (30 cm/120 cm/30 cm× 20 cm) + 2 row bush bean in between two paired rows of sorghum 37.50% (30 cm × 5 cm), T_4= Sorghum paired row 100% (30 cm/120 cm/30 cm× 20 cm) + 3 row bush bean in between two paired rows of sorghum 56.25% (30 cm × 5 cm), T_5= Sole sorghum (60 cm × 20cm) and T_6= Sole bush bean (30 cm × 5 cm). The experiment was laid out in a randomized complete block design with three replications and the unit plot size was 4.8 m × 5 m. Sorghum (Var. BARI Sorghum-1) and Bush bean (Var. BARI Jharsheem-2) were used in the experiment. Sorghum and bush bean seeds were sown on 22 November 2021. The seeds of both crops were treated with provex @ 3g/ kg of seed. Fertilizers were applied at the rate of 120-48-75-30-3-1 kg/ha of N, P, K, S, Zn, B (FRG, 2018) as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid for sole sorghum and intercrop. One third of N, whole amount of TSP, MoP, gypsum, zinc sulphate and boric acid were applied as basal. Remaining 2/3 N was top dressed at 25 and 45 days after sowing (DAS) of sorghum. In intercrop, extra N (40 kg/ha) was applied in 2 splits at 25 and 45 DAS of bush bean. Sole bush bean was fertilized at the rate of 88- 35-53-11-2.2-1.5 kg/ha of N, P, K, S and Zn (FRG, 2018). 1/3 N and all other fertilizer were applied as basal at the time of final land preparation. Remaining N was applied as side dress at 20 and 35 DAS under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Light availability or Photo synthetically active radiation (PAR) was measured by PAR Ceptometer (Model – LP-80, Accu PAR, Decagon, USA). The PAR was measured at 5-day intervals from 25 to 65 days after sowing (DAS) at around 11:30 am to 13:00 pm. Four readings each of PARinc and PARt were recorded at different spots of each plot. The proportion of intercepted PAR (PARint) was calculated using the following equation and expressed in percentage (Ahmed *et al*., 2013):

$$\text{Light availability \{PARint (\%)\}} = \frac{\text{PARinc} - \text{PARt}}{\text{PARinc}} \times 100$$

whrer, PARinc= Incident PAR, PARt= Transmitted PAR, PARint= Intercepted PAR.

Data on yield contributing characters of sorghum were taken from randomly selected 5 plants from each plot. Yields of both the crops were taken from whole plot area. Sorghum was harvested on 04 April, 2022 and bush bean was harvested 2 times on 02 and 10 February, 2022. Sorghum equivalent yield (SEY) was calculated by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula (Islam *et al*., 2012) as given below:

$$\text{SEY} = \text{Yis} + \frac{\text{Yibn} \times \text{Pbn}}{\text{Ps}}$$

Where, Yis = Yield of intercropped sorghum, Yibn = Yield of intercropped bush bean,
Pbn = Market price of bush bean and Ps = Market price of sorghum.

Land equivalent ratio (LER) was obtained according to Willey (1979) as follows:

$$\text{LER} = \frac{S_{IY}}{S_{SY}} + \frac{B_{IY}}{B_{SY}}$$

Where,
S_{IY} = Yield of intercrop sorghum
S_{SY} = Yield of sole sorghum
B_{IY}= Yield of intercrop (Component crop)
B_{SY} = Yield of sole crop (Component crop)

Collected data of both the crops were analyzed statistically and the means were adjudged using $LSD_{(0.05)}$ test. Economic analysis was also done considering local market price of harvested crops.

Result and Discussion

Light availability

Availability of light on sorghum and bush bean was not markedly affected with each other because bush bean was harvested at 67-74 DAS. At that time sorghum canopy could not produce much shade which might affect bush bean. Irrespective of treatments, availability of light on bush bean canopy was almost 100% at earlier growth stage, 30 DAS of bush bean and it decreased with the increase of shade produced by sorghum canopy over the time up to 74 DAS or up to harvest of bush bean. However, among the intercropping treatments the higher light availability on bush bean was observed in T_3 treatment (SPR 100% (30 cm/ 120 cm/ 30 cm × 20cm) + 2 row bush bean 37.50% (30 cm × 5 cm) followed by T_4 treatment (SPR 100% (30 cm/ 120 cm/30 cm × 20cm) + 3 rows bush bean 56.25% (30cm×5cm) throughout the growing period. The lowest light availability on bush bean was observed in T_2 treatment (SNR 100% + 2 rows bush bean 87.50% followed by T_1 treatment (SNR + 2 rows bush bean 43.75%) at 65 DAS of bush bean. Among all treatments, the highest light availability was observed in sole bush bean T_5 treatment (Fig.1).

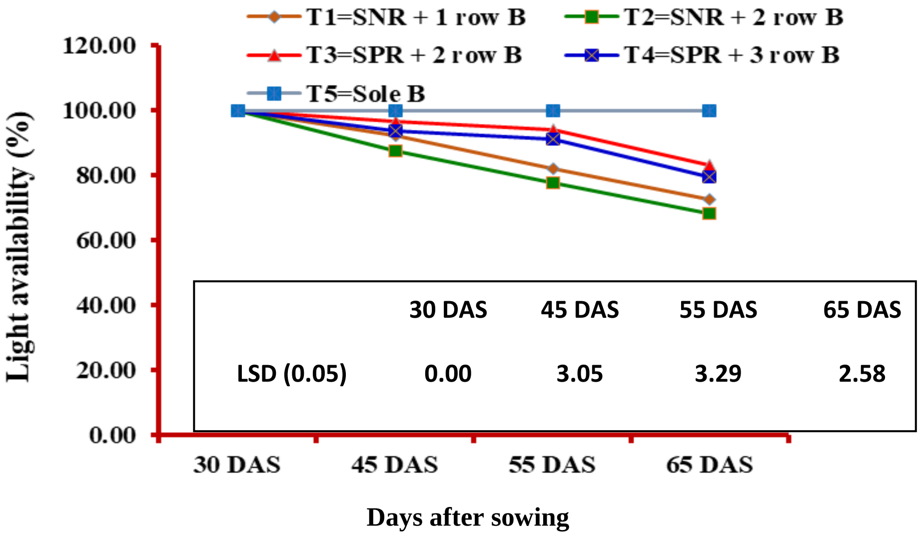

Fig. 1. Light availability on bush bean canopy in sorghum + bush bean intercropping system during *rabi* season 2021-22 at Gazipur.

Grain yield and yield contributing characters of sorghum

Panicle length, number of grains/panicle, 1000-grain weight, and grain yield of sorghum was significantly varied due to intercropping of sorghum with bush bean and sole crop of sorghum except plant height (Table 1). Higher panicle length (18.44 cm) was obtained from sole planting of sorghum and it was statistically identical with T_1 (17.46 cm) and T_2 (16.83 cm) treatments. The lowest panicle length 15.40 cm was recorded in T_4 treatment and it was statistically identical with and T_3 (16.13cm) treatment. Similar trend was found in case of number of grains/panicle and 1000-grain weight. The highest number of grains/panicle (1841) and 1000-grain weight (36.25g) was recorded in sole sorghum (T_5 treatment). Among the intercropping situation the highest number of grains/panicle (1646) and 1000-grain weight (33.47 g) was obtained from T_1 treatment and it was statistically identical with T_2 (1590 and 32.38 g) and T_3 (1500 and 30.76g) treatments and the lowest number of grains/panicle (1401) and 1000-grain weight (30.57 g) was recorded in T_4 treatment. The highest grain yield 4.52 t/ha was obtained in sole sorghum (T_5 treatment) due to no intercrop competition for growth resource like light, nutrient, moisture and space in sole cropping. This corroborates with the findings of Begum *et al.* (2016). Under intercropping the maximum grain yield 4.33 t/ha was recorded in T_1 treatment and it was statistically identical with T_2 (3.96 t/ha) and T_3 (3.81 t/ha) treatments. The lowest grain yield 3.67 t/ha was recorded in T_4 treatment. However, grain yield of sorghum in different treatments were attributed by the cumulative effect of yield components. Islam *et al.*, (2012) also reported similar result.

Table 1. Grain yield and yield attributes of sorghum in sorghum + bush bean intercropping system during *rabi* season 2021-22.

Treatment	Plant height (cm)	Panicle length (cm)	Grains/panicle (no.)	1000- grain wt. (g)	Grain yield (t/ha)
T_1	188.67	17.46	1646	33.47	4.33
T_2	186.67	16.83	1590	32.38	3.96
T_3	194.33	16.13	1500	30.76	3.81
T_4	190.00	15.40	1401	30.57	3.67
T_5	197.33	18.44	1841	36.25	4.52
LSD $_{(0.05)}$	NS	1.76	232	1.81	0.57
CV (%)	4.72	5.53	7.72	2.94	7.54

Green pod yield and yield contributing characters of bush bean

Plant/m^2, plant height, pods/plant, pod length (cm), 10-green pod weight (g) and green pod yield of bush bean was markedly differed by intercrop combination (Table 2). The maximum number of plant/m^2 of bush bean 58/ m^2 was obtained from T_6 treatment (Sole bush bean). Among the intercropping situation the maximum number of plant/m^2 of bush bean 44/ m^2 was obtained from T_2 treatment and the minimum number of plant/m^2 of bush bean 25/m^2 was recorded in T_3 treatment and it was statistically identical with T_1 (26/m^2) and T_4 (31/m^2) treatments due to variation of planting system. The highest plant height (47.41 cm), number of pod/plant (7.85), pod length (11.77 cm) and 10-green pod weight (57.43 g) was recorded in T_6 treatment (sole bush bean). Among the intercropping situation the highest plant height (44.97 cm) was obtained from T_3 treatment which was statistically identical with T_4 (41.11 cm) and T_1 (41.22 cm) treatments and the lowest plant height (37.40 cm) was obtained from T_2 treatment. Similar trend was found in case of pods/plant, pod length and 10-green pod weight. The maximum number of pods/plant (7.18), pod length (11.02 cm), and 10-green pod weight (50.70g) was obtained from T_3 treatment which was statistically identical with T_1 treatment. The minimum number of pods/plant (5.97), pod length (9.16 cm) and 10-green pod weight (47.05 g) was recorded in T_2 treatment. The highest green pod yield of bush bean 11.82 t/ha was obtained from T_6 treatment (Sole bush bean) due to higher plant population per unit area. There was no intercrop competition for growth resource in sole bush bean. Among the intercropping situation the highest green pod yield of bush bean 10.34 t/ha was obtained from T_2 treatment followed by T_4 (6.65 t/ha) and T_1 (5.17 t/ha) treatments. The lowest green pod yield of bush bean 4.43 t/ha was obtained from T_3 treatment due to the lowest number of plant population per unit area. The higher green pod yield in bush bean was attributed to maximum number of plant/m^2. Faruque *et al.,* (2006) also reported similar result.

Table 2. Green pod yield and yield attributes of bush bean under sorghum + bush bean intercropping system during *rabi* season 2021-22.

Treatment	Plant/m^2 (no.)	Plant height (cm.)	Pod/plant (no.)	Pod length (cm)	10- green pod weight (g)	Green pod yield(t/ha)
T_1	26	41.22	6.92	10.59	50.35	5.17
T_2	44	37.40	5.97	9.16	47.05	10.34
T_3	25	44.97	7.18	11.02	50.70	4.43
T_4	31	41.11	6.33	10.41	48.24	6.65
T_6	58	47.41	7.85	11.77	57.43	11.82
LSD $_{(0.05)}$	6.55	4.50	0.98	1.13	5.11	0.95
CV (%)	9.47	5.64	7.59	5.67	5.34	6.56

Sorghum and bush bean intercrop productivity was evaluated on the basis of sorghum equivalent yield (SEY) and land equivalent ratio (Bandyophadhyay, 1984). Sorghum equivalent yield (SEY) and land equivalent ratio have been presented in Table 3.

Sorghum equivalent yield

Sorghum equivalent yield expressed total productivity. Sorghum equivalent yield were higher in all the intercrops (6.03 to 9.13 t/ha) than the sole crop of sorghum 4.52 t/ha (Table 3). In intercrop combination the highest sorghum equivalent yield 9.13 t/ha was recorded in T_2 treatment followed by T_4 treatment 7.00 t/ha. The lowest sorghum equivalent yield 6.03 t/ha was obtained from T_3 treatment over the sole sorghum. Total productivity also increased of 101.99, 54.72, 52.99 and 33.30 at T_2, T_4, T_1 and T_3 treatments, respectively. Ahmed *et al.,* (2013) also reported that intercrop combination increase the equivalent yield.

Land equivalent ratio

Highest land equivalent ratio 1.75 was recorded in T_2 treatment followed by T_1 (1.40) and T_4 (1.37) treatments (Table 3) and the lowest land equivalent ratio 1.22 was recorded in T_3 treatment. LER of different crop combinations ranged from 1.22 to 1.75 which indicating land utilization increased 22 to 75% by intercropping. The mean value of LER (more than one) in all intercropping treatments indicated that land was more efficiently utilized under intercropping than sole cropping of sorghum and bush bean.

Table 3. Sorghum equivalent yield (SEY), land equivalent ratio (LER) and % increase of SEY over sole sorghum in sorghum + bush bean intercropping system during *rabi* season 2021-2022.

Treatment	SEY (t/ha)	% increase of SEY over sole sorghum	LER
T_1 (SNR + 1 row bush bean)	6.92	52.99	1.40
T_2(SNR + 2 rows bush bean)	9.13	101.99	1.75
T_3(SPR + 2 rows bush bean)	6.03	33.30	1.22
T_4(SPR + 3 rows bush bean)	7.00	54.76	1.37
T_5(Sole sorghum)	4.52	-	1.00
T_6(Sole bush bean)	5.91	-	1.00

Cost and return analysis

Cost and return analysis is an important tool to evaluate the economic feasibility of intercropping system and monetary advantage was evaluated according to Shah *et al.* (1991). Benefit cost analysis of bush bean with sorghum intercropping system have been presented in Table 4. Gross return and BCR depends on equivalent yield. Intercropping combination of bush bean with sorghum showed higher monetary return than sole crop of sorghum and bush bean (Table 4). The highest gross return (Tk. 1,82,600/ha) was recorded from T_2 treatment. This intercropping combination also gave the highest gross margin (Tk. 1,36,600/ha) and benefit cost ratio (3.97) and it was close to T_1 treatment owing to higher SEY (6.92 t/ha), gross return (Tk. 1,38,300/ha), gross margin (Tk. 94,300/ha) and benefit cost ratio (3.14). The lowest gross return (Tk. 1,20,500/ha), gross margin (Tk. 75,500/ha) and BCR (2.68) was obtained from T_3 treatment. The results of increased productivity and returns were consistent with the earlier reports of yield advantage of crop mixture compared to monoculture (Ahmed *et al*., 2013 and Islam *et al*., 2012).

Table 4. Benefit cost analysis of sorghum +bush bean intercropping under different planting system during *rabi* season of 2021-2022.

Treatment	Gross return (Tk./ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	Benefit cost ratio (BCR)
T_1 (SNR + 1 row bush bean)	1,38,300	44,000	94,300	3.14
T_2 (SNR + 2 rows bush bean)	1,82,600	46,000	1,36,600	3.97
T_3 (SPR + 2 rows bush bean)	1,20,500	45,000	75,500	2.68
T_4 (SPR + 3 rows bush bean)	1,39,900	48,000	91,900	2.91
T_5 (Sole sorghum)	90,400	42,000	48,400	2.15
T_6 (Sole bush bean)	1,18,200	43,000	75,200	2.75

Price: Sorghum: Tk. 20/Kg and Bush bean: Tk. 10/Kg.

Note: SEY= Sorghum equivalent yield (t/ha), LER= Land equivalent ratio.
T_1= Sorghum normal row 100% (60 cm × 20 cm) + 1 row bush bean in between two rows of sorghum 43.75% (30 cm × 5 cm), T_2= Sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean in between two rows of sorghum 87.50% (30 cm × 5 cm), T_3= Sorghum paired row 100% (30 cm/120 cm/30 cm× 20 cm) + 2 row bush bean in between two paired rows of sorghum 37.50% (30 cm × 5 cm), T_4= Sorghum paired row 100% (30 cm/120 cm/30 cm× 20 cm) + 3 row bush bean in between two paired rows of sorghum 56.25% (30 cm × 5 cm), T_5= Sole sorghum (60 cm × 20 cm) and T_6= Sole bush bean (30 cm × 5 cm).

Conclusion

The results revealed that all intercropping combination were productive and profitability than growing sole sorghum. Among the sorghum bush bean intercropping system, Sorghum normal row 100% (60 cm × 20 cm) + 2 rows bush bean 87.50% (30 cm × 5 cm) intercropping combination was found agronomically feasible and economically profitable in respect of SEY (Sorghum equivalent yield) and BCR (benefit cost ratio).

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SORGHUM- LEGUME STRIP CROPPING FOR RESOURCE CONSERVATION

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Abstract

A field experiment was conducted at the research field of Agronomy Division BARI, Gazipur during *rabi* season of 2020-21 to find out the effect of strip cropping on maintain sustainable productivity and conserve soil health. The research area belongs to AEZ-28. The soil was clay loam with pH 6.3. Four treatments viz., T_1= Sorghum 4 rows alternate with 8 rows garden pea, T_2= Sorghum 4 rows alternate with 8 rows lentil, T_3= Sorghum 4 rows alternate with 6 rows chickpea, T_4= Sole Sorghum 8 rows were used. The maximum grain yield of sorghum was observed in sole sorghum (3.77 t/ha). The maximum sorghum equivalent yield (5.49 t/ha) and gross return (Tk. 1,09,700/ha) was obtained from T_3 treatment (Sorghum 4 rows alternate with 6 rows chickpea strip cropping). But maximum gross margin (Tk. 35,767/ha) and benefit cost ratio (BCR) 1.49 were observed in T_2 treatment (Sorghum 4 rows alternate with 6 rows lentil strip cropping) due to lower cost of production. But maximum gross return, gross margin and benefit cost ratio (BCR) were higher in all strip plots than sole sorghum plot. The result revealed that the farmers can be benefited by cultivating any one sorghum legume strip cropping with higher productivity. But among the three strips cropping sorghum + chick pea strip cropping was economically profitable and agronomically feasible.

Introduction

Intercropping is a traditional practice in Bangladesh and it increases total productivity per unit area through maximum utilization of land, labour and growth resources (Ahmed *et al*., 2013; Islam *et al.,* 2006; Mahfuza *et al*., 2012). Strip cropping is like any other intercropping strategy based on the management of plant interactions to maximize growth and productivity caused by efficient use of plant growth resources such as light, water and nutrients (Glowacka, 2014). By judicious choice of compatible crops and adopting appropriate planting geometry, inter/intra specific competition may be minimized resulting higher total productivity as well as family income (Alom *et al.*,2013). Canopy architecture of tall stature crop regulates the availability of light on under storied crop (Faruque *et al.*, 2006). Strip cropping offers the possibility of yield advantage relative to sole cropping through yield stability and improved total yield as well as total productivity (Nazir *et al*., 2002; Malik *et al*., 2002; Bhatti *et al*., 2005). Strip cropping is a method of farming in which two or more crops are grown simultaneously into long narrow strips wide enough to permit independent cultivation but narrow enough to interact agronomical. Strip intercropping is de-fined as the production of two or more crops within the same field in strips wide enough that each can be managed independently by existing machinery; yet narrow enough that the strip components can interact. Strip cropping helps to maintain or improve the status of organic content in the soil, thereby enriching the soil fertility and enabling to develop more stable aggregates in the soil, increase in soil nitrogen, resulting from nitrogen fixation, associated to the legume crops. Sorghum is an un-branched and erect cereal crops with wide spacing. Sorghum grain is as nutritious as other cereal grains; contain about 11% water. 340 k/Cal of energy, 11.6% protein, 73% carbohydrate and 3% fat by weight (Thimmaiah, 2002, Taylor *et al*., 2006 and Yan *et al*., 2012). Sorghum is used as food, feed, fodder and fuel. Recently it is getting the special importance by the government of Bangladesh due to huge demand in medicine industry and low water required for cultivation. On the other hand legume crops can fix atmospheric nitrogen through symbiotic relationship with rhizobium bacteria and improves the soil fertility (Yadav *et al.*, 1994). Legume crops are excellent source of proteins and minerals for most of the peoples of Bangladesh. In addition, legume crops may increase soil fertility and organic matter content when incorporated into soil after harvest. Generally legumes in association with non-legumes not only helps in utilization of the nitrogen being fixed in the current growing season, but also helps in residual nutrients buildup of the soil (Sharma *et al*., 2009). Farmers often demand for quick return from their crops, so they can get quick return by growing sorghum with legume crops. Sorghum is a tall architecture stature crop that can help regulates the availability of light on under storied crop. So, strip cropping help to maintain or improve the status of organic content in the soil, thereby enriching the soil fertility and enabling to develop more stable aggregates in the soil, increase in soil nitrogen, resulting from nitrogen fixation, associated to the legume crops. The selection of plants with different developmental cycles and morphological structures enables more efficient utilization of nutrients, water, and light in strip cropping than in sole cropping. Thus, the experiment was undertaken to evaluate the effect of strip cropping on maintain sustainable productivity and conserve soil health.

Materials and Methods

The experiment was conducted at the research field of Agronomy Division BARI, Gazipur during *rabi* season of 2021-22. The soil of the research area belongs to AEZ-28. The soil was clay loam with pH 6.3. The experiment consisted of four different treatments viz., T_1= Sorghum 4 rows alternate with 8 rows garden pea, T_2= Sorghum 4 rows alternate with 8 rows lentil, T_3= Sorghum 4 rows alternate with 6 rows chickpea, T_4= Sole Sorghum 8 rows. The experiment was laid out in a RCB design with three replications. The unit plot size was 4.8 m × 9.0m. Seeds of sorghum (var. BARI Sorghum-1), garden pea (var. BARI Motorsuti-3) lentil (var. BARI Masur-6), and chickpea (var. BARI Chola-9) were sown on 23 November 2021 with maintaining spacing for sorghum 60 cm×20 cm, garden pea 30 cm×5 cm, lentil 30 cm×5 cm and chickpea 40 cm×5 cm. Recommended dose of fertilizer was applied to all crops (for sorghum: 120-48-75-30-3-1 kg/ha N-P-K- S-Zn- B; for garden pea 45-24-30-12-1.4 kg/ha N-P-K-S-Zn, lentil: 21-18-21-9-2-1.2 kg/ha N- P-K- S-Zn- B and for chickpea: 21-18-28-9-2-1.4 kg/ha N-P-K-S-Zn-B (FRG, 2018) in the form of urea, TSP ,MOP, Gypsum, Zinc sulphate and Boric acid. For sorghum one third of N, whole amount of TSP, MoP, gypsum, zinc sulphate and boric acid were applied as basal. Remaining 2/3 N was top dressed at 25 and 45 days after sowing (DAS) of sorghum under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. For other three crops all fertilizer were applied during final land preparation. Five t/ha of cowdung was applied to the crop before sowing. The seeds of all crops were treated with provex @ 3g/ kg of seed. A light irrigation was given after sowing of all seeds for proper germination. All intercultural operation and plant protection were done as and when required. Sorghum was harvested on 10 April 2022, Garden pea 01 February 2022, Lentil 15 March 2022 and Chickpea 04 April 2022. Sorghum equivalent yield (SEY) was calculated by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Islam *et al*., (2012) as given below:

$$\text{SEY} = \text{Yis} + \frac{\text{Yicp} \times \text{Pcp}}{\text{Ps}}$$

Where, Yis = Yield of intercropped sorghum, Yicp = Yield of component crops (garden pea, lentil and chickpea), Pcp = Market price of component crop (garden pea, lentil and chick pea) and Ps = Market price of sorghum. At harvest the yield data was recorded whole plot wise. Collected data of all crops were analyzed statistically and the means were adjudged using $LSD_{(0.05)}$ test. Economic analysis was also done considering local market price of harvested crops.

Result and Discussion

Grain yield of sorghum was significantly varied due to strip cropping of sorghum with garden pea, lentil, chickpea and sole crop of sorghum. Yield of sorghum varied from 1.56 t/ha to 3.77 t/ha due to influence exerted by different treatments. The highest grain yield 3.77 t/ha of sorghum was obtained from T_4 treatment (Sole sorghum). Among the strip cropping, the maximum grain yield 1.70 t/ha of sorghum was recorded in T_1 treatment (Sorghum 4 rows alternate with 8 rows garden pea) which was statistically identical with T_3 (1.62 t/ha) Sorghum 4 rows alternate with 6 rows chickpea pea) and T_2 (1.56 t/ha; Sorghum 4 rows alternate with 8 rows lentil) treatments (Table 1 and Fig. 1).

In case of component crop garden pea produced the maximum green pod yield (2.29 t/ha) from T_1 treatment (Sorghum 4 rows alternate with 8 rows garden pea) followed by chickpea seed yield 1.10 t/ha in the T_3 treatment **(**Sorghum 4 rows alternate with 6 rows chickpea pea) and the lowest seed yield 1.03 t/ha from T_2 treatment **(**Sorghum 4 rows alternate with 8 rows lentil) in case of lentil (Table 1 and Fig. 1)**.**

Sorghum equivalent yield expressed total productivity. Strip cropping influenced the yield of sorghum (Table 1 and Fig 1). Sorghum equivalent yield were higher in the entire strip cropping (5.14-5.49 t/ha) than the sole crop of sorghum (3.77 t/ha). In strip cropping combination, the highest sorghum equivalent yield 5.49 t/ha was recorded in T_3 treatment (Sorghum 4 rows alternate with 6 rows chickpea pea) followed by T_2 treatment (5.43 t/ha) and T_1 treatment (5.14 t/ha). The lowest sorghum equivalent yield was recorded in sole sorghum T_4 treatment (3.77 t/ha). The equivalent yield of sorghum was higher (36-46%) in all strip cropping, as compared to sole cropping of sorghum. The increase of sorghum equivalent yield occurred due to addition of component crop or its strong response to the edge effect (Glowacka, 2014) and efficient utilization of sunlight. This might also be related to the corresponding below ground root length growth and distribution advantages at later growth stages of the sorghum after the intercropped plants have been harvested (Xia *et al*., 2013). Ahmed *et al.*, (2013) also reported that intercrop/strip crop combination increase the equivalent yield.

Table 1. Grain yield of sorghum, component crop and sorghum equivalent yield (SEY) in sorghum legume strip cropping during *rabi* season 2021-22.

Treatment	Sorghum grain yield (t/ha)	Component crops yield (t/ha)	Sorghum equivalent yield (t/ha)	SEY increase over sole sorghum (%)
T_1= Sorghum 4 rows alternate with 8 rows garden pea	1.70	2.29	5.14	36
T_2= Sorghum 4 rows alternate with 8 rows lentil	1.56	1.03	5.43	44
T_3= Sorghum 4 rows alternate with 6 rows chickpea pea	1.62	1.10	5.49	46
T_4= Sole sorghum (8 rows)	3.77	-	3.77	
LSD $_{(0.05)}$	0.27	0.36		
CV (%)	6.30	10.62		

Market price (Tk./kg): Sorghum = 20, garden pea = 30, lentil= 75, Chick pea = 70. SEY = Sorghum equivalent yield (t/ha)

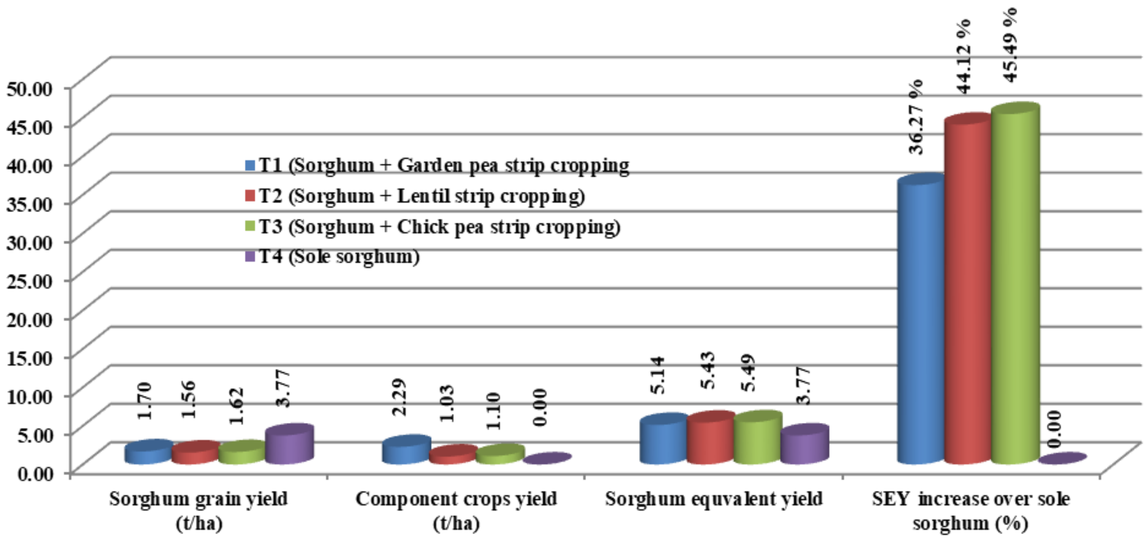

Fig 1: Grain yield (t/ha) of sorghum, Lentil, chick pea and green pod yield of garden pea, SEY (sorghum equivalent yield t/ha) and SEY increase over sole sorghum (%).

Cost and return analysis

Cost and return analysis is an important tool to evaluate the economic feasibility of intercropping system and monetary advantage was evaluated according to Shah *et al.* (1991). Benefit cost analysis of sorghum legume strip cropping system have been presented in Table 2. Gross return and benefit cost ratio (BCR) depends on equivalent yield. Strip cropping combination of sorghum with legume crops showed higher monetary return than sole crop of sorghum (Table 2). The highest gross return (Tk. 1,09,700/ha) was recorded from T_3 treatment (Sorghum 4 rows alternate with 6 rows chickpea pea). But the highest gross margin (Tk. 35,767/ha) and benefit cost ratio (1.49) was recorded in T_2 treatment (Sorghum 4 rows alternate with 8 rows lentil) due to lower cost of production and it was close to T_3 treatment (Sorghum 4 rows alternate with 6 rows chickpea) owing to gross margin (Tk. 34,000/ha) and benefit cost ratio (1.45). The lowest gross return (Tk. 75,400/ha), gross margin (Tk. 10,400/ha) and BCR (1.16) was obtained from sole sorghum T_4 treatment. The results of increased productivity and returns were consistent with the earlier reports of yield advantage of crop mixture compared to monoculture (Akhteruzzaman *et al*., 1991, Islam *et al*., 2012 and Ahmed *et al*., 2013).

Table 2. Cost and return analysis of sorghum legume strip cropping during *rabi* season 2021-22**.**

Treatment	SEY (t/ha)	Gross return (Tk/ha)	Cost of production (Tk/ha)	Gross margin (Tk/ha)	Benefit cost ratio
T_1	5.14	102750	71500	31250	1.44
T_2	5.43	108667	72900	35767	1.49
T_3	5.49	109700	75700	34000	1.45
T_4	3.77	75400	65000	10400	1.16

Market price (Tk./kg): Sorghum = 20, garden pea = 30, lentil= 75, Chick pea = 70

Conclusion

The results revealed that all strip cropping combination showed better productive and profitability than growing sole sorghum and farmers can be benefited by cultivating any one sorghum legume strip cropping with higher productivity. But among the three strip cropping's sorghum 4 rows alternate with 8 rows lentil strip cropping combination was found economically profitable and agronomically feasible.

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COMPATIBILITY OF MINOR CEREALS - GROUNDNUT INTERCROPPING

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Abstract

The experiment was conducted in agronomy research field, Bangladesh Agricultural Research Institute, Gazipur, during rabi 2021-22. The experiment was laid out in RCBD design with nine treatmentsi.e.T_1=(Groundnut:Sorghum=6:1),T_2=(Groundnut:Cheena=6:1),T_3=Groundnut: Cheena = 6:2), T_4 = (Groundnut:Kaon = 6:1), T_5= (Groundnut:Kaon = 6:2) and T_6 = Sole groundnut, T_7= (Sole sorghum), T_8 = (Sole cheena), T_9= (Sole kaon) . The highest groundnut equivalent yield as well as gross margin was found in Groundnut:Kaon = (6:1). Considering equivalent yields, land equivalent ratio (LER) values, competitive ratio (CR), relative crowding coefficient (RCC) and economic return, Groundnut: Cheena=(6:2) combination was found suitable.

Introduction

Groundnut is an important oilseed crop of Bangladesh and it prefers sandy loam soil, mainly in char region, during November to December. It is the third most important oilseed crop grown in Bangladesh. 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 occupy less than one percent (0.204%) of total cropped area (BBS 2020). On the other hand, minor cereals are also in the risk of existence as a result of crop competition. Their uses mainly confined in some bakeries and as bird feed. But minor cereals are highly nutritious and could be a better option for human nutrition. In this situation, intercropping provides an opportunity to avoid crop competition along with increased production (Rahman, 1999 and Mondal *et al.,* 1999). Research in different countries reveals that intercropping has several benefits like reduction in farm inputs, diversification of diet, addition of cash crops, increased labour utilization efficiency, reduced risk of crop failure, more efficient use of water resources, nutrients and reduced problems caused by pests, diseases and weeds (Awal et al., 2006). Considering the above issues, the proposed study was undertaken to find out the compatibility of minor cereals intercropped with groundnut.

Materials and Methods

The experiment was conducted in agronomy research field, Bangladesh Agricultural Research Institute, Gazipur, during rabi 2021-22. The experiment was laid out in RCBD design with nine treatments i.e. T_1=(Groundnut:Sorghum= 6:1), T_2=(Groundnut:Cheena= 6:1), T_3= (Groundnut:Cheena = 6:2), T_4 = (Groundnut:Kaon = 6:1), T_5 = (Groundnut:Kaon= 6:2) and T_6= Sole groundnut, T_7= (Sole sorghum), T_8 = (Sole cheena), T_9= (Sole kaon) . BARI Cheenabadam-8, BARI sorghum-1, Tushar and BARI kaon-3 were respectively taken as groundnut, sorghum, cheena and kaon verieties. Twelve rows of groundnut were sown in line with adjusted row to row distance for each treatment along with 15 cm plant to plant distance in 5.4 m × 3.6 m plot. Sorghum, cheena and kaon are used as additve series and are sown in between two rows of grondnut and as of treatment combination (row to row distance for 6:1 combination= 24 cm, for 6:2 combination= 20 cm and plant to plant distance for groundnut=15 cm, cheena, kaon = 5 cm). The plants were fertilized with 15- 80- 60- 60-1.8 kg/ha of N-P-K-S-B respectively. Half N and all of other fertilizers were applied during final land preparation. Rest half N was applied at 40-45 DAS. Irrigation was done as and when necessary. Data on grain yield (Kg/ha), tillers per plant, panicles per plant and 1000-grain weight were collected for cereals while seeds per pod, pods per plant, number of primary branches per plant, 100-seed weight and shelling percentage were collected for groundnut.

Crops were harvested as whole plot basis. Mean comparison among the treatments was made by LSD test at 5% level of significance.

Groundnut equivalent yield (GEY): Groundnut equivalent yield was calculated as;

(GEY) = Yig + (Yia × Pa)/Pg

Where, Yig= Yield of intercrop groundnut, Pg= Price of groundnut, Pa= Price of other intercrop component “a” and Yia= Yield of intercrop “a”

Economic Analysis: To determine the most profitable groundnut-minor cereal intercropping pattern, economic analysis was done through;

Gross margin (Tk/ha) = Gross returns (Tk/ha) - Cost of cultivation (Tk/ha)

Benefit cost ratio (BCR) = Gross return (Tk/ha) / Cost of cultivation (Tk/ha)

Land equivalent Ratio (LER): To determine land use efficiency LERs were calculated thus:

LER= La + Lb = Ya / Sa + Yb / Sb

Where La and Lb = Partial LERs of crop a (sorghum) and b (groundnut)
Ya and Yb = Individual crop yields in intercropping,
Sa and Sb = Individual crop yields in sole crop and intercrop.

Competitive Indices: Two measures of competitiveness of crops in intercropping, namely, competitive ratio (CR) and the relative crowding coefficient (RCC) were calculated as follows:

(i) Competitive Ratio, CR

CRa = {(Yia/Ysa)/(Yib/Ysb)} x (Zb / Za)
CRb = {(Yib/Ysb)/(Yia/Ysa)} x (Za / Zb)

Where:

CRa = Competitive Ratio of crop ‘a’
CRb = Competitive Ratio of crop ‘b’
Yia = Yield of intercrop crop ‘a’
Ysa = Yield of sole crop ‘a’
Yib = Yield of intercrop crop ‘b’
Ysb = Yield of sole crop ‘b’
Za = Proportion of crop ‘a’ in intercrop
Zb = Proportion of crop ‘b’ in intercrop

(ii) Relative Crowding Coefficient, RCC

RCCa = {(Yia × Zb)/(Ysa – Yia)} × Za
RCCb = {(Yib × Za)/(Ysb – Yib)} × Zb

Where:

RCCa = Relative Crowding Coefficient of crop ‘a’
RCCb = Relative Crowding Coefficient of crop ‘b’
Yia = Yield of intercrop crop ‘a’
Ysa = Yield of sole crop ‘a’
Yib = Yield of intercrop crop ‘b’

Ysb = Yield of sole crop ‘b’
Za = Proportion of crop ‘a’ in intercrop
Zb = Proportion of crop ‘b’ in intercrop

Results and Discussion

(A) Yield and Yield Components

Groundnut:

Yield and yield attributes of groundnut as influenced by different intercropping treatments are presented in Table 1. Among the intercropped treatments, the maximum plant height, number of pods/plant, pod yield/plant and pod yield/ha were recorded from groundnut/Kaon combination (T_4). Higher number of pods and pod yields/plant were obtained from the sole groundnut (T_6). The highest pod yield of groundnut from sole might be due to higher number of pods/plant and pod yield/plant. The highest pod yield from the sole was also reported by Mondal *et al* (2004).

Sorghum

The performance of sorghum in both intercrop and sole crops in respect to yield and its components is given in Table 2. Intercropping significantly affected the yield of sorghum. The highest grain yield was found in sole sorghum (T_7). There was little difference in 1000-grain weight between the treatments. Similar result was reported by Langat *et al* (2006).

Cheena

The performance of cheena in both intercrop and sole crops in respect to yield and its components is given in Table 2. Intercropping significantly affected the yield of cheena. The highest grain yield was found in sole cheena (T_8). Among the intercropped treatments, higher grain yield was found in T_3. There was little difference in 1000-grain weight between the treatments.

Kaon

The performance of kaon in both intercrop and sole crops in respect to yield and its components is given in Table 2. Intercropping significantly affected the yield of kaon. The highest grain yield was found in sole kaon (T_8). Among the intercropped treatments, higher grain yield was found in T_5. There was little difference in 1000-grain weight between the treatments.

(B) Economic analysis

Monetary returns for the various cropping systems are presented in Table 3. Most intercrop combinations were more profitable than sole crops. The highest groundnut equivalent yield as well as gross margin was found in T_3 followed by T_1 and T_4. These gross margin were higher than those from sole crops.

(C) Competitive Indices

Relative Crowding Coefficient (RCC):

The RCC for groundnut were consistently higher in 6:1 ratios but lower in 6:2 ratios (Table 4). This indicated a generally more competitive ability of the cereal over the legume component. The RCC above unity mean that by introducing those combinations in groundnut fields, cereals will not have a negative effect on the groundnut. Also an RCC less than unity means that higher yield than expected has been realized.

Competitive Ratios

All competitive ratios (CRs) were less than 1 in all intercrop treatments (Table 4). This index measures the existence of a yield advantage, such that if the competitive ratio is less than 1, then there is an advantage in intercropping (Willey, 1981). Thus, all intercropping patterns were advantageous over sole cropping except T_2 and T_5.

Land Equivalent Ratio (LER):

The values of LERs indicated better land use in all intercrop treatments (Table 4). All the intercrop pattern showed yield advantages between 11% (LER =1.11) in T_2 and 42% (LER =1.42) in T_3. The higher yield advantages realized in intercropping were possibly because the vegetative and reproductive phases of the component crops did not coincide.

Conclusion

Intercropping minor cereals with groundnut gave maximum productivity as well as economic return than monoculture of component crops. Considering equivalent yields, land equivalent ratio (LER) values, competitive ratio (CR), relative crowding coefficient (RCC) and economic return, Groundnut : Cheena (6:2) combination was found superior i.e, two rows cheena in between six rows of groundnut could be accommodated for higher productivity with profitability for the farmers instead of sole crops.

Table 1. Growth parameters and pod yield of groundnut as influenced by intercropping groundnut and minor cereals during rabi 2021-22

Treatment	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	Pod yield/ plant (g)	Pod Yield (t/ha)
T_1 (Groundnut:Sorghum = 6:1)	56.33	4.33	21.33	81.07	2.37
T_2 (Groundnut:Cheena = 6:1)	56.33	3.67	18.00	68.40	2.00
T_3 (Groundnut:Cheena = 6:2)	48.33	3.33	16.67	63.33	1.85
T_4 (Groundnut:Kaon = 6:1)	65.00	5.67	23.00	87.40	2.56
T_5 (Groundnut:Kaon = 6:2)	41.67	5.00	13.00	49.40	1.44
T_6 (Sole groundnut)	67.33	4.33	26.00	98.80	2.89
$LSD_{(0.05)}$	9.33	1.77	2.37	9.02	0.26
CV(%)	5.90	14.21	4.25	4.25	4.26

Table 2. Grain yield and yield attributes of minor cereals as influenced by intercropping with groundnut and as sole during rabi 2021-22

Treatment	Crop	1000 SW	Yield (t/ha)	GEY
T_1 (Groundnut:Sorghum = 6:1)	Sorghum	33.20	1.18	3.55
T_2 (Groundnut:Cheena = 6:1)	Cheena	4.64	0.83	3.00
T_3 (Groundnut:Cheena = 6:2)	Cheena	4.53	1.56	3.72
T_4 (Groundnut:Kaon = 6:1)	Kaon	1.96	0.91	3.47
T_5 (Groundnut:Kaon = 6:2)	Kaon	1.92	1.78	3.22
T_7 (Sole sorghum)	Sorghum	34.20	2.85	2.85
T_8 (Sole cheena)	Cheena	4.59	2.00	2.40
T_9 (Sole kaon)	Kaon	1.97	2.20	2.20

* Market price: Groundnut- Tk 100/kg, sorghum- Tk 100/kg, cheena- Tk 120/kg, kaon- Tk 100/kg

Table 3. Yield, Groundnut Equivalent yield and economic analysis of groundnut and carrot intercropping during rabi 2021-22

Treatment	GEY	Gross return	Total Cost	Gross margin	BCR
T_1 (Groundnut:Sorghum = 6:1)	3.55	355000	65000	290000	5.46
T_2 (Groundnut:Cheena = 6:1)	3.00	299600	65000	234600	4.61
T_3 (Groundnut:Cheena = 6:2)	3.72	372000	65000	307000	5.72
T_4 (Groundnut:Kaon = 6:1)	3.47	347000	65000	282000	5.34
T_5 (Groundnut:Kaon = 6:2)	3.22	322000	65000	257000	4.95
T_6 (Sole groundnut)	2.89	289000	55000	234000	5.25
T_7 (Sole sorghum)	2.85	285000	60000	225000	4.75
T_8 (Sole cheena)	2.4	240000	55000	185000	4.36
T_9 (Sole kaon)	2.2	220000	55000	165000	4.00

* Market price: Groundnut- Tk 100/kg, sorghum- Tk 100/kg, cheena- Tk 120/kg, kaon- Tk 100/kg

Table 4. Land equivalent Ratio (LER), competitive ratio (CR) and relative crowding coefficient (RCC) as influenced by intercropping minor cereals with groundnut

Treatment	LER	CR		RCC	
		Cereal	Groundnut	Cereal	Groundnut
T_1 (Groundnut:Sorghum = 6:1)	1.23	1.22	0.82	0.29	1.89
T_2 (Groundnut:Cheena = 6:1)	1.11	1.45	0.69	0.29	0.93
T_3 (Groundnut:Cheena = 6:2)	1.42	1.47	0.68	2.94	1.47
T_4 (Groundnut:Kaon = 6:1)	1.30	1.13	0.89	0.29	3.21
T_5 (Groundnut:Kaon = 6:2)	1.31	1.96	0.51	3.51	0.82

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LONG TERM EFFECT OF FOUR CROP BASED CROPPING PATTERN ON SOIL HEALTH AND CROP PRODUCTIVITY

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Abstract

The experiment was conducted at the Research Field of Agronomy Division BARI, Gazipur (AEZ 28), during rabi season of 2017-18 to2020-21 to increase cropping intensity and productivity in rice based cropping pattern along with maintaining soil health. Four treatments of cropping sequence were: CP_1=Mustard-Mungbean-T. Aus-T.aman; CP_2=Potato-Mungbean-T.Aus- T.aman; CP_3=Garden pea-Mungbean-T.Aus-T.aman; CP_4=Potato-Red amaranth-Maize-T.aman. The results showed that four crops could be grown successfully one after another in a sequence in all the cropping patterns. The highest Rice Equivalent Yield (REY) was recorded from the cropping sequence CP_4 (38.44). The highest gross margin was obtained from CP_4 (Tk.491873). The highest benefit cost ratio (BCR) was found in CP_4 (3.46). Increased nitrogen level was found in al cropping patterns (70.18, 60.32, 57.58 and 57.41 percent in CP_4, CP_2, CP_1 and CP_3 respectively). Amount of phosphorus were also increased in all patterns (41, 38.50, 15.33 and 11.67 percent in CP_4, CP_3, CP_1 and CP_2 respectively). Potassium content was also increased in all the patterns (114.29, 70, 60 and 32.86 percent in CP_4, CP_3, CP_1 and CP_2 respectively).Sulfur is likely to be limiting. Micro elements like boron and zinc, levels were decreased in all the cropping patterns. Considering crop productivity and soil nutrient changing trends, CP_4 (Potato-Red amaranth-Maize-T.aman) was found the most suitable pattern for sustainable crop production along with maintaining soil health.

Introduction

Bangladesh is predominantly a rice growing country and rice is the staple food. Rice occupies about 74% of the total cropped area and is cultivated in three seasons in a year (BBS, 2017). In rice based cropping pattern, T.*aman*-Fallow-*Boro*-Fallow is dominant where cropping intensity is 200% (Aziz *et al.,* 2011). Some short duration crops like red amaranth, spinach may be included in the existing pattern for increasing productivity, cropping intensity and food security. Acute shortage of edible oil has been prevailing in Bangladesh during last several decades.

Rapeseed-mustard production can be increased by 20-25% only replacing traditional variety by high yielding short duration varieties like BARI Sarisha-14 and BARI Sarisha-15 in T.*aman*-mustard- *Boro* cropping pattern in some areas (Wahhab *et al.*, 2002). Most of the farmers are growing short duration vegetable such as red amaranth during the *rabi* season. Garden pea is also grown mainly for green pod to get tender seeds. Green pods are rich in vitamins, protein and minerals.

Mungbean (*Vigana radiata* L.) is a short duration pulse crop in Bangladesh which contains 51% carbohydrates, 26% protein, 4% mineral and 3% vitamins (Kaul, 1982). It can improve soil health by fixing atmospheric nitrogen. Being a short duration crop it fits well into the intensive cropping system (Ahmed *et al*., 1978). Inclusion of potato, spinach, mungbean and T. aus in T.*aman*-Fallow-*Boro*-Fallow cropping pattern would generate employment and additional income for the rural poor and save foreign exchange.

Considering the above issues, the study was undertaken to increase cropping intensity and productivity through crop intensification in rice based cropping system and find out its effect on soil health.

Materials and Methods

The experiment was conducted at the Research Field of Agronomy Division BARI, Gazipur (AEZ 28. Four treatments of cropping sequence were: CP_1 = Mustard-Mungbean-T. Aus-T.aman; CP_2 = Potato-Mungbean-T.Aus-T.aman; CP_3=Garden pea-Mungbean-T. Aus-T.aman; CP_4= Potato-Lalshak-Maize-T.aman. The experiment was laid out in a RCB design with 3 replications. The unit plot size was 4.8 m x 4.2 m. Different dates of operation and durations followed are described in the following table:

Pattern	Crop	Sowing/ Transplanted time	Harvesting time	Crop Covering
Pattern 1	Mustard	November 15	January 30	340
	Mungbean	February 1	March 28	
	T. *aus*	April 2	July 11	
	T. *aman*	July 15	November 3	
Pattern 2	Potato	November 15	January 24	335
	Mungbean	February 1	March 27	
	T. *aus*	April 2	July11	
	T. *aman*	July 15	November 3	
Pattern 3	Garden Pea	November 15	January 18	315
	Mungbean	February 1	March 27	
	T. *aus*	April 2	July 11	
	T. *aman*	July 15	November 3	
Pattern 4	Potato	November 15	January 24	331
	Red amaranth	January 27	February 25	
	Maize	March 1	July 1	
	T. *aman*	July 15	November 3	

Potato tubers (cv. Diamant) were planted in *rabi* season with 60 cm × 25 cm spacing. Half of urea, full amount of other fertilizers (@ 330-200-280-100-8-6 kg/ha of urea-TSP-MoP-gypsum-zinc sulphate-boric acid respectively) and full amount of CD (@ 10 t/ha) were applied as basal. The remaining ½ N was top-dressed at 30 days after planting (DAP) followed by earthing up and irrigation. Other irrigations were given at 40 and 60 DAP. Intercultural operations were done as and when required. Tuber yield was taken from whole plot. Residue was incorporated to the soil.

Mustard (var. BARI Sarisha-14) was grown during *rabi* season. Mustard was sown with 30 cm × 5 cm spacing. Half of urea, full amount of other fertilizers (@ 280-170-90-160-6-10 kg/ha of urea-TSP-MoP-gypsum-zinc sulphate-boric acid, respectively) and full amount of CD (@ 10 ton/ha) were applied as basal. The remaining ½ N was top-dressed as the first flower appeared. Irrigations were given at 25 and 55 days after sowing (DAS). Intercultural operations were done as and when required. Seed yield was taken from whole plot.

Garden pea (var. BARI Motorshuti-3) was grown during *rabi* season with 30 cm × 5 cm spacing. A pre-sowing irrigation was given for proper emergence of the crop. Full amount of fertilizers (@ 30-80-40-50-7 kg/ha of urea-TSP- MoP- gypsum - boric acid, respectively) were applied as basal during final land preparation. Two irrigations were given at 25 and 45 days after sowing (DAS). Intercultural operations were done as and when required. Green pod of garden pea was harvested and pod yield was taken from whole plot. Residue was incorporated to the soil.

Red amaranth (var. BARI lal shak-1) was broadcasted during early *Kharif-I* season. A pre-sowing irrigation was given for proper emergence of the crop. Intercultural operations were done as and when required. Leafy vegetable yield was taken from whole plot. Mung bean was grown during *Kharif-I* season. Full amount of fertilizer (Urea-TSP-MP @ 40-80-35-115 kg/ha) were applied at the time of final land preparation. Mung bean seeds (var. BARI Mung-6) were sown in continuous line with 30 cm row to row spacing. A pre-sowing irrigation was given for proper emergence of the crop. Anther irrigation was given at 35 days after sowing (DAS). Intercultural operations were done as and when necessary. Grain yield and biomass weight of mung bean were taken from entire plot. After harvesting of pods, mung bean plants were incorporated into the soil. Residue was incorporated to the soil.

Maize (var. BARI hybrid maize-9) was sown during *Kharif* season. One third urea and full amount of other fertilizers (Urea-TSP- MoP-Gypsum-Boron @ 250-130-90-125-8kg/ha) were applied at the time of final land preparation. Rest of the urea was top dressed in two equal splits at 20 and 40 days after seedling emergence. Maize was sown at 60 cm × 20 cm spacing. A pre-sowing irrigation was given for proper emergence of the crop. Three irrigations were provided at 20, 40 and 75 days after sowing (DAS). Intercultural operations were done as and when required.

Transplanted *aus* (var. Parija) rice was transplanted (twenty five days aged seedling) with 15cm × 15 cm spacing. One third urea and full amount of TSP and MoP @ 135-55-85 kg/ha, respectively, were applied as basal during final land preparation. Rest of the urea was applied in two equal splits at 15 and 45 days after transplanting (DAT). Intercultural operations were done when necessary. Grain yield was taken from whole plot.

Transplanted *aman* (var. BRRI dhan 62) rice (twenty five days aged seedling) was transplanted during Kharif II season. One third urea and full amount of TSP, MoP and gypsum @ 150-55-85-60 kg/ha, respectively, were applied as basal during final land preparation. Rest of the urea was applied in two equal splits at 15 and 40 days after transplanting (DAT). Intercultural operations were done when necessary. Grain yield was taken from whole plot.

Yield

At maturity, crops were harvested, processed and dried up to recommended moisture level for each crop. Then whole plot yield were taken and yield per hectare were calculated. The rice equivalent yield (REY) was calculated to compare system performance by converting the yield of non-rice crops into equivalent rice yield on a price basis, using the formula: REY = $Y_x(P_x/P_r)$, where Y_x is the yield of non-rice crops (kg/ha), P_x is the price of non-rice crops (Tk./kg), and P_r is the price of rice (Tk./kg). Prices of individual inputs and outputs were assumed to be stable during the experimental period. For calculating system productivity, rice yield of wet season and rice equivalent yield of dry season crops were summed up and expressed as kg/ha.

Economic analysis

Gross margin (Tk/ha) and benefit cost ratio (BCR) were calculated by considering the sale prices of different wet and dry season crops and cost of cultivation. Economics based on the average data of the different crops was computed by using variable cost and income from sale of rice and dry season crops. The variable cost of cultivation of rice and other crops included cost involved in different operations (eg. rice nursery raising, tillage for seed bed preparation, field preparation, seeding, weeding, harvesting, threshing) and the inputs (seed, irrigation, fertilizers, agro-chemicals and labors) used for raising the crops. The cost of cultivation was kept same for both growing cycle. Minimum market price (Rice: 18/-, Mustard: 55/-, Mungbean: 65/-, Maize: 20/-, Potato: 10/-, Red amaranth: 15/-, Gardenpea: 30/- per kg) were taken as the prevailing price in the local markets at the time of harvest. Gross margin, benefit ratio (BCR), land use efficiency, production efficiency and economic efficiency were calculated by the following formulas:

Gross margin (Tk/ha) = Gross returns (Tk/ha) - Cost of cultivation (Tk/ha)
Benefit cost ratio (BCR) = Gross margin (Tk/ha) / Cost of cultivation (Tk/ha)
Land use efficiency = (Number of days land is used in a year × 100) / 365
Production efficiency (kg/ha/day) = Grain yield (kg/ha) / total duration of crops (days)
Economic efficiency (Tk./ha/day) = Gross margin (Tk./ha)/ total duration of crops (days)

Soil nutrient analysis

Soil sample were collected at 15 cm depth with auger. Nitrogen was estimated following modified Kjeldahl method (Subbiah and Asija, 1956). Phosphorus was estimated following Olsen's method (Olsen *et al*., 1954) as the soil pH was nearly neutral. Potassium was estimated with the help of flame photometer (Toth and Prince, 1949). Sulfur was estimated using barium sulphate precipitation method (Singh *et al*., 1999). Boron was estimated through hot water extraction of soil as developed by Berger and Truog (1939). Zinc was estimated through extraction method using EDTA + ammonium carbonate extractant (Singh *et al*., 1999).

Results and Discussion

Yield

Yield of different component crops in each cropping pattern has been presented in Table 1.

CP_1 = Mustard- Mungbean-T. *Aus*- T. *Aman*

In CP_1, average yield of mustard, mungbean, T. *aus* and T. *aman* were found 1.41, 1.12, 3.42 and 4.47 t/ha respectively where the beginning yield of those crops were 1.40, 1.12, 3.41 and 4.45 t/ha respectively (Table 1). Yield of those crops shown consistency in spite of intensive cultivation.

CP_2: Potato- Mungbean- T. *aus*- T. *aman*

In CP_2, average yield of potato, mungbean, T. *aus* and T. *aman* were found 20.79, 1.14, 3.31 and 4.40 t/ha respectively where the beginning yield of those crops were 20.38, 1.25, 3.25 and 4.31 t/ha respectively (Table 1). Yield of those crops shown consistency in spite of intensive cultivation.

CP_3 = Garden pea- Mungbean- T. *aus*- T. *aman*

In CP_3, average yield of garden pea, mungbean, T. *aus* and T. *aman* were found 5.02, 1.10, 3.26 and 4.48 t/ha respectively where the beginning yield of those crops were 4.97, 1.15, 3.18 and 4.43 t/ha respectively (Table 1). Yield of those crops shown consistency in spite of intensive cultivation.

CP_4: Potato- Red amaranth-Maize- T. *aman*

In CP_4, average yield of potato, red amaranth, maize and T. *aman* were found 20.36, 15.13, 9.07 and 4.44 t/ha respectively where the beginning yield of those crops were 19.25, 15.38, 9.13 and 4.34 t/ha respectively (Table 1). Yield of those crops shown consistency in spite of intensive cultivation.

Rice equivalent yield

Total productivity of different cropping patterns in terms of rice equivalent yield (REY) is presented in Table 2. Rice equivalent yield varied under different cropping patterns. The highest average REY was recorded from CP_4 (38.44 t/ha) and the lowest REY (16.23 t/ha) was obtained from CP_1. High value crop with higher yield or crop with huge yield results in higher rice equivalent yield.

Economic Analysis

Economic analysis of different cropping patterns is shown in Table 4. The highest average gross margin (Tk. 491873) was obtained from and the lowest was found in CP_1 (Tk. 184848). Pattern with higher rice equivalent yield produce higher gross margin. The highest BCR (average) was found in CP_4 (3.46) and the lowest was found in CP_2 (2.32). Cropping pattern with higher yield produce higher BCR while with higher input i.e. seed cost produce lower BCR. The highest average land use efficiency was found in CP_4 (98.68) meaning maximum utilization of resources and the lowest was in CP_3 (86.30). The highest average production efficiency was found in CP_4 (116.13 kg/ha/day) meaning maximum output of system and the lowest was in CP_1 (47.75 kg/ha/day). The economic efficiency was also found highest in CP_4 (1486.02 Tk./ha/day) meaning maximum income and the lowest was in CP_1 (540.85 Tk./ha/day and 542.44 Tk./ha/day). Production efficiency is related to yield. So, cropping pattern with higher yield i.e. REY produce higher production efficiency. Economic efficiency is related to gross margin. So, cropping pattern with higher gross margin produces higher economic efficiency.

Soil nutrient analysis

Nitrogen

Nitrogen was estimated following modified Kjeldahl method (Subbiah and Asija, 1956). Nitrogen level was found increased in all the patterns (figure 7). Highest nitrogen increase was found in CP_4 (70.18%). This increase might be due to left over nitrogenous fertilizer and decomposed crop residues.

Phosphorus

Amount of phosphorus was increased in all the patterns (figure 7). Highest phosphorus increase was found in CP_4 (41%). This might be due to incorporation of plant residues after each cropping and left over fertilizer after plant uptake.

Potassium

Potassium was estimated with the help of flame photometer (Toth and Prince, 1949). Amount of potassium was increased in all the patterns (figure 7). Highest potassium increase as found in CP_4 (70.18%). Increase of potassium might be due to incorporation of plant residues after each cropping and left over fertilizer after plant uptake.

Sulfur

Sulfur was estimated using barium sulphate precipitation method (Singh *et al*., 1999). Sulfur level were improved in all the patterns except CP_1, where sulfur levels were decreased (figure 7) meaning more sulfur fertilization needed for this pattern.

Boron

Boron was estimated through hot water extraction of soil as developed by Berger and Truog (1939). In all the patterns, boron levels were decreased (figure 7) meaning more boron fertilization needed for this pattern.

Zinc

Zinc was estimated through extraction method using EDTA + ammonium carbonate extractant (Singh *et al*., 1999). In all the patterns, zinc levels were decreased (figure 7) meaning more zinc fertilization needed for this pattern.

Conclusion

Potato (var. Diamant)- Red amaranth (BARI lalshak 1) –Maize (BHM-9) - T. *aman* (Parija) was found economic among the four examined patterns and it was the most suitable pattern for sustainable crop production along with maintaining soil health. Crop productivity and soil nutrient status vary over time due to intensive cropping.

Table 1. Yield of crops in different cropping pattern during 2017-18 to 2020-21

Crop. pattern	Season	Yield (t/ha)							
		Potato	Mustard	Garden pea	Red amaranth	Mung	Maize	T. aus	T. aman
CP_1	2017-18	-	1.40	-	-	1.12	-	3.41	4.45
	Av. up to 2020-21	-	1.41	-	-	1.12	-	3.42	4.47
CP_2	2017-18	20.38	-	-	-	1.25	-	3.25	4.31
	Av. up to 2020-21	20.79	-	-	-	1.14	-	3.31	4.40
CP_3	2017-18	-	-	4.97	-	1.15	-	3.18	4.43
	Av. up to 2020-21	-	-	5.02	-	1.10	-	3.26	4.48
CP_4	2017-18	19.25	-	-	15.38	-	9.13	-	4.34
	Av. up to 2020-21	20.36	-	-	15.13	-	9.07	-	4.44

Table 2. Rice equivalent yield (REY) from different cropping patterns during 2017-18 to 2019-20

Crop. pattern	Yield (t/ha)								
	Potato	Mustard	Garden-pea	Red amaranth	Mung	Maize	T. aus	T. aman	Total
CP_1		4.31			4.03		3.42	4.47	16.23
CP_2	11.55				4.11		3.31	4.40	23.38
CP_3			8.37		3.96		3.26	4.48	20.06
CP_4	11.31			12.61		10.08		4.44	38.44

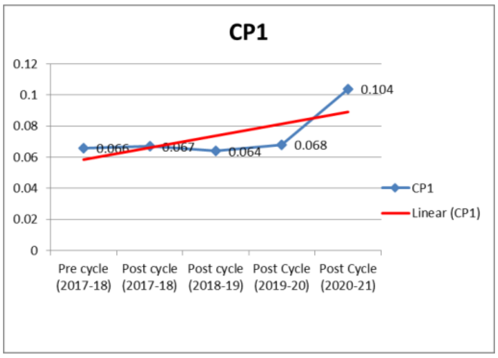
Table 3: Total variable cost in different cropping pattern

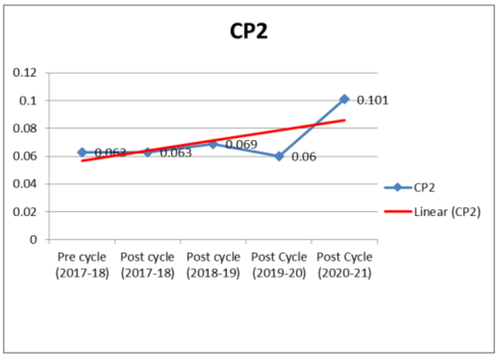
Crop. pattern	Total Cost of Production (Tk/ha)								
	Potato	Mustard	Garden-pea	Red amaranth	Mung	Maize	T. aus	T. aman	Total
CP_1		18,928			13,370		33,434	41,620	107352
CP_2	92,677				13,370		33,434	41,620	181101
CP_3			25,200		13,370		33,434	41,620	113624
CP_4	92,677			15,750		50000	-	41,620	200047

Table 4: Economic analysis from different cropping patterns

Cropping pattern	Gross Margin (TK/ha)	BCR	Land use efficiency	Production efficiency (kg ha^{-1} day^{-1})	Economic efficiency (Tk. ha^{-1} day^{-1})
CP_1	184848	2.72	93.15	47.75	543.67
CP_2	239739	2.32	91.78	69.79	715.64
CP_3	225023.7	3.12	86.30	63.69	714.36
CP_4	491873	3.46	98.68	116.13	1486.02

Market price (Tk/kg): Rice: 18/-, Mustard: 55/-, Mungbean: 65/-, Maize: 20/-, Potato: 10/-, Red amaranth: 15/-, Gardenpea: 30/-





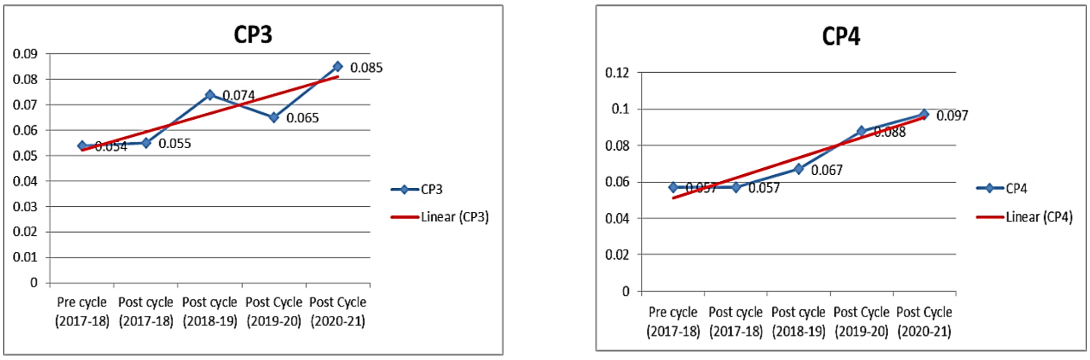


Fig. 1: Changes in N% over time

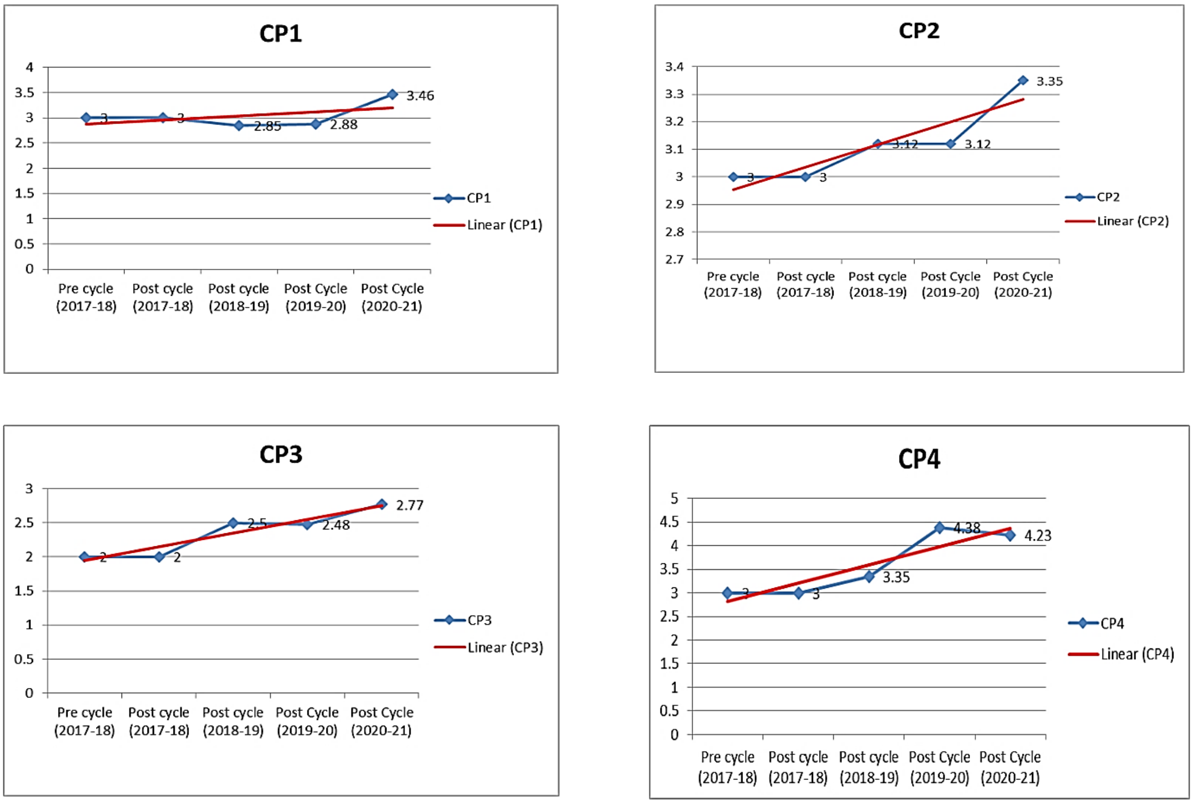
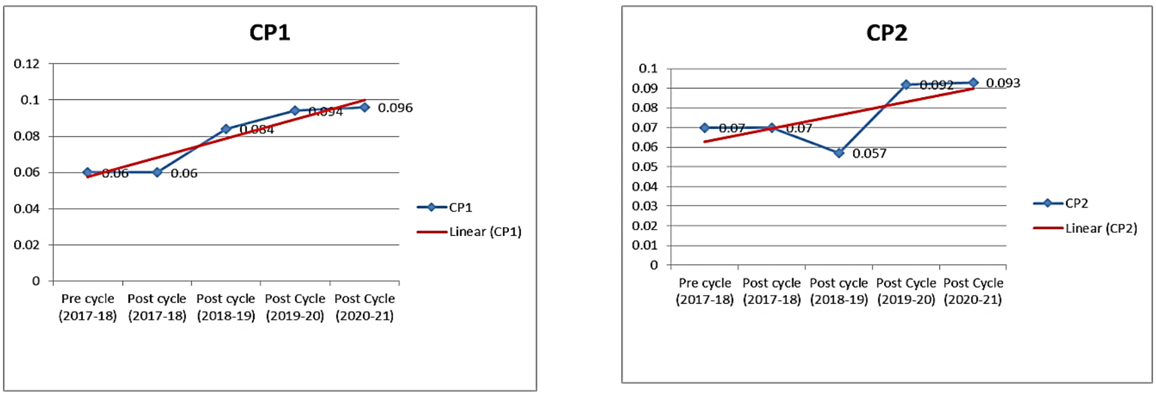


Fig. 2: Changes in P (μg/g) over time



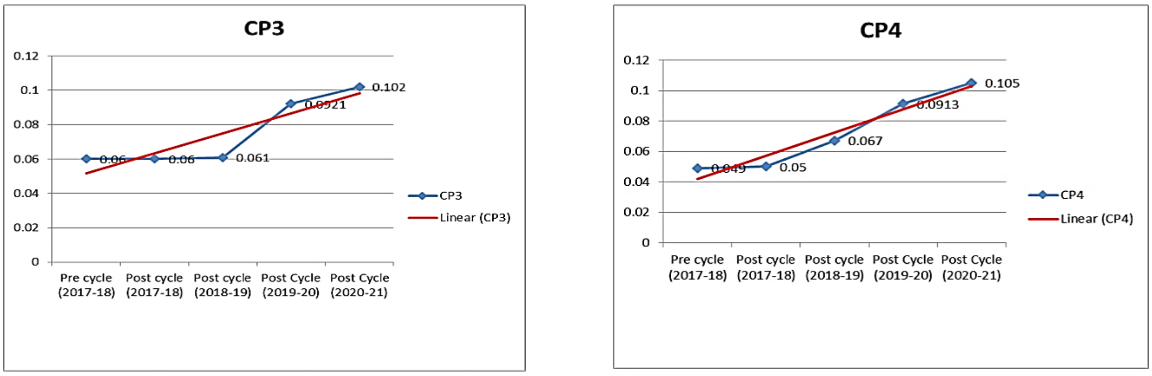


Fig. 3: Changes in K (meq/100 g) over time

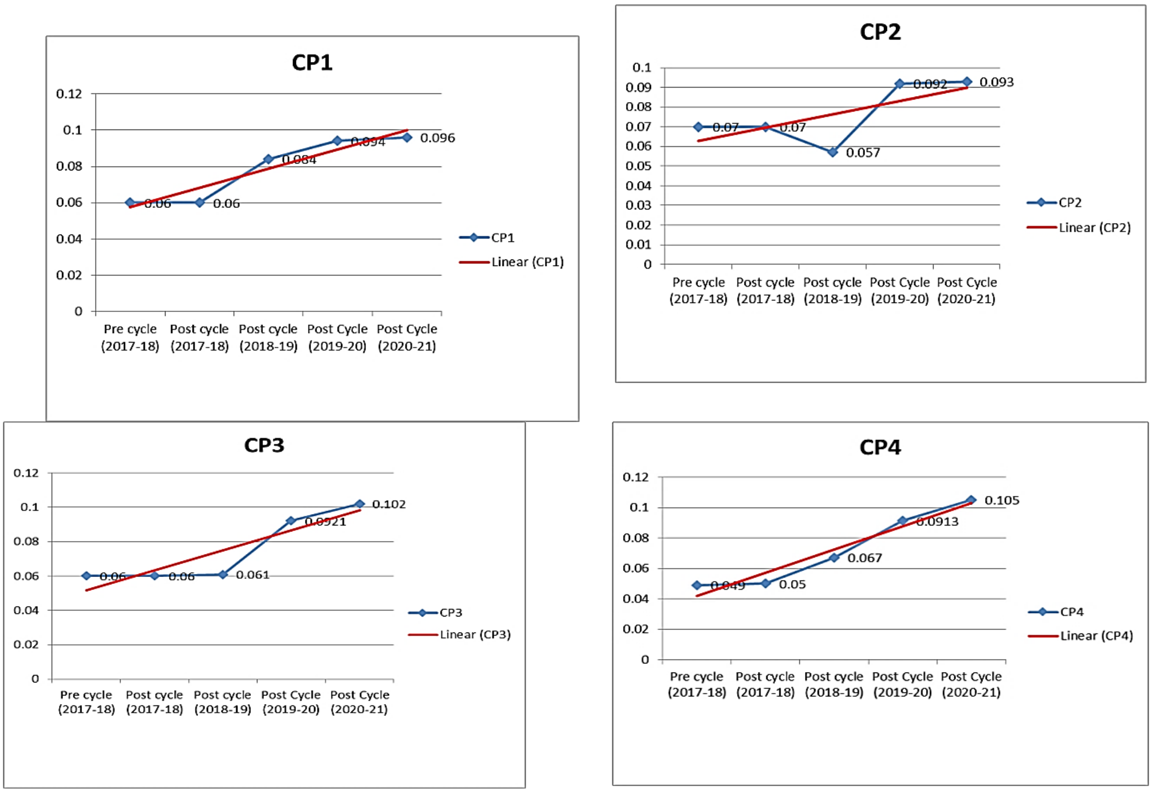


Fig. 3: Changes in K (meq/100 g) over time

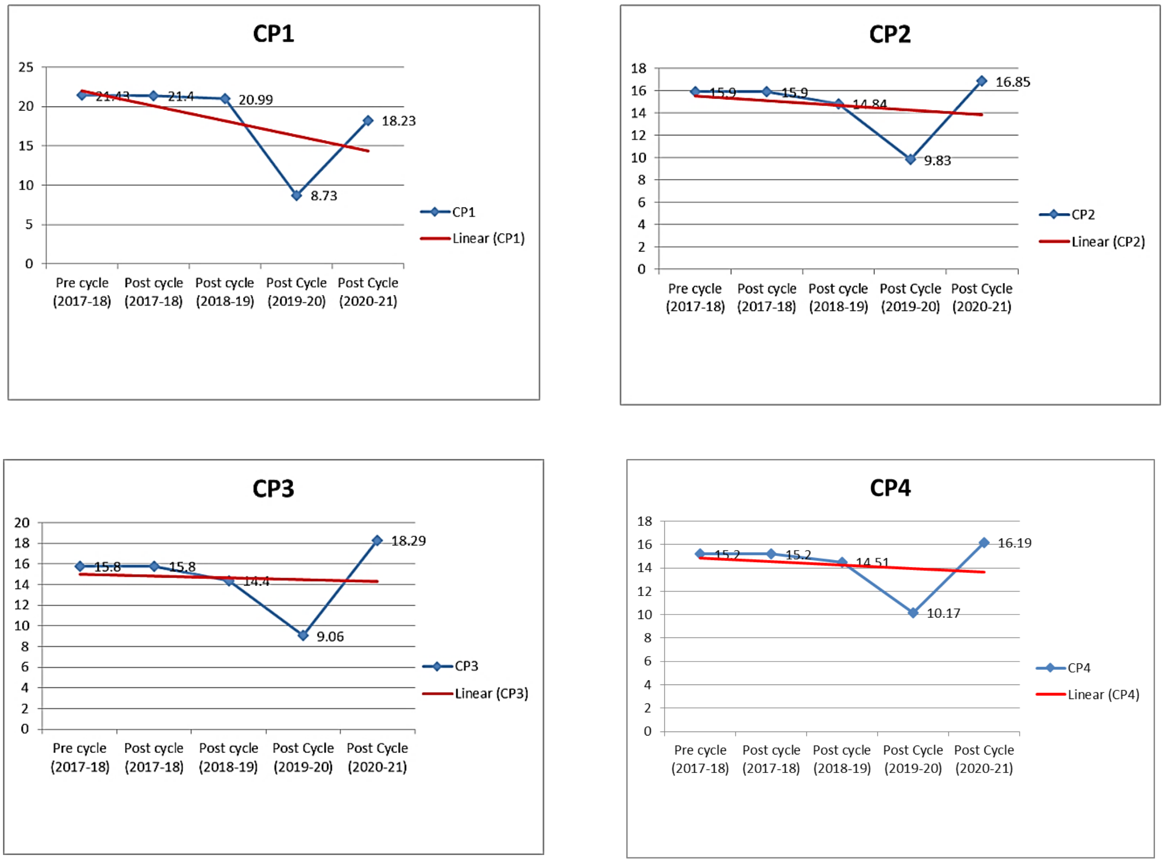
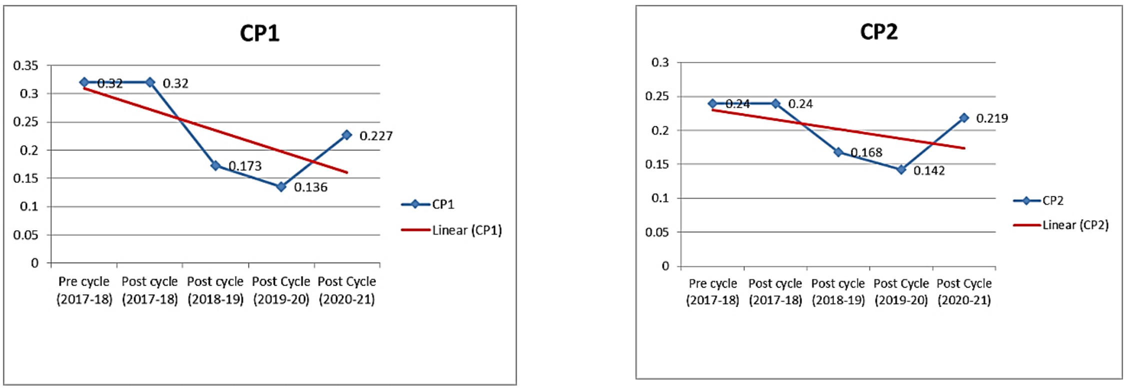


Fig. 4: Changes in S (µg/g) over time



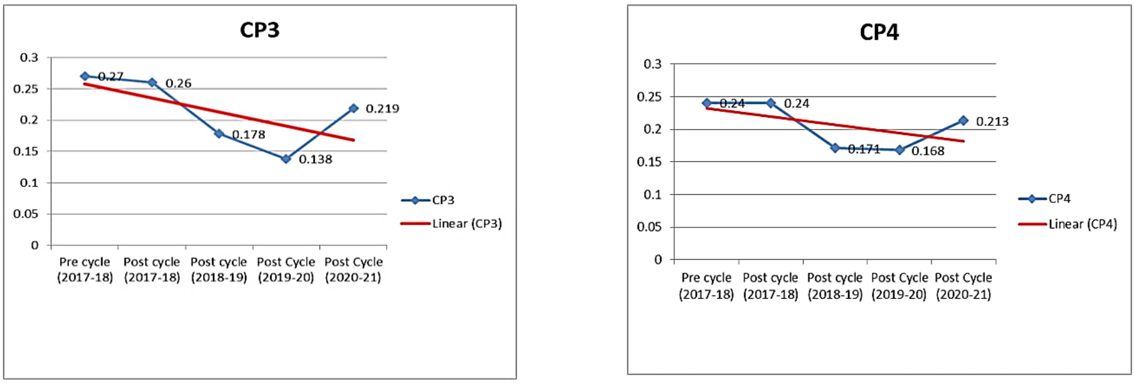


Fig. 5: Changes in B (µg/g) over time

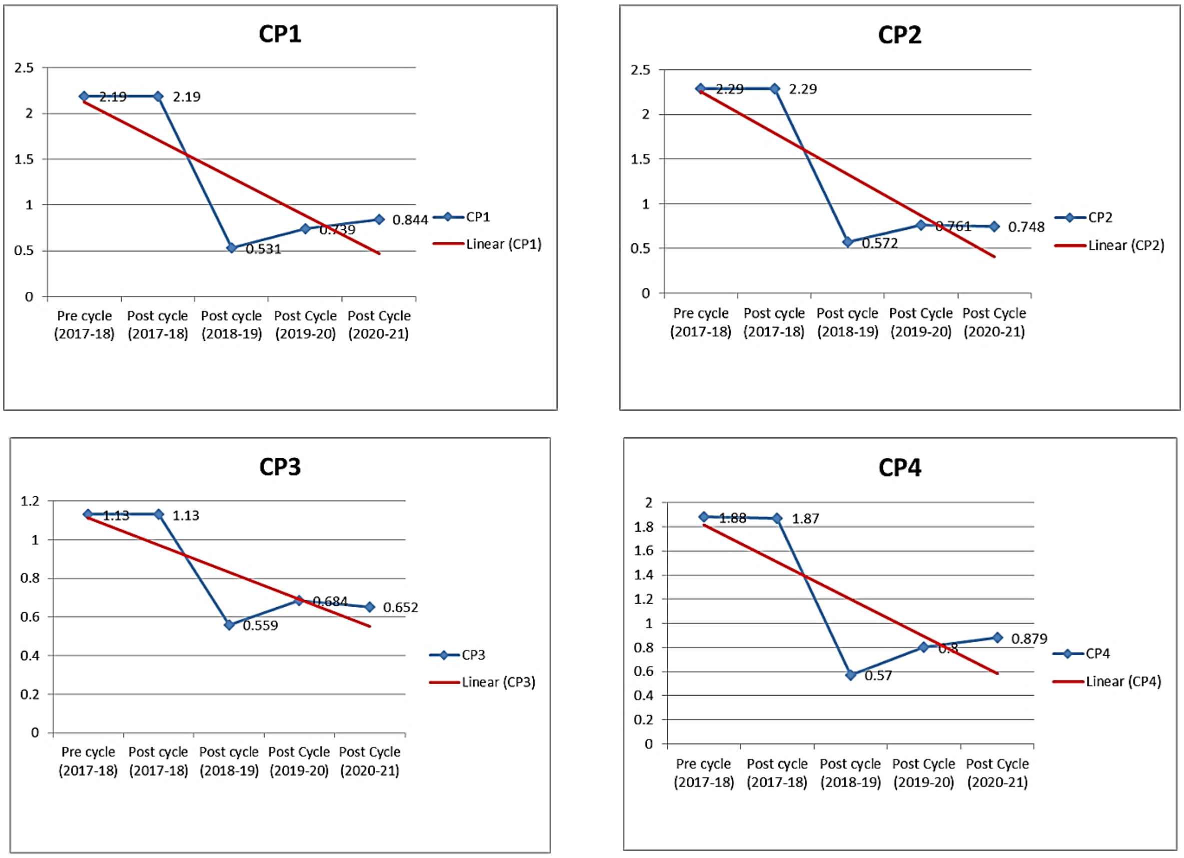


Fig. 6: Changes in Zn (µg/g) over time

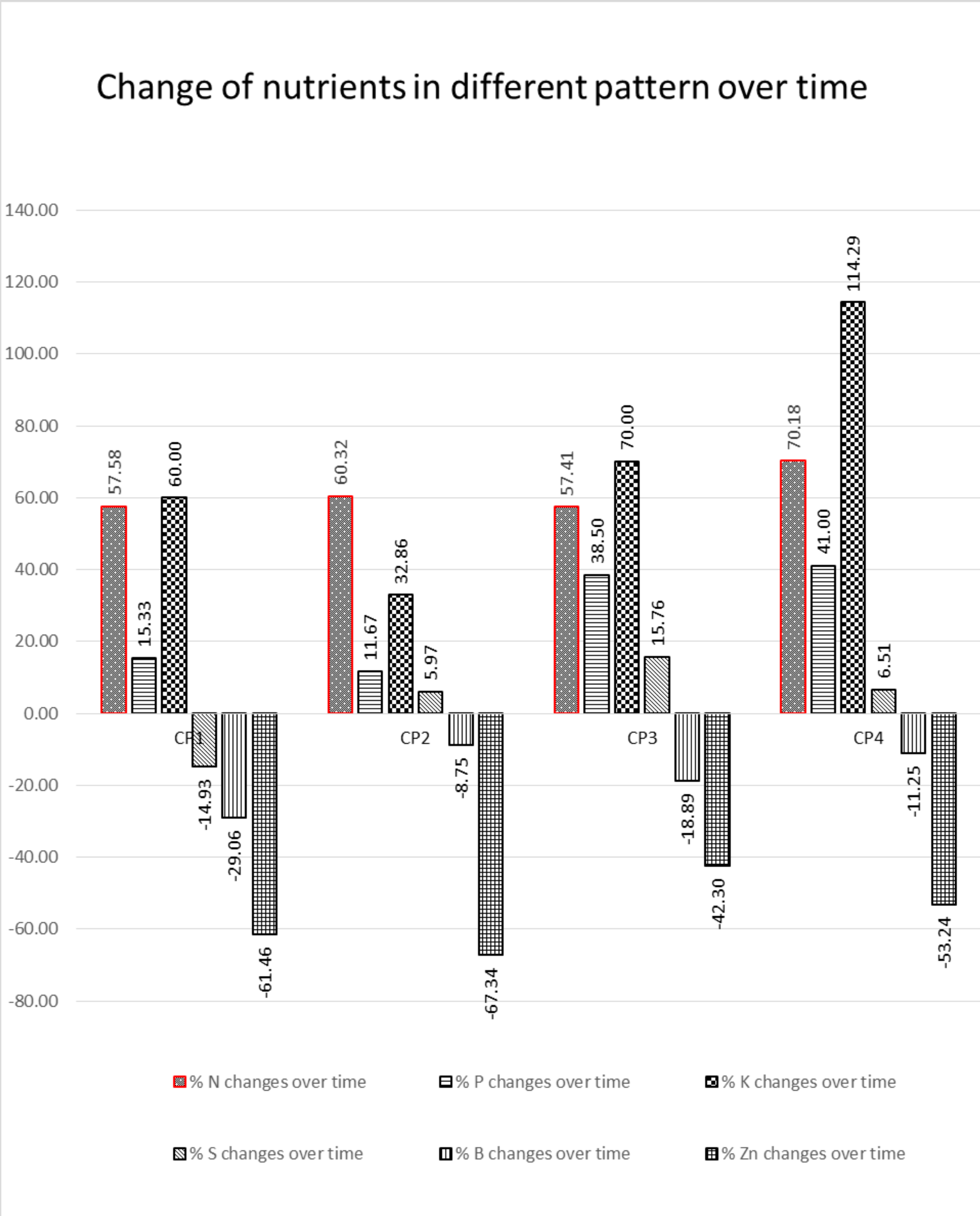


Fig. 7: Changes in Zn (µg/g) over time

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PERFORMANCE OF BLACKGRAM UNDER MANGO ORCHARD

A.A.M.M. MUSTAKIM, M.R. ISLAM, M. S. ALAM, J. HOSSAIN, M.S. ISLAM AND M.M. UDDIN

Abstract

The field experiment was conducted at Regional Agricultural Research Station, BARI, Ishwardi, during the Kharif season of 2021 to observe the performance of different Black gram varieties for growing under mango orchard, to increase the land use efficiency and productivity as well as farmers income of northern region of Bangladesh. The treatments consists of four varieties viz., BARI Mash-1, BARI Mash-2, BARI Mash-3 and BARI Mash-4. All the treatments were sown on September 7, 2021 using the line sowing method in a mango grove. Experimental results revealed that all the blackgram varieties had no significant effect on growing under mango orchard. However, the numerically highest seed yield was obtained in BARI Mash-2 (1.09 t/ha) followed by BARI Mash-4 (1.03 t/ha). The lowest yield was recorded in BARI Mash-1 (0.95 t/ha).

Introduction

According to FAO, most of the developing countries do not have sufficient land resources to meet the daily food requirements with use of low inputs. Hence, effective utilization of land resources necessitates the introduction of integrated farming system by incorporating tree crop. There is no scope for horizontal land expansion. However, it could be manifold extended vertically considering different layer of agro forestry system, which are applicable to small holding to provide maximum returns as land sustainability. Mango is one of the most important and widely cultivated tropical fruits of the world. In the 2020-21 seasons, 17,943 hectares of land in the district that yielded about 2.17 lakh MTs of mangoes. In the 2019-20 season, 17686 hectares of land mango orchards yielded about 1.80 lakh MTs of mangoes. Interspaces between the rows of trees can be successfully utilized for some pulse crops. This practice, besides providing income to the grower, suppresses weed growth, improves soil fertility and prevents leaching of nutrients and erosion of soil, achieves higher gross return per unit area. This practice also provides greater stability in production as well as helps the farmers in maintaining the soil fertility level.

Materials and Methods

The field experiment was carried out at the Regional Agricultural Research Station, BARI, Ishwardi, during Kharif season of 2021 to observe the performance of different Black gram varieties for growing under mango orchard, to increase the land use efficiency and productivity as well as farmers income of northern region of Bangladesh. The experimental site is located under the agro-ecological zone 11 (AEZ-11). Four Black gram varieties viz., BARI Mash-1, BARI Mash-2, BARI Mash-3 and BARI Mash-4 were used. The experiment was laid out in randomized complete block design (RCBD). Each treatment was replicated thrice (03) times with plot size 3m × 4m. The open space in between the mango tree line consider as a replication. The average caopy coverage of the mango tree was 6 m2. The land was opened in the last week of August 2021 with a power tiller. Then the land further became harrowed, ploughed and cross-ploughed followed by laddering for fine tilth. Weeds and stubbles were removed from the experimental plot. The seeds were sown maintaining 30 cm apart row with continuous seeding on 10 September 2021 under mango orchard. The germination percentage of the tested crop seeds were 90%. All the seeds were treated before sowing with Bavistin 250 WP @ 2g/kg seed. The experimental plots were fertilized @18-24-30-18-2.0-1 kg/ha N-P-K-S-Zn and B as per FRG, 2018. All fertilizers were applied during final land preparation A post sowing irrigation was applied for ensure proper germination and seedling establishment. Other intercultural operations were done as when necessary. Thinning was done at 15 days after emergence to maintaining 5-6cm plant-to-plant distances. Weed control was also done during the thinning time. For controlling Powdery Mildew disease theovit Fungicide @ 2g per litre was sprayed thrice times at 40, 50 and 60 DAS. To prevent pod borer insect Imitaf @ 0.5ml per litre was sprayed at 40 and 50DAS. Five plants were selected randomly from middle rows of each plots for recording the yield contributing data. The yield was measured by whole plot basis.The recorded data were statistically analyzed and the mean values were adjusted by LSD at 0.05 levels of probability.

Result and Discussion

Yield and Yield Contributing Characters of Different Black gram varieties under Mango Orchard

Table 1 showed that except biomass yield all the yield and yield contributing characters of various black gram varieties was found non significant. However, BARI Mash-2 showed numerically higher seed yield (1.09 t/ha) and the lowest seed yield (0.95 t/ha) in BARI Mash-1. Plant height, pods per plant, seed per pod, pod length and thousands seed weight ranged from 32.67-35.67cm, 19.33-22.67, 3.67-4.67, 4-5cm, 42.19-47.97g, respectively. Biomass yield was highest (1105.6 g/m^2) found in BARI Mash-4 and the lowest (816.28 g/m^2) in BARI Mash- 3. It might be due to the genetic potentiality of the variety. Time took for days to flowers and maturity of the tested varieties was 41-42 days and 75 to 82 days, respectively. The variation of traits might be due to genetic capability of the respective Black gram varieties.

Table 1. Performance of different black gram verities under mango orchard

Variety	DF	DM	PH	PPP	SPP	PL	TSW	BY	SY
BARI Mash-1	42	82	32.67	22.67	3.67	4.00	42.19	844.56	0.95
BARI Mash-2	42	81	33.00	22.00	3.67	4.47	42.83	1019.1	1.09
BARI Mash-3	41	78	34.00	19.33	4.67	5.00	47.97	816.28	0.99
BARI Mash-4	42	75	35.67	21.67	3.67	4.80	47.45	1105.06	1.03
LSD(0.05)	1.73	7.59	6.68	3.35	2.00	0.82	7.25	217.19	0.12
CV (%)	2.06	4.81	9.88	7.82	25.53	9.03	8.04	11.49	5.72

Where, DF=Days to flowering; DM= Days to Maturity; PH=Plant height; PPP=pods per plant; SPP= Seed per pod; PL Pod length; TSW= Thousands seed weight; SY= Seed Yield; BY= Biomass Yield

Conclusion

Blackgram var. BARI Mash-2 was found better in terms of seed yield compare to other varieties. Next year data will provide a complete scenario on the economic contribution of both mango and blackgram varieties.

PERFORMANCES OF DIFFERENT PULSE CROPS UNDER MANGO ORCHARD IN SOUTHERN REGION OF BANGLADESH

M.M. RAHMAN, M. R. ISLASM, M.A. RAHMAN AND M. R. UDDIN

Abstract

The field experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during the Rabi and Late Rabi season of 2021-2022 to select the most appropriate pulse crop(s) for growing under mange orchard, to increase the cropping intensity to maximize the productivity as well as farmers income of southern region of Bangladesh. The treatments were: T_1= Mango + Grasspea (Var. BARI Kheshari-3), T_2= Mango + Blackgram (Var. BARI Mash-3),T_3= Mango + Mungbean (Var. BARI Mung-6),T_4= Mango + Cowpea (Var. BARI Felon-1),T_5= Mango + Fieldpea (Var. BARI Motor-3). All pulses except mungbean seeds were sown through line sowing method on 12 December, under mango orchard. Mungbean seeds were sown on 27 January; 2021.Experimental results revealed that different pulse crops had significant effect on growing under mango orchard. The highest seed yield of field pea was recorded in T_5 treatment (1811.2 kg/ha). The lowest yield of blackgram was obtained from T_2 (448 kg/ha). The economic analysis results showed that the highest (Tk.72448/ha) from var. BARI Motor-3. The lowest gross return (Tk. 17040/ha) was found from var. BARI Mash-3. Similarly, the gross margin was found the highest (Tk. 43075/ha) from var. BARI Motor-3.Var. BARI Mash-3 produced negative gross margin (Tk. -5987/ha). Benefit cost ratio (BCR) revealed the highest (2.47) in var. BARI Motor-3 whereas lowest (0.74) in var. BARI Mash-3. Field pea var. BARI Motor-3 could be cultivated as most appropriate component crops under mango orchard in southern region of Bangladesh.

Introduction

Mango is one of the most important and widely cultivated tropical fruits of the world. In Bangladesh, it occupies an area of 37,830 hectares of land with an annual production of 116,1685 metric ton (MT) (BBS, 2016). From that in greater Barishal region the acreage was 455 acre and the total production including inside and outside garden was 18137 metric ton (MT) (BBS, 2016). In this region the acreage of mango orchard is increasing day by day. The plant start bearing 3 to 5 years after planting and reach their maximum bearing capacity within 12-15 years after planting. The mango plants when planted at a spacing of 10m × 10m provide an ample scope for growing of short duration crops as intercrops during initial years. The inter row space in mango remains underutilized in the early growing period where duration, location specific and market driven crops may be grown as intercrops for efficiently utilize the space and other natural resources. The intercrops not only generate an extra income but also helps to check the soil erosion through ground coverage and improves the physico-chemical properties of the soil. Intercropping is one of the techniques of land utilization for optimum production (Bhatanagar *et al.*2007). Experimental evidences have also proved that yield stability is grater with intercropping than sole cropping. Intercropping can provide substantial yield advantages compared with sole cropping. However, the success of intercropping system depends mainly on selection of suitable crops. Therefore, the experiment was conducted on intercropping in a earlier adult bearing mango orchard under rainfed upland situation to study the effect of intercropping on main crop mango and to select the most appropriate intercropping system.

Materials and Methods

The field experiment was carried out at the Regional Agricultural Research Station, BARI, Rahmatpur, Barishal during the rabi and late rabi season of 2021-2022 to select the most appropriate pulse crop(s) for growing under mange orchard as well as to increase the cropping intensity as well as maximizes the productivity for farmers income. The experimental site is situated in the latitudes and longitudes of 22°47/20.48/N and 90°17/37.65/E. The experimental site is located under the agro-ecological zone Ganges Tidal Floodplain (AEZ-13). The soil type is medium high land and soil texture is loamy. The treatments were: T_1= Mango + Grasspea (Var. BARI Kheshari-3), T_2= Mango + Blackgram (Var. BARI Mash-3), T_3= Mango + Mungbean (Var. BARI Mung-6), T_4= Mango + Cowpea (Var. BARI Felon-1),T_5= Mango + Fieldpea (Var. BARI Motor-3). All pulses except mungbean seeds were sown in line sowing method on 12 December, 2021 under mango orchard. Mungbean seeds were sownon 27 January, 2021. Seed rate for grasspea, blackgram, mungbean, cowpea and fieldpea was 7, 30, 22, 40 and 90 kg/ha respectively. The experiment was laid out in randomized complete block design with four replications. The unit plot size was 7 m × 3 m. The experimental plots were fertilized as per FRG, 2018. All fertilizers will be applied during final land preparation. Irrigation was applied two times and other intercultural operations were done as shown in BARI, 2019. Data were collected on different parameters such as plant population/m^2, days to 50% flowering, days to maturity, plant height, number of pod/plant, number of seeds/pod, 1000-seed weight and seed yield/ha. Data were analyzed statistically and the mean differences were adjudged with LSD test with 5% level of significant (Gomez and Gomez, 1984).

Results and Discussion

Yield and Yield contributing characters of different pulses under mango orchard has been presented in Table 1. All the parameters were statistically significant. The highest number of plant/m^2 was given by BARI Motor-3 (29.75) the lowest plant population form BARI Mash-3 (18.75). Powdery mildew and continuous drought condition provided higher seedling mortality was recorded. Among different pulse crops BARI Felon-1 is a long duration crop and it required 123 days to reach maturity where as BARI Mung-6 minimum (58) under mango orchard. The highest plant height under mango orchard was derived from BARI motor-3 (178.98 cm), as well as highest pod yielder (38.87) where the lowest yielder BARI Mung-6 (11.20). In raised bed condition of mango orchard BARI Mung-6 showed deficit moisture condition hence produce the lowest pod/plant. Seed/pod for pulse crops is a genetic character that varied among the pulse crops. The highest 1000- seed weight was obtained from BARI Motor-3 (105.13 g). From table 1 it was evident that highest seed yield was obtained from BARI Motor-3 (1811.2 kg/ha). It had highest seedling establishment rate, higher moisture retention capacity, higher canopy coverage than other pulse crops under mango orchard.

Table1. Seed yield and yield contributing characters of different pulse crops under mango orchard

Treatment	Plants /m^2 (no.)	Days to flowering (day)	Days to Maturity (day)	Plant height (cm)	Pod/ plant (no.)	Seed/ pod (no.)	1000-seeds wt. (g)	Seed yield (kg/ha)
BARI Khesari-3	24.00	64	120	72.19	22.44	4.49	53.04	722.3
BARI Mash-3	18.75	34	63	64.75	12.36	6.32	50.07	426.0
BARI Mung-6	20.50	33	58	42.09	11.20	10.86	52.19	506.6
BARI Felon-1	27.75	62	123	102.65	19.25	14.33	100.03	1070.4
BARI Motor-3	29.75	58	103	178.98	37.87	5.61	105.13	1811.2
CV(%)	3.44	0.44	15.26	15.26	14.12	8.16	8.90	17.55
$LSD_{(0.05)}$	1.28	0.55	0.80	20.14	4.45	1.05	0.66	227.47

Cost and return analysis

The economic analysis of different pulse crops under mango orchard has been presented in Table 2. The analysis results revealed that the gross return became the highest (Tk. 72448/ha) in BARI Motor-3. The lowest gross return (Tk. 17040/ha) was found in BARI Mash-3. Similarly, the gross margin was found the highest (Tk.43075/ha) in BARI Motor-3 whereas BARI Mash-3produced negative gross margin (Tk.-5987/ha). The value of benefit cost ratio (BCR) revealed the highest (2.47) in BARI Motor-3 whereas the lowest (0.74) in BARI Mash-3. From economic point of view field pea var. BARI Motor-3 might be cultivated under mango orchard for getting extra income from the orchard during Rabi season.

Table 2. Economic return of different pulse crops under mango orchard

Treatment	Yield (kg/ha)	Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)	BCR
Grasspea var. BARI Khesari-3	722.3	36115	30096	6019	1.20
Blackgram var. BARI Mash-3	426	17040	23027	-5987	0.74
Mung bean var. BARI Mung-6	506.6	30396	28781	1615	1.06
Cowpea var. BARI Felon-1	1070.4	42816	31693	11123	1.35
Fieldpea var. BARI Motor-3	1811.2	72448	29373	43075	2.47

Note: Seed and product price: Grass pea,black gram, mungbean, cowpea and field pea price Tk. 50, 40, 60, 40 and 40/kg, respectively.

Conclusion

From the economic point of view fieldpea var. BARI Motor-3 could be cultivated as most appropriate component crops under mango orchard in southern region of Bangladesh. This was the second year experiment and therefore final recommendation will be made by repeating the experimentation indifferent locations of the region.

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INTERCROPPING OF VEGETABLES AND SPICES WITH CHILLI IN CHATTOGRAM REGION

M.M. ALAM AND Z.A. FIROZ

Abstract

The experiment was conducted at Regional Agricultural Research Station, Hathazari, Chattogram during December 2021 to April 2022 to assess the performance of radish, carrot, onion and garlic with chilli as intercrop for higher productivity and economic return. There were five treatments viz., T_1= Sole chilli, T_2= Chilli + two rows radish, T_3= Chilli + two rows carrot, T_4= Chilli + two rows onion and T_5= Chilli + two rows garlic. The result revealed that Chilli + two rows onion intercrop gave the highest equivalent yield (8.76 t/ha). The maximum gross return, gross margin and benefit cost ratio was achieved from chilli + onion intercrop.

Introduction

Intercropping provides several major advantages namely; diversification reduces risk associated with crop failure, offers greater yield stability and utilizes the available growth resources more efficiently and sustainably. Usually plants differing in grow duration, height, rooting systems and nutrient requirement are considered to growth together in intercropping systems. Better intercrop production could be achieved with the choice of the appropriate crops, population density and planting geometry of component crops. Chilli is grown in Rabi season over a large area in Hathazari. But farmers of this region practiced chilli cultivation as a sole crop. If another crop can be grown in between two rows of chilli, the farmers can earn some additional income and it is very possible to grow suitable crop. Therefore, the present study was undertaken keeping in mind to find out which crop can be produced successfully without hampering the main crop and to evaluate the performance of the intercropping system of vegetables with chilli for higher productivity and economic return.

Materials and Methods

The experiment was carried out at Regional Agricultural Research Station, Hathazari, Chattogram during December 2021 to April 2022. There were five treatments viz. T_1= Sole chilli, T_2= Chilli + two rows radish, T_3= Chilli + two rows carrot, T_4= Chilli + two rows onion and T5= Chilli + two rows garlic. The experiment was laid out in RCB design with three replications. The unit plot size was 5m × 4m. Radish and carrot seeds; onion and garlic bulbs and 30 days old chilli seedlings were sown/ transplanted on 15 December, 2021. The land was fertilized at the rate of 97- 66-100-1 kg ha-1 NPKS, respectively in case of sole chilli and 20% additional fertilizer were used in intercropped plot. Half of N and all other fertilizer were applied as basal. Rest N was applied at 30 DAS. Chilli and radish were harvested during February to April 2022 but carrot, onion and garlic were harvested on 2^{nd} week of March, last week of March and 1st week of April 2022, respectively. All chilli fruit harvested as green chilli. Data on yield and yield contributing parameters were recorded and statistically analyzed with the help of statistical package Statistix 10 and mean separation was tested by Duncan's Multiple Range Test (DMRT).

Results and Discussion

The yield of chilli and component crops have been presented in Table 1. The results revealed that the highest fruit yield of chilli was obtained from sole chilli. Chilli equivalent yield of all intercropping were higher than sole chilli indicated all intercropping were more productive than sole chilli. The maximum chilli equivalent yield (8.76 t/ha) was obtained from Chilli + onion intercropping. The highest gross margin (Tk. 1,48,300/ha) and benefit cost ratio (1.74) was obtained from Chilli + onion intercropping system.

Table 1. Yield of different spices with chilli during 2021-22 at RARS, Hathazari

Treat.	Fruit yield of green chilli (t/ha)	Yield of component crops (t/ha)	Chilli Equivalent yield (t/ha)	Gross return (Tk/ha)	Cost of cultivation (Tk/ha)	Gross margin (Tk/ha)	BCR
T_1	12.05 a	-	12.05	241000	180000	61000	1.34
T_2	9.48 b	16.20 a	13.53	270600	185000	85600	1.46
T_3	8.34 c	7.88 b	16.22	324400	188000	136400	1.73
T_4	8.24 c	7.34 c	17.42	348300	200000	148300	1.74
T_5	8.76 c	3.27 d	15.30	306000	220000	46000	1.39
CV (%)	5.21	4.43	3.51	-	-	-	-
F-test	**	**	**	-	-	-	-

T_1= Sole chilli, T_2= Chilli + radish, T_3= Chilli+ carrot, T_4= Chilli + onion and T_5= Chilli + garlic
Price (Tk./kg): Green chilli= 20, Radish= 5, Carrot= 20, Onion= 25, Garlic =40

Conclusion

From the results it might be concluded that all intercropping showed higher productivity than sole chilli. But among the intercropping, chilli + two rows onion intercropping was more productive and profitable than other intercropping. For confirmation of the result, the experiment could be repeated in the next year.

PERFORMANCE OF COWPEA INTERCROPPING WITH MAIZE AT CHOTTOGRAM REGION

M.M. ALAM AND Z.A. FIROZ

Abstract

The experiment was conducted at Regional Agricultural Research Station, Hathazari, Chattogram during December 2021 to April 2022 to evaluate the performance of maize-cowpea intercrop as influence by planting arrangement for higher productivity. Four treatment combinations viz., T_1= Maize normal row (MNR) (60cm × 20cm) + one row cowpea (60cm × 10cm), T_2= MNR (60cm × 20cm) + two row cowpea (20cm × 10cm), T_3= MNR (60cm × 20cm) + cowpea broadcast and T_4=

Sole cowpea (40cm × 10cm) were tested. The different intercrop combinations have significant effect on yield and yield attributes. Cowpea equivalent yield of all intercrop combinations were higher (3.52- 4.10 t/ha) than sole cowpea (1.05 t/ha) indicated all intercropping were more productive than sole cropping. The highest cowpea equivalent yield (4.10) was recorded in Maize normal row (60cm × 20cm) + one row cowpea (60cm × 10cm). The maximum gross return (Tk. 205000/ha), gross margin (Tk. 125000/ha) and BCR (2.73) were also recorded in same treatment. The overall results indicated that maize normal row + one row cowpea intercropping was more effective than other intercrop combinations.

Introduction

Maize (Zea mays L.) is a priority crop of modern farmers as a staple food in many rural communities of Bangladesh and is one of the most important cereal crops grown in Bangladesh. It is an important dual purpose crop used in human diet and animal feed in Agro industries (Atunewa and Afolbi 2001). Cowpea is also another most important food leguminous crop in north south region. It is well adapted to the drier region of the tropics. It has the ability to fixed atmospheric nitrogen through its root nodules and it grow well in a poor soil with more than 85% and with less than 0.2% organic matter (Scott, 2008). In addition, it is shade tolerant, so is compatible as an intercrop with maize, millet sorghum sugarcane and cotton. The use of intercropping by small holder farmers is a common practice (Ofuso-Amin and Limbani, 2007). The beneficial effects of intercropping maize-cowpea have not been fully exploited correct combination of intercropping, planting pattern that will enhance growth and yield of the two components in intercrop. Felon cultivation is a popular farming method in Hathazari area. In the farmers of Hathazari region they cultivate felon as a sole crop. If felon can be grown in between two rows of maize, the farmer can earn additional income. Hence, the experiment was conducted to evaluate the performance of maize-cowpea intercrop as influence by planting arrangement for higher productivity and economic return.

Materials and Methods

The experiment was carried out during 2021-2022 at Regional Agricultural Research Station, Hathazari, Chattogram. Maize cultivar BARI hybrid maize-9 and cowpea cultivars BARI felon -2 were evaluated in this study. The experiment was laid out in a randomized complete block design. The treatments were T_1= One row maize (60cm × 20cm) + one row cowpea, T_2= One row maize (60cm × 20cm) + two row cowpea and T_3= One row maize (60cm × 20cm) + cowpea broadcast. The experiment had three replications with 4m × 4.8 m individual plot size. Maize var. BARI Hybrid maize-9 and cowpea var. BARI felon-1 were used as test crops. Maize seeds were sown on 23 December in 2021. Three maize seeds were sown per hole and later thinned to one plant per stand at 14 days after seeding (DAS). Cowpea seeds were sown at two weeks after maize sown. Sole Maize and intercrop were fertilized with 250-55-120-50-5-1 NPKSZnB kg/ha, respectively. Sole cowpea was fertilized with 20-20-25 NPK kg/ha, respectively. In case of Sole maize 1/3 N and all other fertilizers as basal. Rest N was be applied at 35 and 55 DAS. In case of Sole cowpea all fertilizers will be applied as basal at the time of final land preparation. In case of Intercrop 1/3 N and all other fertilizers as basal. Rest N was applied at 25 & 45 DAS. Additional N (30 kg/ha) was applied in 2 split at 20 and 35 DAS as side dressing to cowpea in intercrop treatment. Plots were kept weed-free using hand hoes. During vegetative, flowering and pod development stages, cowpea plants were sprayed with insecticide Karate (50 g L -1). This was applied at the rate of 1.0 L/ha at the time when a few insects were noticed. Cow pea was harvested during 3rd week of March to 2nd week of April 2022. Maize was harvested during 3rd week of April to 2nd week of May 2022. Data were collected on an individual plant basis from five (5) randomly selected plants of each plot in such a way that the border effect was avoided for high precision. Data on yield and yield contributing parameters were recorded and statistically analyzed with the help of statistical package Statistix 10 (Analytical Software. Tallahassee, Fla, USA) and mean separation was tested by Duncan's Multiple Range Test (DMRT) (Steel and Torrie, 1960). Equivalent yield and economic analysis was also done.

Results and Discussion

The results of yield and yield attributes of different intercrop combination have been shown in Table1 and Table 2. The highest maize grain yield (8.45 t/ha) was observed in T_1 (MNR+ 1row cowpea) and lowest grain yield (6.86 t/ha) was found in T_3 (MNR+ Broadcast cowpea). On the other hand, the highest seed yield of cowpea (1050 kg/ha) was observed in T_4 (Sole cowpea) and lowest (720 kg/ha) was found in T_1 (MNR+ 1 row cowpea). The lower yield in intercropping treatment might be due to high competition for the limited growth resources.

Table1. Yield and yield attributes of maize in cowpea intercropping with maize at Chattogram region during 2021-2022

Treatment	Plant height (cm)	No. of grains/ cob (no.)	1000- grain wt. (g)	Grain yield (t/ha)
T_1= MNR+ 1row cowpea	202.5 c	763.4 ab	342 a	8.45 a
T_2= MNR+ 2row cowpea	205.8 b	750.8 b	317 c	7.21 b
T_3= (MNR+ Broadcast cowpea)	209.7 a	746.1 b	338 b	6.86 b
T_4= Sole cowpea	-	-	-	-
CV (%)	12.87	11.94	6.84	3.48
F-test	NS	**	**	**

Table 2. Yield and yield attributes of cowpea in cowpea intercropping with maize at Chattogram region during 2021-2022

Treatment	Plant height (cm)	Pod/plant (no.)	Seed/pod (no.)	1000- seed wt. (g)	Seed yield of cowpea (kg/ha)
T_1=MNR+ 1row cowpea	100.0	18 .5	13.5	100.0	720 bc
T_2=MNR+ 2row cowpea	102.5	17.0	12.0	99.50	850 b
T_3=MNR+ Broadcast cowpea	101.0	16.7	11.5	99.40	780 bc
T_4=Sole cowpea	102.7	19.25	14.33	100.03	1050 a
CV (%)	5.78	7.12	9.20	7.25	6.34
F-test	NS	NS	NS	NS	**

Productivity of maize + cowpea intercropping

Cowpea equivalent yield was expressed in total productivity. Cowpea equivalent yield were higher (3.52-4.10 t/ha) in all the intercrops than the sole crop of cowpea (1.05 t/ha) indicated higher productivity than sole cropping (Table 3). Among the intercrop combination the maximum cowpea equivalent yield (4.10 t/ha) was recorded in T_1 (MNR+ 1row cowpea) followed by T2 (MNR+ 2 rows cowpea) and the lowest cowpea equivalent yield (1.05 t/ha) from T_4 treatment (Sole cowpea). Ahmed et al. (2013) also reported that intercrop combination increase the equivalent yield than sole crop.

Cost and return analysis

Intercropping combination of cowpea with maize showed higher monetary return than sole crop (Table 3). The highest gross return (Tk. 205000/ha), gross margin (Tk.125000/ha) and BCR (2.73) was found in the intercrop combination T_1 (MNR+ 1row cowpea) followed by T_2 (MNR+ 2 rows cowpea) (Table 3). The overall results indicated that cultivation of maize with one row cowpea was more profitable than other intercrop combinations. The results of increased productivity and returns were consistent with the earlier reports of yield advantages of crop mixture compared to monoculture (Islam *et al.* 2012 and Ahmed *et al.* 2013).

Table 3. Cost and return analysis in cowpea intercropping with maize at Chattogram region during 2021-22

Treatment	Cowpea equivalent yield (t/ha)	Gross Return (Tk./ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1=MNR+ 1row cowpea	4.10	205000	80000	125000	2.73
T_2=MNR+ 2row cowpea	3.68	184000	82000	102000	2.39
T_3=MNR+ Broadcast cowpea	3.52	176000	83000	93000	2.26
T_4=Sole cowpea	1.05	52500	35000	17500	1.50

Prize (Tk./kg): Maize= 20, Cowpea= 50

Conclusion

The overall results indicated that all intercropping were productive as compared to sole cowpea. Among the intercropping, one row cowpea (60cm × 10cm) in between two rows of maize (60cm × 20cm) was more productive and profitable in respect of cowpea equivalent yield and monetary return. It should be repeated next year for final recommendation.

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INTERCROPPING COWPEA WITH SORGHUM UNDER DIFFERENT PLANTING SYSTEM

M.M. ALAM AND Z.A. FIROZ

Abstract

The experiment was conducted at Regional Agricultural Research Station, Hathazari, Chattogram during December 2021 to April 2022 to evaluate the performance of sorghum cowpea intercrop as influence by planting arrangement for higher productivity and economic return. Five treatment combinations viz., T_1= Sorghum normal row (SNR) (60cm × 10cm) + one row cowpea (60cm × 10cm), T_2= SNR (60cm × 10cm) + two row cowpea (20cm × 10cm), T_3= SNR (60cm × 10cm) + cowpea broadcast and T_4= Sole sorghum (60cm × 10cm) and T_5= Sole cowpea (40cm × 10cm) were tested. The different intercrop combinations were significantly different in terms of yield and yield attributes. The highest sorghum grain yield (2.85 t/ha) and cowpea seed yield (1.25 t/ha) was obtained from treatment T_4 and T_5 as sole cropping. Higher sorghum equivalent yield (2.48-2.65 t/ha) and land equivalent ratio (1.37-1.47) were observed in intercropping system than sole cropping. The maximum gross margin (Tk.60500/ha) and BCR (1.86) were recorded in sorghum normal row (60cm × 10cm) + one row cowpea (60cm × 10cm) intercropping system.

Introduction

Sorghum is an unbranched and erect cereal crop with wide spacing. Sorghum is used as food, feed, fodder and fuel. Recently it is getting the special importance by the government of Bangladesh due to huge demand in medicine industry and low water required for cultivation. On the other hand, cowpea is also another most important food leguminous crop in north south region. It is well adapted to the drier region of the tropics. It has the ability to fixed atmospheric nitrogen through its root nodules and it grow well in a poor soil with more than 85% and with less than 0.2% organic matter (Scott, 2008). By judicious choice of compatible crops and adopting appropriate planting geometry, inter/intra specific competition may be minimized resulting higher total productivity (Alom *et al*. 2013). But literature is meager regarding sorghum + cowpea intercropping under different planting systems in Bangladesh condition. By adopting appropriate planting geometry in the intercropping system, the total productivity of the crops can be enhanced (Umrani *et al.*, 1984). So, this experiment was conducted to find out suitable planting systems of sorghum and cowpea as intercropping for higher productivity, economic return and national nutritional food security.

Methods and Materials

The experiment was carried out during 2021-2022 at Regional Agricultural Research Station, Hathazari, Chattogram. Sorghum cultivar BARI Sorghum-1 and cowpea cultivars BARI felon -2 were evaluated in this study. The experiment was laid out in a randomized complete block design. The treatments were T_1= Sorghum normal row (SNR) (60cm × 10cm) + one row cowpea (60cm × 10cm),

T_2= SNR (60cm × 10cm) + two row cowpea (20cm × 10cm), T_3= SNR (60cm × 10cm) + cowpea broadcast (100%), T_4= Sole sorghum (60cm × 10cm) and T_5= Sole cowpea (40cm × 10cm). The experiment had three replications with 5m × 4.8 m individual plot size. Sorghum seeds were sown on 22 December in 2021. Three maize seeds were sown per hole and later thinned to one plant per stand at 14 days after seeding (DAS). Cowpea seeds were sown at two weeks after sorghum sown. Sole sorghum and intercrop was fertilized with 120-48-75-30-3-1 kg/ha N-P-K-S-Zn-B, respectively. Sole cowpea was fertilized with 20-20-25 NPK kg/ha, respectively. In sole sorghum: 1/3 N and all other fertilizers were applied as basal. Rest N was applied at 25 & 45 DAS. In sole cowpea: All fertilizers were applied as basal at the time of final land preparation. Intercrop: 1/3 N and all other fertilizers as basal. Rest N was applied at 25 & 45 DAS. Additional N (30 kg/ha) was applied in 2 split at 20 and 35 DAS as side dressing to cowpea. Plots were kept weed-free using hand hoes. During vegetative, flowering and pod development stage. Cowpea plants were sprayed with Karate (50 g L -1). This was applied at the rate of 1.0 L ha-1 at the time when a few insects were noticed. Cow pea was harvested during 3rd week of March to 2nd week of April 2022. Sorghum was harvested during 3rd week of April to 2nd week of May 2022. Data on yield and yield contributing parameters were recorded and statistically analyzed with the help of statistical package statistix 10 (Analytical Software. Tallahassee, Fla, USA) and mean separation was tested by Duncan's Multiple Range Test (DMRT) (Steel and Torrie, 1960). Equivalent yield and economic analysis was also done.

Results and Discussions

Grain and stover yield of both sorghum and cowpea were higher in sole cropping than the intercropping. (Table 1). The stover yield of both crops in intercropping followed similar trend as in grain yields. This observation thus reflect an inter-specific relationship of mutual inhibition in which both crops in their mixtures at the various planting patterns yielded less than their potential (expected) yields in monoculture.

The effect of different planting arrangements on land equivalent ratio (LER) are presented in Table 1. LER was higher in all intercropping system than sole cropping indicated land utilization was higher in intercropping than sole cropping. The highest LER (1.47) was observed in normal row sorghum with two rows cowpea (T2) followed by normal row sorghum with one row cowpea (T2) where land were utilized 47% and 42% higher than sole cropping, respectively.

Table 1.Yield, Equivalent yield (EY) and Land equivalent ratio (LER) of sorghum-cowpea intercropping systems during 2021-22

Treatment	Grain yield of sorghum (t/ha)	Seed yield of Cowpea (t/ha)	Cowpea Equivalent Yield (t/ha)	Land Equivalent ratio		
				Sorghum	Cowpea	Total
T_1	2.31	0.76	2.61	0.81	0.61	1.42
T_2	2.25	0.85	2.65	0.79	0.68	1.47
T_3	2.12	0.78	2.48	0.74	0.62	1.37
T_4	2.85	-	-	-	-	1.00
T_5	-	1.25	1.25			1.00
CV (%)	3.46	2.85				
F-test	**	**				

T_1= Sorghum normal row + 1 row cowpea, T_2= Sorghum normal row + 2 rows cowpea, T_3= Sorghum normal row + cow pea broadcast T_4= Sole sorghum and T_5= Sole cow pea.

Prize (Tk/kg): Sorghum= 40, Cowpea =50

Cost and return analysis

Sorghum normal row (60cm × 10cm) + one row cowpea (60cm × 10cm) and Sorghum normal row (60cm × 10cm) + two row cowpea (20cm × 10cm) intercrop combination showed higher monetary return than sole crop (Table 2). The highest gross return (Tk. 132500/ha) was observed in Sorghum normal row (60cm × 10cm) + two row cowpea (20cm × 10cm) intercrop combination but the maximum gross margin (Tk.60500/ha) and BCR (1.86) was found in the intercrop combination T1 (SNR + 1row cowpea) (Table 2).

Table 2. Cost and return analysis in cowpea intercropping with sorghum at Chattogram region during 2021-22

Treatment	Cowpea equivalent yield (t/ha)	Gross Return (Tk./ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1=SNR+ 1row cowpea	2.61	130500	70000	60500	1.86
T_2=SNR+ 2row cowpea	2.65	132500	73000	59500	1.81
T_3=SNR+ Broadcast cowpea	2.48	124000	72000	52000	1.72
T_4=Sole cowpea	1.25	62500	35000	27500	1.78

Prize (Tk./kg): Sorghum =40, Cowpea= 50

Conclusion

The overall results indicated that Sorghum normal row (60cm × 10cm) + one row cowpea (60cm × 10cm) and Sorghum normal row (60cm × 10cm) + two row cowpea (20cm × 10cm) intercrop combination were productive and profitable as compared to sole cowpea. But Sorghum normal row (60cm × 10cm) + one row cowpea (60cm × 10cm) intercrop combination was more profitable in respect of BCR. It should be repeated in next year for final recommendation.

PRODUCTIVITY AND PROFITABILITY ANALYSIS OF INTERCROPPING HYBRID MAIZE WITH POTATO AT DIFFERENT PLANTING SYSTEM

M.M. KHANUM, M.S. HUDA, A.A. BEGUM AND D.A. CHOUDHURY

Abstract

The experiment was carried out at the research field of Agricultural Research Station, Rajbari, Dinajpur (Latitude: 25.6279° N, Longitude: 88.6332° E) during rabi season of 2020-21 and 2021-22 to assess the economic performance of intercropping potato with maize. Six treatments viz., T_1= Sole maize (60cm×20cm), T_2= Maize planting (60cm × 20cm) + 1 row potato in between two maize rows, T_3= Maize paired row (30cm/120cm/30cm × 20cm) + 1 row potato, T_4= Maize paired row (30cm/120cm/30cm × 20cm) + 2 rows potato, T_5= Maize paired row (30cm/120cm/30cm × 20cm) +3 rows potato and T_6= Sole potato (60cm × 25cm). Among the intercropping, the highest maize yield was recorded in Maize planting (60cm × 20cm) + 1 row potato in between two maize rows while the highest potato yield was recorded in Maize paired row (30cm/120cm/30cm × 20cm) + 3 rows potato. The highest maize equivalent yield was also obtained in Maize paired row (30cm/120cm/30cm × 20cm) + 3 rows potato. The highest gross return, gross margin and BCR were obtained in Maize paired row (30cm/120cm/30cm × 20cm) + 2 rows potato and the lowest in sole maize.

Introduction

Intercropping may be defined as the cultivation of two or more crops at the same time in the same field (Ouma and Jeruto, 2010). The advantages is often attributed to the fact that different crops complement each other and make better use of resources when grown together rather than separately (Ahmed *et al.,* 2018). Besides, intercropping also acts as insurance for resource poor farmers if one crop fails, they get some yield of another crop (Islam *et al.,* 2014). Maize (Zea mays) is a versatile photo insensitive crop which can give high yield relatively in a shorter period of time due to its unique photosynthetic mechanism as C4 plant (Hatch and Slack, 1998). The area coverage under maize in Dinajpur is expanding rapidly instead of wheat. Due to development of some potential hybrid maize and its availability in this region, farmers tend to shift their cultivation with maize crop in Rabi season (Shaheenuzzaman *et al.,* 2015). In addition to that, favorable agro-climatic conditions have made this crop suitable for greater adoption in winter season in Dinajpur region. Being row and spaced crop, some short duration vegetables or tuber crops may have access to grow with maize as intercrop for extra quick cash generation without hampering maize yield. Growing of short duration tuber crops specially potato as intercrop with maize in between row may offer considerable yield advantage over sole cropping due to efficient utilization of growth resources (Talukder *et al.*,2016). Potato and maize may be grown as intercrop as they have different photosynthetic pathway, growth habit, growth duration and demand for growth resources. Intercropping practices lead to more monetary return and better utilization of land and inputs (Quayyum *et al.,* 1985). Regarding this views, an attempt was undertaken to get maximum benefit from intercropping by optimizing plant population of maize and potato.

Materials and Methods

Experimental site description

The experiment was conducted at the research field of Agricultural Research Station, BARI, Rajbari, Dinajpur during rabi season of 2020-21 and 2021-22. The experimental site was located at Latitude: Latitude: 25.6279° N, Longitude: 88.6332° E at an elevation of 37 m above mean sea level and it belongs to the Agro-ecological Zone-1 (Old Himalayan piedmont plain) in Bangladesh (FRG, 2018). The initial soil sample (0-15 cm) was analyzed at the Soil Resources Development Institute (SRDI), Dinajpur, Bangladesh. The soil of the experimental site was medium-high and clay loam texture having 0.96% organic matter, pH 6.30, 0.10% total nitrogen (N), 0.10 meq 100 g-1 soil potassium (K), 23.5 μg/g phosphorus (P), 7.20 μg/g sulfur (S), 0.89 μg/g zinc (Zn) and 0.35 μg/g boron (B). During crop growth period, Monthly weather data on temperature (maximum and minimum) and rainfall (mm) were recorded in the years (Figure 1). The average maximum and minimum temperature in the crop season (November to April) were ranged 22.69°C-33.99°C and 11.15°C-21.76°C during in 2020-21 and 22.25°C-33.43°C and 11.4°C-23.28°C in 2021-22 respectively. The weather of the experimental site is hot sub-humid with total rainfall of 25 mm in 2020-21 and 106 mm in 2021-22 during crop season.

Experimental design and treatments

The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 14.4 m^2 (4m × 3.6m). Six different treatments were employed in the study viz. T_1= Sole maize (60cm×20cm), T_2= Maize planting (60cm × 20cm) + 1 row potato in between two maize rows, T_3= Maize paired row (30cm/120cm/30cm × 20cm) + 1 row potato, T_4= Maize paired row (30cm/120cm/30cm × 20cm) + 2 rows potato, T_5= Maize paired row (30cm/120cm/30cm × 20cm) +3 rows potato and T_6= Sole potato (60cm × 25cm).

Crop husbandry

The land of the experimental plot was prepared with a power tiller for good tilth. Fertilizers were applied @ 260-72-148-48-4-2 kg ha-1 NPKSZnB and 180-40-180-20-6-1.2 kg ha-1 NPKSZnB and 320-73-170-50-6-2 kg ha-1 NPKSZnB in the form of Urea-TSP-MOP-Gypsum-ZnSO4-Boric acid for the sole maize and sole potato and for intercrop combinations. One third of urea and full amount of other fertilizers were applied at final land preparation. Remaining urea was applied at 30 and 50 DAS in two equal splits. Maize (BARI hybrid bhutta-16) and potato (BARI Potato-36) were sown on 12 November, 2020 and 13 November, 2021 during the both conducting years. Two irrigations were provided after top dressing of urea. Earthing up and other intercultural operations were done when required. Other plant protection measures were taken when required. Potato was harvested at 80 DAP and then 3rd irrigation of maize was applied. Insecticide Tracer 45 SC (Spinosad) 0.4ml/L water was sprayed at every 7 days interval 2-3 times to control fall army warm on maize and Fungicide Acrobat MZ (Mencozeb+Dimethomorph) 4gm/L water or Headline Team (Pyraclostrabin+ Dimethomorph) 2.5gm/L water was sprayed at every 7-10 days interval to control late blight on potato. Maize grain yield and potato yield were measured from the whole plot and then calculated per hectare basis maintaining standard moisture content. The relative yield was obtained by dividing the intercrop yield of a crop with the respective sole crop yield of that crop using the formula (Dewit and Vander Bergh, 1965).

Maize equivalent yield was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Bandyopadhyay (1984) as given below:

Maize equivalent yield = Yim + (Yip× Pp) / Pm Where, Yim = Yield of intercrop maize, Yip = Yield of intercrop potato, Pm = Market price of maize and Pp = Market price of potato. Collected data were statistically analyzed by using R software packages and mean differences for each character were compared by Least Significant Difference (LSD) test

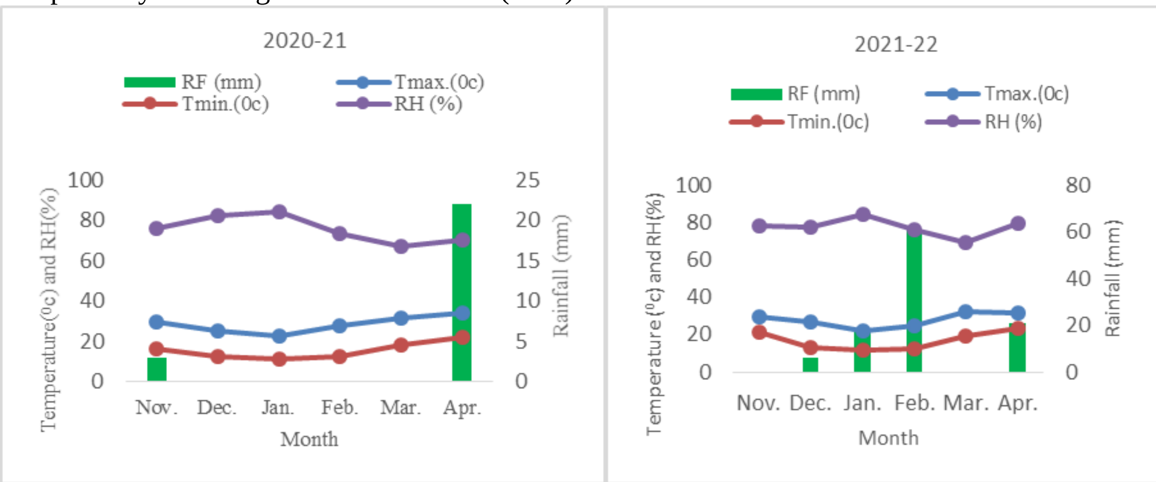

Figure 1. Monthly average maximum & minimum temperature, Relative humidity and rainfall during the growing period of garlic experiment (2020-21 and 2021-22)

Results and Discussion

Effect on yield and yield components of maize

Yield and yield contributing characters of intercropped maize were statistically significant (Table 1). The highest plant height (184.70 cm) was recorded from sole maize and the lowest plant height (170.07 cm) from Maize paired row (30cm/120cm/30cm × 20cm) + 3 rows potato intercropping combination. The highest number of grains cob-1 (585.) was recorded from sole maize plot and the lowest number of grains cob-1 (547) was found in Maize paired row (30cm/120cm/30cm×20cm) +3 rows potato intercropping combination. The same trend was observed in case of 1000-grain weight and it was ranged from 377.00-425.83 g in different treatments. The highest 1000-grain weight (425.83 g) was recorded from sole maize and the lowest 1000-grain weight (377.00 g) from Maize paired row (30cm/120cm/30cm×20cm) + 3 rows potato intercropping combination. The highest grain yield (9.99 t ha-1) was recorded from sole maize, which could be due to higher no. of grains cob-1 and 1000-grain weight. The grain yield of maize in intercropped combination varied from 9.68-9.99 t ha-1 in two consecutive years.

Effect of intercrops

The intercrop yield of potato was influenced significantly by different intercropping combinations (Table 2). The highest potato yield (35.05 t/ha) was recorded from sole potato. The lowest yield was obtained from Maize normal sowing (60cm × 20cm) + 1 row potato in between maize rows intercropping combination (15.77 t/ha).

Maize equivalent yield

All the intercropped combinations showed higher maize equivalent yield than sole maize. Among the treatments, the highest maize equivalent yield (37.89 t/ha) was obtained from Maize paired row (30cm/120cm/30cm × 20cm) + 3 rows potato intercrop combination. The lowest maize equivalent yield (22.89 t/ha) was obtained from Maize normal row (60cm × 20cm) + 1 row potato in between two maize rows intercrop combination. The yield data indicated that due crop competition in intercropping yield loss of maize was minimum (1 to 3%).

Cost and return analysis

The cost and return analysis of sole and intercropping of maize and potato are presented in Table 3. Higher gross return was obtained from all intercrop combinations than sole crop. The result revealed that the highest gross return (Tk. 454680 ha-1) and gross margin (Tk. 344580 ha-1) were obtained in Maize paired row (30cm/120cm/30cm×20cm) +3 rows potato. The lowest gross return and gross margin was obtained from sole maize. The highest benefit cost ratio (4.12) was also obtained from Maize paired row (30cm/120cm/30cm×20cm) +3 rows potato and the lowest in sole maize (1.69).

Table 1. Yield contributing characters of maize, yield of maize and potato under intercropping situation at ARS, Rajbari, Dinajpur (pooled data of two years)

Treatments	Plant height (cm)	Grain/cob (no.)	1000-grain wt. (g)	Yield (t/ha)	
				Maize	Potato
T_1	184.70	585.03	425.83	9.99	-
T_2	182.90	573.30	415.83	9.86	30.40
T_3	175.20	568.53	392.33	9.75	15.77
T_4	172.00	560.63	383.33	9.70	25.10
T_5	170.07	547.00	377.80	9.68	33.85
T_6	-	-	-	-	35.74
$LSD_{(0.05)}$	4.38	19.86	14.68	5.30	1.85
CV (%)	1.31	1.86	1.96	1.05	3.48

Table 2. Maize grain yield, tuber yield potato, maize relative and equivalent yield influenced by intercropping with potato at ARS, Rajbari, Dinajpur (pooled data of two years)

Treatments	Maize grain yield (t/ha)	Tuber yield of potato (t/ha)	Relative yield of maize (t/ha)	Maize equivalent yield (t/ha)
T_1	9.99	-	-	9.99
T_2	9.86	30.40	0.99	35.19
T_3	9.75	15.77	0.98	22.89
T_4	9.70	25.10	0.97	30.62
T_5	9.68	33.85	0.97	37.89
T_6	-	35.74	-	29.78

Table 3. Cost and return analysis of maize and potato under sole and intercropping situations

Treatments	Gross return (Tk./ha)	cost cultivation (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1	119880	70620	49260	1.69
T_2	422280	106920	315360	3.94
T_3	274680	95930	178750	2.86
T_4	367440	100680	266760	3.64
T_5	454680	110100	344580	4.12
T_6	357360	95943	261417	3.72

Market price: Maize: 12 Tk.kg-1, Potato: 10 Tk.kg-1

T_1= Sole maize (60cm×20cm), T_2= Maize normal row (60cm × 20cm) + 1 row potato in between two maize rows, T_3= Maize paired row (30cm/120cm/30cm × 20cm) + 1 row potato, T_4= Maize paired row (30cm/120cm/30cm × 20cm) + 2 rows potato, T_5= Maize paired row (30cm/120cm/30cm × 20cm) + 3 rows potato and T_6= Sole potato (60cm × 25cm).

Conclusion

The results revealed that the highest grain yield of maize was obtained in sole cropping but the highest maize equivalent yield was obtained in Maize paired row (30cm/120cm/30cm×20cm) + 3 rows potato. The highest gross return, gross margin and BCR were also obtained in Maize paired row (30cm/120cm/30cm×20cm) + 3 rows potato and the lowest in sole maize.

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INTERCROPPING ONION, GARLIC, CORIANDER WITH CHILLI IN CUMILLA REGION

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Abstract

An experiment was conducted at the research field of Regional Agricultural Research Station (RARS), BARI, Cumilla during 2021-22 to find out the suitable crop combination of onion, garlic and coriander with chilli for increasing total productivity, economic return and maximize land utilization through intercropping system. Seven treatments viz., T_1 = Sole chilli (50 cm × 50 cm) , T_2 =Two rows of onion (15 cm × 10 cm) in between two rows of chilli (50 cm × 50 cm), T_3 = Two rows of garlic (15 cm × 10 cm) in between two rows of chilli (50 cm × 50 cm), T_4 = 100% coriander (leaf) (broadcast) in between two rows of chilli (50 cm × 50 cm), T_5 = Sole onion (15 cm × 10 cm), T_6 = Sole garlic (15 cm × 10 cm), T_7 = Sole coriander (15 cm × 5 cm). The trial was set up in a randomized complete block design with three replications. The chilli was (Var. BARI Marich- 3) a main crop and onion (var. BARI Piaj- 6), garlic (Var. BARI Rashun- 2) and coriander (BARI Dhonia- 1) were used as intercrops in the study. The sole crop of chilli was planted at a spacing of 50 cm × 50 cm, the sole crop of onion and garlic was planted at a spacing of 15 cm × 10 cm. As intercropping system two rows of onion and two rows of garlic were planted as in between two rows of chilli and coriander (100%) was broadcast in between two rows of chilli. Results showed that, different intercropping combination significantly influenced yield and yield contributing characters of chilli. The yield of chilli was comparatively lower in intercropping than sole chilli but total productivity was increased due to additional yield of onion, garlic and coriander. Increased total productivity in terms of chilli equivalent yield (CEY) was 12.80 to 15.27 tha-1 in intercrop combination compared to sole chilli 10.93 t/ha (main crop). All the intercropping combinations showed better performance in terms of chilli equivalent yield, gross return and benefit cost ratio (BCR) over sole crops. Among the intercropping combinations two rows of onion in between two rows of chilli was the most feasible and profitable intercropping system in respect of chilli equivalent yield (15.27 t/ha), gross return (Tk.7,63500 ha-1), gross margin (Tk. 5,07300 ha-1) and benefit cost ratio (2.98).

Introduction

Bangladesh is a densely populated country. Day by day cultivable area is declining due to over growing population, urbanization and industrialization. As a result, total food demands are increasing but cultivable land area is decreasing. Intercropping is a traditional practice in Bangladesh and it increases total productivity per unit area through maximum utilization of land, labor and growth resources. By judicious choice of compatible crops and adopting appropriate planting geometry, inter/intra specific competition may be minimized resulting higher total productivity. Canopy architecture of tall stature crop regulates the availability of light on under storied crop. In Bangladesh small farmers constitute 79.45 of our farming community and their cultivated lands are shrinking day by day. In that context, intercropping is one of the viable technologies to ensure efficient utilization of their resources for increased production and family income. Intercropping offers the possibility of yield advantage relative to sole cropping through yield stability and improved yield in tropical and sub-tropical areas. Chilli is an important spices crop is cultivated round the year throughout the country. It is tall structure, long duration (150-200 days) and wide spread (60-80 cm). So, there is a great scope to cultivate short duration spices like onion, garlic and leafy spices (coriander) in the inter row space of chilli could be introduced as intercrop. Short duration spices like onion, garlic and leafy spice coriander being short duration quick growing crops can be easily intercropped between two rows of chilli at early growth stage for getting higher economic return. However, the literature regarding onion-chilli, garlic-chilli and coriander- chilli intercropping is very scarce. Keeping this view in mind, the experiment was undertaken to find out the most suitable crop combination of onion, garlic and coriander with chilli for increasing total productivity, economic return and maximize land utilization through intercropping system.

Materials and Methods

A field experiment was conducted at research field of Regional Agricultural Research Station, BARI, Cumilla during 2021-22. The treatment were; T_1 = Sole chilli (50 cm × 50 cm), T_2 =Two rows of onion (15 cm × 10 cm) in between two rows of chilli (50 cm × 50 cm), T_3 = Two rows of garlic (15 cm × 10 cm) in between two rows of chilli (50 cm × 50 cm), T_4 = 100% coriander (leaf) in between two rows of chilli (50 cm × 50 cm), T_5 = Sole onion (15 cm × 10 cm), T_6 = Sole garlic (15 cm × 10 cm), T_7 = Sole coriander (20 cm × 5 cm). The trial was set up in a randomized complete block design with three replications. The unit plot size was 2.5 m × 2.0 m. Sole chilli and intercrop treatments were fertilized with 120-80-120-20-4 NPKSZn kg ha-1 respectively. For sole onion, sole garlic and sole coriander were fertilized with 90-45-120-30 NPKS kg ha-1, respectively. For sole chilli and intercrop treatments; half N and all other fertilizers were used as basal. Rest N was applied at 20 and 50 days after transplanting. For sole onion and other sole crop; half of N, K and full dose of P, S were applied at the time of final land preparation and remaining N and K were top dressed at 25 and 50 days after transplanting followed by irrigation. The sole crop of chilli was planted at a spacing of 50 cm × 50 cm, the sole crop of onion and garlic was planted at a spacing of 15 cm × 10 cm. As intercropping system two rows of onion and two rows of garlic were planted as per treatment. Coriander seed (100%) was broadcast in between two rows of chilli. Chilli (25 days old seedling) was transplanted on 24 November 2021. Onion seedling, garlic bulb and coriander seeds were planted and sown on 26 November 2021. Irrigation and pesticide were applied as per necessary. The coriander leaf was harvested on 20 December at 24 days after sowing. Onion and garlic were harvested on 1 March 2022 and 10 March 2022 respectively. Chilli was harvested at four times and it was harvested on 10 March, 22 March,10 April and 30 April 2022. For chilli data on yield and yield contributing characters were taken and analyzed statistically. The yield component data of chilli was taken from 10 randomly selected plants prior to harvest from each plot. For chilli, onion, garlic, and coriander at harvest the yield data was recorded plot wise. The collected data were analyzed statistically using statistix10 package and means were adjudged by LSD at 5% level of probability. Chilly equivalent yield (CEY) was converted by converting yield of intercrops on the basis of market price of individual crop following the formula:

Chilli Equivalent Yield (CEY) = Yield of intercrop Chilli + $\frac{Yi \times Pi}{\text{Price of chilli}}$

Where, Yi = Yield of intercrops (Onion/garlic/coriander) and Pi = Price of intercrops (Onion/garlic/coriander).

Land equivalent ratio (LER) values were determined from the yield data ofthe crops according to Mian (2008).

$$LER = \frac{YiC}{Y\,syc} + \frac{Yicc}{Ysycc}$$

Where,
Yic= Intercrop yield of chilli
Ysyc = Sole yield of chilli
Yicc = Intercrop yield of component crops
Ysycc = Sole yield of component crops

Results and Discussion

Yield and yield attributing characters of chilli

Plant height, number of fruits plant-1, single fruit weight, fruit length and green chilli yield were significantly influenced due to intercropping (Table 1). The highest plant height (67.1cm) was obtained from T_4 and the lowest (62.3 cm) was in T1 treatment. The maximum number of fruits plant-1 (288.4) was recorded in sole chilli (T1) which was identical to (248.1) T_2 treatment. The maximum single fruit weight (1.95 g) was obtained from sole chilli (T1) which was statistically similar (1.88) with T_2 treatment. Higher fruit length (5.45 cm) was obtained from sole chilli (T1) which was statistically similar with T_4 and T_2 treatment and the lowest (5.12 cm) was recorded in T3.

The highest green chilli yield (10.93 t/ha) was obtained from T_1 treatment and the lowest (7.00 t/ha) from T_4 treatment. The higher fruit yield and higher single fruit weight in sole crop was attributed to more number of fruits plant-1.Islam *et al*. (2014) also reported similar result.

Table 1. Yield and yield attributes of chilli under sole and intercropping situation during rabi 2020-21

Treatment	Plant height (cm)	No. of branch plant-1	No. of fruits plant-1	Single fruit weight (g)	Fruit length (cm)	Green chilli yield (t/ha)
T_1	62.3	7.73	288.4	1.95	5.45	10.93
T_2	64.1	7.20	248.1	1.88	5.25	9.00
T_3	64.2	7.13	216.1	1.84	5.12	8.80
T_4	67.1	7.40	230.7	1.79	5.30	7.00
$LSD_{(0.05)}$	2.67	NS	48.94	0.10	0.32	1.68
CV(%)	2.08	11.53	9.97	6.3	5.1	8.77

Yield of component crops

The yield of onion, garlic and coriander was significantly influenced by intercroponion, garlic and coriander with chilli (Table 2). The maximum yield was recorded in sole onion (13.95 t/ha) in sole treatment followed by (10.45 t/ha) in T_2 treatment (Two rows of onion in between two rows of chilli) and the lowest yield (5.8 t/ha) was in T_4 treatment 100% coriander (leaf) in between two rows of chilli. In case of garlic and coriander the similar trend was also observed. Faruque *et. al.* (2006) also reported the similar result.

Table 2.Yield of onion, garlic and coriander under sole and intercropping situation during rabi of 2021-22

Treatment	Yield (t/ha)
T_2 (Two rows of onion in between two rows of chilli)	10.45
T_3 (Two rows of garlic in between two rows of chilli)	6.06
T_4 (100% coriander (leaf) in between two rows of chilli)	5.80
T_5 (Sole onion)	13.95
T_6 (Sole garlic)	9.95
T_7 (Sole coriander)	8.60
LSD $_{(0.05)}$	1.92
CV (%)	7.20

Chilli equivalent yield

Chilli equivalent yield is expressed in total productivity. Chilli equivalent yield were higher (12.80 -15.27 t/ha) in all the intercrops than the sole crop of chilli (10.93 t/ha), onion (8.37 t/ha), garlic (9.95 t/ha) and coriander (9.95 t/ha). In intercrop combination the maximum chilli equivalent yield (15.27 t/ha) was recorded in T_2 treatment (Two rows of onion in between two rows of chilli) which was followed by (14.86 t/ha) T_3 treatment (Two rows of garlic in between two rows of chilli) and the lowest chilli equivalent yield (8.60 t/ha) from T_7 treatment (Sole coriander). Ahmed (2013) also reported that intercrop combination increase the equivalent yield.

Land equivalent ratio

Land equivalent ratio is the most common index adopted in intercropping to measure the land productivity. It is often used as an indicator to determine the efficacy of intercropping (Brintha and Seran, 2009). The maximum land equivalent ratio (1.57) was recorded in T_2 treatment (Two rows of onion in between two rows of chilli) followed by (1.41) T_3 treatment (Two rows of garlic in between two rows of chilli) and the lowest Land equivalent ratio (1.31) in T3 treatment (100% coriander in between two rows of chilli). LER of different crop combinations ranged from 1.31% to 1.57% indicating land utilization 31-57% increased by intercropping. The mean values of LER (more than one) in all intercropping treatments indicated that land was more efficiently utilized under intercropping than sole cropping of chilli, onion, garlic and coriander.

Cost benefit analysis

Intercropping combination of onion, garlic and coriander with chilli showed higher monetary return than sole crop (Table 3). The highest gross return (Tk. 7,63500) was recorded from T_2 treatment (Two rows of onion in between two rows of chilli) which was 39.7% higher than the sole chilli. This (T_2 treatment) intercropping combination also gave the higher gross margin (Tk. 5,07300) and benefit cost ratio (2.98) followed by T_3 treatment (Two rows of garlic in between two rows of chilli) with 2.87 BCR. The results of increased productivity and returns were consistent with the earlier reports of yield advantages of crop mixture compared to monoculture (Islam *et al*. 2012 and Ahmed *et al*. 2013).

Table 3. Chilli equivalent yield (CEY), Land equivalent ratio (LER) and Cost and return analysis of chili, onion, garlic and coriander under sole and intercropping situation

Treatment	CEY (t/ha)	LER	Gross return (Tk.ha-1)	Cost of production (Tk.ha-1)	Gross margin (Tk.ha-1)	Benefit cost ratio (BCR)
T_1	10.93	1.00	546500	235250	311250	2.32
T_2	15.27	1.57	763500	256200	507300	2.98
T_3	14.86	1.41	743000	258500	484500	2.87
T_4	12.80	1.31	640000	240250	399750	2.66
T_5	8.37	1.00	418500	232100	186400	1.80
T_6	9.95	1.00	497500	235100	262400	2.11
T_7	8.60	1.00	430000	202500	186800	2.12

CEY= Chilli equivalent yield; LER= Land equivalent ratio

T_1 = Sole chilli (50 cm × 50 cm) , T_2 =Two rows of onion in between two rows of chilli (15 cm × 10 cm), T_3 = Two rows of garlic in between two rows of chilli (15 cm × 10 cm), T_4 = 100% coriander (leaf) in between two rows of chilli, T_5 = Sole onion (15 cm × 10 cm), T_6 = Sole garlic (15 cm × 10 cm), T_7 = Sole coriander (15 cm × 5 cm).

Price: Onion-30/-; Garlic-50/-; Chilli-50/-; Coriander leaf-50/-

Conclusion

The result revealed that all intercropping treatments were productive as compared to sole treatments. Among the treatments, Two rows of onion (15 cm × 10 cm) in between two rows of chilli (50 cm × 50 cm) was more productive and profitable in respect of chilli equivalent yield and monetary return. Two rows of garlic (15 cm × 10 cm) in between two rows of chilli (50 cm × 50 cm) and 100% coriander (leaf broadcast) in between two rows of chilli (50 cm × 50 cm) combinations were also found profitable in respect of CEY and BCR.

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INTERCROPPING OF SUMMER ONION WITH MUKHIKACHU IN CUMILLA REGION

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Abstract

An experiment was conducted at the research field of Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Cumilla during Kharif I, 2021 to find out the suitable combination of onion with mukhikachu for increasing total productivity, economic return and maximize land utilization through intercropping system. Seven treatments viz., i) Sole mukhikachu (60 cm × 45 cm), ii) Two rows of summer onion (20 cm × 10 cm) in between two rows of mukhikachu (60 cm × 45 cm), iii) Three rows of summer onion (15 cm × 10 cm) in between two rows of mukhikachu (60 cm × 45 cm), iv) Two rows of summer onion (18 cm × 10 cm) in between two double rows of mukhikachu (20cm/55cm/20 × 45 cm), v) Three rows of summer onion (15 cm × 10 cm) in between two double rows of mukhikachu (20cm/55cm/20 × 45 cm), vi) Sole summer onion (15 cm × 10 cm). Mukhikachu was (Var. BARI Mukhikachu-1) a main crop and onion (Var. BARI Piaj-5) were used as intercrops. Results showed that, different intercropping combination significantly influenced yield and yield contributing characters of mukhikachu. The yield of mukhikachu was comparatively lower in intercropping than sole mukhikachu but total productivity was increased due to additional yield of onion. Increased total productivity in terms of mukhikachu equivalent yield (MEY) was 38.72 to 42.28 t/ha in intercrop combination compared to sole mukhikachu 31.70 t ha-1 (main crop). All the intercropping combinations showed better performance in terms of mukhikachu equivalent yield, gross return and benefit cost ratio (BCR) over sole crops. Among the intercropping combinations three rows of onion in between two double rows of mukhikachu was the most feasible intercropping system in respect of mukhikachu equivalent yield (42.28 t/ha), gross return (Tk.8,45600), gross margin (Tk. 5,18100) and benefit cost ratio (2.58).

Introduction

Mukhikachu (Colocasia esculenta) is an important edible aroid in Bangladesh as well as in some other countries of the world. Mukhikachu is rich in iron and vitamin ‘A’. In Bangladesh, it comes to market as an important summer vegetable when most of the vegetables are not available. After plantation, the crop requires six months for shoot growth. Then it declines and cormel growth starts and continues to grow about 2 to 3 months till maturity, in this condition 8-9 months are required for cultivation of mukhikachu. Onion is one of the most important spices as well as vegetable crops of Bangladesh. It is widely cultivated during winter season. But now-a-days some onion varieties are also cultivate in summer season. This crop may be harvest within very short time. Onion could be cultivated in between the rows of mukhikachu as an extra crop. The present experiment was undertaken to find out the suitable intercrop combination of summer onion with mukhikachu.

Materials and Methods

A field experiment was conducted at research field of Regional Agricultural Research (RARS) Station, Bangladesh Agricultural Research Institute (BARI), Cumilla during Kharif I 2021. The treatments were: i) Sole mukhikachu (60 cm × 45 cm), ii) Two rows of summer onion (20 cm × 10 cm) in between two rows of mukhikachu (60 cm × 45 cm), iii) Three rows of summer onion (15 cm × 10 cm) in between two rows of mukhikachu (60 cm × 45 cm), iv) Two rows of summer onion (18 cm × 10 cm) in between two double rows of mukhikachu (20cm/55cm/20 × 45 cm), v) Three rows of summer onion (15 cm × 10 cm) in between two double rows of mukhikachu (20cm/55cm/20 × 45 cm), vi) Sole summer onion (15 cm × 10 cm). BARI Mukhikachu- 1(main crop) and BARI Onion -3 (component crop) were used as variety. The trial was set up in a randomized complete block design with three replications. The unit plot size was 3.0 m × 2.70 m. Sole mukhikachu and intercrop treatments were fertilized with NPKS 96-27-81-18 kg ha-1 respectively. Full amount of PKS was applied as basal. N was applied in two equal splits, one at 20 days after planting (DAP) and another at 45 DAP.The sole crop of normal mukhikachu was planted at a spacing of 60 cm × 45 cm, incase of double rows mukhikachu was planted 55cm ×20cm ×45cm. The onion was planted at a spacing of 15 cm × 10 cm. Mukhikachu was planted on 24 April 2021. Onion seedling was transplanted on 26 April 2021. Irrigation and pesticide were applied as per necessary.

For mukhikachu data on yield and yield contributing characters was taken and analyzed statistically. The yield component data of mukhikachu and onion was taken from 10 randomly selected plants prior to harvest from each plot. For mukhikachu and onion at harvest the yield data were recorded plot wise. The collected data were analyzed statistically using statistix 10 package and means were adjudged by LSD at 5%level of probability. Mukhikachu equivalent yield (MEY) was converted by converting yield of intercrops on the basis of market price of individual crop following the formula:

$$\text{Mukhikachu Equivalent Yield} = \text{Yield of intercrop Mukhikachu} + \frac{Yi \times Pi}{\text{Price of Mukhikachu}}$$

Where, Yi = Yield of intercrop (Onion) and Pi = Price of intercrop (Onion).

Land equivalent ratio (LER) values were determined from the yield data of the crops according to Mian (2008).

$$\text{LER} = \frac{YiC}{\text{Y syc}} + \frac{Yicc}{\text{Ysycc}}$$

Where,
Yic= Intercrop yield of Mukhikachu
Ysyc = Sole yield of Mukhikachu
Yicc = Intercrop yield of component crop (onion)
Ysycc = Sole yield of component crop (onion)

Results and Discussion

Yield and yield attributing characters of chilli

Plant height, number of corm plant-1, number of cormel plant-1, cormel wt. plant-1 and yield were significantly influenced due to sole and intercropping onion with mukhikachu (Table 1). The highest plant height (112.33) was obtained from T_1 and the lowest (103.33 cm) in T_2 treatment. The highest number of corm plant-1 (10.8), and cormel plant-1(30.2) was recorded in (T_5) treatment. The maximum cormel wt. plant-1 (517.5 g) was obtained from sole mukhikachu (T_1) which was statistically similar with T_5 (515.0 g) and T_4 (512) treatment. The highest corm yield (31.70 t/ha) was obtained from T_1 treatment and the lowest (28.80 t/ha) from T_2 treatment. Islam *et al*. (2014) also reported similar result.

Table 1. Yield and yield attributes of mukhikachu under sole and intercropping situation during Kharif 2021

Treatment	Plant height (cm)	Corm plant- 1 (no.)	Corm weight plant-1 (g)	Cormel plant-1 (no.)	Cormel weight plant-1 (g)	Yield (t/ha)
T_1= (Sole mukhikachu)	112.33	8.87	488	29.0	517.5	31.70
T_2=(Two rows of summer onion in between two rows of mukhikachu)	103.33	8.13	493	25.4	434.0	28.80
T_3=(Three rows of summer onion in between two rows of mukhikachu)	107.27	9.73	507	27.6	468.7	29.20
T_4=(Two rows of summer onion in between two double rows of mukhikachu)	108.73	10.2	508	29.8	512.0	30.30
T_5=(Three rows of summer onion in between two double rows of mukhikachu)	108.47	10.8	471	30.2	515.0	31.00
$LSD_{(0.05)}$	5.3	2.1	NS	3.2	32.7	2.1
CV(%)	8.4	5.6	9.8	11.2	7.5	9.5

Yield and yield attributes of intercrop onion

Branch plant-1, bulb height, bulb diameter, single bulb weight and yield were significantly influenced due to sole and intercropping onion (Table 2). The highest branch plant-1 (6.13 cm) was obtained from T_6 and the lowest (5.86 cm) in T_5 treatment. The maximum bulb height (5.00 cm) was recorded in T3 treatment which was identical to T_4, T_5 and T_6 treatment. The highest bulb diameter (3.70 cm) was obtained from sole onion (T_6) which was statistically similar (3.60) with T_2 treatment. The maximum single bulb weight (24.93 g) was obtained from sole onion (T6) which was statistically similar (23.73) with T_4 treatment and the lowest (22.07 g) in T_2 treatment. The highest onion bulb yield (8.38 t/ha) was obtained from T_6 treatment and the lowest (4.96 t/ha) from T_2 treatment. The bulb yield and higher single bulb weight in sole crop was attributed to more number of fruits plant-1.Islam *et al.* (2014) also reported similar result.

Table 2.Bulb yield of onion under sole and intercropping situation during Kharif I 2021

Treatment	Plant height (cm)	Branch plant-1 (no.)	Bulb height (cm)	Bulb diameter (cm)	Single bulb wt. (g)	Bulb yield (t/ha)
T_2	37.13	5.93	4.63	3.60	22.07	4.96
T_3	35.33	5.93	5.00	3.37	23.00	6.34
T_4	35.40	5.93	4.97	3.50	23.73	5.22
T_5	37.33	5.86	4.80	3.33	22.27	5.64
T_6	39.20	6.13	4.93	3.70	24.93	8.38
$LSD_{(0.05)}$	NS	0.18	0.22	0.10	1.42	
CV(%)	10.5	9.8	8.8	8.7	8.9	5.8

i) T_1= Sole mukhikachu ii) T_2= Two rows of summer onion in between two rows of mukhikachu iii) T_3 =Three rows of summer onion in between two rows of mukhikachu iv) T_4=Two rows of summer onion in between two double rows of mukhikachu v) T_5=Three rows of summer onion in between two double rows of mukhikachu vi) T_6 =Sole summer onion.

Mukhikachu Equivalent Yield (MEY)

Mukhikachu equivalent yield is expressed in total productivity. Mukhikachu equivalent yield were higher (38.72 - 42.28 (t/ha) in all the intercrops than the sole crop of mukhikachu (31.70 (t/ha) and onion (16.76 (t/ha). In intercrop combination, the maximum mukhikachu equivalent yield (42.28 (t/ha) was recorded in T_5 treatment (Three rows of summer onion in between two double rows of mukhikachu) which was followed by (41.88 (t/ha) T3 treatment (Three rows of summer onion in between two rows of mukhikachu) and the lowest mukhikachu equivalent yield (16.76 (t/ha) from T_6 treatment (Sole onion). Ahmed *et al*. (2013) also reported that intercrop combination increase the equivalent yield.

Table 3. Mukhikachu equivalent yield (MEY), Land equivalent ratio (LER) and Cost and return analysis of mukhikachu and onion under sole and intercropping situation at RARS, BARI, Cumilla

Treatment	MEY (t/ha)	LER	Gross return (Tk. /ha^{-1})	Cost of production (Tk. /ha^{-1})	Gross margin (Tk. /ha^{-1})	BCR
T_1	31.70	1.00	634000	275000	359000	2.30
T_2	38.72	1.81	774400	325000	449400	2.38
T_3	41.88	2.07	837600	327500	510100	2.56
T_4	40.74	1.90	814800	325000	489800	2.51
T_5	42.28	2.00	845600	327500	518100	2.58
T_6	16.76	1.00	335200	165000	170200	2.03

CEY= Chilli equivalent yield; LER= Land equivalent ratio

i) T_1=Sole mukhikachu ii) T_2=Two rows of summer onion in between two rows of mukhikachu iii) T_3=Three rows of summer onion in between two rows of mukhikachu iv) T_4=Two rows of summer onion in between two double rows of mukhikachu v) T_5=Three rows of summer onion in between two double rows of mukhikachu vi) T_6 =Sole summer onion.

Cost Benefit Analysis

Intercropping combination of onion with mukhikachu showed higher monetary return than sole crop (Table 3). The highest gross return (Tk. 8,45600) was recorded from T5 treatment (Three rows of summer ,onion in between two double rows of mukhikachu) which was 33.3% higher than the sole mukhikachu. This intercropping combination also gave the higher gross margin (Tk. 5,18100) and benefit cost ratio (2.58) followed by T_3 treatment (Three rows of summer onion in between two rows of mukhikachu) with 2.56 BCR. The results of increased productivity and returns were consistent with the earlier reports of yield advantages of crop mixture compared to monoculture (Islam *et al*. 2012 and Ahmed *et al*. 2013).

Conclusion

The result revealed that all intercropping treatments were productive as compared to sole treatments. Among the treatments, Three rows of summer onion in between two double rows of mukhikachu were more productive and profitable in respect of chilli equivalent yield and monetary return. Three rows of summer onion in between two rows of mukhikachu combination was also profitable in respect of MEY and BCR.

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DEVELOPMENT OF FERTILIZER PACKAGES FOR FIVE CROP BASED CROPPING PATTERN IN RICE BASED CROPPING SYSTEM

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Abstract

An experiment was conducted at the Regional Agricultural Research Station, Jashore during 2019-2020, 2020-2021 and 2021-2022 consecutive years. The objectives of this study were to develop the fertilizer packages for five crop based cropping pattern, to assess the agronomic performance and to estimate economic return of five crop based cropping pattern in rice based cropping systems. The eight fertilizer treatments were: T_1 = 100% NPKSZnB (STB), T_2= T1+ 25% N, T_3= T1+ 25% NP, T_4= T1+ 25% NK, T_5= T1+ 25% PK, T_6= T1+ 25% NPK, T_7= 75% of T1 and T_8= Native fertility. This cropping pattern is composed with five crops; namely, T.Aman - broccoli - spinach- yardlong bean - T.Aus. The maximum total REY 44.5 t/ha was recorded from the treatment T_6 which was followed by T_4 (42.1 t/ha), T3 (40.4 t/ha), T_5 (40.3 t/ha) and $_{T2}$ (36.6 t/ha). The lowest total REY (11.2 t/ha) was obtained from the native nutrient treatment (T_8). Higher gross margin (Tk.180850 ha-1) was recorded from the treatment T_6 which was followed by T4 (Tk.136000 ha-1). But the highest marginal benefit cost ratio (MBCR) 35.0 was obtained from the treatment T4which was followed by the treatment T_6 (29.5) and T_5 (29.3). Total REY wasincreased by (T_6) 26.66, (T_4) 19.94, and (T_3) 15.1 % compared to the STB (100%) nutrient treatment (T_1), respectively. The income was increased by 297 (T6), 276 (T_4), 261 (T_3) and 260% (T_5) compared to the STB (100%) nutrient treatment (T_1), respectively.

Introduction

The present cropping intensely of 190% and this can be increased up to 400% by improving the present cropping pattern, incorporating short duration crops and through management of cultivation practices and sowing time (Annual Research Report, ORC, 2013). Most of the popular cropping pattern practiced around the country are comprises of two or three crops a year. In order to produce more food within a limited area, the cropping intensity should be increased producing three or more crops on the same land in a year keeping the productive efficiency of the component crops of their high levels.

Intensive crop cultivation using high yielding varieties of crop with imbalanced fertilization has led to mining out the inherent plant nutrients from the soils and thereby fertility status of the soils severely declined in Bangladesh. Mono-crop based fertilizer recommendations are proving to be costly to the poor farmers. On the other hand rich farmers are using high dose of chemical fertilizer especially urea for some crops which creates imbalance in soil nutrients. The nutrients added to the soil in the form of fertilizers are not being removed or utilized by the crops in one season. Some amounts are left over in the field. So, proper fertilizer management is very important considering the residual effect of the nutrients. Moreover, inclusion of a pulse crops in the cropping pattern would reduce the requirement of chemical fertilizers in the next crop maintaining a good health of soils through biological nitrogen fixing and addition of organic matter to soil.

There are a several number of cropping patterns in Bangladesh. The patterns are mainly rice based and vary on agro-ecological conditions and availability of irrigation facility. On the other hand two and three crop base cropping patterns are common in many places of Bangladesh. Recently four crop based cropping pattern has been introduced at many AEZs. Soil fertility is a major determinant for the success and failure of a crop production system. Long term soil fertility monitoring under a specific cropping system would be of great help in determining a better soil fertility management program for sustained productivity at high level. On the other hand the management practices in a crop of a cropping pattern greatly influence the other crop of the same pattern. The present study was undertaken with the long-term objectives to a) find out judicious fertilizer recommendation for T.Aman- broccoli-spinach-yard long bean-T.Aus cropping pattern for sustainable yield, b) monitor soil health after each cropping cycle and c) estimate uptake of different plant nutrients and make a balance sheet for each of the nutrients.

Materials and Methods

The field experiment was conducted at RARS, Jashore (AEZ-11) during 2019-2020, 2020-2021and 2021-2022 consecutive years. The soil was silty clay loam in texture with pH of 8.3.The eight fertilizer treatments were as follows: T_1 = 100% NPKSZnB (STB), T_2= T1+ 25% N, T_3= T1+ 25% NP, T_4= T1+ 25% NK, T_5= T1+ 25% PK, T_6= T1+ 25% NPK, T_7= 75% of T1 and T_8= Native fertility. This cropping pattern is composed with five crops; namely, T.Aman- broccoli- spinach- yard long bean- T.Aus. The experiment was laid out in a Randomized Complete Block (RCB) design with 3 replications. The unit plot size was 4 m × 3 m.

Table 1a. Initial soil chemical properties of experimental site before transplanting of T.Aus rice at RARS, Jashore during 2019

Soil depth (cm)	pH	SOC	SOM	Total N	K	P	S	B	Zn
		%			meq/100g	ppm			
0-15	8.2	0.82	1.41	0.08	0.19	36.21	20.34	0.24	0.98
15-30	8.3	0.91	1.57	0.09	0.21	54.4	16.58	0.19	1.06

Table 1b. Chemical properties ofpost-harvest soil

Treatment	Soil depth (cm)	pH	SOC	SOM	Total N	K	P	S	B	Zn
			%			meq/100g	ppm			
T_1	0-15	7.95	1.12	1.94	0.10	0.23	51.24	22.54	0.31	1.11
	15-30	7.65	0.78	1.35	0.08	0.22	48.12	14.65	0.22	0.92
T_2	0-15	7.80	0.84	1.45	0.08	0.22	62.86	18.89	0.18	1.08
	15-30	7.95	1.08	1.86	0.10	0.20	64.56	24.61	0.34	1.14
T_3	0-15	7.90	0.82	1.42	0.08	0.23	57.85	18.92	0.17	1.08
	15-30	8.10	1.10	1.90	0.10	0.25	44.33	26.18	0.29	0.96
T_4	0-15	7.80	0.81	1.40	0.08	0.22	62.11	28.18	0.30	0.95
	15-30	7.80	0.92	1.58	0.09	0.24	55.63	17.87	0.21	0.98
T_5	0-15	7.95	0.93	1.60	0.09	0.22	56.29	19.12	0.19	0.91
	15-30	7.60	0.90	1.55	0.09	0.21	45.62	17.8	0.31	1.02
T_6	0-15	7.85	1.12	1.92	0.10	0.24	46.54	19.69	0.27	0.88
	15-30	7.90	0.94	1.62	0.09	0.20	58.18	22.63	0.29	1.12
T_7	0-15	7.85	1.12	1.93	0.10	0.23	70.08	20.29	0.16	1.01
	15-30	7.90	0.94	1.62	0.09	0.25	65.63	17.66	0.33	0.98
T_8	0-15	8.0	0.95	1.64	0.09	0.22	52.18	15.95	0.25	1.06
	15-30	7.85	1.09	1.88	0.10	0.27	61.08	16.84	0.24	1.05

Thirty days old seedlings of Transplanted Aman (T. Aman) rice Binadhan-16 was transplanted on 21 August 2020 during the Kharif-1 season. Fertilizer doses were applied as per treatment requirements in the form of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively (Table 2b). The entire amount of TSP, MoP, Gypsum and Zinc sulphate were applied as basal. Seedlings were grown in separate plot. Urea was top dressed in three equal splits at 15, 30 and 45 days after transplanting (DAT). Intercultural operations like weeding, mulching were done as per requirement. T. Aman rice was harvested on 08November 2020. Grain yield (t/ha) was taken from the whole plot.

Thirty days old seedlings of broccoli were transplantedwith the spacing of 60 cm × 30 cm on 15 November 2020. Fertilizer doses were applied as per treatment requirements in the form of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively (Table 2c). Half of urea and entire amount of TSP, MoP, Gypsum, Zinc sulphate and Boric acid were applied as basal. The remaining urea was top-dressed at 15 days after planting (DAP) followed by irrigation. Other two irrigations were given at 45 and 60 DAP. Intercultural operations done as and when required.Broccoliwas harvested on 02 February 2021.

Spinach was grown during rabi season. Spinach seeds (Local) were sown on 11 February 2021. Fertilizer doses were applied as per treatment requirements in the form of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively (Table da). Half of urea and entire amount of TSP, MoP, Gypsum, Zinc sulphate and Boric acid were applied as basal. Two irrigation was given at 10 DAP and 20 DAP. Spinach was harvested on 22 March 2021 as leafy vegetable. Weeding and other intercultural operations were done as and when necessary.

Seeds of yard long bean were grown during Kharif-I season. Yard long bean seeds (BARI Borboti-2) were sown on 24 March 2021. One irrigation was given at 30 DAP. Irrigation and other intercultural operations were done as and when necessary. Yard long bean was harvested on 18 May 2021. After harvesting of pods, yard long bean plants incorporated into the soil.

Transplanted aus (T.Aus) rice was fifth crop of the sequence. Fertilizer doses were applied as per treatment requirements in the form of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively (Table 2a). Half of urea and entire amount of TSP, MoP, Gypsum, Zinc sulphate and Boric acid were applied as basal The full amount of TSP, MoP, Gypsum, Zinc sulphate and Boric acid were applied as basal. Twenty five days aged seedling of Parija was transplanted with 15 cm × 10 cm spacing on 08 June 2021 during Kharif season.Urea was top dressed in two equal splits at 15 and 35 days after transplanting (DAT). Intercultural operations were done when necessary. T. Aus were harvested on 17August 2020.

Table 2a. Rate of fertilizer for T. Aus rice (Var. Binadhan-19)

Treatments	Treatment combinations					
	N	P	K	S	Zn	B
	kg ha-1					
T_1= 100% NPKSZn (STB)	70	12	13	0	0	0
T_2= T1+ 25% N	88	12	13	0	0	0
T_3= T1+ 25% NP	88	15	13	0	0	0
T_4= T1+ 25% NK	88	12	16	0	0	0
$T_{5=}$ T1+ 25% PK	70	15	16	0	0	0
T_6= T1+ 25% NPK	88	15	16	0	0	0
T_7= 75% of T1	53	9	10	0	0	0
T_8=Native fertility	Native Fertility					

Table 2b. Rate of fertilizer for T. Aman rice (Var. Binadhan-16)

Treatments	Treatment combinations					
	N	P	K	S	Zn	B
	kg ha-1					
T_1 = 100% NPKSZn (STB)	92	16	18	0	0.5	0
T_2= T1+ 25% N	115	16	18	0	0.5	0
T_3= T1+ 25% NP	115	20	18	0	0.5	0
T_4= T1+ 25% NK	115	16	23	0	0.5	0
T_5= T1+ 25% PK	92	20	23	0	0.5	0
T_6= T1+ 25% NPK	115	20	23	0	0.5	0
T_7= 75% of T1	69	12	14	0	0.4	0
T_8=Native fertility	Native Fertility					

Table 2c. Rate of fertilizer for broccoli (Var. local hybrid)

Treatments	Treatment combinations					
	N	P	K	S	Zn	B
	kg ha-1					
T1 = 100% NPKSZn (STB)	116	35	51	0	1.0	0.5
T2= T1+ 25% N	145	35	51	0	1.0	0.5
T3= T1+ 25% NP	145	44	51	0	1.0	0.5
T4= T1+ 25% NK	145	35	63	0	1.0	0.5
T5= T1+ 25% PK	116	44	63	0	1.0	0.5
T6= T1+ 25% NPK	145	44	63	0	1.0	0.5
T7= 75% of T1	87	26	38	0	0.7	0.4
T8=Native fertility	Native Fertility					

Table 2d. Rate of fertilizer for spinach (local)

Treatments	Treatment combinations					
	N	P	K	S	Zn	B
	kg ha-1					
T_1 = 100% NPKSZn (STB)	46	0	50	0	0	0
T_2= T1+ 25% N	58	0	50	0	0	0
T_3= T1+ 25% NP	58	0	50	0	0	0
T_4= T1+ 25% NK	58	0	63	0	0	0
T_5= T1+ 25% PK	46	0	63	0	0	0
T_6= T1+ 25% NPK	58	0	63	0	0	0
T_7= 75% of T1	35	0	38	0	0	0
T_8=Native fertility	Native Fertility					

Results and Discussion

T. Aus rice

The maximum grain yield 5.25, 5.03 and 3.70 (t/ha)of T. Aus rice were produced by the treatment T_6 (25% additional NPK was added with the 100% STB rates) followed by T_5, T_3, T_4 and T_2 treatments and the lowest grain yield 3.31 (t/ha), 2.58 (t/ha)and 2.37 (t/ha)produced by the control treatment (T_8) during 2019, 2020 and 2021consecutive year, respectively (Table 3a).

Table 3a. Grain yield of T. Aus rice (Var. Binadhan-19) during the year 2019-2022

Treatments	Grain yield (t/ha)			
	2019	2020	2021	Pooled
T_1 = 100% NPKSZn	4.63	5.25	3.29	3.67
T_2= T1+ 25% N	4.78	4.92	2.99	3.60
T_3= T1+ 25% NP	4.88	4.49	3.46	3.61
T_4= T1+ 25% NK	4.63	3.59	3.44	3.50
T_5= T1+ 25% PK	4.82	4.22	3.47	3.53
T_6= T1+ 25% NPK	5.25	5.03	3.70	3.88
T_7= 75% of T1	4.74	4.33	3.12	3.16
T8=Native fertility	3.31	2.58	2.37	2.22
CV (%)	6.63	7.22	3.0	7.39
$LSD_{(0.05)}$	0.53	1.29	0.17	0.22

T. Aman

The maximum grain yield 4.10, 5.14 and 3.70 t/ha of T. Aman rice were produced by the treatment T_6 (25% additional NPK was added with the 100% STB rates) followed by T_4, T_5, T_3 and T_2 treatments and the lowest grain yield 2.94, 2.31 and 2.33 t/ha produced by the control treatment during 2019, 2020 and 2021 consecutive year, respectively (Table 3b).

Table 3b. Grain yield of T. Aman rice (Var. Binadhan-16) during the year 2019-2022

Treatments	Grain yield (t/ha)			
	2019	2020	2021	Pooled
T_1 = 100% NPKSZn	4.13	3.50	3.29	3.64
T_2= T1+ 25% N	4.19	3.61	3.02	4.05
T_3= T1+ 25% NP	3.59	3.11	3.46	3.90
T_4= T1+ 25% NK	3.42	3.61	3.43	3.93
T_5= T1+ 25% PK	3.45	3.47	3.47	3.82
T_6= T1+ 25% NPK	4.10	5.14	3.70	4.55
T_7= 75% of T1	3.36	3.89	3.15	3.32
T_8=Native fertility	2.94	2.31	2.33	2.53
CV (%)	11.66	10.87	2.96	6.32
LSD $_{(0.05)}$	0.75	0.68	0.17	0.24

Broccoli

The highest economic yield of broccoli 18.56 t/ha, 17.11 t/ha and 20 t/ha were produced from the treatment T_6 where 25% extra NPK was added over the 100% STB fertilizer rates which followed by T_1, T_3, T_4 and T_5 treatments during 2020, 2021 and 2022 consecutive year, respectively (Table 3c). The native fertility treatment produced the lowest economic yield of broccoli for 2020, 2021 and 2022 consecutive year, respectively.

Table 3c. Yield of Broccoli (Var. Local hybrid) during the year 2020-2022

Treatments	Economical yield (t/ha)			
	2020	2021	2022	Pooled
T_1 = 100% NPKSZn	12.54	11.50	13.58	12.5
T_2= T1+ 25% N	14.88	16.67	13.08	14.9
T_3= T1+ 25% NP	16.78	15.89	17.67	16.8
T_4= T1+ 25% NK	17.64	16.94	18.33	17.6
T_5= T1+ 25% PK	17.00	16.25	17.75	17.0
T_6= T1+ 25% NPK	18.56	17.11	20.00	18.6
T_7= 75% of T1	15.47	13.86	17.08	15.5
T_8=Native fertility	2.17	0.00	4.33	2.2
CV (%)	6.32	11.35	4.1	18.12
LSD $_{(0.05)}$	1.59	2.68	1.09	142.0

Table 3d. Fresh yield of Spinach (Var. local) as leafy vegetable during the year 2020-2022

Treatments	Fresh yield (tha-1) as leafy vegetable			
	2020	2021	2022	Pooled
T_1 = 100% NPKSZn	24.64	9.17	11.32	15.04
T_2= T1+ 25% N	20.72	10.28	10.90	13.97
T_3= T1+ 25% NP	23.94	8.33	14.72	15.67
T_4= T1+ 25% NK	24.00	8.89	15.28	16.05
T_5= T1+ 25% PK	24.78	6.39	14.79	15.32
T_6= T1+ 25% NPK	26.17	7.78	16.66	16.87
T_7= 75% of T1	24.50	5.83	14.23	14.86
T_8=Native fertility	3.28	0.00	3.60	2.29
CV (%)	7.16	13.68	4.09	21.04
LSD $_{(0.05)}$	2.69	1.69	0.91	2.53

Spinach

The fresh yield regarding spinach as influenced by the fertilizer rates has been presented in table 3e. The highest fresh spinach vegetable yield 26.17 t/ha, 7.78 tha-1and 16.66 tha-1were produced from the treatment T6 where 25% extra NPK was added over the 100% STB fertilizer rates during 2020, 2021 and 2022 consecutive year, respectively (Table 3e). The native fertility treatment produced the lowest fresh spinach vegetable yield for2020, 2021 and 2022 consecutive year, respectively.

Yard long bean

The data regarding economic yield of yard long bean was not influenced by the fertilizer dose (Table 3d). The highest economic yield of yard long bean 3.2 t/hafrom T6 at 2020and 3.8 tha-1from T4 and T1 were produced at 2021 consecutive year, respectively.

Table 3e. Yield of yard long bean (BARI Borboti-2) during the year during 2020-2022

Treatments	Economical yield (tha-1)			
	2020	2021	2022	Pooled
T_1 = 100% NPKSZn	2.3	3.8		3.1
T_2 = T1+ 25% N	2.3	2.0		2.2
T_3 = T1+ 25% NP	2.5	2.8		2.7
T_4 = T1+ 25% NK	2.4	3.8		3.1
T_5 = T1+ 25% PK	2.7	2.7		2.7
T_6 = T1+ 25% NPK	3.2	2.7		2.9
T_7 = 75% of T1	1.7	2.6		2.2
T_8 = Native fertility	1.4	2.0		1.7
CV (%)	8.59	9.23		15.63
$LSD_{(0.05)}$	0.75	1.44		NS

Table 4. Yield of different crops under different crops in the cropping pattern during 2019-2022 (Pooled)

Treatments	T. Aus	T. Aman	Broccoli	Spinach	Yard long bean	Total REY (t/ha)
	Pooled (t/ha)	Pooled (t/ha)	Pooled (t/ha)	Pooled (t/ha)	Pooled (t/ha)	
T_1 = 100% NPKSZn	3.67	3.64	12.5	15.04	3.1	35.11
T_2 = T1+ 25% N	3.6	4.05	14.9	13.97	2.2	36.56
T_3 = T1+ 25% NP	3.61	3.9	16.8	15.67	2.7	40.40
T_4 = T1+ 25% NK	3.5	3.93	17.6	16.05	3.1	42.11
T_5 = T1+ 25% PK	3.53	3.82	17	15.32	2.7	40.31
T_6 = T1+ 25% PKN	3.88	4.55	18.6	16.87	2.9	44.47
T_7 = 75% of T1	3.16	3.32	15.5	14.86	2.2	36.59
T_8 = Native fertility	2.22	2.53	2.2	2.29	1.7	11.20
CV (%)	7.39	6.32	18.12	21.04	15.63	6.29
$LSD_{(0.05)}$	0.22	0.24	142	2.53	NS	1.46

Rice equivalent yield

Total productivity of this cropping sequence for different fertilizer treatments was determined by rice equivalent yield (REY) and it was calculated from yield of component crops. Rice equivalent yield was different under different treatment (Table 4). The highest total REY 44.47 t/ha was recorded from the treatment T_6 which was followed by T_4 (42.11 t/ha),T3 (40.40 t/ha), T_5 (40.31 t/ha) and T_2 (36.56 t/ha). The lowest total REY (11.20 t/ha) was obtained from the native nutrient treatment (T_8).

Economic Analysis

Economics of system productivity of different fertilizer treatments under this five crop based cropping sequences showed that the gross return was different for different fertilizer treatments. The highest gross margin (Tk.180850ha-1) was recorded from the treatment T6 which was followed by T4

(Tk.136000ha-1) and T5(Tk.100550ha-1),respectively (Table 5). The highest marginal benefit cost ratio (MBCR) 35.0was obtained from the treatment T4which was followed by the treatment T6 (29.5) and T5 (29.3). Total REY was increased by (T6) 26.66 %, (T4) 19.94 %, and (T3) 15.1 %compared to the STB (100%) nutrient treatment (T1),respectively. The income was increased by (T6) 297 %, (T4) 276 %, (T3) 261 % and (T5) 260 %compared to the STB (100%) nutrient treatment (T1), respectively (Table 5).

Table 5. Rice equivalent yield, cost and return of different fertilizer treatments during 2019-2022 (Average)

Treat.	Total REY (t/ha)	Gross Return (Tk. ha-1)	Marginal Gross Return (Tk. ha-1)	Total Variable cost (Tk.ha-1)	Marginal Variable cost (Tk. ha-1)	Gross Margin (Tk.ha-1)	MBCR	REY increase over STB	REY increase over control (%)
T_1	35.11	702100	0	249377	0	0		0	214
T_2	36.56	731200	29100	252387	3010	26090	9.7	4.14	227
T_3	40.40	807900	105800	254737	5360	100440	19.7	15.07	261
T_4	42.11	842100	140000	253377	4000	136000	35.0	19.94	276
T_5	40.31	806200	104100	252927	3550	100550	29.3	14.83	260
T_6	44.47	889300	187200	255727	6350	180850	29.5	26.66	297
T_7	36.59	731700	29600	243154	-6223	35823	-4.8	4.22	227
T_8	11.20	223900	-478200	220935	-28442	-449758	16.8	-68.11	0.00

Price Tk. kg-1: Rice = 20, Yard long bean = 30, Broccoli = 25, Spinach= 10

T1 = 100% NPKSZn; T2 = T1+ 25% N; T3 = T1+ 25% NP; T4 = T1+ 25% NK; T5 = T1+ 25% PK; T6 = T1+ 25% NPK; T7 = 75% of T1; T8 = Native fertility

Conclusion

The field experiment on five crop based cropping pattern (T.aman-Broccoli-Spinach-Yard long bean-T.aus) was conducted to find out a suitable fertilizer combination for higher and sustainable yield of the pattern. 25% additional NPK produced higher yield of the component crops, the other treatments were showed significant variation among the component crop yield. Data obtained so far has little indication of any change in the fertilizer rates from the STB (100% of NPKSZnB) values for the individual crops of the pattern.

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DEVELOPMENT IMPROVED CROPPING PATTERN FOR INCREASING CROPPING INTENSITY AND ENSURING NUTRITION

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Abstract

In the context of developing improved cropping patterns and ensuring nutrition, a field experiment was conducted at the Regional Agricultural Research Station, Jashore, Bangladesh during 2018-19, 2019-20 and 2020-21 consecutive years to find out the suitable cropping pattern for higher productivity and nutritionas well as economic return.The cropping patterns were as: CP1= T.Aman rice (Var. Binadhan-16)-Spinach (Var. local) – Gardenpea (Var. BARI Motorshuti-3) -Mungbean (Var. BARI Mung-6)-T.Aus rice (Var. Binadhan-19); CP2= T. Aman rice-Cabbage(Var. Atlas70)-Spinach-Yard long bean (Var. Aduri)- T. Aus rice; CP3= T. Aman rice-Cauliflower (Var. Snowball)-Spinach-Yard long bean-T. Aus rice; CP4=T. Aman rice–Coriander (Var. BARI Dhonia-1)-Gardenpea-Mungbean-T. Aus rice; CP5=T. Aman rice –Cauliflower-Spinach-Mungbean-T. Aus rice and CP6 (farmer's practice)=T. Aman rice–Cauliflower-Mungbean-T.Aus rice. The results showed that five crops may be grown successfully one after another in a sequence with nutrition enriched improved cropping patterns. The average highest rice equivalent yield (REY) 35.32 t/ha was recorded from the cropping pattern CP3 which was followed by CP2 (34.93 t/ha) and CP5 (32.81 t/ha). The average lowest REY (20.97 t/ha) was obtained from the cropping pattern CP1. The average highest gross return (Tk.7,06,400/ha) was recorded from CP3cropping pattern which was followed by CP2 (Tk. 6, 98,600/ha) and CP5 (Tk. 6, 57,192/ha). But average highest gross margin (Tk.3, 97,330/ha) was obtained from CP2which was followed by CP3 (Tk.3, 93,725/ha). In terms of rice equivalent yield, the rice equivalent yield was increased by 15.3% in CP3 followed by 14.4 % in CP2and 8.8 % in CP5 cropping pattern compared to Farmers' practice (FP). In case of gross margin, the income was increased by 17.5% in CP2 followed by 16.8 % in CP3 and 5.8 % in CP5 cropping pattern compared to farmers' practice (FP). The highest marginal benefit cost ratio (MBCR) 3.26 was obtained from the cropping pattern CP2which was followed by CP3 (2.56) and CP5 (1.53).

Introduction

Bangladesh a South-Asian deltaic country having 160 million population lives within a small geographical area of 147, 570 square kilometer (BBS, 2014). The current population is expected to increase by approximately 1.14 % per annum to 191.1 million (51.8%) by 2030 (World Bank, 2010) and to 212.5 million by 2050 i.e. adding 1.7 million population per year (World Bank, 2013). On the contrary, cultivable land area is decreasing at about one percent per year. Only eight and half million hectares of cultivable land (54 % of total land area) farmers grow/rare hundreds of field crops, vegetables, variety of fruits, agro forestry, fisheries along with capturing of fish from river and sea, and domestic animals and poultry for production of the country's food and fiber and their livelihoods (Ali, 2014). Farmers try to grow two or more crops per year in the same piece of land with small land holdings. Our current food grain production is 40.01 million tones (including pulses and oilseed). But 10-12 million tons of food grains to be produced in 2050 (Ahmed et al., 2012). Bangladesh is predominantly rice growing country and rice occupies about 80% of the total cropped area which is cultivated in three seasons of a year. In rice based cropping system T. Aman-Fallow-Boro-Fallow is a dominant cropping pattern where cropping intensity is 200% (22% of total cultivable land area). Among the rice crop, Boro rice receives the most irrigation water of all crops, with an estimated amount of 1,000 mm/cycle. For production one kg rice grain 3000-5000 L water is required (Rahman et al., 2013 and Hossain et al., 2014). So, the water table frequently falls below the reach of traditional shallow tube wells and resulting in drastic loss of rice yield, arsenic pollution, salinity and ecological imbalance. On the contrary, mustard, lentil, gardenpea, wheat, potato, mungbean, maize, vegetables like cabbage, cauliflower, yardlong bean, spinach and aus rice receive less irrigation water for successfully cultivation than boro rice. Cultivation of these crops needs only 2-4 times irrigation during rabi season. People of our country uptake 416, 14.30, 166.10, 66.26 gram per capita per day of rice, pulses, vegetables, protein and 2318.3 K. Cal per capita per day of calorie, respectively. Vegetables are the most important component of our food, and rich in vitamins, minerals and fibers that are essential for human health. Although the production of food grains has reached to self-sufficiency in Bangladesh, the production of fruits and vegetables, though increased remarkably, but are still far behind of our requirements.

Vegetables are the most important component of food, and are rich in vitamins, minerals and fibers that are essential for human health. The present consumption is only 44 grams/day/head against 220 grams of RDA. However, there is always a gap between the present level of production and demand. Efforts should be made to minimize this gap through research leading to increased yields. Food and nutrition security is a matter of multi-sectorial and dimensional issue; where agriculture has a pivotal role to play. Agricultural production system should therefore be reoriented into a food based system to ensure a balanced diet for the nation. Sustainable crop production in Bangladesh through improvement of cropping pattern 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 per unit yield by at least 50% through manipulating the limited land resource. In this regard, the challenges for the agronomist are to understand crop production problems and process to develop the best ways of production technologies for the management of sustainable food production. 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. Although there is very little scope of increasing cultivable land horizontally but there are some scope of increasing cropping intensity from the present cropping intensity 191% up to 400% by improving present cropping pattern through incorporating short duration, nutrition enriched and low input used crops like; garden pea, cabbage, cauliflower, spinach, coriander, yard long bean, mungbean and aus rice in the rice based cropping pattern. Potential adoption of these improved cropping patterns intensifying garden pea, cabbage, cauliflower, spinach, coriander, yard long bean, mungbean and aus rice in T.Aman-Fallow-Boro-Fallow cropping system would generate employment and additional income for the rural poor. Considering the above issues, the study was undertaken to develop, standardize and popularize nutrition enriched improved cropping patterns.

Materials and Methods

A field experiment was conducted at RARS, Jashore (AEZ-11), during 2018-2019, 2019-2020 and 2020-2021 consecutive years to find out the suitable cropping pattern for higher productivity and nutrition as well as economic return. The soil was silty clay loam in texture with pH of 8.5.The cropping patterns were as: CP1= T.Aman rice (Var. Binadhan-16)-Spinach (Var. local) – Gardenpea (Var. BARI Motorshuti-3) -Mungbean (Var. BARI Mung-6)-T.Aus rice (Var. Binadhan-19); CP2= T. Aman rice-Cabbage(Var. Atlas70)–Spinach – Yard long bean (Var. Aduri)- T. Aus rice; CP3= T. Aman rice- Cauliflower (Var. Snowball)–Spinach -Yard long bean- T. Aus rice; CP4= T. Aman rice–Coriander (Var. BARI Dhonia-1)- Gardenpea- Mungbean - T. Aus rice; CP5= T. Aman rice – Cauliflower–Spinach-Mungbean-T. Aus rice and CP6 (farmer's practice) = T. Aman rice–Cauliflower–Mungbean- T. Aus rice.

The experiment was laid out in a Randomized Complete Block (RCB) design with four replications. The unit plot size was 6 m × 4 m. Thirty days old seedlings of T. Aman rice var. BRRI dhan75 and var. Binadhan-16 was transplanted on 12 August 2018 and 08 August 2019 during the Kharif-2 season, respectively and it was the first crop of the sequence. All agronomic activities including sowing/transplanting, harvesting, weeding, irrigation, fertilizer and crop protection management etc. are presented in Table 1a to 6a. Recommended fertilizer doses (FRG, 2018) along with the application methods were applied to support the normal growth of the crops. Grain and economic yield were taken from whole plot. For economic comparison of these crop sequences, the yield of all crops was converted into rice 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 were also calculated on the basis of prevailing market price of the commodities.

Results and Discussion

Total productivity of different cropping sequence was determined by rice equivalent yield (REY) and it was calculated from yield of component crops.Yield and economic return of the cropping patterns are shown in Table 1b to 6b. Yield contribution of different crops was different under different cropping sequence (Table 1). Contribution of rice equivalent yield (REY) of different crops under different cropping sequence was different (Fig.1).

Yield performance

During 2018-2019, 2019-2020and 2020-2021consecutive years, the average seed yield of mungbean and grain yield of rice was 1.05 and 4.74 tha-1, respectively. The economical yield of spinach, coriander, gardenpea, cabbage and cauliflower were 10.97, 3.49, 7.94, 52.38 and 30.80 t ha-1, respectively. Among the cropping pattern, the average highest REY (35.32 tha-1) was recorded from the cropping pattern CP3 which was followed byCP2 (34.93 tha-1) and CP5 (32.81 tha-1). The average lowest REY (20.97 t/ha) was obtained from the cropping pattern CP1.

Table 1.Yield contribution of different crops in different improved cropping pattern during 2018-19 to 2020-21at RARS, Jashore (Average)

Cropping pattern	T. Aman (t/ha)	Spinach (t/ha)	Coriander (t/ha)	Cabbage (t/ha)	Cauliflower (t/ha)	Gardenpea (t/ha)	Yard long bean (t/ha)	Mungbean (t/ha)	T. Aus (t/ha)	Duration (day)
CP1	4.10	11.14	-	-	-	8.37	-	0.97	4.90	345
CP2	4.20	12.40	-	52.38	-	-	7.43	-	4.84	339
CP3	4.10	9.10	-		32.10	-	8.24	-	4.75	337
CP4	4.00	-	3.49	-	-	7.51	-	1.07	4.74	345
CP5	4.00	11.25	-	-	30.49	-	-	1.15	4.31	352
CP6	4.10	-	-	-	29.81	-	-	1.00	4.92	316
Avg.	4.08	10.97	3.49	52.38	30.80	7.94	7.84	1.05	4.74	

CP1 : Spinach – Gardenpea – Mungbean -T. aus –T. Aman
CP2 : Cabbage – Spinach – Yardlongbean -T. Aus –T. Aman
CP3 : Cauliflower – Spinach – Yardlongbean -T. Aus–T. Aman
CP4 : Coriander- Gardenpea – Mungbean -T. Aus –T. Aman
CP5 : Cauliflower – Spinach –Mungbean-T. Aus–T. Aman
CP6 : Cauliflower – Mungbean –T. Aus–T. Aman

Economic performance

Economics of cropping system of improved cropping pattern showed that the gross return and total duration were different under different cropping pattern (Table 1b to 6b). During 2018-2019, 2019-2020 and 2020-2021 consecutive years, the average highest gross return (Tk.7,06,400/ha) was recorded from CP3cropping pattern which was followed by CP2 (Tk. 6, 98,600/ha) and CP5 (Tk. 6, 57,192/ha). The average highest gross margin (Tk.3, 97,330/ha) was obtained from CP2which was followed by CP3 (Tk.3, 93,725/ha).The highest marginal benefit cost ratio (MBCR) 3.26 was obtained from the cropping pattern CP2 which was followed by CP3(2.56) and CP5 (1.53).The highest land use efficiency 96.44% was obtained from the cropping pattern CP5 followed by those of

94.52, 92.88 and 92.33 % were obtained from the cropping pattern CP5, CP1, CP2, CP3, respectively. In terms of rice equivalent yield, the rice equivalent yield was increased by 15.3% in CP3 followed by 14.4 % in CP2 and 8.8 % in CP5 cropping pattern compared to Farmers' practice (FP). In case of gross margin, the income was increased by 17.5% in CP2 followed by 16.8 % in CP3 and 5.8 % in CP5 cropping pattern compared to farmers' practice (FP).

Table 2. Rice equivalent yield, cost and return of different improved CP during 2018-2021 at RARS, Jashore (Average)

Cropping pattern	Total REY (t/ha)	REY increase over FP (%)	Gross return (Tk./ha)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	MBCR	Income increase over FP (%)	Land use efficiency (%)
CP1	20.97	-42.6	419400	272940	146460	-72.98	-123.8	94.52
CP2	34.93	14.4	698600	301270	397330	3.26	17.5	92.88
CP3	35.32	15.3	706400	312675	393725	2.56	16.8	92.33
CP4	24.56	-21.8	491200	272940	218260	-43.67	-50.1	94.52
CP5	32.81	9.0	656200	308345	347855	1.53	5.8	96.44
FP	29.91	0.0	598200	270490	327710		0.0	86.58

Market price of per kg rice, spinach (leafy vegetable), coriander (leafy vegetable), gardenpea (green vegetable), cauliflower, cabbage, yard log bean and mungbean are Tk. 20, 5, 40, 15, 12, 7, 12 and 60, respectively.

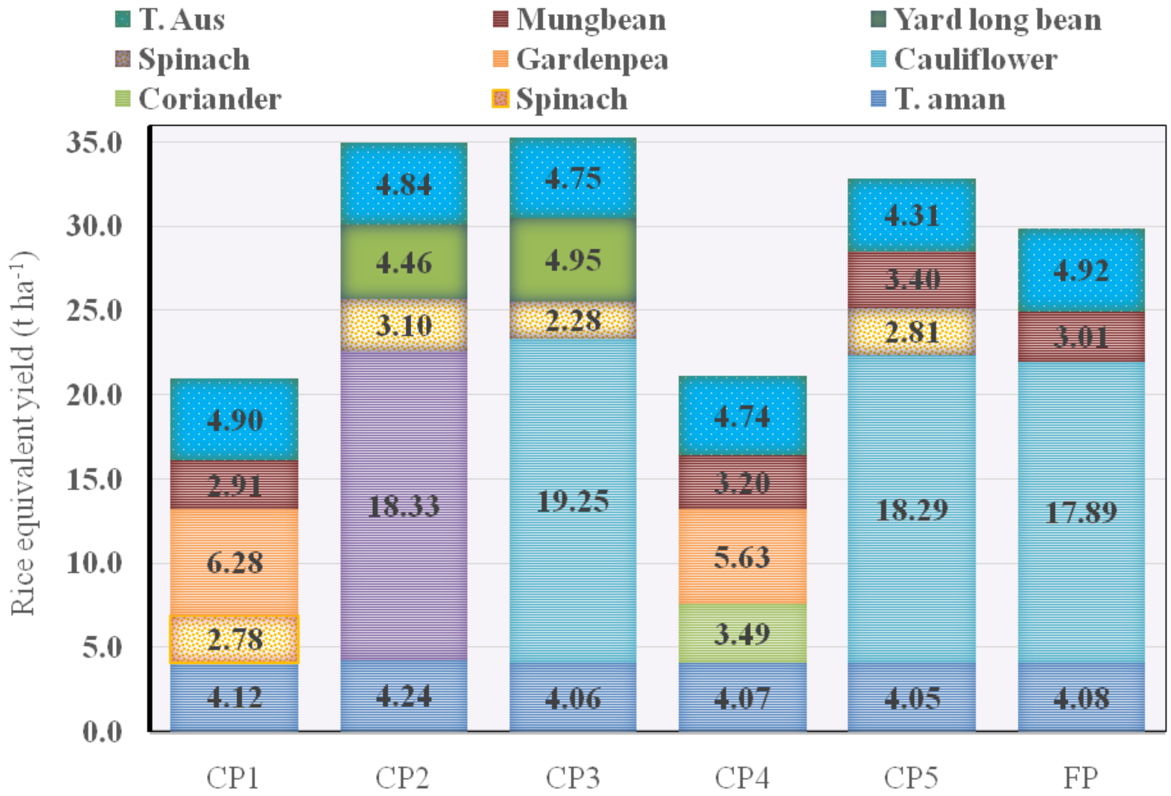

Fig 1. Yield contribution of different crops in vegetable based CP to get rice equivalent yield (REY) during 2018-2020

Conclusion

From the result it can be concluded that the development and popularization of improved cropping patterns could be possible. This trial is third year and results are partial and completion of two years cycle is required to obtain final results.

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Table 1a. Crop management practices of T. Aman- Spinach – Gardenpea- Mungbean- T. Aus cropping pattern during 2018-2021 at RARS, Jashore

Crop	T. Aman	Spinach	Garden pea	Mungbean	T. Aus
Variety	Binadhan-16	Local	BARI Motorshuti-3	BARI Mung-6	Binadhan-19
Unit plot size(m)	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
Spacing(cm)	20 × 15	30 × continuous	30 × 05	30 × 10	20 × 15
Planting procedure	Line transplanting	Line sowing with tillage	Line sowing with zero tillage	Line sowing with zero tillage	Line transplanting
Fertilizer dose (NPKSZnB kg/ha)	80: 25:30:5.0:2.0	25:10:25	25:25:30:5.0:2.0	-	80: 20:30:5.0:2.0
Fertilizer application	Basal & top dress	Basal & top dress	Basal & top dress	-	Basal & top dress
Date of transplanting/sowing	8-Aug-19	6-Nov-19	17-Dec-19	16-Mar-20	6-Jun-20
Irrigation (no.)	3	2	2	1	10
Weeding (no.)	1	1	1	1	1
Plant protection (no.)	2	No	no	3	2
Date of harvesting	28-Oct-19	15-Dec-19	2-Mar-20	30-May-20	19-Aug-20
Field duration (days)	81	39	76	75	74
Total duration (day)	345				
Turnaround time (day)	9	2	14	7	3

Table 1b. Yield and economic return of T. Aman- Spinach – Garden pea- Mungbean- T. Aus cropping pattern during 2018-2021 at RARS, Jashore

Crop	T. Aman	Spinach	Garden pea	Mungbean	T. Aus
Variety	Binadhan-16	Local	BARI Motorshuti-3	BARI Mung-6	Binadhan-19
Seed/grain yield (t/ha)	4.10	11.14	8.37	0.969	4.9
Rice equivalent yield (t/ha)	4.10	2.79	6.28	2.91	4.9
Total REY (t/ha)	20.97	-	-	-	
Gross return (Tk/ha)	82000	55700	125550	58140	98000
Total Gross return (Tk/ha)	419400				
Variable cost (Tk/ha)	56875	37855	70560	48325	59325
Total variable cost (Tk/ha)	272940				
Gross margin (Tk/ha)	146460				
Production Efficiency (Kg/ha/day)	61				
Systems profitability (Tk/ha/day)	401				
Land use efficiency-LUE (%)	94.52				
BCR	1.5				

Table 2a. Crop management practices of T. Aman – Cabbage– Spinach – Yard long bean- T. Aus cropping pattern during 2018-2021 at RARS, Jashore

Crop	T. Aman	Cabbage	Spinach	Yard long bean	T. Aus
Variety	Binadhan-16	Atlas70	Local	Adhuri	Binadhan-19
Unit plot size(m)	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
Spacing(cm)	20 × 15	60 × 40	30 × continuous	40 × 20	20 × 15
Planting procedure				Line sowing with zero tillage	
Fertilizer dose (NPKSZnB kg/ha)	80: 25:30:5.0:2.0	100: 50:100:10:2.0	25:10:25	40: 20:50:1.0	80: 20:30:5.0:2.0
Fertilizer application	Basal & top dress	Basal & top dress	Basal & top dress	Basal & top dress	Basal & top dress
Date of transplanting/sowing	8-Aug-19	6-Nov-19	3-Feb-20	18-Mar-20	6-Jun-20
Irrigation (no.)	3	4	2	2	10
Weeding (no.)	1	2	1	1	1
Plant protection (no.)	2	2	no	3	2
Date of harvesting	28-Oct-19	30-Jan-20	10-Mar-20	20-May-20	19-Aug-20
Field duration (days)	81	85	36	63	74
Total duration (day)	339				
Turnaround time (day)	9	4	8	17	3

Table 2b. Yield and economic return of T. Aman– Cabbage– Spinach – Yard long bean- T. Aus cropping pattern during 2018-2021 at RARS, Jashore

Crop	T. Aman	Cabbage	Spinach	Yard long bean	T. Aus
Variety	Binadhan-16	Atlas70	Local	Adhuri	Binadhan-19
Seed/grain yield (t/ha)	4.20	52.38	12.40	7.43	4.84
Rice equivalent yield (t/ha)	4.20	18.33	3.10	4.46	4.84
Total REY (t/ha)	34.93				
Gross return (Tk/ha)	84000	366660	62000	89160	96800
Total Gross return (Tk/ha)	698600				
Variable cost (Tk/ha)	56875	94560	37855	52655	59325
Total variable cost (Tk/ha)	301270				
Gross margin (Tk/ha)	397330				
Production Efficiency (kg/ha/day)	103				

Systems profitability (Tk/ha/day)	1089				
Land use efficiency-LUE (%)	92.88				
BCR	2.3				

Table 3a. Crop management practices of T. Aman – Cauliflower– Spinach– Yard long bean- T. Aus cropping pattern during 2018-2021

Crop	T. Aman	Cauliflower	Spinach	Yard long bean	T. Aus
Variety	Binadhan-16	Snowball	Local	Adhuri	Binadhan-19
Unit plot size(m)	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
Spacing(cm)	20 × 15	60 × 40	30 × continuous	40 × 20	20 × 15
Planting procedure				Line sowing with zero tillage	
Fertilizer dose (NPKSZnB kg/ha)	80: 25:30:5.0:2.0	100: 50:100:10:2.0	25:10:25	40: 20:50:1.0	80: 20:30:5.0:2.0
Fertilizer application	Basal & top dress	Basal & top dress	Basal & top dress	Basal & top dress	Basal & top dress
Date of transplanting/sowing	8-Aug-19	6-Nov-19	3-Feb-20	18-Mar-20	6-Jun-20
Irrigation (no.)	3	4	2	2	10
Weeding (no.)	1	2	1	1	1
Plant protection (no.)	2	2	no	3	2
Date of harvesting	28-Oct-19	28-Jan-20	10-Mar-20	20-May-20	19-Aug-20
Field duration (days)	81	83	36	63	74
Total duration (day)	337				
Turnaround time (day)	9	6	8	17	3

Table 3b. Yield and economic return of T. Aman – Cauliflower – Spinach – Yard long bean- T. Aus cropping pattern during 2018-2021 at RARS, Jashore

Crop	T. Aman	Cauliflower	Spinach	Yard long bean	T. Aus
Variety	Binadhan-16	Snowball	Local	Adhuri	Binadhan-19
Seed/grain yield (t/ha)	4.10	32.08	9.10	8.24	4.75
Rice equivalent yield (t/ha)	4.10	19.25	2.28	4.94	4.75
Total REY (t/ha)	35.32				
Gross return (Tk/ha)	82000	384960	45500	98880	95000
Total Gross return (Tk/ha)	706400				
Variable cost (Tk/ha)	56875	105965	37855	52655	59325
Total variable cost (Tk/ha)	312675				
Gross margin (Tk/ha)	393725				
Production Efficiency (Kg/ha/day)	105				
Systems profitability (Tk/ha/day)	1079				
Land use efficiency-LUE (%)	92.33				
BCR	2.3				

Table 4a. Crop management practices of T. Aman– Coriander– Garden pea – Mungbean- T. Aus cropping pattern during 2018-2021

Crop	T. Aman	Coriander	Garden pea	Mungbean	T. Aus
Variety	Binadhan-16	BARI Dhonia-1	BARI Motorshuti-3	BARI Mung-6	Binadhan-19
Unit plot size(m)	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
Spacing(cm)	20 × 15	30 × continuous	30 × 05	30 × 10	20 × 15
Planting procedure			Line sowing with zero tillage	Line sowing with zero tillage	
Fertilizer dose (NPKSZnB kg/ha)	80: 25:30:5.0:2.0	25:10:25	15:20:20:5.0:0:2.0		80: 20:30:5.0:2.0
Fertilizer application	Basal & top dress	Basal & top dress	Basal & top dress	Basal	Basal & top dress
Date of transplanting/sowing	8-Aug-19	6-Nov-19	17-Dec-19	16-Mar-20	6-Jun-20
Irrigation (no.)	3	2	2	1	10
Weeding (no.)	1	1	1	1	1
Plant protection (no.)	2	No	no	3	2
Date of harvesting	28-Oct-19	15-Dec-19	2-Mar-20	30-May-20	19-Aug-20
Field duration (days)	81	39	76	75	74
Total duration (day)	345				
Turnaround time (day)	9	2	14	7	3

Table 4b. Yield and economic return of T. Aman– Coriander– Garden pea – Mungbean- T. Aus cropping pattern during 2018-2021 at RARS, Jashore

Crop Variety	T. Aman Binadhan-16	Coriander BARI Dhonia-1	Garden pea BARI Motorshuti-3	Mungbean BARI Mung-6	T. Aus Binadhan-19
Seed/grain yield (t/ha)	4.10	3.49	7.51	1068	4.74
Rice equivalent yield (t/ha)	4.10	6.98	5.63	3.20	4.74
Total REY (t/ha)	24.56				
Gross return (Tk/ha)	82000	139600	112650	64080	94800
Total Gross return (Tk/ha)	491200				
Variable cost (Tk/ha)	56875	37855	70560	48325	59325
Total variable cost (Tk/ha)	272940				
Gross margin (Tk/ha)	218260				
Production Efficiency (kg/ha/day)	71				
Systems profitability (Tk/ha/day)	598				
Land use efficiency-LUE (%)	94.52				
BCR	1.8				

Table 5a. Crop management practices of T. Aman – Cauliflower – Spinach – Mungbean- T. Aus cropping pattern during 2018-2021 at RARS, Jashore

Crop	T. Aman	Cauliflower	Spinach	Mungbean	T. Aus
Variety	Binadhan-16	Snowball	Local	BARI Mung-6	Binadhan-19
Unit plot size(m)	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
Spacing(cm)	20 × 15	60 × 40	30 × continuous	30 ×10	20 × 15
Planting procedure				Line sowing with zero tillage	
Fertilizer dose (NPKSZnB kg/ha)	80: 25:30:5.0:2.0	100: 50:100:10:2.0	25:10:25		80: 20:30:5.0:2.0
Fertilizer application	Basal & top dress	Basal & top dress	Basal & top dress	Basal	Basal & top dress
Date of transplanting/sowing	8-Aug-19	6-Nov-19	3-Feb-20	13-Mar-20	6-Jun-20
Irrigation (no.)	3	4	2	1	10
Weeding (no.)	1	2	1	1	1
Plant protection (no.)	2	2	no	3	2
Date of harvesting	28-Oct-19	28-Jan-20	10-Mar-20	30-May-20	19-Aug-20
Field duration (days)	81	83	36	78	74
Total duration (day)	352				
Turn-around time (day)	9	6	3	7	3

Table 5b. Yield and economic return of T. Aman-Cauliflower-Spinach-Mungbean- T. Aus cropping pattern during 2018-2021 at RARS, Jashore

Crop Variety	T. Aman Binadhan-16	Cauliflower Snowball	Spinach Local	Mungbean BARI Mung-6	T. Aus Binadhan-19
Seed/grain yield (t/ha)	4.00	30.49	11.25	1132	4.31
Rice equivalent yield (t/ha)	4.00	18.29	2.81	3.40	4.31
Total REY (t/ha)	32.81				
Gross return (Tk/ha)	80000	365880	56250	67920	86200
Total Gross return (Tk/ha)	656200				
Variable cost (Tk/ha)	56875	105965	37855	48325	59325
Total variable cost (Tk/ha)	308345				
Gross margin (Tk/ha)	348755				
Production Efficiency (kg/ha/day)	93				
Systems profitability (Tk/ha/day)	953				
Land use efficiency-LUE (%)	96.44				
BCR	2.1				

Table 6a. Crop management practices of T. Aman– Cauliflower – Mungbean- T. Aus cropping pattern during 2018-2021 at Jashore

Crop	T. Aman	Cauliflower	Mungbean	T. Aus
Variety	Binadhan-16	Snowball	BARI Mung-6	Binadhan-19
Unit plot size(m)	6 × 4	6 × 4	6 × 4	6 × 4
Spacing(cm)	20 × 15	60 × 40	30 × 10	20 × 15
Planting procedure				
Fertilizer dose (NPKSZnB kg/ha)	80: 25:30:5.0:2.0	100: 50:100:10:2.0		80: 20:30:5.0:2.0
Fertilizer application	Basal & top dress	Basal & top dress	Basal	Basal & top dress
Date of transplanting/sowing	8-Aug-19	6-Nov-19	13-Mar-20	6-Jun-20
Irrigation (no.)	3	4	1	10
Weeding (no.)	1	2	1	1
Plant protection (no.)	2	2	3	2
Date of harvesting	28-Oct-19	28-Jan-20	30-May-20	19-Aug-20
Field duration (days)	81	83	78	74
Total duration (day)	316			
Turnaround time (day)	9	45	7	3

Table 6b. Yield and economic return of T. Aman– Cauliflower – Mungbean- T. Aus cropping pattern during 2018-2021 at RARS, Jashore

Crop Variety	T. Aman Binadhan-16	Cauliflower Snowball	Mungbean BARI Mung-6	T. Aus Binadhan-19
Seed/grain yield (t/ha)	4.10	29.81	1002	4.92
Rice equivalent yield (t/ha)	4.10	17.89	3.01	4.92
Total REY (t/ha)	29.91			
Gross return (Tk/ha)	82000	357720	60120	98400
Total Gross return (Tk/ha)	598200			
Variable cost (Tk/ha)	56875	105965	48325	59325
Total variable cost (Tk/ha)	270490			
Gross margin (Tk/ha)	327710			
Production Efficiency (kg/ha/day)	95			
Systems profitability (Tk/ha/day)	898			
Land use efficiency-LUE (%)	86.58			
BCR	2.2			

INTEGRATED NUTRIENT MANAGEMENT ON GARLIC- MAIZE -T.AMAN CROPPINGPATTERN IN RANGPUR REGION

S. HASAN, S.M.A.H. M. KAMAL AND A. K. SAHA

Abstract

A field trail was conducted at RARS, BARI, Burirhat, Rangpur with five treatments to find out the best fertilizer dose and economic return for Garlic-Maize-T.Aman cropping pattern during Rabi season 2020-21. There were five fertilizer dose treatments such as T_1= Fertilizer Recommended Guide (FRG) 2018, T_2= FRG, 2018 + 5 t/ha cowdung, T3= FRG, 2018 + 2 t/ha vermicompost, T4= FRG, 2018 + 3 t/ha poultry manure and F5 = Control (Native fertilizer).The highest bulb yield of garlic (9.58 t/ha), Maize (9.75 t/ha) ,T amanricr(4.60 t/ha), rice equivalent yield (32.78 t/ha) and gross return (819500 t/ha) were recorded from T3 due to vermicompost use which was identical to T_1 ,T_2 and T_4 . But the highest benefit cost ratio was recorded from T_1 due to higher price of vermicompost.The lowest garlic bulb yield (1.67 t/ha), maize (2.67 t/ha) and T aman (0.73 t/ha) were recorded from T_5 Control (Native fertilizer) treatments.

Introduction

Garlic (Allium sativum) is one of the important spice crops in Bangladesh. It is widely cultivated during winter season. Garlic is sensitive to growing temperature and photoperiod. The major cropping patterns in the Tista Meander Floodplain of AEZ-3 are potato-maize containing T. Aman rice and potato as a base crop. But the Tista Mender Floodplain is situated in the northern part of Bangladesh is very suitable for garlic production. Organic farming is a production system that avoids excessive use of chemical fertilizers and pesticides in monoculture agriculture. Vermicomposting is a biological process using a variety of worms including earthworms to transform organic waste into natural nutrient-rich compost, which breaks down organic material through the interaction between worms and microorganisms. Vermicompost is an excellent soil amendment coordinator that enhances porosity, aeration, bulk density, drainage, water-holding capacity and microbial activity of soil (Lim *et al.,* 2014 and Orozco *et al.*,1996)., improves soil fertility in continuous cropping (Zhang *et al.*,2010),increases nitrogen uptake (Tomati, *et al.*,1994),and dry matter production in plants (Edwards , 1995 and Liu *et al.*,1988. This nutrient-rich organic substance can be added to the soils to enhance organic matter content and available nutrients, soil fertility and quality. Using earthworms to convert organic wastes is an ecologically safe method that leads to an environmentally safe product. In fact, vermicompost can enhance soil fertility physically, chemically and biologically. A number of researchers reported that the application of vermicompost in crop fields increases activity as compared to inorganic agriculture .Vermicompost also provides macro elements, such as, nitrogen, phosphorus, potassium, calcium and manganese and microelements, such as, iron, zinc and copper. Studies also indicated that vermicompost can retain more soil moisture and thus reduces demand for irrigation by about 30–40%. Considering these human and soil health hazards, farmers in developed and underdeveloped countries are encouraged to convert their farms into organic farms. The main aim of this research is to find out the best fertilizer dose and economic return by using organic manure in Garlic-Maize-T. Aman cropping pattern.

Materials and Methods

The experiment was conducted at RARS, Burirhat, Rangpur during Rabi season 2020-21. The experiment was started on 18 November, 2020. The size of the unit plot was 3 m × 4 m. The design was followed by RCB with 3 replications. There were five fertilizer dose treatments such as T_1= Fertilizer Recommended Guide (FRG) 2018, T_2= FRG, 2018 + 5 t/ha cowdung, T_3= FRG, 2018 + 2 t/ha vermicompost, T_4= FRG, 2018 + 3 t/ha poultry manure and F5 = Control (Native fertilizer). Weeding, irrigation and spraying were done as required. Data were taken on different growth parameters like plant height, number of leaves per plant, one garlic weight and bulb yield per plot. Collected data was compiled and analyzed with Statistics -10 software.

Table1. Analytical results of initial soil of Garlic- Maize-T.aman cropping patterns at RARS, Burirhat, Rangpur (2020--21)

Soil Status	Treat.	pH	OM (%)	Total N (%)	Ca	Mg	K	P	S	Zn	B
					Meq/100 g.			µg/g.			
Initial	Soil	5.00	1.86	0.09	1.59	0.62	0.26	73.99.21	1.91	3.20	0.11

Table 2. Details of variety, seed rate and spacing of different crops

Crops	Variety	Seed rate (kg/ha)	Spacing
Garlic	Local	400	15 cm × 10cm
Maize	NK-40	22	60 cm × 25 cm
T.Aman	BRRI dhan -75	30	20 cm × 15 cm

Table 3. Fertilizer doses for different crops

Treat.	N-P-K-S-Zn-B-Mg-cowdung-vermicompost-poultry manure (kg/ha)		
	Garlic	Maize	T.Aman
T1	152-64-120-40-4-4-0-0-0-0	300-80-160-60-20-6-2-0-0-0	120-20-100-16-2-0-0-0-0-0
T2	152-64-120-40-4-4 -0-5000-0-0	300-80-160-60-20-6-2-5000-0-0	120-20-100-16-2-0-0-5000-0-0
T3	152-64-120-40-4-4-0-0-2000-0	300-80-160-60-20-6-2-0-2000-0	120-20-100-16-2-0-0-0-2000-0
T4	152-64-120-40-4-4-0-0-0-3000	300-80-160-60-20-6-2-0-0-3000	120-20-100-16-2-0-0-0-0-3000
T5	0-0-0-0-0-0	0-0-0-0-0-0	0-0-0-0-0

Table 4. Performance of different crops under Garlic – Maize- T Aman cropping pattern during 2020-2021

Parameter	Crops		
	Garlic	Maize	T.Aman
Transplanting date	10/11/2020	7/4/2021	11/8/2021
Harvesting date	3/4/2021	9/8/2021	1/11/2021
Crop duration	143	116	85
Turn around period	8	4	2

Results and Discussion

The results of Garlic, Maize and T.Aman presented in table 5, 6 and 7. The highest bulb yield of garlic was recorded from T_3 (9.58 t/ha) due to vermi-compost use which was identical toT_1 ,T_2 and T_4. The lowest garlic bulb yield (1.67 t/ha) was recorded from T_5 Control (Native fertilizer) treatments. The maximum grain yield of maize was recorded from T_3 (9.75 t/ha) due to vermicompost use which was identical to T_1,T_2 and T_4. The lowest maize yield (2.67 t/ha) was recorded from T_5 Control (Native fertilizer). The maximum grain yield of T.Aman was recorded from T_3 (4.45 t/ha) due to vermicompost use which was identical to T_1 ,T_2 and T_4. The lowest T.aman yield (0.73 t/ha) was recorded from T_5 Control (Native fertilizer). The same results were observed in case of plant height, number of leaves, number of tiller/ plant, panicle length, grain/ panicle and 1000 grain weight. There were no significant difference among the treatments except T_5 treatments. Cowdung, vermicompost and poultry manure had an effect on yield and yield contributing characters. The highest rice equivalent yield (32.78 t/ha) was obtained from T_3 treatment (FRG ,2018 + 2 t/ha verrmi-compost) followed by T_4,T_3,T_1treatment and the lowest rice equivalent yield was obtained from T_5 (6.68 t/ha). The maximum gross return (Tk.819500 ha-1) were recorded from T_3 due to vermicompost use which was identical to T_1 ,T_2 and T_4 . But the highest benefit cost ratio was recorded from T_1 due to higher price of vermicompost.The lowest garlic bulb yield (1.67 t/ha), maize (2.67 t/ha) T.Aman (0.73 t/ha) were recorded from T5 Control (Native fertilizer).

Conclusion

First year (one cycle completion) result was shown in Table 5. So, the experiment should be repeated for another year to confirm the findings.

Table 5. Bulb yield and yield contributing characters of garlic at RARS Burirhat, Rangpur during Rabi 2020-21

Treatments	Plant height (cm)	No.of leaves/ Plant (no.)	Bulb weight/Plant (g)	Bulb yield (t/ha)
T_1= FRG, 2018	70.35a	7.23a	16.34a	9.00a
T_2= FRG, 2018 + 5 t/ha cowdung	67.67a	7.35a	16.23a	9.54a
T_3= FRG ,2018 + t/ha verrmicompost	68.78a	7.98a	17.56a	9.58a
T_4= FRG , 2018 + 3 t/ha poultry manure	70.64a	6.99a	17.23a	9.54a
T_5= Control (Native fertilizer)	46.23b	5.27b	8.23b	1.67b
CV (%)	6.15	7.87	13.82	12.38

Table 6. Grain yield and yield contributing characters of maize at RARS Burirhat, Rangpur during Rabi 2020-21

Treatments	Plant height(cm)	Ear height (cm.)	No of grains /Cob	100 – grain wt.	Grain yield (t/ha)
T1= FRG, 2018	207.65a	86.37a	456.40a	37.20a	9.10a
T2= FRG, 2018 + 5 t/ha cowdung	208.36a	82.45a	465.12a	37.50a	9.67a
T3= FRG, 2018 + t/ha verrmicompost	204.20a	88.98a	460.32a	37.99a	9.75a
T4= FRG, 2018 + 3 t/ha poultry manure	200.48a	86.99a	460.45a	37.47a	9.40a
T5= Control (Native fertilizer)	63.23b	53.27b	225.21b	16.21b	2.67b
CV (%)	6.63	7.12	3.68	5.88	5.60

Table 7. Yield and yield contributing characters of T.Aman at RARS Burirhat, Rangpur during Rabi 2020-21

Treatments	Plant height (cm)	No of tiller/ hill	Panicle Length (cm)	Grain /Panicle (no.)	1000 - grain wt (g)	Grain yield (t/ha)	Straw yield (t/ha)
T1=FRG, 2018	105.78a	22.20a	22.22a	122.73a	20.23a	4.25a	5.28a
T2=FRG, 2018 + 5 t/ha cowdung	100.89a	23.00a	25.66a	127.13a	20.89a	4.45a	5.95a
T3=FRG, 2018 +t/ha verrmi compost	101.90a	22.99a	27.93a	125.47a	19.99a	4.60a	5.45a
T4=FRG,2018+3 t/ha poultry manure	105.78a	19.89a	25.89a	125.29a	20.36a	4.50a	5.40a
T5=Control(Native fertilizer)	65.89b	9.23b	16.44b	25.88b	14.00b	0.73b	2.08a
CV (%)	7.068	8.75	7.90	3.90	1.00	6.23	4.68

Table 8. Yield of Garlic, Maize, T. Aman rice and rice equivalent yield of Garlic-Maize- T.Aman rice cropping pattern (2020-21)

Treatments	Bulb yield of garlic (t/ha)	Grain yield of maize (t/ha)	Grain yield of T.aman (t/ha)	Rice Equiv. Yield (t/ha)
T_1= FRG, 2018	9.00	9.10	4.25	30.81
T_2= FRG, 2018 + 5 t/ha cowdung	9.54	9.67	4.45	32.48
T_3= FRG, 2018 + t/ha verrmicompost	9.58	9.75	4.60	32.78
T_4= FRG, 2018 + 3 t/ha poultry manure	9.54	9.40	4.50	32.25
T_5= Control (Native fertilizer)	1.67	3.00	0.73	6.86

Table 9. Cost and return analysis of garlic-maize- T.Aman rice cropping pattern (2020-21)

Treatments	Gross return (Tk./ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1= FRG, 2018	770250/-	345153/-	425097/-	2.23
T_2= FRG, 2018 + 5 t/ha cowdung	812000/-	375153/-	436847/-	2.16
T_3= FRG, 2018 + t/ha verrmicompost	819500/-	425153/-	394347/-	1.93
T_4= FRG, 2018 + 3 t/ha poultry manure	806250/-	372153/-	434096/-	2.17
T_5= Control (Native fertilizer)	171500/-	282959/-	111459/-	-

Price: Garlic = 45/-, Maize =26/-, Maize seed=400/- and T.Aman rice =25/-

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DEVELOPMENT OF ALTERNATE CROPPING PATTERN FOR INCREASING CROPPING INTENSITY AND PRODUCTIVITY IN RANGPUR REGION

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Abstract

A study was undertaken through a field evaluation of different cropping patterns during 2019-20 and 2020-21. The study was laid out in RCB design with three replications comprising four cropping patterns viz., Early potato-Potato-T.aus rice-T. aman rice (CP1), Early potato-Potato/Maize relay-T. aman rice (CP2), Early potato-Wheat-Mungbean- T. aman rice (CP3) and one farmers' improved pattern Potato-Maize-T. aman rice (CP4) at RARS, Rangpur. In terms of productivity and profitability the CP1 and CP2 performed better as compared to the other cropping patterns. The results showed that the highest rice equivalent yield (REY), production efficiency and gross return were recorded in CP2 and the lowest in CP4. The mean (average of two year) REY of CP2, CP1 and CP3 patterns were 30.36, 29.97 and 22.30 t/ha which were 52, 50 and 12% higher, respectively than that of the CP4 (19.97 t/ha). The gross margin was higher in CP2 cropping pattern with system profitability (Tk. 1230.81 ha/day in 2019-20 and Tk.1208.86ha/day in 2020-21). The highest marginal benefit cost ratio (2.55 in 2019-20 and 2.58 in 2020-21) was obtained in CP3. Results revealed that the highest land use efficiency (91.51 and 89.86% in 2019-20 and 2020-21, respectively) was recorded in CP2 and the highest labour employment was generated in CP1 (528) pattern with an increase of 49% over CP4 (355). The cropping pattern CP2 gave the highest additional income (Tk. 174900/ha in 2019-20 and Tk. 169940/ha in 2020-21) over the CP4 pattern. After completion of experiment, organic matter slightly increased in most of the cropping patterns as compared to initial soil. There were little changes with respect to other elements but all the elements maintained above critical level. Thus, without deteriorating soil nutrient, an intensive crop cultivation, Early potato-Potato/Maize relay--T. aman rice (CP2), Early potato-Potato-T. aus rice-T. aman rice (CP1), Early potato-Wheat-Mungbean- T. aman rice (CP3) cropping patterns were more productive and remunerative cropping patterns and farmers of Rangpur region of Bangladesh.

Introduction

Bangladesh predominantly a rice growing country and rice occupies about 80% of the total cropped area is cultivated in three seasons a year. In rice based cropping system Potato-Maize-T. aman rice is a popular farmers' improved cropping pattern in Rangpur region. In the pace of per capita land availability decrease and production shortage the existence of fallow land in rice based cropping system is very inconsistent to national perspective. Potential adoption of this improved cropping pattern intensifying early potato, maize, mungbean and T. aus rice in Potato-Maize-T. aman rice cropping pattern would generate employment and additional income for the rural poor. The farm level adoptions of improved maize, pulses and potatoes in rice based cropping system have already been created a wide range of socio-economic impacts that need to be evaluated properly to understand the output of research and development. Considering the above issues, the proposed study was undertaken to find out the productivity and profitability of said cropping pattern.

Materials and Methods

The experiment was conducted at Regional Agriculture Research Station, Burirhat, Rangpur during 2019-20 and 2020-21.

Soil

The soil of the experimental field belongs to the agro-ecological zone of Tista Meander Floodplain Soil. Random soil samples (before sowing) were taken from the experimental plots up to depth of 0-15 cm and mixed together to form a composite sample. After completion of one cycle of experiment, soil samples were collected from each plot for chemical analysis. The samples were collected from the fields with the help of an auger following a zigzag pattern. Soil samples were air-dried soon after collection and powdered with a wooden roller. Coarse concretions, stones and organic debris were removed. The samples were analyzed in the SRDI laboratory, Dinajpur. The initial soil reports are given in Table 1 and 2.

Table 1. Physical properties of initial soil of RARS, Rangpur

Sl. No.	Particulars	
1	Soil series	Gangacghara
2	Textural class	Sandy clay loam
3	CEC (cmol kg-1)	5.1
4	Sand (%)	58
5	Silt (%)	22
6	Clay (%)	20

Table 2. Chemical properties of initial soil of RARS, Rangpur

	pH	Organic matter (%)	Total N (%)	K	Mg	P	S	Zn	B
				meq/100g soil		µg/g soil			
Amount	5.40	1.72	0.09	0.20	0.65	54.33	11.01	0.85	0.20
Critical limit	-	-	0.10	0.08	0.50	8.0	8.0	0.50	0.18
Interpretation	Acidic	Low	Low	Low	Low	High	Low	Optimum	Medium

Treatment details

In the present investigation, 4 cropping patterns were selected of which Potato-Maize-T. aman rice also covered 7% area and popular after Potato-Boro rice-T. aman rice (8%) in the Rangpur region of Bangladesh. Potato and maize is the popular and profitable crop in Rangpur region i.e. farmers' improved pattern. Possible diversifications and intensifications were tried as treatment details given in Table 3.

Table 3. Details of treatment

Sl. No.	Pattern	Symbol used
1	Early potato - Potato - T. aus rice - T. aman rice	CP1
2	Early potato – Potato/ Maize relay - T. aman rice	CP2
3	Early potato - Wheat-Mungbean - T. aman rice	CP3
4	Potato-Maize-T. aman rice (Farmers' improved pattern)	CP4

Note: After picking pods of mungbean, the plants were incorporated into the soil.

Experimental design

The experiment was laid-out in a randomized complete block design with three replications. The unit plot size was 4 m × 4 m where the field layout was permanent and all plots were divided with strong levee of 20 cm height and 25 cm width to avoid soil fertility contamination.

Production technology of the crops used in different cropping patterns

Details of crop variety, seed rate and spacing are given in Table 4. The fertilizer dose is given in Table 5. Organic fertilizers were applied once to the first crop of different cropping patterns at the rate of 5 t ha-1 on dry weight basis for cow dung. The sowing date or transplanting date, harvesting date and crop duration for all crops in different cropping patterns are presented in Table 6 and 7.

Table 4. Details of variety, seed rate and spacing of different crops

Crop	Variety	Seed rate (kg/ha)	Spacing
Potato	Granola	2400	60cm × 25cm
Wheat	BARI Gom-30	130	20cm × continuous
Mungbean	BARI Mung-6	30	30cm × continuous
Maize	BHM-9	25	60cm × 25cm
T.Aus rice	BRRI dhan48	25	20cm × 15cm
T.Aman rice	Binadhan-7 and BRRI dhan49	25	20cm × 15cm

Table 5. Fertilizer dose for different crop

Crop	Fertilizer (N-P-K-S-Zn-B-Mg kg/ha)
Potato	158-10-68-13-4-1-8
Wheat	141-10-46-13-2.1-1-5
Mungbean	22-9-19-16-1.6-1
Maize	298-25-61-45-3.1-1.1-13
T.Aus rice	88-5-24-8-1
T.Aman rice (Binadhan-7 and BRRI dhan49)	71-4-31-8-1

Table 6. Performance of different crops under different cropping patterns during 2019-20 and 2020-21

Parameter	Years	CP1: Early potato-Potato-T. aus rice -T. aman rice				CP2: Early potato-Potato/Relay maize-T. aman rice			
		Early potato (Granola)	Potato (Granola)	T.aus (BRRI dhan48)	T.aman (Bina dhan-7)	Early potato (Granola)	Potato (Granola)	Maize (BHM-9)	T.aman (Binadhan-7)
Sowing/ Transplanting date	1st	25.10.19	28.12.19	14.4.20	19.7.20	25.10.19	28.12.19	28.1.20	19.7.20
	2nd	24.10.20	29.12.20	16.4.21	23.7.21	24.10.20	29.12.20	24.1.21	23.7.21
Harvesting date	1st	26.12.19	18.3.20	13.7.20	15.10.20	26.12.19	18.3.20	30.6.20	15.10.20
	2nd	27.12.20	21.3.21	16.7.21	17.10.21	27.12.20	21.3.21	24.6.21	17.10.21
Crop duration	1st	62	80	90	88	62	80	153	88
	2nd	64	82	91	86	64	82	151	86
Turn around period	1st	10	2	27	6	10	2	-	19
	2nd	7	2	26	7	7	2	-	29

Contd.

Parameter	Years	CP3: Early potato-Wheat-Mungbean-T. aman rice				CP4: Potato-Maize -T. aman rice		
		Early potato (Granola)	Wheat (BARI Gom-30)	Mungbean (BARI Mung-6)	T.aman (Binadhan--7))	Potato (Granola)	Maize (BHM-9)	T.aman (BRRI dhan49)
Sowing /Transplanting date	1st	25.10.19	27.12.19	22.4.20	19.7.20	21.11.19	28.2.20	17.7.20
	2nd	24.10.20	28.12.20	16.4.21	23.7.21	25.11.20	17.3.21	19.7.21
Harvesting date	1st	26.12.19	14.4.20	25.6.20	15.10.20	20.2.20	13.6.20	07.11.20
	2nd	27.12.20	13.4.21	21.6.21	17.10.21	27.2.21	6.7.21	12.11.21
Crop duration	1st	62	108	64	88	91	105	113
	2nd	64	106	66	86	93	111	116
Turn around period	1st	10	1	8	24	14	8	34
	2nd	7	1	3	32	13	18	13

Rice equivalent yield (REY)

To compare and evaluate different cropping patterns, the yield of all non-rice crops were converted into rice equivalent yield on the basis of yield and prevailed market price of respective crop and unit price of rice (Verma and Modgal, 1983).

$$\text{REY (t/ha/yr)} = \text{Individual yield} \times \frac{\text{Unit price of that crop}}{\text{Unit price of rice crop}}$$

System approach

(a) Production efficiency
Production efficiency value in terms of kg/ha/day was calculated by total production in a cropping pattern divided by total duration of crops in that pattern (Tomer and Tiweri, 1990).

$$\text{Production efficiency} = \frac{Y1+Y2+Y3+Y4}{d1+d2+d3+d4}$$

Where,
Y1 = Yield of 1st crop
Y2 = Yield of 2nd crop
Y3 = Yield of 3rd crop
Y4 = Yield of 4th crop

d1 = Duration of 1st crop of the pattern
d2 = Duration of 2nd crop of the pattern
d3 = Duration of 3rd crop of the pattern
d4 = Duration of 4th crop of the pattern

(b) Land use efficiency
Land use efficiency was calculated by dividing total duration of different crops in a pattern by 365 days and expressed in percentage (Singh et al., 1993).

$$\text{LUE (\%)} = \frac{\text{Duration of pattern (days)}}{\text{Duration of year (365)}} \times 100$$

$$= \frac{d1 + d2 + d3 + d4}{365} \times 100$$

Where,
d1 = Duration of 1st crop of the pattern
d2 = Duration of 2nd crop of the pattern
d3 = Duration of 3rd crop of the pattern
d4 = Duration of 4th crop of the pattern

(c) Productivity
Total production (rice equivalent yield) in a system divided by 365 was calculated and expressed in kg/ha/day(Singh et al., 1993).

(d) Profitability
Total gross margin in a system was divided by 365 and expressed as Tk./ha/day.

(e) Employment generation
Total number of labourers required for various agronomic practices under different cropping systems in one year and total requirement ha-1 was worked out (Newaj andYadav, 1992).

Economic analysis
Economic analysis was done based on the total variable cost. Cost of land preparation, labour, inputs, irrigation, etc. and price of produces were collected from the farmers and local markets to compute total variable cost (TVC), gross return (GR), gross margin (GM) and marginal benefit cost ratio (MBCR).

(a) Cost of cultivation: The cost of cultivation of various cropping patterns (used) was worked out based on the recent standard price of inputs.

(b) Gross return (GR): Yield of different component crops in a pattern was converted into gross return in taka based on current market price.

(c) Gross margin (GM): Gross margin for each pattern was calculated by deducting the cost of cultivation from gross return. The gross margin (GM) was computed as follows (Willey, 1979):

GM = Gross return (GR)–total production cost

(d) Marginal benefit cost ratio (MBCR): The marginal benefit cost ratio (MBCR) was computed as follows:

$$\text{MBCR} = \frac{\text{Gross return (Tk./ha)}}{\text{Total production cost (Tk./ha)}}$$

Relative economic efficiency (REE)

Relative economic efficiency is comparative measure of economic gains over the existing system. The following method was used to calculate the REE and expressed as percentage.

$$\text{REE (\%)} = \frac{A-B}{B} \times 100$$

Whereas, A=Gross margin of diversified system (Tk./ha) and B= Gross margin of existing system (Tk./ha).

Results and Discussions

Crop duration and turn around period in different cropping patterns

Turn around period means the time or day of the succeeding crop is planted after the preceding crop has been harvested. In a cropping pattern, individual crop wise duration, turn around period, year wise total crop duration of a cropping pattern and total turn around period were presented in Tables 6-8. In both the years, Early potato-Potato/ Maize relay -T. aman rice cropping pattern occupied the longest field duration with the lowest turn around period. The lowest crop duration and the highest turn around period were calculated in Potato-Maize-T.amanrice cropping pattern (Table 8).

Table 8. Crop duration and turn around period in a year of the different cropping patterns during 2019-20 and 2020-21

Pattern	Duration of different cropping patterns (days)		Total turn around period (days)	
	2019-20	2020-21	2019-20	2020-21
CP1:Early Potato - Potato - T. aus rice - T. aman rice	320	323	45	42
CP2:Early potato – Potato/ Maize relay - T. aman rice	334	328	31	37
CP3:Early Potato - Wheat-Mungbean - T. aman rice	322	322	43	43
CP4:Potato-Maize-T. aman rice	309	321	56	44

Pattern productivity

There were four cropping patterns under this study. Total productivity were calculated from all cropping patterns and converted into rice equivalent yield.

(a) Early Potato - Potato - T. aus rice - T. aman rice

During 2019-20, the yield of early potato, potato, T.aus rice and T.aman rice of this pattern were 10.91, 27.60, 3.75 and 3.70 t/ha, respectively. These yields and rice straw yield were calculated in rice equivalent yield and it was 10.91, 11.04, 3.79 and 4.25 t/ha of early potato, potato, T.aus rice and T.aman rice, respectively. The total rice equivalent yield of this pattern was 29.99 t/ha(Table 9 and 10). In 2020-21, the total rice equivalent yield of this pattern was found out 29.89 t/ ha (Early potato: 11.27 t/ha, potato: 10.73 t/ha, T. aus rice: 3.65 t/ha and T. aman rice: 4.24 t/ha) (Table 9 and 10).

(b) Early potato – Potato/Relay maize - T. aman rice

In the year of 2019-20, the grain yield and straw yield (3.57 and 4.95 t/ha) of T.aman rice were converted into rice equivalent yield and it was 4.07 t/ha. The same process was followed in maize crop. The rice equivalent yield of early potato, potato and maize in this pattern were 11.44, 11.32 and 3.69 t/ha, respectively. The aggregate rice equivalent yield of this pattern was 30.52 t/ha (Table 9 and 10). The same process was followed in 2020-21 and total rice equivalent yield was found 30.20 t/ha (Table 9 and 10).

(c) Early Potato - Wheat-Mungbean - T. aman rice

During 2019-20, the yield of early potato, wheat, mungbean and T.aman rice of this pattern were 11.44, 3.14, 1.26 and 3.85 t/ha, respectively. These yields and straw yield of rice and wheat were calculated in rice equivalent yield. The rice equivalent yield of early potato, wheat, mungbean and T.aman rice in this pattern were 11.78, 2.97, 3.02 and 4.39 t/ha, respectively and the aggregates of rice equivalent yield in this pattern was 22.16 t/ha (Table 9 and 10). In 2020-21, the same process was followed and the total rice equivalent yield of this pattern was recorded 22.44 t/ha (Table 9 and 10).

(d) Potato-Maize-T. aman rice

In case of 2019-20, the yield of potato, maize and T. aman rice of this pattern were 29.05 t/ha, 6.42 t/ha and 4.03 t/ha, respectively. These yields with straw or stover yield of rice and maize were calculated into rice equivalent yield and it was 11.62 t/ha, 3.89 t/ha and 4.51 t/ha of potato, maize and T.aman rice, respectively. The total rice equivalent yield of this pattern was calculated and it was 20.02 t/ha (Table 9 and 10). During 2020-21, the rice equivalent yield of potato, maize and T. aman rice of this pattern were 11.51 t/ha, 3.73 t/ha and 4.67 t/ha, respectively and total rice equivalent yield was 19.91 t/ha (Table 9 and 10).

Rice equivalent yield (REY) of the patterns

Individually crop wise rice equivalent yield was added to compute rice equivalent yield of different cropping patterns. The total rice equivalent yield varied due to different cropping patterns (Table 10). In both the year, among the different cropping patterns, the highest total rice equivalent yield (30.52 t/ha in 2019-20 and 30.20 t/ha in 2020-21) was found in Early potato-Potato/Maize relay-T.aman rice (CP2) cropping patterns which was 52.4% in 2019-20 and 51.7% in 2020-21 higher than that of the Potato-Maize-T. aman rice pattern(CP4). The lowest REY (20.02 t/ha and 19.91 t/ha in 2019-20 and 2020-21, respectively) was found in Potato-Maize-T. aman rice (CP4) cropping pattern.

Table 9. Yield performance of different crops under different cropping patterns during 2019-20 and 2020-21

Parameter	Year	CP1: Early potato-Potato-T. aus rice -T. aman rice				CP2: Early potato-Potato/Relay maize-T. aman rice			
		Early potato (Granola)	Potato (Granola)	T.aus (BRRI dhan48)	T.aman (Bina dhan-7)	Early potato (Granola)	Potato (Granola)	Maize (BHM-9)	T.aman (Bina dhan-7)
Yield (t/ha)	1st	10.91	27.60	3.75	3.70	11.44	28.29	6.02	3.57
	2nd	11.27	26.82	3.55	3.74	10.89	26.92	6.85	3.88
By product yield (t/ha)	1st	-	-	5.08	5.55	-	-	14.12	4.95
	2nd	-	-	5.60	5.02	-	-	14.30	5.40
		CP3:Earlypotato-Wheat-Mungbean-T.aman rice				CP4: Potato-Maize -T. aman rice			
		Early potato (Granola)	Wheat (BARI Gom-30)	Mungbean (BARI Mung-6)	T.aman (Bina dhan-7)	Potato (Granola)	Maize (BHM-9)	T.aman (BRRI dhan49)	
Yield (t/ha)	1st	11.44	3.14	1.26	3.85	29.05	6.42	4.03	
	2nd	11.56	3.40	1.42	3.76	28.78	6.10	4.22	
Byproduct yield (t/ha)	1st	-	3.84	-	5.36	-	13.68	4.84	
	2nd	-	3.68	-	5.14	-	14.06	5.56	

Table 10. Crop wise rice equivalent yield of different cropping patterns at RARS, Burirhat, Rangpur

Pattern	Crop wise rice equivalent yield of different cropping patterns (t/ha)				Total rice equivalent yield (t/ha)	Increased REY (%)
Year : 2019-20						
CP1	Early potato	Potato	T. aus rice	T. aman rice		
	10.91	11.04	3.79 (3.38+0.41)	4.25 (3.70+0.55)	29.99	49.8
CP2	Early potato	Potato	Maize relay	T. aman rice		
	11.44	11.32	3.69 (3.13+0.56)	4.07 (3.57+0.50)	30.52	52.4
CP3	Early potato	Wheat	Mungbean	T. aman rice		
	11.78	2.97 (2.89+0.08)	3.02	4.39 (3.85+0.54)	22.16	10.7
CP4	Potato	Maize	T. aman rice			
	11.62	3.89 (3.34+0.55)	4.51 (4.03+0.48)		20.02	-
Year : 2020-21						
CP1	Early potato	Potato	T. aus rice	T. aman rice		
	11.27	10.73	3.65 (3.20+0.45)	4.24 (3.74+0.50)	29.89	50.1
CP2	Early potato	Potato	Maize relay	T. aman rice		
	10.89	10.76	4.13 (3.56+0.57)	4.42 (3.88+0.54)	30.20	51.7
CP3	Early potato	Wheat	Mungbean	T. aman rice		
	11.56	3.20 (3.13+0.07)	3.41	4.27 (3.76+0.51)	22.44	12.7
CP4	Potato	Maize	T. aman rice			
	11.51	3.73 (3.17+0.56)	4.67 (4.11+0.56)	-	19.91	-

Note: CP1 = Early Potato - Potato - T. aus rice - T. aman rice, CP2 = Early potato – Potato/ Maize relay- T. aman rice, CP3 = Early Potato - Wheat-Mungbean - T. aman rice, CP4 = Potato – Maize -T. aman rice

Land use efficiency
In general, patterns intensified with more than two or three crops recorded higher land use efficiency. The data on land use efficiency (%) under different cropping patterns is shown in Table 11. The maximum (91.51% in 2019-20 and 89.86% in 2020-21) duration of land was occupied in Early potato-Potato/Maize relay-T.aman rice (CP2) and minimum (84.66% in 2019-20 and 87.94% in 2020-21) was in Potato-Maize-T. aman rice cropping pattern. It may be pointed out that land use efficiency is directly related to total duration of component crops in the field. The similar results have also been reported by Verma et al. (2003), Yadav et al. (2005) and Saroch et al. (2005).

Production efficiency
Under different cropping patterns the data on production efficiency (kg/ha/day) are presented in Table 11. Among the different cropping patterns, the maximum (93.72 and 92.54 kg/ha/day in 2019-20 and 2020-21, respectively) production efficiency was observed in Early Potato - Potato - T. aus rice - T. aman rice (CP1) and minimum (64.79 kg/ha/day in 2019-20 and 62.02 kg/ha/day in 2020-21) was in Potato-Maize-T. aman rice (CP4)cropping pattern.

Employment generation in patterns
The average of employment generation on labour employment (man days/year) under different cropping patterns are presented in Table 12. A close examination of the data clearly indicated that in general, patterns involving more crops in a pattern employed more labourers. Maximum labour employment (528) was generated in Early Potato - Potato - T. aus rice - T. aman rice (CP1) followed byEarly potato-Potato/Maize relay-T.aman rice (493). Minimum labour employment (355) was generated in Potato-Maize-T. aman rice (CP4). Early potato-Potato-T.aus rice-T. aman rice (CP1) and Early potato-Potato/Maize relay-T.aman rice (CP2)gave 49% and 39% more employment over Potato-Maize-T. aman rice cropping pattern, respectively. The results also showed that the highest labour employment generation was created in high value crop based cropping pattern. The high labour requirement of sequential cropping with more than 300% intensity indicates the potential for employment. Similar views were also expressed by Newaj and Yadav (1992), Moniruzzaman (2000), Rao and Reddy (2001), Bastia et al.(2008),Chitale et al. (2011) and Rahman et al. (2018).

System productivity
Data on productivity (kg/ha/day) pertaining to different cropping patterns showed in Table 12. Intensification of Potato-Maize-T.aman rice (CP4)pattern brought marked improvement in total production. The maximum system productivity (83.62 and 82.74 kg/ha/day in 2019-20 and 2020-21, respectively) was recorded in Early potato-Potato/Maize relay-T.aman rice (CP2) pattern and showed superiority over rest of the patterns. Other improved cropping patterns e.g. Early Potato-Potato-T. aus rice-T. aman rice (CP1) and Early Potato-Wheat-Mungbean-T. aman rice (CP3) also had higher system productivity than that of farmers' improved cropping pattern (CP4). The higher equivalent yield and system productivity of these patterns was due to higher yield potential, market price and efficient utilization of time and space (Chitale et al., 2011 and Uday et al., 2014). It was proved that these patterns were superior due to highest production efficiency and rice equivalent yield of this patterns in which the contribution of early potato was quite obvious.The lowest (54.85 kg/ha/day in 2019-20 and 54.55 kg/ha/day in 2020-21) system productivity was observed in Potato-Maize-T. aman rice (CP4) pattern.

Profitability
The data on profitability (Tk./ha/day) of different cropping patterns are presented in Table 12. Profitability depends on the duration of crop and gross margin of the pattern. In both the years, the higher profitability (Tk. 1230.81/ha/day in 2019-20 and Tk. 1208.86/ha/day) was obtained in Early potato-Potato/Maize relay-T.aman rice (CP2) cropping pattern than that of the other patterns. This could be attributed to higher productivity as well as gross margin of this pattern. Potato-Maize-T.aman rice (CP4) gave the lowest profitability (Tk. 751.63/ha/day in 2019-20 and Tk. 743.27/ha/day in 2020-21).

Table 11. Land use efficiency and production efficiency in different cropping patterns during 2019-20 and 2020-21

Pattern	Land use efficiency (%)		Production efficiency (kg/ha/day)	
	2019-20	2020-21	2019-20	2020-21
CP1:Early Potato - Potato - T. aus rice - T. aman rice	87.67	88.49	93.72	92.54
CP2:Early potato – Potato/ Maize relay - T. aman rice	91.51	89.86	91.38	92.07
CP3:Early Potato - Wheat-Mungbean - T. aman rice	88.22	88.22	68.82	69.69
CP4:Potato-Maize-T. aman rice	84.66	87.95	64.79	62.02

Table 12. Employment generation, System productivity and profitability in different cropping patterns during 2019-20 and 2020-21

Pattern	Employment generation (man days/year)		System productivity (kg/ha/day)		Profitability (BDT/ha/day)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
CP1:Early Potato-Potato - T. aus rice - T. aman rice	528	528	82.16	81.89	1194.37	1187.38
CP2:Early potato-Potato/Maize relay - T. aman rice	493	493	83.62	82.74	1230.81	1208.86
CP3:Early Potato-Wheat-Mungbean - T. aman rice	402	402	60.71	61.48	923.33	941.82
CP4:Potato-Maize-T. aman rice	355	355	54.85	54.55	751.63	743.27

Economic analysis

Economic studies including cost of cultivation, gross return, net return and benefit cost ratio of different cropping patterns are shown in Table 13.

Cost of cultivation

Inclusion of high value maize and potato crops in cropping pattern markedly enhanced cost of cultivation. Among all the cropping patterns, Early Potato-Potato-T.aus rice-T. aman rice (CP1) cropping pattern had maximum cost of cultivation and next in Early potato-Potato/Maize relay-T.Aman rice (CP2) pattern. The lowest production cost was calculated in Early Potato-Wheat-Mungbean-T. aman rice (CP2) cropping pattern.

Gross return

Gross return of different cropping patterns gave the highest (Tk. 762900 in 1st year and Tk.755000 in 2nd year) in Early potato-Potato/Maize relay-T.aman rice (CP2) and the lowest (Tk. 500500 and Tk. 497800 in 1st and 2nd year, respectively) in Potato-Maize-T.aman rice (CP4) cropping pattern.

Gross margin

In both the years, Early potato-Potato/ Maize relay - T. aman rice (CP2) cropping pattern produced higher gross margin (Tk. 449245 in 1st year and Tk. 441235 in 2nd year) than that of the rest cropping patterns. The second highest gross margin was obtained in Early Potato - Potato - T. aus rice - T. aman rice (CP1) pattern. Potato-Maize-T.amanrice pattern (Tk. 274345 in 1st year and Tk. 271295 in 2nd year) resulted in the lowest gross margin amongst all cropping patterns.

Marginal benefit cost ratio (MBCR)

In both the year, the highest (2.55 in 2019-20 and 2.58 in 2020-21) marginal benefit cost ratio was obtained in Early Potato-Wheat-Mungbean-T. aman rice (CP3) cropping pattern due to lower cost of cultivation. The second highest (2.43 and 2.41 in 2019-20 and 2020-21, respectively) MBCR was observed in Early potato – Potato/ Maize relay - T. aman rice (CP2). Potato-Maize-T.aman rice (CP4) cropping pattern produced the lower marginal benefit cost ratio than that of other patterns in both the year.

Table 13. Production cost, gross return, net return and MBCR of different cropping patterns during 2019-20 and 2020-21

Patterns	Production Cost (Tk./ha)		Gross Return (Tk./ha)		Gross margin (Tk./ha)		MBCR	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
CP1	313805	313805	749750	747200	435945	433395	2.39	2.38
CP2	313655	313655	762900	755000	449245	441235	2.43	2.41
CP3	217086	217086	554100	560950	337014	343763	2.55	2.58
CP4	226155	226155	500500	497800	274345	271295	2.21	2.20

CP1:Early Potato Potato-T. aus rice-T. aman rice; CP2:Early potato-Potato/ Maize relay - T. aman rice; CP3:Early Potato - Wheat-Mungbean - T. aman rice; CP4:Potato-Maize-T. aman rice

Market price (Tk./kg)
Early potato-25.0, Potato-10.00, T.aus rice-22.50, T.aus straw-2.0, T.aman rice-25.00, T.aman straw-2.50, Mustard-55.0, Mustard sraw-3.0, Maize seed-13.00, Maize stover-1.0, Mungbean-60.0, Lalshak-12.0, Garden pea-20, Radish-7.50

Additional income over Potato-Maize-T.Aman rice cropping pattern
Additional income of different cropping patterns is showen in Table 14. The farmers' improved pattern was Potato-Maize-T. aman rice (CP4). In both the year, the highest additional income (Tk. 174900/ha in 2019-20 and Tk. 169940/ha in 2020-21) over farmers' improved pattern (CP4) was found in Early potato-Potato/ Maize relay-T. aman rice (CP2) cropping pattern which was 63.8% in 2019-20 and 62.6% in 2020-21 higher and the second position was occupied Early Potato - Potato-T. aus rice - T. aman rice (Tk. 161600/ha in 2019-20 and Tk. 162100/ha in 2020-21) which was higher 58.9% in 2019-20 and 59.8% in 2020-21.

Relative economic efficiency (REE)
Relative economic efficiency of alternate cropping patterns tested against the Potato-Maize-T. aman rice (CP4) cropping pattern indicated that Early potato-Potato/Relay maize-T. aman rice (CP2) pattern recorded the highest relative economic efficiency (63.8% in 2019-20 and 62.6% in 2020-21) compared to rest of the cropping patterns. The lowest (22.8% and 26.7% in 2019-20 and 2020-21, respectively) relative economic efficiency was recorded with Early Potato-Wheat-Mungbean-T. aman rice (CP3) cropping pattern. This might be due to the lowest gross margin recorded with Early Potato-Wheat-Mungbean-T.aman rice (CP3). Similar results were also reported by Alok et al. (2012).

Table 14. Additional income (BDT./ha) over Potato-Maize-T.Aman rice cropping pattern and REE (%) in different cropping patterns during 2019-20 and 2020-21

Pattern	Additional income over Potato-Maize-T. aman rice (Tk/ha)		REE (%)	
	2019-20	2020-21	2019-20	2020-21
CP1:Early Potato-Potato-T. aus rice-T. aman rice	161600	162100	58.9	59.75
CP2:Early potato-Potato/ Maize relay-T. aman rice	174900	169940	63.8	62.64
CP3:Early Potato -Wheat-Mungbean-T. aman rice	62669	72468	22.8	26.71
CP4:Potato-Maize-T. aman rice	-	-	-	-

Effect of different cropping patterns on soil properties
At the end of the experiment, the nutrient status of soil is shown in Table 15. After completion of experiment soil chemical analysis of different cropping patterns revealed that the soil pH slightly increased in all the cropping patterns. The nutrient status of soil showed variation in macro and micro nutrients. The highest amount of organic matter was found in the cropping patterns where high amount of mungbean stover after picking of pods was added. The organic matter status

considerably improved due to the incorporation of mungbean stover to soil. Such observations are in agreement with the findings of Badanur et al. (1990), Bhardwaj and Omanwar (1994) and Zaman *et al.* (1994). Ahlawat *et al.* (1981) also reported that inclusion of legume in rotation in general, increased the soil organic carbon and nitrogen in many sequences. Similar results were also obtained by Lal and Mathur (1987), Singh and Prasad (1994) and Prakash et al. (1999). Mg in soil increased as compared to initial value in all patterns. There was no definite trend followed with respect to total N and S. As compared to initial soil, in all the cropping patterns the S and B status in soil had higher. In case of available P, exchangeable K and available Zn decreasing were observed but maintained above critical level.

Table 15. Soil fertility status in different cropping patterns at the end of the experiment during 2019-20 and 2020-21

Patterns	pH	OM (%)	Total N (%)	K	Mg	P	S	Zn	B
				meq / 100g soil		µg/ g soil			
Year : 2019-20									
CP1	5.75	1.79	0.09	0.16	0.69	37.27	12.68	0.83	0.22
CP2	5.70	1.70	0.09	0.16	0.71	33.70	12.11	0.76	0.21
CP3	5.70	1.81	0.08	0.15	0.66	30.73	11.45	0.80	0.22
CP4	5.65	1.70	0.09	0.18	0.69	32.44	11.12	0.73	0.21
Year : 2020-21									
CP1	5.70	1.90	0.1	0.20	0.66	30.78	11.10	0.79	0.21
CP2	5.90	1.68	0.1	0.17	0.70	28.57	12.30	0.74	0.18
CP3	5.70	1.90	0.1	0.17	0.58	41.20	11.65	0.70	0.23
CP4	5.90	1.66	0.1	0.21	0.68	28.52	12.32	0.7 3	0.19
Initial soil	5.40	1.72	0.09	0.20	0.65	54.33	11.01	0.85	0.20

Note: CP1 = Early Potato-Potato - T. aus rice-T. aman rice, CP2= Early potato-Potato/ Maize relay- T. aman rice, CP3 = Early Potato - Wheat-Mungbean-T. aman rice, CP4 = Potato-Maize-T. aman rice

Conclusion

In the view of the above findings, following conclusions could be suggested:

i. Early potato–Potato/Maize relay-T. amanrice pattern gave higher REY.

ii. Early potato and maize relay cropped with potato in cropping patterns for intensification gave higher gross return and gross margin. Cropping pattern Early potato–Potato/Maize relay-T. aman rice gave the highest gross return and gross margin among all the cropping patterns used in the study.

iii. Highest MBCR was obtained in Early potato–Wheat–Mungbean–T. aman rice cropping pattern with less cost of production than the other four crops containing cropping pattern.

iv. Findings revealed that the highest crop duration of 334 days in 2019-20 and 328 days in 2020-21 was required for one cycle in a year where it ssowed that Early potato–Potato/Maize relay-T. amanrice cropping pattern was agronomically feasible.

v. Intensification by inclusion of early potato in four crops containing cropping pattern land use efficiency was markedly improved. The highest land use efficiency was calculated in Early potato–Potato/Maize relay-T. aman rice.

vi. Due to growing four crops in a year in the same piece of land created more employment opportunity. Maximum number of labour was employed in Early Potato - Potato - T. aus rice - T. aman rice while minimum in farmers' pattern.

vii.The system productivity and profitability were the highest in Early potato-Potato/Maize relay-T. amanrice cropping pattern.

Recommendation

On the basis of above findings the following recommendations can be made:

i. All the four crops containing cropping patterns viz., Early Potato-Potato-T. aus rice-T.aman rice, Early potato-Potato/Maize relay-T. aman rice and Early Potato-Wheat-Mungbean-T.aman rice, are suitable for higher productivity in the light soil of northwestern part of Bangladesh.

ii. From the economic point of view Early potato-Potato/Maize relay-T.Aman rice cropping pattern could be sustainable in farmers' field condition.

iii. Considering more employment opportunity for labours, farmers might practice Early Potato - Potato - T. aus rice - T. aman rice pattern.

iv. Due to low cost of cultivation, farmers could follow Early Potato - Wheat-Mungbean - T. aman rice cropping pattern.

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Unfavolurable Eco-System

High Temperature

ESTIMATION OF TEMPERATURE CO-EFFICIENT OF WHEAT FOR ADJUSTING OPTIMUM SOWING TIME

A.A. BEGUM, M.A.K. MIAN AND D.A. CHOUDHURY

Abstract

The field experiment was conducted at Agronomy Research Field, Gazipur, BARI during *rabi* season of 2021-2022 to observe the growth behavior and yield of wheat as influenced by prevailing air temperature based on sowing time. The treatments were five sowing dates: D_1 = 10 November, D_2=20 November, D_3 = 30 November, D_4=10 December and D_5=20 December. Sowing time showed great influence on total dry matter (TDM) production, leaf area index (LAI), physiological maturity, yield components and yield of wheat. The 30 November sowing produced the maximum TDM and LAI followed by 10 December and 20 November sowing. These parameters finally contributed to higher grain yield than earlier and later sowing date. The 30 November sowing took the longest crop growth duration (107 days for physiological maturity) due to prevailing lowest temperature (21.3°C) with highest GDD (1766) produced the highest grain yield and 20 December sowing took the shortest period (94 days for physiological maturity) due to prevailing highest temperature (22.3°C) with lowest GDD (1581) produced the lowest grain yield of wheat. It was also found that 30 November sowing produced the maximum grain yield (4.53 t/ha). The results revealed that 20 November to 10 December sowing produced higher grain yield might be due to favourable air temperature for growth and development. Early or late sowing before 20 November and after 10 December produced lower grain yield due to higher temperature prevailed at early growth stage (November) and the later growth stage (March) of wheat at Gazipur region. The temperature co-efficient of wheat was estimated at 1.11 t/ha indicated that grain yield would reduce @ 1.11 t/ha per increase of 1°C of air temperature.

Introduction

Wheat (*Triticum aestivum* L.) is the world's most outstanding crop that excels all other cereals both inarea and production known as king of cereals (Costa *et al*., 2013). It is also one of the most nutritious cereals that contributed to human diet putting it in the first rank to feed the world. In Bangladesh, it is the second major cereal crop after rice as human food. Wheat is primarily grown across the exceptionally diverse range of environments. The optimum temperature for anthesis and grain filling of wheat ranges from 12 to 22 °C. The optimum temperature required for wheat growing period is 20° to 25° C and the maximum temperature is 35° C. If temperature is more than 30°C at the time of maturity, it leads to force maturity which is responsible for yield loss. Post-anthesis heat stress in wheat induces several physiological functions which eventually produce in lesser grain weight as a result of reduced grain filling period and starch synthesis duration or the combined effect of both. The Organization for Economic Co-operation and Development (OECD) (2003) focused on rises in temperature of 1.4°C by 2050 and 2.4°C by 2100 in Bangladesh. Islam (2009) estimated that temperature increases over the past 100 years for all over of Bangladesh at 0.62°C (maximum) and 1.54°C (minimum) occurred in February from 34 meteorological Climate sites in Bangladesh. Those predictions of climate change and prediction of the effect of global warming is becoming the reality in Bangladesh. Thus the crop is being exposed to biotic and abiotic stresses due to adverse effect of climatic change. The seasonal and yearly variations in temperatures, humidity and rainfall distribution caused fluctuation in yield and production of wheat in last couples of years in Bangladesh. Experimentations have been done to improve wheat yield through manipulating sowing time (Hossain *et al*, 2009). The sowing date of wheat is considered as most important factor limiting the wheat yield and it is reported that wheat yield decreased at the rate of 1.3% per day delay sowing after 30th November under the short spell of winter in Bangladesh (Ahmed *et al*, 1998). Since, wheat is grown in winter season and winter is becoming warmer and shorter due to climate change, the dry matter production, grain growth and yield of wheat crop may be affected by higher temperature. Sowing time of wheat may be adjusted to exploit the full yield potentiality exploring the agro-environmental benefit. Therefore, the experiment was conducted to observe the growth behaviour and yield of wheat as influenced by prevailing air temperature as well as other weather elements based on sowing time.

Materials and Methods

The experiment was conducted at the research field, Gazipur, BARI during *rabi* of 2021 – 2022. The soil was silty clay in texture at experimental sight (AEZ-28).The treatments were five sowing date: D_1 = 10 November, D_2 =20 November, D_3 = 30 November, D_4=10 December and D_5=20 December.The experiment was laid out in a RCB design with three replications and the unit plot size was 5m × 4m. Wheat seeds (var. BARI Gom-30) were sown as per treatment in line with maintaining 20 cm row to row spacing. Fertilizers were applied @ 120-30-90-15-3-1 kg/ ha of N-P-K-S-Zn-B respectively (FRG, 2012), in the form of urea, TSP, MoP, gypsum, zinc sulphate and boric acid. Two third of urea and full doses of other fertilizers were applied at the time of final land preparation. The remaining one third of urea was top dressed at CRI stage followed by irrigation. Data on growth parameters like leaf area and dry matter accumulation were measured at different dates with 15 days interval. To record dry matter weight and leaf area, one linear meter was sampled at 15, 30, 45, 60, 75 DAS and at harvest. Collected samples were separated in to different plant parts and then oven dried at 80°C for 72 hours. Leaf area was measured by an automatic leaf area meter (L13100 c, L1COR, USA). Daily air temperatures were recorded for computing the growing degree days (GDD). The GDD was calculated using the following formula:

$$GDD = \sum \frac{Tmax + Tmin}{2} - T_{base}$$

Where, T_{max} and T_{min}were daily maximum and minimum air temperatures, respectively. T_{base} indicated base temperature of wheat (5°C). The GDD can be summed over days to indicate the amount of heat for growth that the crop has received over the period of the growing season (Kumar *et al*., 2008).

For estimation of physiological maturity and graingrowth study, five spikes were harvested from each plot after anthesis starting from 5 days after anthesis at four days interval. It was continued up to 36 days after anthesis (DAA). The harvested spikes were oven dried at 70°C for 72 hours. Twenty grains of each spike were separated from the middle of each spike and then weight was taken. The crop was harvested at physiological maturity. Yield contributing characters were recorded from one linear meter at the time of harvest. Yield data were recorded by harvesting ten square meter area excluding border. Collected data was analyzed statistically following MSTAT-C software package and means were compared using LSD test at 5% level of significance.

Results and Discussion

Effect of sowing time on leaf area index

The LAI was influenced by different sowing dates over time (Fig. 1). The LAI increased sharply and reached the peak at 60 DAS in all sowing dates except 20 December sowing. On the other hand, LAI reached the peak at 45 DAS when sown on 20 December then declined up to harvest. The reduction of LAI after the peak might be due to leaf senescence. Among the sowing dates, 30 November sowing showed the highest LAI (4.6) at 60 DAS and it was higher throughout the growing period except at 45 DAS. This has happened due to optimum sowing time (30 November sowing) producing the highest LAI across the different sowing dates. The lower LAI was observed on 20 December sowing at all over growing period except 45 DAS.

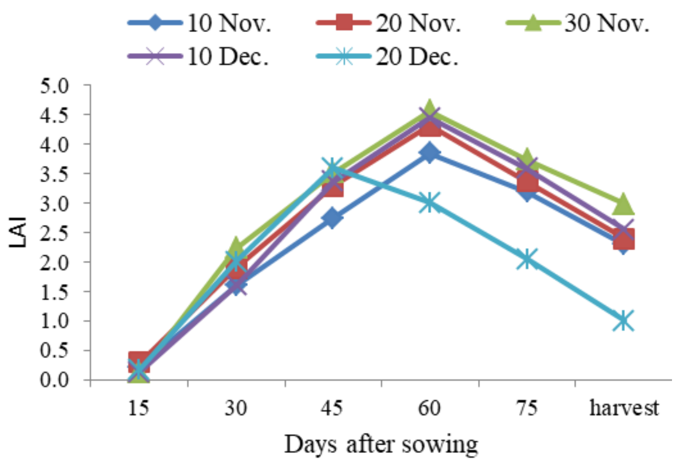


Fig.1. LAI of wheat at different DAS as influenced by sowing dates during *rabi* 2021-2022.

Effect of sowing time on TDM production

The pattern of TDM accumulation in wheat over time was influenced by different sowing dates (Fig.2). The TDM of wheat increased slowly up to 30 DAS. After 30 DAS dry matter accumulation rate increased rapidly up to harvest in all sowings except 10 November and 20 December sowing. In these two sowing, TDM increased slowly up to 30 DAS. After 30 DAS dry matter accumulation rate increased rapidly up to 75 DAS and then increased slowly till the harvest. The highest TDM accumulation/m^2 was obtained from 30 November sowing at harvest followed by 10 December and 20 November sowing and it was higher than other sowing throughout the growing period. The crop sown on 30 November may have got longer duration due to favourable temperature for growth and development as compared to other sowing dates and produced the maximum TDM. The results are in agreement with Kamrozzaman *et al.* (2016) and Ahmad *et al*. (2005) who stated that sowing dates had significant different on dry matter production. The lowest TDM was observed in 20 December sowing at all over the growing period.

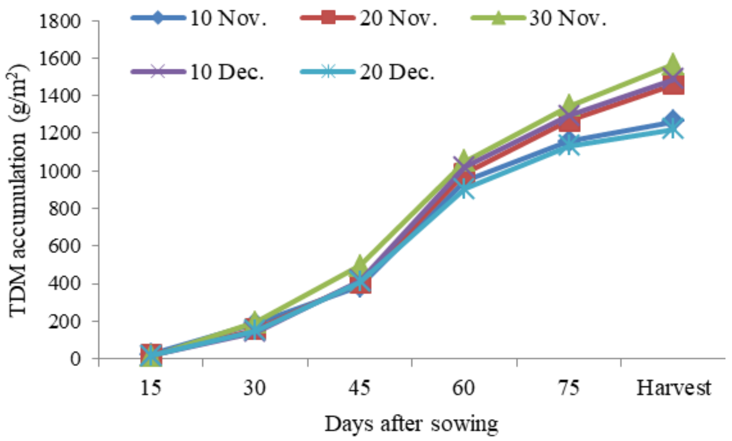
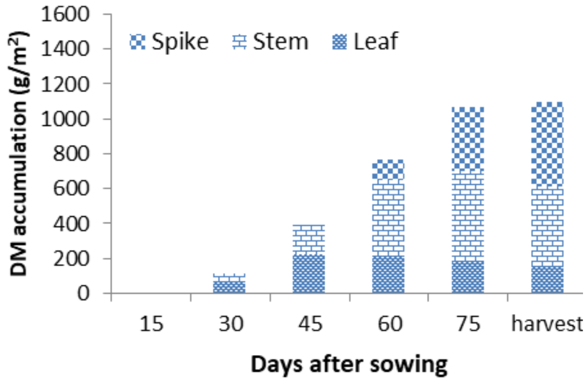


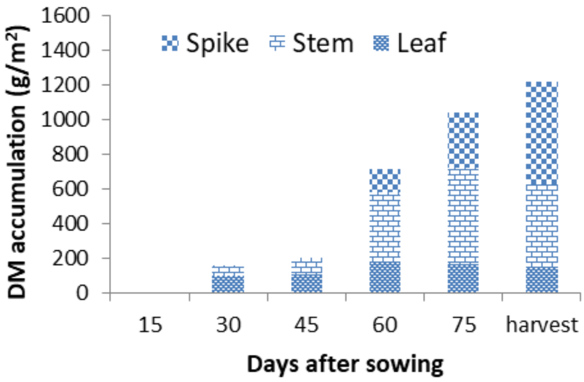
Fig.2. TDM accumulation of wheat at different days after sowing as influenced by sowing dates.

Effect of sowing time on dry matter partitioning

Pattern of DM distribution in different parts of wheat crop in response to planting times have shown in Fig. 3. Irrespective of treatments, the difference in dry weight of leaf, stem and spike of wheat was smaller at early growth stages and widened with the advancement of growth. Sowing times had pronounced effect on DM distribution of wheat over the growth stages. Pattern of DM distribution of wheat was similar in all the planting times such that allocation of assimilates to leaves and stems increased to a peak and then decreased with concomitant increase in allocation to reproductive organ (spike). Irrespective of planting time, dry matter distribution to leaf of wheat peaked at 60 DAS when sown on 10, 20, 30 November and 10 December and peaked at 45 DAS when sown on 20 December. On the other hand, stem dry matter distribution of wheat peaked at 75 DAS at all sowing dates. The highest leaf and stem dry matter was produced by 30 November sowing and the lowest leaf and stem dry matter was produced by 20 December sowing at all over the growing period. The reduction in dry matter of vegetative parts (leaf+stem) after peak might be due to remobilization of stored assimilates into the grain of wheat. The highest spike dry matter was produced by 30 November sowing and the lowest spike dry matter was produced by 20 December sowing.

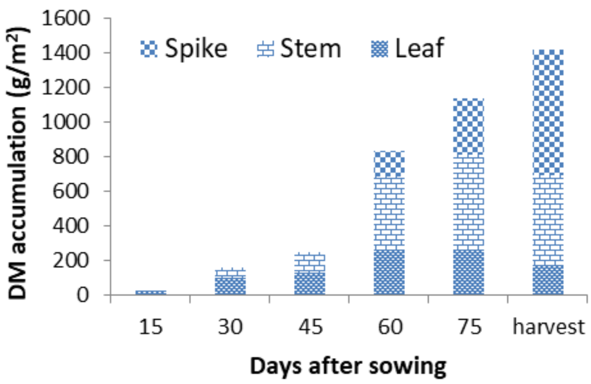


a.10 November



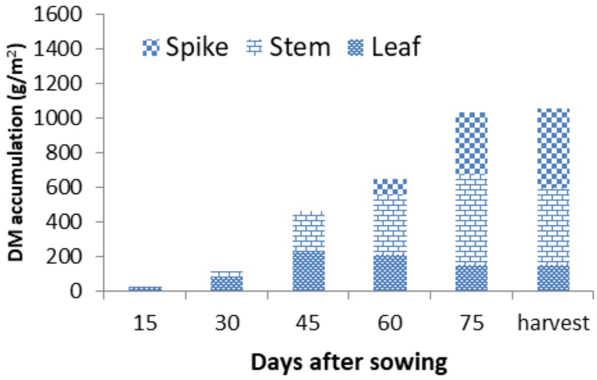
b. 20 November

0



c. 30 Novemver

d.10 December



e.20 December

Fig.3. Dry matter distribution pattern of wheat as influenced by sowing date.

Dry matter distribution of wheat at harvest

Dry matter distribution pattern of wheat at harvest in response to planting times have shown in Fig. 4. Sowing times had pronounced effect on DM distribution at harvest of wheat. The highest leaf, stem and spike dry matter was produced by 30 November sowing followed by 10 December and 20 November sowing. The lowest leaf, stem and spike dry matter was produced by 20 December sowing followed by 10 November sowing. The crop sown on 30 November might have got longer duration due to favourable temperature for growth and development as compared to other sowing dates and produced the maximum TDM (leaf dry matter=177 g/m^2, stem dry matter=554 g/m^2 and spike dry matter =836 g/m^2) whereas, 20 December sowing produced the minimum TDM (leaf dry matter=164g/m^2, stem dry matter=498g/m^2 and spike dry matter =562 g/m^2). Thirty November sowing produced 53% spike dry matter, 35% stem dry matter and 12% leaf dry matter of TDM which was 49%, 11% and 8% higher than those of 20 December sowing (Fig.4).

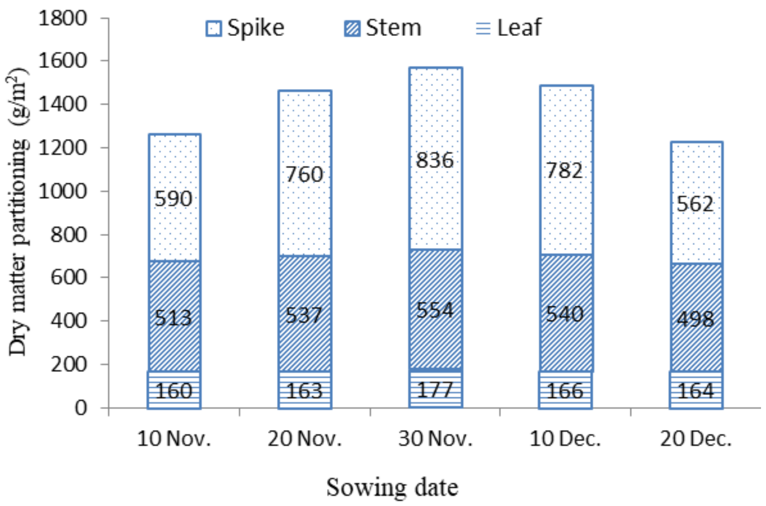


Fig.4. Dry matter distribution pattern of wheat at harvest as influenced by sowing date during *rabi* 2021-2022.

Effect of sowing time on grain growth

Effect of sowing date on grain growth of wheat has been presented in Fig. 5. Among the different sowing dates, 30 November sowing exhibited higher grain growth in all over the grain filling period. It might be due to prevailing optimum air temperature on 30 November sowing. Sowing on 20 November-10 December exhibited higher trend of grain growth as compared to earlier and later sowing (10 November and 20 December sowing).Grain growth reached peak at 32 days after anthesis (DAA) when crop sown on 30 November sowing. The maximum grain weight (74.0 mg/grain) was observed at 32 (DAA) when crop sown on 30 November sowing followed by 10 December sowing at same DAA (71.0 mg/grain) and 20 November sowing at 34 DAA (70.0 mg/grain). Higher grain growth duration (36 DAA) was observed at 10 November sowing but did not produce the maximum grain weight. It might be due to 10 November sowing took the maximum grain growth duration (36 days) but shorter vegetative phase (67 days) with higher air temperature gained comparatively lower dry matter which failed to produce higher grain weight and longer vegetative phase (75 days) gained maximum dry matter with lower temperature on 30 November sowing which produced the maximum grain weight of wheat. The lowest grain weight (53.0 mg/grain) was observed at 25 DAA on 20 December sowing. It indicated that grain weight reduced in late sown condition due to higher air temperature prevailed at later growth stage (March) shortening the growth period of wheat. Similar results were also have been found by Mian *et al*. (2016) and Khan and Aziz (2015).

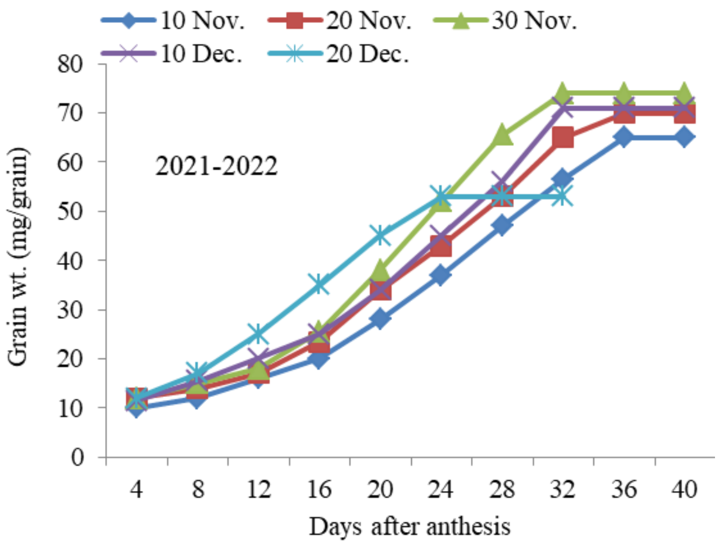


Fig. 5. Grain growth of wheat as influenced by sowing dates during *rabi* 2021-2022.

Effect of sowing time on growth duration, mean air temperature and GDD

Duration, mean air temperature and growing degree day (GDD) for anthesis and physiological maturity of wheat as affected by sowing date have been presented in Table 1, Table 2 and Table 3. Temperature is an important factor which influence duration of different growth stages of wheat. The shortest vegetative phase (67 days) with the lower GDD (1140) was observed in 10 November sowing due to prevailing higher mean temperature (21.8°C) and the longest vegetative phase (75 days) with higher GDD (1166) was observed in 30 November sowing due to prevailing lower mean air temperature (20.3°C).On the other hand, the longest reproductive phase (36 days with the lowest GDD 523) was observed in 10 November sowing due to prevailing the lowest mean temperature (19.5°C) and the shortest reproductive phase (25 days with lower GDD 530) was observed on 20 December sowing due to prevailing maximum mean air temperature (26.2°C) shown in Table 1 and Table 2. As a result, 20 December sowing took the minimum duration (94 days to reach physiological maturity with minimum GDD (1581) and 30 November sowing took the maximum duration to reach physiological maturity with maximum GDD (1766) followed by 10 December and 20 November sowing (Table 3). It might be due to comparatively higher temperature prevailed at the earlier and later sowing than 20 November to 10 December sowing. The longest duration (107 days) due to prevailing lowest temperature (21.3°C) with highest GDD (1766) produced the highest grain yield and the shortest duration (94 days) due to prevailing highest temperature (22.3°C) with lowest GDD (1581) produced the lowest grain yield of wheat (Table 3). The result of the present experiment was also supported by (Ahmed *et al.*, 2015).

Table 1. Required duration, mean temperature and GDD for vegetative phase as affected by sowing date during *rabi* of 2021-2022

Sowing date	Vegetative phase (Seeding to Anthesis)		
	Duration (days)	Mean air temperature (°C)	Growing degree day (GDD)
10 November	67	21.8	1140
20 November	70	20.9	1145
30 November	75	20.3	1166
10 December	72	19.9	1145
20 December	69	20.0	1052

Table 2. Required duration, mean temperature and GDD for reproductive phase as affected by sowing date during *rabi*of 2021-2022

Sowing date	Reproductive phase (Anthesis to Physiological maturity)		
	Duration (days)	Mean air temperature (˚C)	Growing degree day (GDD)
10 November	36	19.5	523
20 November	34	21.1	586
30 November	32	22.4	599
10 December	32	24.2	607
20 December	25	26.2	530

Table 3. Required duration, mean temperature and GDD for physiologicalmaturity as affected by sowing date during *rabi*of 2021-2022

Sowing date	Crop duration (Seeding to Physiological maturity)		
	Duration (days)	Mean air temperature (˚C)	Growing degree day (GDD)
10 November	103	21.5	1663
20 November	104	21.4	1731
30 November	107	21.3	1766
10 December	104	21.5	1752
20 December	94	22.3	1581

Yield attributes and yield

Yield contributing characters and yield of wheat have been presented in Table 4 and Table 5. The maximum spikes/m^2 (471) was observed in 30 November sowing followed by 10 December and 20 November sowing and the lowest was observed in 20 December sowing followed by 10 November sowing. The maximum spike length (9.50 cm) was obtained from 20 December sowing and statistically similar spike length was observed on 20 November to 10 December sowing and the minimum spike length (8.23 cm) was obtained from 10 November sowing which was statistically different from other sowing dates. The highest number of grains/ spike (46.9) was observed in 30 November sowing which was statistically similar with 20 November and 10 November sowing and the lowest (38.9) was observed in 20 December sowing and it was statistically different from other sowing dates. The highest 1000-grain weight (49.52 g) was observed in 30 November sowing which was statistically similar with 20 November and 10 December sowing and the lowest (46.59 g) was observed in 20 December sowing followed by 10 November sowing. The highest grain yield (4.53 t/ha) was observed in 30 November sowing which was statistically similar with 10 December and 20 November sowing due to cumulative effect of better yield components and the lowest grain yield (3.22 t/ha) was observed in 20 December sowing followed by 10 November sowing due to cumulative effect of poor yield components. It was observed that 30 November sowing received lower temperature during cropping period that caused longer crop growth duration and ultimately produced higher LAI and TDM and translocation of higher TDM to grain. It might be 30 November sowing probably received favourable environment mainly optimum temperature resulting better vegetative growth of the plants which ultimately led to the better flowering, grain filling and finally increased grain yield. On the other hand, the lowest grain yield was observed in 20 December sowing. It was found that 20 December sowing crop received cool temperature at early growth stage which produced profuse tillering and higher temperature at reproductive phase that hastened maturity and reduced TDM production and translocation of less dry matter to the reproductive organ (grain).Yield change was observed (+21 to -14%) over 10 November sowing and early or late sown caused about 17-29% yield reduction over 30 November sowing. The result of the present study was also supported by Kamrozzaman *et al.* (2016) and they reported that 25 November sowing gave the highest grain yield and 15 December gave the lowest grain yield when the crop sown on 5 November, 15 November, 25 November, 5 December and 15 December. The variations in yield and yield contributing characters of wheat due to sowing date were also observed by Gul *et al.* (2012) and Uddin *et al.* (2015). Similar trend was also observed in straw yield, biological yield and harvest index (HI) shown in Table 5.

Table 4. Plant height, spikes/m^2, yield and yield components of wheat as affected by sowing date during *rabi* of 2021-2022

Sowing date	Plant height (cm)	Spikes/ m^2 (no.)	Spike length (cm)	Grains/ spike (no.)	1000-grain wt (g)	Grain yield (t/ha)	Yield change over 10 Nov. sowing (%)	Yield decrease over 30 Nov. sowing (%)
10 Nov.	90.4	435	8.23	42.3	47.65	3.75	-	17
20 Nov.	90.7	456	8.99	45.9	48.80	4.20	+12	7
30 Nov.	92.0	471	9.07	46.9	49.52	4.53	+21	-
10 Dec.	91.5	468	9.10	45.5	48.83	4.23	+13	7
20 Dec.	90.3	389	9.50	38.9	46.59	3.22	-14	29
LSD $_{(0.05)}$	NS	56.04	0.29	4.37	1.89	0.83	-	-
CV (%)	3.40	6.71	1.74	5.28	2.08	5.62	-	-

Table 5. Straw yield, biological yield and harvest index of wheat as affected by sowing date during *rabi* of 2021-2022

Sowing date	Straw yield (t/ha)	Biological yield (t/ha)	HI (%)
10 November	4.06	7.81	47.97
20 November	4.52	8.71	48.13
30 November	4.58	9.12	49.53
10 December	4.57	8.80	48.03
20 December	6.64	9.86	32.66
LSD $_{(0.05)}$	0.79	1.18	5.75
CV (%)	8.63	7.09	6.75

Weekly maximum and minimum air temperature

Weekly mean of maximum and minimum air temperature during wheat growing period has been presented in Fig. 6. The highest weekly mean of maximum air temperature was observed in 15-21 March (35.7°C) and the lowest (19.59°C) was recorded in 15-21 February. On the other hand, the highest weekly mean of minimum air temperature (23.4°C) was observed in 22-31 March and the lowest (12.9°C) was recorded in 15 - 21 February.

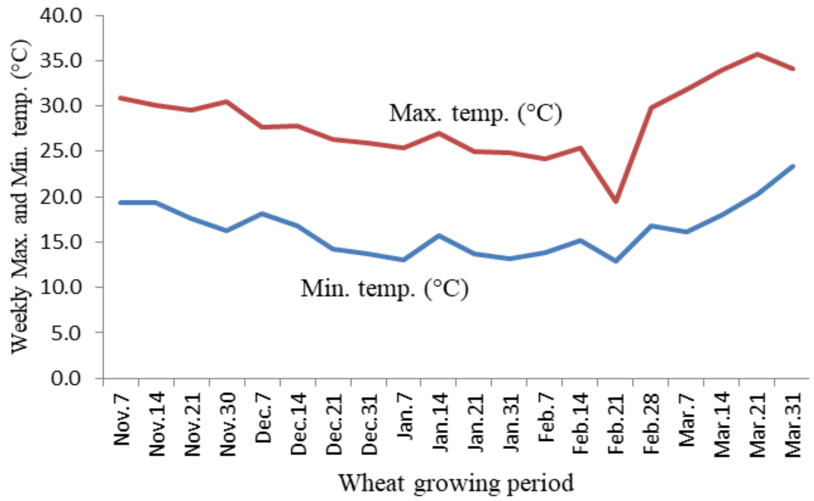


Fig 6.Weekly maximum and minimum air temperature during crop growing period in 2021-2022.

Relationship between grain yield and air temperature

There was a negative linear relationship between grain yield (t/ha) of wheat and air temperature has been shown in Fig. 7. At the regression line (Y= -1.105x + 27.88, R^2=0.80) indicated that the regression of co-efficient (x) was 1.105.This expressed that grain yield of wheat would decrease at the rate of 1.105 t/ha per increase of 1°C air temperature. The co-efficient of determination (R^2=0.80) value indicated that air temperature had 80% effect on grain yield of wheat. The result revealed that increasing temperature decreasing the grain yield of wheat. Similar results also have been described by Mian *et al.* (2016). Temperature co-efficient of wheat was estimated at 1.11 t/ha per increasing 1°C air temperature. Effect of temperature on the grain yield of wheat was estimated at 80%. Similar results have also been reported by Senthold *et al.* (2010). They surprisingly, observed variations in average growing-season temperatures of ±2 °C in the main wheat growing regions of Australia can cause reductions in grain production of up to 50%.

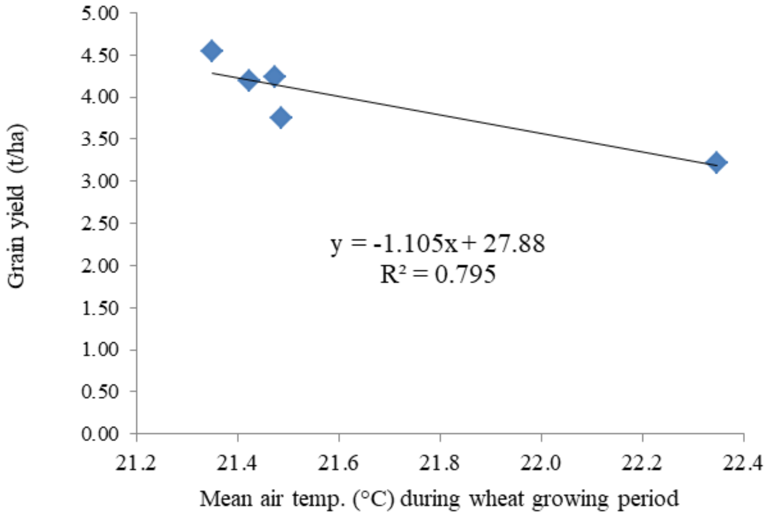


Fig. 7.Functional relationship between mean air temperature and grain yield of wheat.

Conclusion

The results revealed that physiological maturity period as well as crop duration of wheat was reduced as influenced by higher temperature. 20 November to 10 December sowing would be the optimum sowing time for wheat in relation to air temperature and early or late sown caused about 17-29% yield reduction over 30 November sowing or yield change was observed (+21 to -14%) over 10 November sowing. Temperature co-efficient of wheat was estimated at 1.11 t/ha per increasing 1°C air temperature and the effect of temperature on grain yield of wheat was estimated at 80%.

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Water Logging

EFFECT OF EXOGENOUS CHEMICAL APPLICATION ON GROWTH AND PHYSIOLOGICAL CHANGES OF CHILLI UNDER WATERLOG CONDITION

M.R. KARIM, J.A. CHOWDHURY, S.S. KAKON, S.T. ZANNAT, I.M. AHMED AND D.A. CHOUDHURY

Abstracts

The experiment was conducted in the field laboratory of Agronomy Division, Bangladesh Agricultural Research Institute, Gazipur-1701 during the period from December 2021 to May 2022. The experiment was laid out in randomized complete block design (RCBD) with four replications and six treatments viz. T_1 = Seedling pretreatment with ethophonn @ 35 µM, T_2 = Seedling pretreatment with ALA (5-aminolevulinic acid) @ 5mg/l, T_3 = Application of Ca^{++} @ 10 mM/l (after stress) , T_4 = Seedling pretreatment with ascorbic acid @ 6mM, T_5 = Application of KCl solution @ 60 kg/h (after stress) and T_6 = Control (No chemical application). Highest shoot length was found in T_3 (82.33 cm). Root length was found the highest in T_1 (14.67 cm). Highest number of adventitious root was found in T_4 (77). Highest root dry weight was found in T_4 (5.03 g). Highest number of fruits plant was found in T_4 (40). Highest fruit yield per plant was found in T_4 (83.90g). Application of exogenous chemicals on chili under waterlogging were found effective. On the basis of yield and other parameters, seedling pretreatment with ascorbic acid @ 6mM (T_4) found more effective under waterlogging condition.

Introduction

Chilli is the most essential and important spices crops in Bangladesh. It can be cultivated in both the summer and winter seasons and is widely cultivated in Bangladesh. The production of chilli largely depends on the use of fertilizers, irrigation, pesticide etc. The Government of Bangladesh has, therefore, provided priority to the agriculture sector to increase the production of chilli by giving subsidy to the farmers on different inputs such as seeds, fertilizer, irrigation etc. to achieve self-sufficiency in chilli production. Chilli plants should be watered regularly. But it can't withstand waterlogging more than four (04) days (Suh *et al*., 1987). Waterlogging stress seriously inhibited the longitudinal elongation of pepper roots and plants (Song *et al*., 2019). Due to these, there is a crisis and price hike of green chilli during summer and onward up to next winter. Chilli is cultivated in about 191076 acre producing 111963 MT chilli during rabi season, while during kharif, it is cultivated only in 48367 acre producing 45644 MT chilli i.e., 74.69% decrease in cultivated area and 59.23% decrease in production during kharif than rabi season (BBS, 2020). It has been well-documented that ALA improves plant growth, not only under normal conditions, but more notably upon environmental stresses (Hotta *et al.,* 1997*).* Spraying exogenous Ca^{2+} can effectively alleviate injury to pepper plants caused by waterlogging stress and improve the quality of pepper fruit (Li-Jun Ou *et al*., 2017). ASC at a concentration of 3 mM was the most successful in relieving effects of waterlogging stress on plants (Ihsan Ullah *et al.*, 2017). Waterlogged plants supplemented with K showed a significant improvement in growth, photosynthetic pigments and photosynthetic capacity (Muhammad Arslan Ashraf *et al*., 2011).

So, this experiment will be conducted to develop waterlogging tolerance in chili.

Materials and Methods

The experiment was conducted in the field laboratory of Agronomy Division, Bangladesh Agricultural Research Institute, Gazipur-1701 during the period from December 2021 to May 2022. The experiment was laid out in randomized complete block design (RCBD) with four replications and six treatments viz. T_1=Seedling pretreatment with ethophonn @ 35 µM, T_2 = Seedling pretreatment with ALA (5-aminolevulinic acid) @ 5mg/l, T_3 = Application of Ca^{++} @ 10 mM/l (after stress), T_4 = Seedling pretreatment with ascorbic acid @ 6mM, T_5 = Application of

KCl solution @ 60 kg/h (after stress) and T_6 = Control (No chemical application). Roots of 25 days old seedlings are soaked in chemical formulation according to the treatment (for T_1, T_2 and T_4) for 24 hours. Seedlings for T_3, T_5 and T_6 were soaked in pure distilled water. After ten days of sowing, seedlings were dipped for 48 hours to create waterlogging stress. Immadietly after stress, T_3 and T_5 treatments were imposed. Irrigation were done on the basis of requirement. Disease and insect control measures were taken as and when necessary. Data was collected on shoot length, root length, number of adventitious root, fresh biomass, dry biomass and yield. Statistical analysis was done with the help of 'STAR' computer software.

Results and Discussion

Exogenous chemical application on chilli under waterlog condition showed significant differences in shoot length, root dry weight and shoot dry weight. Non-significant differences were found in case of root length, number of adventitious root, number of fruit per plant and fruit weight per plant. Highest shoot length was found in T_3 (82.33 cm) which is statistically similar with T_1 (81.67 cm), T_2 (77 cm) and T_5 (76 cm). Root length was found the highest in T_1 (14.67 cm) and the lowest was found in T_6 (9.33). Highest number of adventitious root was found in T_4 (77) followed by T_1 (68.67), T_3 (58.33) and T_5 (57). Highest root dry weight was found in T_4 (5.03 g) followed by T_3 (4.87) and T_1 (4.60). The lowest root dry weight was found in T_2 (2.50 g). Shoot dry weight was found the highest in T_1 (29.90 g) followed by T_3 (25.13), T_2 (23.77) and T_5 (23.03). The lowest shoot dry weight was found in T_6 (18.30 g). Highest number of fruits plant was found in T_4 (40) followed by T_3 (31.33). The lowest number of fruits plant was found in T_6 (25). Highest fruit yield per plant was found in T_4 (83.90g). The lowest number of fruits plant was found in T_6 (39.40g)

Conclusion

Application of exogenous chemicals on chili under waterlogging were found effective. On the basis of yield and other parameters, seedling pretreatment with ascorbic acid @ 6mM found more effective under waterlogging condition.

Table 1. Phenological parameter of chili under waterlogging stress treated with different chemicals

Treat	Shoot length (cm)	Root length (cm)	Number of adventitious root	Root dry weight (g)	Shoot dry weight (g)	Number of fruits per plant	Fruit weight per plant (g)
T_1	81.67	14.67	68.67	4.60	29.90	28.33	56.69
T_2	77.00	14.00	44.33	2.50	23.77	25.67	44.24
T_3	82.33	12.33	58.33	4.87	25.13	31.33	52.71
T_4	64.67	12.33	77.00	5.03	21.43	40.00	83.90
T_5	76.00	11.33	57.00	2.57	23.03	25.67	52.64
T_6	63.33	9.33	36.67	3.07	18.30	25.00	39.40
$LSD_{(0.05)}$	6.3	NS	NS	2.73	0.79	NS	NS
CV	3.02	17.39	27.70	25.55	1.18	26.09	31.64

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EFFECT OF FOLIC ACID SEED TREATMENT ON SUNFLOWER UNDER SALINITY STRESS

M. R. KARIM, J. A. CHOWDHURY, A. A. BEGUM, S. S. KAKON, S. T. ZANNAT AND D. A. CHOWDHURY

Abstract

A pot trial was conducted in the field laboratory of Agronomy Division, Bangladesh Agricultural Research Institute, Gazipur-1701 during 15 December 2021 to 15 April 2022. Six treatments, viz. S_0F_0= No salinity + No folic acid, S_0F_1= No salinity + 50 µM folic acid, S_1F_0= 6.0 ds/m salinity + No folic acid, S_1F_1= 6.0 ds/m salinity + 50 µM folic acid, S_2F_0= 8.0 ds/m salinity + No folic acid, S_2F_1= 8.0 ds/m salinity + 50 µM folic acid were imposed in randomized complete block design (RCBD) with three replications. Seed treatment with 50 µM folic acid has been found superior regarding plant height (cm), head diameter (cm), head breadth (cm), seed per plant, 1000-SW and yield per plant (g) under salinity stress. The maximum plant height was found in S_0F_0 (69 cm) which was statistically similar with S_0F_1 (68.33 cm). Highest influence of folic acid on head diameter was found in S_1F_1 (7.8 cm) which is 0.34 cm more than S_1F_0. Highest influence of folic acid on head breadth was found in S_1F_1 (8.37 cm) which is 0.60 cm more than S_1F_0. Highest number of seed per plant was found in S_0F_1 (288 seed per plant) which is statistically similar with S_1F_1 (279 seed per plant). Highest thousand seed weight was found in S_2F_1 (58.34 g). Highest yield was found in S_1F_1 (14.02 g seed per plant) which is statistically similar with S_0F_1 (13.48 g seed per plant). Seed pretreatment with 50 µM folic acid may be useful for amelioration of salinity stress.

Introduction

Sunflower (Suryamukhi) annual or perennial herb, Helianthus annuus, of the family Asteraceae. The cultivated sunflower probably originated in Mexico. In Bangladesh, it was first introduced as a garden plant, but in the 1980s some dwarf varieties were introduced to cultivate as oil seed crop. The plant is now being cultivated as kharif and rabi crop in some central and northern districts. The world agriculture faced lots of problems due to soil salinity as its damage the various cellular function of plant. The land is becoming non-productive due to accumulation of salt in fresh soil through tidal flow close proximity to sea level in each year. Plant growth and productivity drastically restricted by salinity that is of the major environmental factors (Schleiff *et. al.*, 2008). Among all of the life cycle of plant, the germination and seedling stage is the sensitive to salinity than the adult stage (Ashraf *et. al*, 1986).

Application of 20 mg/L folic acid to sunflower seeds, increase their viability and germination rate, and significant increases observed in vigour parameters (shoot and root lengths, dry weights, and shoot to root ratio) (Farouk and EL-Saidy, 2013). Plant shows vigorous growth and large flowers when seeds treated with folic acid (Karim *et. al*., 2022). FA increases proline biosynthesis under stressful conditions, thus helping the plant to gain endurance against stress (Burguieres *et al*., 2007).

So, this study is undertaken to find out the effect of seed treatment with folic acid and potassium fertilizer foliar application on sunflower under salinity stress condition.

Materials and Methods

A pot trial was conducted in the field laboratory of Agronomy Division, Bangladesh Agricultural Research Institute, Gazipur during 15 December 2021 to 15 April 2022. The seeds of BARI Surjomukhi - 3 was used in this experiment. Six treatments, viz. S_0F_0= 0 dS/m + 0 µM folic acid, S_0F_1= 0 dS/m + 50 µM folic acid, S_1F_0= 6.0 ds/m salinity + 0 µM folic acid, S_1F_1= 6.0 ds/m salinity + 50 µM folic acid, S_2F_0= 8.0 ds/m salinity + 0 µM folic acid, S_2F_1= 8.0 ds/m salinity + 50 µM folic acid were imposed in randomized complete block design (RCBD) with three replications. Adequate amount of seeds for application was pre-soaked in beakers containing distilled water and

FA under room temperature for 24 h. Three soaked seeds were then sown in each prepared pot. Irrigation was done using fresh and salt solution (as per treatment). Half urea and full amount of other fertilizers (Urea-TSP- MoP-Gypsum-Boron @ 2.0-1.5-1.2-1.2-0.1 g/pot) were applied at the time of final pot preparation. Rest amount of urea were applied in two split (25DAE & 45 DAE). After seedling emergence, keeping healthy one, rest were discarded. Appropriate care and pest-diseases control were confirmed in each pot during the experimental period.

Data collection

Data were collected on plant height (cm), head diameter (cm), head breadth (cm), seed per plant, 1000-SW and yield per plant (g) accordingly.

Statistical analysis

The collected data were analyzed statistically with the help of computer using 'STAR' analysis software.

Results and Discussion

Plant Height

Plant height were influenced by folic acid treatment (figure 1). Highest plant height was found in S_0F_0 (69 cm) which is statistically similar with S_0F_1 (68.33 cm). Highest influence of folic acid was found in S_1F_1 (61.33 cm) which is 8.66 cm more than S_1F_0.

Head Diameter

Head diameter were influenced by folic acid treatment (figure 3). Highest head diameter was found in S_1F_1 (7.8 cm). Highest influence of folic acid was found in S_1F_1 (7.8 cm) which is 0.34 cm more than S_1F_0.

Head breadth

Head breadth were also influenced by folic acid treatment (figure 2). Highest head breadth was found in S_0F_0 (9.07 cm). Highest influence of folic acid was found in S_1F_1 (8.37 cm) which is 0.60 cm more than S_1F_0.

Seed per Plant

Seed per plant were significantly influenced by folic acid treatment (figure 4). Highest number of seed per plant was found in S_0F_1 (288 seed per plant) which is statistically similar with S_1F_1 (279 seed per plant). Highest influence of folic acid was found in S_0F_1 (288 seed per plant) which is 48 more than S_0F_0.

1000-SW

Thousand seed weight were influenced by folic acid treatment under salinity stress (figure 5). Highest thousand seed weight was found in S_2F_1 (58.34 g). Highest influence of folic acid was found in S_2F_1 (58.34 cm) which is 5.34 g more than S_2F_0.

Yield per Plant

Yield of sunflower were significantly influenced by folic acid treatment under salinity stress (figure 6). Highest yield was found in S_1F_1 (14.02 g seed per plant) which is statistically similar with S_0F_1 (13.48 g seed per plant). Highest influence of folic acid was found in S_2F_1 (10.07 seed per plant) which is 1.90 g more than S_2F_0.

Conclusions

Seed treatment with 50 µM folic acid has been found superior regarding plant height (cm), head diameter (cm), head breadth (cm), seed per plant, 1000-SW and yield per plant (g) under salinity stress. So, seed treatment with 50 µM folic acid will be helpful to sunflower cultivation for amelioration of salinity stress.

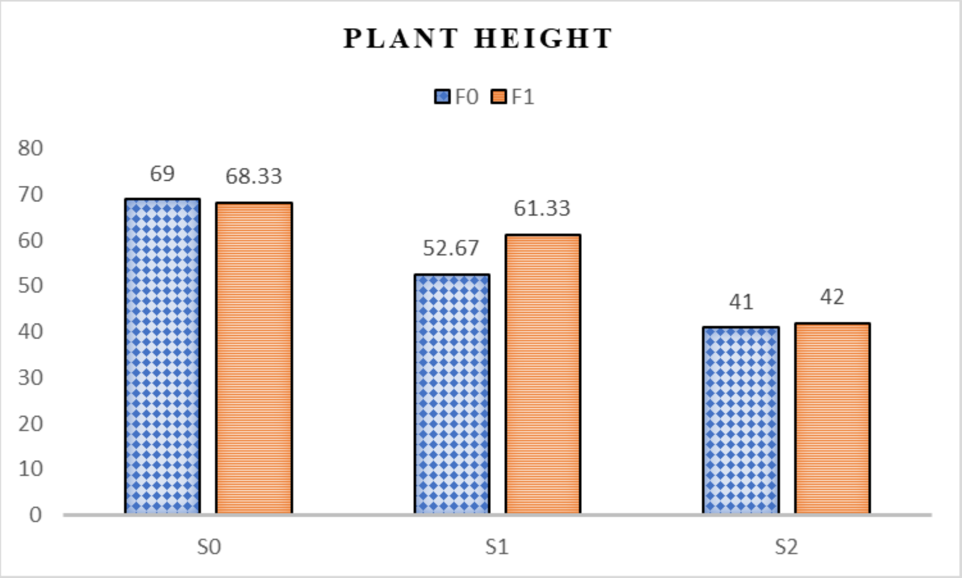

Figure 1: Plant height influenced by folic acid treatment under salinity stress

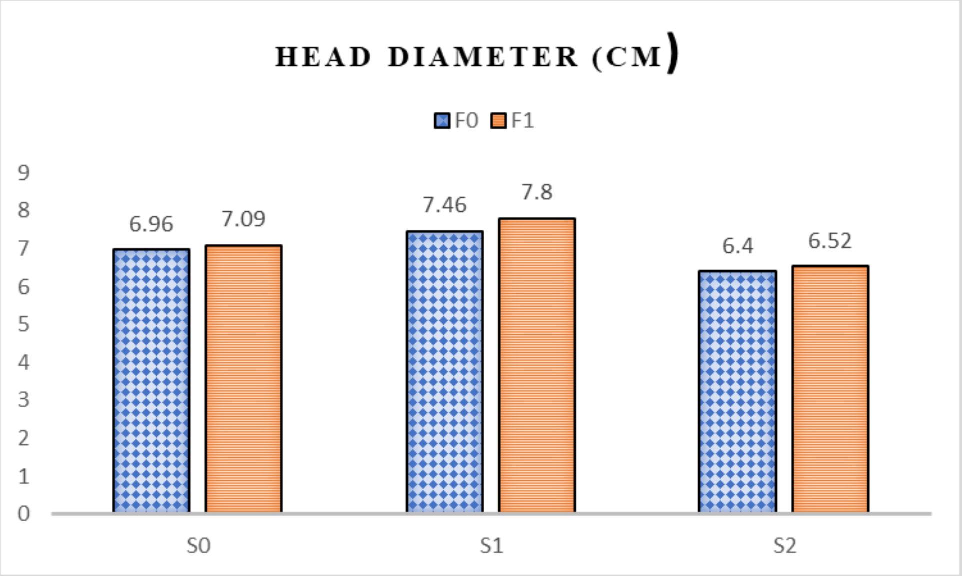

Figure 2: Head diameter influenced by folic acid treatment under salinity stress

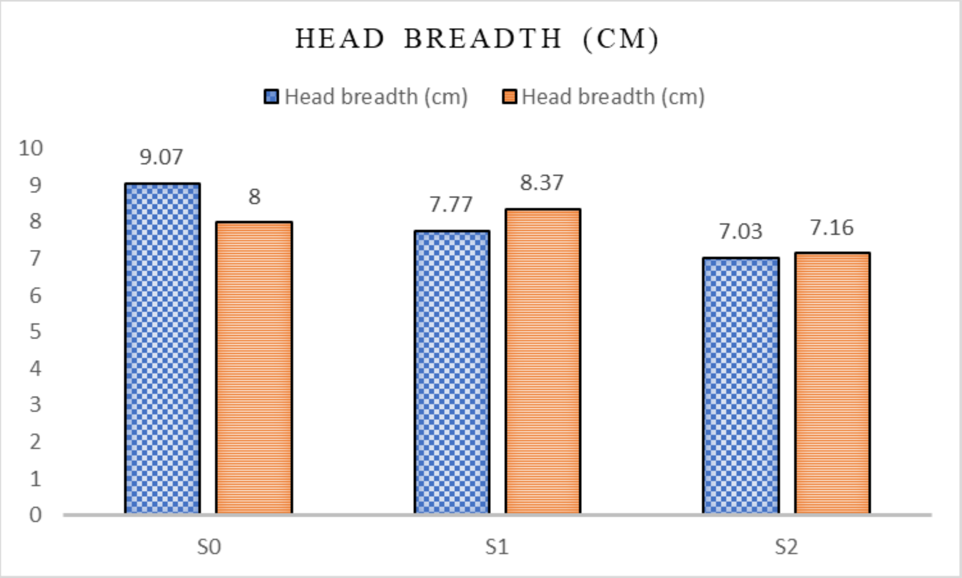

Figure 3: Head breadth influenced by folic acid treatment under salinity stress

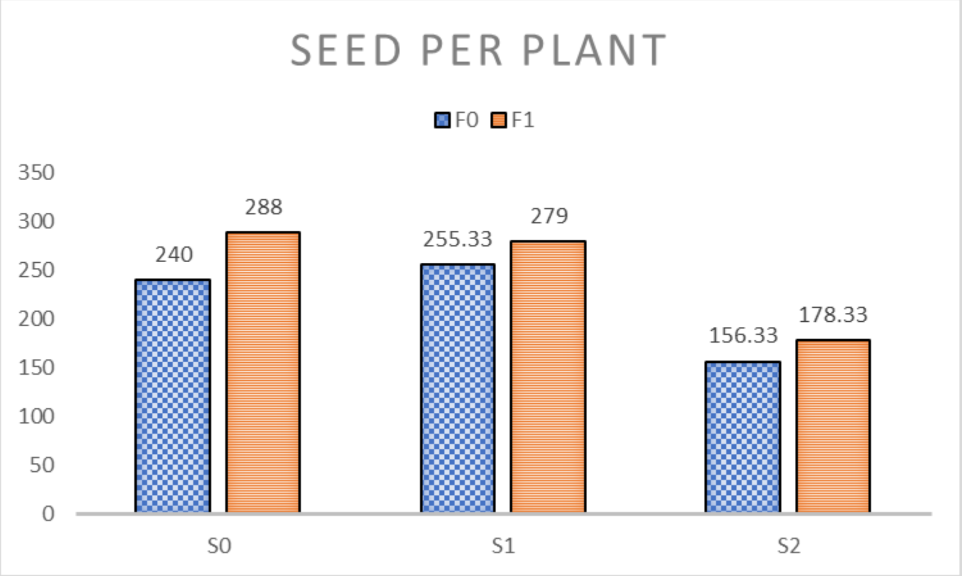

Figure 4: Seed per plant influenced by folic acid treatment under salinity stress

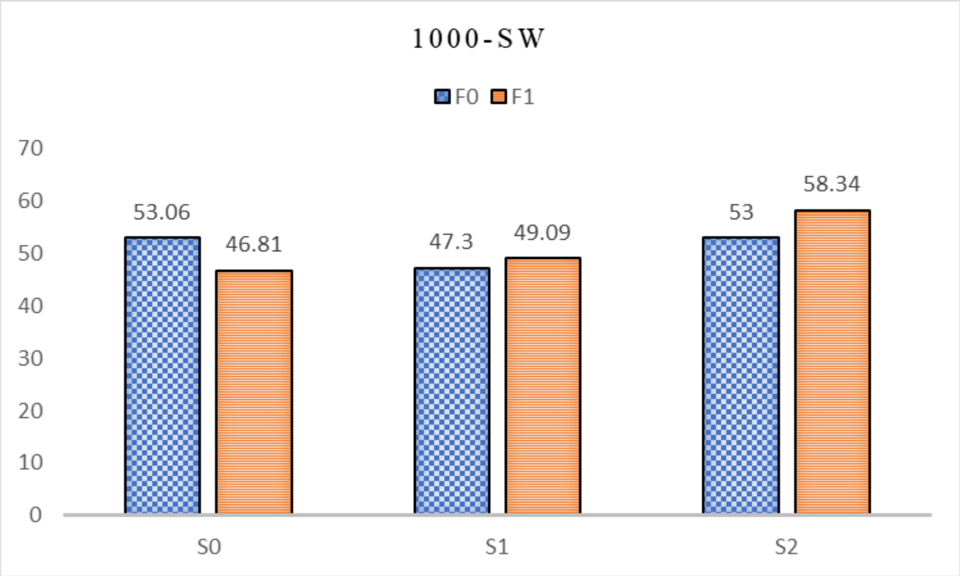

Figure 5: 1000-SW influenced by folic acid treatment under salinity stress

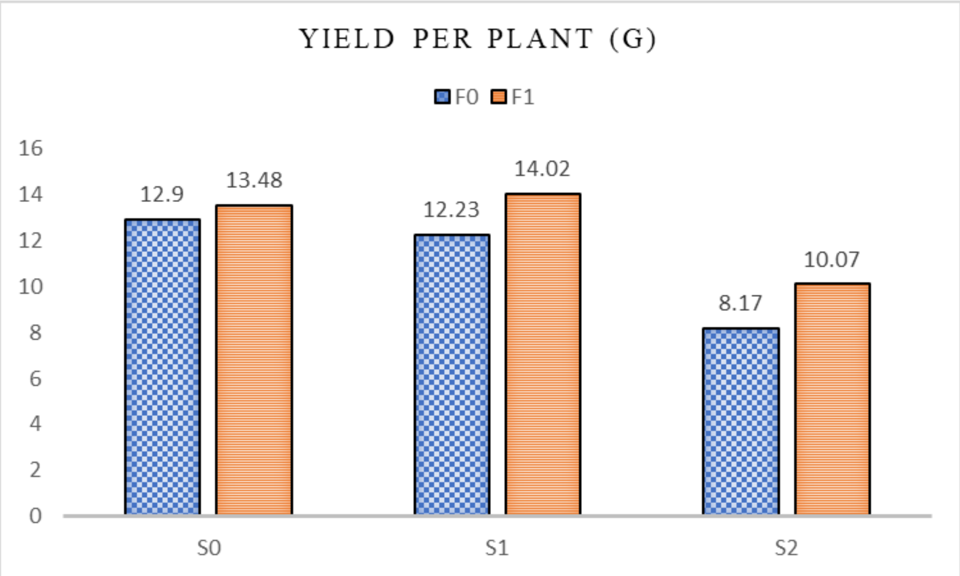

Figure 6: Yield of sunflower influenced by folic acid treatment under salinity stress

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INTEGRATED NUTRIENT MANAGEMENT FOR BITTER GOURD ON FLOATING BED CUM TRELLIS

M.A. RAHMAN

Abstract

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal on bitter gourd (hybrid variety) during two consecutive Kharif seasons of 2020 and 2021. The floating bed was prepared with water hyacinth and water fern (topapana) and then the raised pits were made with dulalilata on floating bed. The nutrient management in bitter gourd comprised of five treatments (fertilizer doses) viz., T_1 = 65-21-10-5-1 kg/ha N-P-K-S-B, respectively (BARC, 2018); T_2 = 75% of T_1; T_3 = 50% of T_1; T_4 = 25% of T_1; T_5 = No fertilizer. In Kharif 2020, fertilizer dose had significant effect on branch/plant, fruit length, fruit diameter, fruit/plant and fruit yield. The treatment T_1 produced the highest yield (13.27 t/ha), which was statistically similar to that of T_2 (12.31 t/ha). The lowest yield was obtained from T_5 treatment (9.02 t/ha). In Kharif 2021, the highest yield of fruit (12.87 t/ha) was obtained from treatment T_1 that was statistically similar to T_2 (11.98 t/ha). The control treatment (T_5) gave the lowest yield (8.43 t/ha). The two years average results (Kharif 2020 and 2021) further indicated that treatment T_1 increased the yield of 49.89%, while T_2, T_3 and T_4 treatments increased the yields of 39.30%, 25.86% and 16.76%, respectively over the control treatment. As treatment T_1 and T_2 (75% of T_1: 75g urea, 80g TSP, 15 MP, 25g gypsum and 5 g boric acid/10m^2 floating bed) produced statistically similar yields, therefore treatment T_2 can be applied for hybrid bitter gourd cultivation on floating bed cum trellis.

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 (*Eichhornia crassipes*) 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 creeper vegetable crops due to lacking of required space on the bed and large canopy size of the crop plant. Recently, floating bed cum trellis (non-tidal model) has been developed for creeper vegetables cultivation. Research works have so far been conducted on nutrient management of cucumber, pumpkin and bottle gourd on floating bed. However, research work has not been conducted yet to develop floating agriculture based nutrient management package for bitter gourd. In this respect, the research work had been designed to develop nutrient management package for bitter gourd on water hyacinth made floating bed cum trellis.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal on bitter gourd (hybrid variety) during *Kharif* seasons of 2020 and 2021. The experimental site is situated in the latitudes and longitudes of 22°47′5.1896″N and 90°17′44.41531″E. The experimental site is located under the agro-ecological zone Ganges Tidal Floodplain (AEZ-13). The nutrient management in hybrid bitter gourd comprised of five treatments (fertilizer doses) viz., T_1 = 65-21-10-5-1 kg/ha N-P-K-S-B, respectively (BARC, 2018); T_2 = 75% of T_1; T_3 = 50% of T_1; T_4 = 25% of T_1; T_5 = No fertilizer. The experiment was laid out in randomized complete block design with three replications. The floating bed was prepared with water hyacinth and water fern (topapana) and then the raised pits were made with dulalilata on floating bed. The initial samples of water hyacinth, water fern (topapana) and dulalilata were collected for determining its chemical composition. The collected samples were sent to the Central Laboratory of Soil Resource Development Institute (SRDI), Farmgate, Dhaka for laboratory analysis and the analytical results are presented in Table 1. The size of the whole floating bed (block) was 9.15 meter long (30 feet), 1.37 meter wide (4.50 feet) and 1.16 meter (3.80 feet) high. Unit floating plot size was (including trellis) 5.03 m x 1.52 m (7.67 m^2) and plant spacing was hill to hill distance 1.0m and number of seedling/hill was 2. Bitter gourd seeds of hybrid variety (namely *Tia*) were primed with pond water for 4 hours and then drained out the water. The wet seeds were kept into a water glass for 2 days covering with topapana to become sprouting. The hypocotyls (root) portion of the sprouted seeds was inserted into the pre-prepared ball/dolla. The ball/*dolla* (6-8 cm diameter) was made with topapana wrapping with dulalilata. The young seedlings (with ball) were transplanted on floating bed in two rows on raised pits (2 seedlings/pit) on 20 September, 2020 and 29 August 2021 in first and second years, respectively.

Table 1. Chemical composition of water hyacinth, water fern (topapana) and dulalilata

Sl. No.	Parameter	Samples of floating bed materials		
		Water hyacinth (*Eichhornia crassipes*)	Water fern (*Salvinia cucullata*)	Dulalilata (*Hygroryza aristata*)
1.	pH	8.40	7.00	7.80
2.	Organic Carbon %	32.25	30.50	27.20
3.	Total Nitrogen (N) %	0.98	1.26	2.85
4.	Phosphorus (P) %	0.19	0.14	0.20
5.	Potassium (K) %	0.52	0.47	0.25
6.	Sulphur (S) %	0.02	0.02	0.07
7.	Zinc (Zn) %	0.01	0.005	0.01
8.	Calcium (Ca) %	4.80	1.20	0.30
9.	Magnesium (Mg) %	0.46	0.38	0.30
10.	Copper (Cu) %	0.0023	0.0001	0.001
11.	Boron (B) ppm	3.45	5.12	0.56
12.	Chromium (Cr) ppm	16.40	15.98	29.13
13.	Cadmium (Cd) ppm	0.21	0.14	0.31
14.	Lead (Pb) ppm	2.91	3.62	2.97
15.	Nickel (Ni) ppm	2.77	3.73	14.57

Source: SRDI Central Laboratory, Farmgate, Dhaka (Date: 10/03/2021)

After transplanting of seedling, trellis was made alongside the floating bed with bamboo pole, nylon rope and dhaincha (sesbania) stick. The trellis between two floating bed was 5 meter wide. The floating bed cum trellis (non-tidal model) is suitable for optimum growth and development of the creeper vegetable crop plants. Fertilizers were applied as per the treatment specifications. Nitrogen and phosphorus were applied on floating bed in the forms of diammonium phosphate and urea, potassium as muriate of potash, sulphur as gypsum, zinc as zinc sulphate and boron was applied in the form of boric acid (T_1 =100g urea, 105g diammonium phosphate, 20g muriate of potash, 31g gypsum, 6g boric acid/10m^2 area). All the chemical fertilizers were applied on the floating bed in liquid form (through mixing with water) surrounding the crop plant or root zone. The fertilizers were applied in five equal splits at 15, 25, 35, 45 and 55 days after seedling transplanting on floating bed. The liquid form of plant nutrients were applied around the crop plants on floating bed. Irrigation was applied daily at the initial stage of seedling transplanting upto the development of root system of the crop plants. All other agronomic practices were done as per requirement of the crop for its better growth and development on floating bed cum trellis. Fruits of bitter gourd were harvested after attaining the harvestable stage. Data were recorded on different plant characters of bitter gourd in terms of plant population/m^2, plant height, root length/plant, root volume/plant, number of branch/plant, fruit length, fruit diameter, fruit/plant, single fruit weight and fruit weight/unit floating bed. The unit floating bed yields were then converted into ton/hectare. Data were analyzed statistically using Statistix 10 computer software and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) as suggested by Gomez and Gomez (1984).

Results and Discussion

Effect of fertilize dose on growth and yield of bitter gourd grown on floating bed (2020-21)

In *Kharif* 2020, fertilizer dose had significant effect on branch/plant, fruit length, fruit diameter, fruit/plant and fruit yield but no significant effect was found in plant population/m^2, vine length and single fruit weight (Table 2). The highest number of branch/plant (28.33) was observed in T_1 [T_1 = 65-21-10-5-1 kg/ha N-P-K-S-B, respectively]. Statistically similar result was also observed in T_2 (26.07). The lowest number of branch/plant was obtained from T_4 (18.73). Likewise, the highest length of fruit (23.35 cm) was found in treatment T_1 that was partially at par to that of T_3 and T_2 (22.45 and 22.42 cm, respectively). The shortest length of fruit (19.71 cm) was obtained from the control treatment. Partially similar length of fruit (21.17 cm) was also found in T_4 treatment. Fruit diameter became the highest (42.79 cm) in T_4 treatment. Statistically identical result (41.87 cm) was also recorded in T_1 treatment. The lowest diameter of fruit was obtained from the control (T_5). The number of fruit/plant showed the highest value (5.14), which was partially identical to that of T_1 and T_2 treatments (4.96 and 4.64, respectively). The control plot gave the lowest number of fruit/plant (3.77). The T_4 treatment showed statistically partially similar result (4.19). The treatment T_1 produced the highest yield (13.27 t/ha), which was statistically similar to that of T_2 (12.31 t/ha) but partially similar to that of treatments T_3 and T_4 (11.07 and 10.78 t/ha, respectively). The lowest yield was obtained from T_5 treatment (9.02 t/ha). The experimental results further showed that application of treatment T_1 increased the yield of bitter gourd 47.09%, while T_2 increased the fruit yield 36.49% over the control treatment. However, treatments T_3 and T_4 increased the fruit yields 22.74% and 19.50%, respectively.

In *Kharif* 2021, plant height, root length/plant, root volume/plant, fruit length, fruit/plant, single fruit weight and fruit yield varied significantly due to different doses of plant nutrients (Table 3). Treatment T_1 gave the longest plant (673.33 cm), which was statistically similar to that of T_3 (663.20 cm) and T_2 (651.80 cm) treatments but the shortest plant (495.00 cm) was found in T_5 treatment. Likewise, the treatment T_1 gave the highest length of root/plant (59.73 cm) that was statistically identical to T_2 (59.27 cm) and partially similar to T_4 (57.67 cm) and T_3 (57.13 cm). The highest volume of root/plant (64.35 cm3) was also observed in T_1 and it was somewhat at par to that of T_3 (57.91 cm^3), T_2 (57.89 cm^3) and T_4 (55.02 cm^3) treatments. The lowest length and volume of root/plant (51.60 cm and 43.67 cm^3, respectively) were found in T_5 treatment. The highest length of fruit (25.13 cm) was recorded in T_1 that was partially identical to that of T_3, T_2 and T_4 (24.80, 24.67 and 24.37 cm, respectively) treatments. Treatments T_1 and T_2 gave higher but statistically similar number of fruit/plant (6.73 and 6.39), which were to some extent at par to that of T_4 (6.18) and T_3 (5.57). Weight of single fruit became the highest (217.07 g) and partially similar weights were also observed in T_3 (203.13 g) and T_2 (202.63 g) treatments. The lowest weight of single fruit (159.00 g) was obtained from T_5. Treatment T_1 exhibited the highest yield of fruit (12.87 t/ha). The result was statistically similar to T_2 (11.98 t/ha) but partially identical to T_3 (10.87 t/ha). On the other hand, the control treatment (T_5) gave the lowest yield (8.43 t/ha). The results indicated that treatment T_1 increased the yield of 52.68%, while T_2, T_3 and T_4 treatments increased the yields of 42.11%, 28.97% and 14.02%, respectively over the control treatment. The experimental results further indicated that integration of chemical fertilizer nutrients with organic sources of plant nutrients (i.e. decomposed floating bed materials like water hyacinth, *topapan*a and *dulalilata*) promoted the growth and development of the crop plants. Judicious amount of chemical fertilizer nutrient (like as T_2) showed optimum growth that increased the yield of bitter gourd by utilizing the plant nutrients efficiently.

Table 2. Effect of fertilize dose on growth and yield of bitter gourd on floating bed in *Kharif* 2020

Treat-ment	Plant pop/m^2 (no.)	Plant height (cm)	Branch/ plant (no.)	Fruit length (cm)	Fruit diameter (cm)	Fruit/ plant (no.)	Single fruit weight (g)	Fruit yield (t/ha)	% Yield increase over control
T_1	4.48	679.33	28.33a	23.35a	41.87a	4.96ab	137.14	13.27a	47.09
T_2	4.28	668.33	26.07a	22.42ab	42.79a	4.64a-c	142.83	12.31a	36.49
T_3	4.08	673.33	22.13b	22.45ab	36.77b	5.14a	125.94	11.07ab	22.74
T_4	4.48	576.67	18.73b	21.17bc	31.96c	4.19bc	132.47	10.78ab	19.50
T_5	4.28	650.00	19.80b	19.71c	28.33c	3.77b	128.51	9.02b	-
CV (%)	8.42	11.97	8.80	4.68	6.17	10.68	9.02	13.29	-
F-test	NS	NS	*	*	*	*	NS	*	-

Table 3. Effect of fertilize dose on growth and yield of bitter gourd on floating bed in *Kharif* 2021

Treat-ment	Plant height (cm)	Root length/ plant (cm)	Root volume/ plant (cm^3)	Branch/ plant (no.)	Fruit length (cm)	Fruit diameter (mm)	Fruit/ plant (no.)	Single fruit wt. (g)	Fruit yield (t/ha)	% Yield increase over control
T_1	673.33a	59.73a	64.35a	19.20	25.13a	51.34	6.73a	217.07a	12.87a	52.68
T_2	651.80a	59.27a	57.89ab	17.33	24.80ab	51.07	6.39a	202.63ab	11.98a	42.11
T_3	663.20a	57.13ab	57.91ab	18.40	24.67ab	50.66	5.57ab	203.13ab	10.87ab	28.97
T_4	574.13b	57.67ab	55.02ab	16.67	24.37ab	51.76	6.18ab	190.33b	9.61bc	14.02
T_5	495.00c	51.60b	43.67b	15.37	22.37b	49.35	4.63b	159.00c	8.43c	-
CV (%)	4.93	6.49	19.37	15.34	5.78	3.72	15.65	5.37	10.83	-
F-test	**	*	*	NS	*	NS	*	**	**	-

Note: T_1 = 65-21-10-5-1 kg/ha N-P-K-S-B; T_2 = 75% of T_1; T_3 = 50% of T_1, T_4 = 25% of T_1, and T_5 = Control; ** Significant at 1% and 5% level of probability, respectively

Conclusion

As treatment T_1 [T_1 = 100g urea, 105g diammonium phosphate, 20g muriate of potash, 31g gypsum, 6g boric acid/10m^2 bed] and treatment T_2 (75% of T_1: 75-80-15-25-5 g/10m^2) produced statistically similar yields, therefore treatment T_2 can be applied for hybrid bitter gourd cultivation on floating bed cum trellis.

Acknowledgement

The experiment had been carried out with the financial assistance of the project entitled, “Research, Extension and Popularization of Vegetables and Spices Cultivation on Floating Bed Project (BARI Part)” Ministry of Agriculture, Government of the People’s Republic of Bangladesh.

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INTEGRATED NUTRIENT MANAGEMENT FOR YARD LONG BEAN ON FLOATING BED CUM TRELLIS

M.A. RAHMAN

Abstract

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal on hybrid yard long bean (variety Hiramon) during Rabi season of 2021-22. The nutrient dose consisted of five treatments (fertilizer doses) viz., T_1 = 45-21-21-6-1 g N-P-K-S-B, respectively/$10m^2$ (BARC, 2018); T_2 = 75% of T_1; T_3 = 50% of T_1; T_4 = 25% of T_1; T_5 = No fertilizer. The experiment was laid out in randomized complete block design with three replications. Seeds of yard long bean were sown directly into the raised lines (1.0-1.5 cm depth) on floating bed with spacing of 6-7 cm seed to seed distance on 31 December, 2021. After sowing of seeds, trellis was made alongside the floating bed. Fertilizers were applied as per the treatment specifications. Nitrogen and phosphorus were applied on floating bed in the forms of diammonium phosphate and urea, potassium as muriate of potash, sulphur as gypsum, zinc as zinc sulphate and boron was applied in the form of boric acid (T_1 = 60g urea, 105g diammonium phosphate, 42g muriate of potash, 38g gypsum, 6g boric acid/$10m^2$). All the chemical fertilizers were applied on the floating bed in liquid form (through mixing with water) surrounding the crop plant or root zone. The fertilizers were applied in five equal splits at 15, 25, 35, 45 and 55 days after seed sowing on floating bed. The studied parameter of yard long bean in terms of plant population/m^2, plant height, number of branch/plant, fruit length, number of fruit/plant and fruit yield varied significantly due to different doses of fertilizers. The treatment T_1 gave the highest yield of fruit (27.25 t/ha), which was statistically similar to that of T_2 treatment (25.35 t/ha). However, treatments T_3 and T_4 produced the yields of 20.00 and 18.97 t/ha, respectively. The lowest yield (15.83 t/ha) was observed in T_5 treatment. The results further showed that treatment T1 increased the yield of 72.08% over the control treatment (T_5). On the other hand, increased yields by the treatments of T_2, T_3 and T_4 were 60.10%, 27.54% and 19.83%, respectively over the control treatment. As treatment T_1 and T_2 (75% of T_1: 45-80-32-30-5 g/$10m^2$) gave statistically similar yields, therefore treatment T_2 can be applied for yard long bean cultivation on floating bed cum trellis.

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 (*Eichhornia crassipes*) 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 creeper vegetable crops due to lacking of required space on the bed and large canopy size of the crop plant. Recently, floating bed cum trellis (non-tidal model) has been developed for creeper vegetables cultivation. Research works have so far been conducted on nutrient management for cucumber, pumpkin and bottle gourd cultivation on floating bed. However, research work has not been conducted yet to develop floating agriculture based nutrient management package for yard long bean. In this respect, the research work had been designed to develop nutrient management package for hybrid yard long bean on floating bed cum trellis.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal on hybrid yard long bean (variety *Hiramon*, marketed by National Seed Company, Bangladesh) during *Rabi* season of 2021-22. The experimental site is situated in the latitudes and longitudes of 22°47′6.71705″N and 90°17′33.31903″E. The experimental site is located under the agro-ecological zone Ganges Tidal Floodplain (AEZ-13). The nutrient dose consisted of five treatments (fertilizer doses) viz., T_1 = 45-21-21-6-1 g N-P-K-S-B, respectively/10m^2 (BARC, 2018); T_2 = 75% of T_1; T_3 = 50% of T_1; T_4 = 25% of T_1; T_5 = No fertilizer. The experiment was laid out in randomized complete block design with three replications. The floating bed was made with water hyacinth. After making of floating bed, one layer (5-7 cm thick) of water fern (topapana) was placed on the bed. The size of the whole floating bed (block) was 9.15 meter long (30 feet), 1.37 meter wide (4.50 feet) and 1.16 meter (3.80 feet) high. Unit floating plot size (including trellis) was 5.03 m long x 1.52 m wide (7.67 m^2). Two raised narrow lines (10 cm high × 10 cm wide) were made along the length on the floating bed by using rotten water hyacinth with spacing row to row distance 50 cm. Seeds of yard long bean were sown directly into the raised lines (1.0-1.5 cm depth) with spacing of 6-7 cm seed to seed distance on 31 December, 2021. After sowing of seeds, trellis was made alongside the floating bed with bamboo pole, nylon rope and dhaincha stick. The trellis between two floating bed was 5 meter wide. The floating bed cum trellis (non-tidal model) is suitable for optimum growth and development of the creeper vegetable crop plants. Fertilizers were applied as per the treatment specifications. Nitrogen and phosphorus were applied on floating bed in the forms of diammonium phosphate and urea, potassium as muriate of potash, sulphur as gypsum, zinc as zinc sulphate and boron was applied in the form of boric acid (T_1 = 60g urea, 105g diammonium phosphate, 42g muriate of potash, 38g gypsum, 6g boric acid/10m^2 bed). All the chemical fertilizers were applied on the floating bed in liquid form (through mixing with water) surrounding the crop plant or root zone. The fertilizers were applied in five equal splits at 15, 25, 35, 45 and 55 days after seed sowing on floating bed. The liquid form of plant nutrients were applied around the crop plants on floating bed. Irrigation was applied daily at the initial stage of seed sowing upto the development of root system of the plants. All other agronomic practices were done as per requirement of the crop for its better growth and development on floating bed cum trellis. Fruits of bitter gourd were harvested after attaining at the harvestable stage. Data were recorded on different plant characters of yard long bean regarding plant population/m^2, plant height, root length/plant, root volume/plant, number of branch/plant, fruit length, number of fruit/plant, single fruit weight and fruit weight/plot. The unit plot yields were then converted into ton/hectare. Data were analyzed statistically using Statistix 10 computer software and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) as suggested by Gomez and Gomez (1984).

Results and Discussion

Effect of fertilize dose on growth and yield of yard long bean (2021-22)

The studied parameter of yard long bean in terms of plant population/m^2, plant height, number of branch/plant, fruit length, number of fruit/plant and fruit yield varied significantly due to different doses of fertilizers (Table 1). Plant height was the highest (297.60 cm) in T_1 treatment that was somewhat similar to that of T_3 (277.20 cm), T_2 (271.67 cm) and T_4 (246.87 cm) treatments. The lowest height (228.33 cm) was obtained from T_5 treatment. Treatment T_2 gave the highest number of branch/plant (14.07), which was to some extent identical to that of T_1 (13.87), T_3 (13.87) and T_4 (13.53). The highest length of fruit (58.73 cm) was obtained from T_1, which was statistically at par to that of T_3 (58.07 cm), T_4 (57.48 cm) and T_2 (57.40 cm) treatments and the lowest length (47.25 cm) was observed in T_5 treatment. Similarly, the highest number of fruit/plant (17.54) was recorded in T_1 and it was statistically identical to T_2 (17.34) but partially at par to that of T_3 treatment (13.04). The lowest number of fruit/plant (10.04) was exhibited by T_5. The treatment T_1 gave the highest yield of fruit (27.25 t/ha), which was statistically similar to that of T_2 treatment (25.35 t/ha). However, treatments T_3 and T_4 produced the yields of 20.00 and 18.97 t/ha, respectively. The lowest yield (15.83 t/ha) was observed in T_5 treatment. The results further showed that treatment T_1 increased the yield of 72.08% over the control treatment (T_5). On the other hand, increased yields by the treatments of T_2, T_3 and T_4 were 60.10%, 27.54% and 19.83%, respectively over the control treatment.

Table 1. Effect of fertilize dose on growth and yield of yard long bean on floating bed (2021-22)

Treat-ment	Plant pop on bed/m^2 (no.)	Plant height (cm)	Branch/ plant (no.)	Root length/ plant (cm)	Root volume/ plant (cm^3)	Fruit length (cm)	Fruit/ plant (no.)	Single fruit wt. (g)	Fruit yield (t/ha)	% Yield increase over control
T_1	20.84	297.60a	13.87ab	585.70	4.04	58.73a	17.54a	28.79	27.25a	72.08
T_2	20.62	271.67ab	14.07a	539.02	3.63	57.40a	17.34a	28.11	25.35a	60.10
T_3	21.29	277.20ab	13.87ab	478.27	3.49	58.07a	13.04ab	26.66	20.20b	27.54
T_4	20.72	246.87ab	13.53ab	472.69	3.86	57.48a	11.32b	26.39	18.97bc	19.83
T_5	20.81	228.33b	11.57b	451.15	3.54	47.25b	10.04b	24.21	15.83c	-
CV (%)	11.29	13.26	9.73	14.39	15.98	5.26	18.26	9.65	9.26	-
F-test	NS	*	*	NS	NS	**	*	NS	**	-

Note: T_1 = 45-21-21-6-1 g/10m^2 N-P-K-S-B, respectively; T_2 = 75% T_1; T_3 = 50% T_1, T_4 = 25% T_1, and T_5 = Control
** Significant at 1% and 5% level of probability, respectively

Conclusion

As treatment T_1 [T_1 = 60g urea, 105g diammonium phosphate (DAP), 42g muriate of potash (MP), 38g gypsum, 6g boric acid/10m^2 bed] and T_2 (75% of T_1: 45-80-32-30-5 g/10m^2) gave statistically similar yields, therefore treatment T_2 can be applied for yard long bean cultivation on floating bed cum trellis in submerged areas of Bangladesh.

Acknowledgement

The experiment had been carried out with the financial assistance of the project entitled, “Research, Extension and Popularization of Vegetables and Spices Cultivation on Floating Bed Project (BARI Part)” Ministry of Agriculture, Government of the People’s Republic of Bangladesh.

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SORJAN BASED INTEGRATED FARMING SYSTEMS RESEARCH FOR INCREASING AGRICULTURAL PRODUCTIVITY IN SOUTHERN REGION

M.A. RAHMAN, M.M. RAHMAN AND M.R. UDDIN

Abstract

The field trial on sorjan based integrated farming systems was conducting since July, 2018 to till now through holistic approach at RARS, Rahmatpur, Barishal. All the potential and eco-friendly components or enterprises like crops (vegetables, spices and fruits), fisheries, dairy and bio-gas plant (for fuel biogas and bio-slurry production) were integrated for interacting each other towards increasing the total system productivity. The dimension of modern sorjan system was bed length x breadth x high = 21m x 6m x 1 meter, canal length x breadth x deep = 21m x 6m x 2.13 meters. The creeper/vine vegetables seedlings were transplanted on the edge of the sorjan beds but their growth and development were taken place on the trellis as made on sorjan canals. Fishes were cultivated in canal water between two sorjan beds. Fodder crop (cv. Packchong) was grown on slope and outside the sorjan beds. The area under sorjan based farming systems was 2820 m^2. Average of two years (2020-21 and 2021-22), total harvested summer and winter vegetable/spice crops (bottle gourd, brinjal, kangkong, country bean, red amaranth, pumpkin, jackbean, knolkhol, cabbage, potato, spinach, stem amaranth, papaya, tomato, snake gourd, Indian spinach, bangi, chili etc.) was 4368 kg. The amount of fruits (guava, malta, mango and pineapple) harvested from the sorjan area was 234 kg. Average of 165 kg fishes (shoil, boal, sing, koi, magur, tilapia etc.) were harvested from the sorjan canal water. Besides, average production of beef meat 270 kg, milk 6274 litre, duck egg 3972 pieces, fodder 5113 kg and bio-slurry 2325 kg were obtained from the sorjan area. Two years average gross returns computed in vegetable and spice crops from the sorjan area was Tk. 66842 (Tk. 237027/ha). Fruit crops provided the gross return Tk. 8430 (Tk. 29894/ha) and sugarcane contributed Tk. 2550 (Tk. 9043/ha). On the other hand, the average gross returns obtained from milk was Tk. 376431 (Tk. 1334862/ha), duck egg Tk. 39720 (Tk. 140852/ha), fodder Tk. 25565 (Tk. 90656/ha), biogas Tk. 24000 (Tk. 85106/ha) and bio-slurry Tk. 11625 (Tk. 41224/ha). Total average gross return from vegetables, spices, fruits, sugarcane, fish, beef meat, milk, duck egg, fodder, biogas and bio-slurry was Tk. 875603 (Tk. 2508826/ha). However, gross return obtained from single rice crops was Tk. 110450/ha. The research findings indicated that sorjan based integrated farming systems are more profitable than that of single cropping system. Actually, the sorjan based integrated farming systems research is a long-term (5-10 years) research programme. Therefore, the final recommendation should be made after implementation of the research programme properly.

Introduction

The Sorjan cropping system, developed by Indonesian farmers, uses a system that constructs alternate deep sinks and raised beds. It is viable in both flood-prone and drought-prone areas in that country (Domingo and Hagerman, 1982). In Bangladesh, the farmers have been practicing sorjan system (locally known as "*Kandi*") since hundred years ago generally for producing of high land crops. The practice is found mostly in flood prone and coast areas of Pirojpur, Barishal, Patuakhali, Bhola, Jhalakati, Noakhali, Bagerhat and Satkhira districts. However, the type of sorjan practices is quite different over locations in southern region based on land topography and agro-ecosystems. In southern region (Barishal, Pirojpur, Jhalakati, Patuakhali, Barguna and Bhola districts), about 1.83 lakh hectares of land (about 21% of the total cultivable land) used for cultivating only single crop in a year under Boro/T.*aman* rice/winter crops – Fallow – Fallow cropping patterns. However, an average of about 31% lands remains fallow in different seasons throughout the year mainly due to soil and water salinity, drought, tidal flooding, soil submergence, unavailability of sweet water for irrigation, lack of suitable adaptation technologies and farmers' knowledge (Rahman, 2015). In the low lying and non-saline tidal flooding areas of Barishal, Pirojpur, Jhalakati districts, only single *Boro* rice or winter crop is cultivated in a year under *Boro* rice/winter crop-Fallow-Fallow cropping pattern due to inundation/submergence of lands (1-3 meter) during monsoon season. Farmers traditionally cultivate some winter and summer crops haphazardly under sorjan system based on their indigenous technological knowledge. However, research works on sorjan based integrated farming systems have not been conducted yet in Bangladesh. Therefore, integration of crops (vegetables, fruits, spices and fodder), fisheries, dairy, ducks, bee keeping and other enterprises is essential for developing location specific sorjan based farming system model(s) towards increasing the total agricultural productivity and profitability of the traditional sorjan systems.

The productivity of traditional sorjan system is very low due to lacking of standardization of sorjan bed and canal size, suitable cropping systems, fisheries, livestock and poultry components, low yielding varieties, incidences of insect-pest and diseases etc. The traditional sorjan beds and canals are not suitable for integration of these components under this system. Integration of potential and eco-friendly enterprises like crops, fisheries, dairy, ducks, bee keeping, bio-gas plant and so on can increase the system productivity of conventional sorjan systems. Therefore, location-specific research works need to be done regarding standardization (bed and canal size) of the sorjan system, introduction of crops (vegetables, fruits, spices and fodder), fisheries, dairy, ducks, bee keeping, bio-gas plant and other enterprises under sorjan based farming systems for developing year round vegetables-fruits-fishes-meat-milk-egg production model(s) in tidal flooding ecosystem by using the existing resources. The farming system components/enterprises are interacted with each other that ultimately increased the productivity of sorjan system. For example, sorjan bed can produce crops (vegetables, fruits and spices), canal water can produce fishes or ducks, fodder crop (grown on slope and outside the sorjan beds) and crop bi-products can be used for dairy/poultry feeds. The fodder crop can also reduce the soil erosion of the sorjan beds. The cowdung or ducks refuse can be used as manure, fish feed and also in bio-gas plant (for fuel gas and bio-slurry production). The dairy and ducks can produce meat, milk and egg for farm households' nutrition and income generation. Introduction of different farming enterprises (crops, fisheries, dairy, ducks, bee keeping etc.) in sorjan system will increase the diversification of those enterprises, which will improve the food and nutritional security as well as farmers' income generation in southern region.

In these circumstances, sorjan based integrated farming systems research had been implementing under tidal flooding ecosystem in southern region of Bangladesh with the following objectives.

1. To develop location specific sorjan based farming systems under tidal flooding ecosystem in southern region of Bangladesh.
2. To integrate crops, fisheries, dairy, ducks and other enterprises for year round production of vegetables-fruits-fishes-meat-milk-egg under sorjan based farming systems.
3. To increase agricultural productivity and profitability of sorjan systems through integration of crops, fishery, dairy, ducks and other enterprises.
4. To increase the agricultural diversity under sorjan systems in southern region.

Materials and Methods

The research programme on sorjan based integrated farming systems had been implementing since July, 2018 to June, 2021 through holistic approach at Regional Agricultural Research Station (RARS), Rahmatpur, Barishal of BARI under tidal flooding ecosystem in the southern region of Bangladesh. The geographical position of the experimental site is latitude $22^{o}47^{/}4.5261^{//}$N and longitude $90^{o}17^{/}30.67518^{//}$E. The experimental site is located under the agro-ecological zone Ganges Tidal Floodplain (AEZ-13). Generally the land type is medium low land. Under this farming systems, all the potential and eco-friendly components or enterprises like crops (vegetables, spices and fruits), fisheries, dairy and bio-gas plant (for fuel biogas and bio-slurry production) were integrated for interacting each other towards increasing the total system productivity (Table 1). BARI developed modern varieties of vegetable, spice and fruit crops (including commercial HYV hybrid and local varieties) were introduced on sorjan beds. Besides, improved varieties of selected fish species (shoil, boal, sing, koi, magur, foli, tilapia etc.) and dairy cows (cv. Holstein Friesian) were integrated with sorjan based farming systems depending upon the local needs, existing resources and agro-ecosystems. In this regard, new sorjans were prepared were renovated. The dimension of new sorjan was: bed length x breadth x high = 70 feet x 20 feet x 3.5 feet (21m x 6m x 1 meter), canal length x breadth x high = 70 feet x 20 feet x 7 feet (21m x 6m x 2.13 meters). The bed side canals were made interconnected with each other through a connection channel for freely wandering of the cultivated fishes in the entire canals' water. The vegetable, spice and fruit crops were grown on sorjan beds following the recommended production technologies of the respective crops (BARI, 2020). Fertilizers were applied as per recommendation rate of the respective crops (FRG, 2018). The fisheries, dairy and poultry (ducks) enterprises were implemented with the help of Department of Fisheries and Department of Livestock. The total sorjan area of RARS, Barishal was 2820 squire meter (1200 m^2 + 1620 m^2). The creeper/vine vegetables seedlings were transplanted on the edge of the sorjan beds but their growth and development were taken place on the trellis as made on the sorjan canals. Trellis was made on the sorjan canals by using bamboo, *dhaincha* and nylon net. On the other hand, the fishes were cultivated in canal water between two sorjan beds. Fodder crops (cv. German grass, napier grass, packchong, para grass etc.) were grown on slope and outside the sorjan beds. Data were recorded on relevant parameters of crops, fisheries, livestock (dairy) and other enterprises. Mathematical and economic analyses were done of the recorded data for preparing the report of the sorjan based research programme.

Table 1. Enterprises under sorjan based integrated farming systems research

Production Spaces	Name of the Enterprises		
	Fruits	Vegetables and Spices	
		Rabi season	*Kharif* season
Sorjan main bed	Guava, malta, golden apple, pineapple, mango, papaya etc.	Tomato, brinjal, cauliflower, cabbage, broccoli, potato, spinach, chilli, radish etc.	Okra, Indian spinach, summer tomato, chili, kangkong, stem amaranth, red amaranth etc.
Edge of sorjan bed (on trellis)	-	Bottle gourd, country bean, sweet gourd etc.	Cucumber, yard long bean, bitter gourd, white gourd, snake gourd, teasel gourd, pointed gourd etc.
Sorjan bed slope	Fodder crops, dragon fruit etc.		
Outside of sorjan	Papaya, aroids, fodder crops, sugarcane etc.		
Sorjan canal water	Fishes and/or ducks		
Farm house	Dairy cows (cv. Holstein Friesian)		
Outside of farm house	Bio-gas plant (Fixed Dome Anaerobic Digestion Plant)		

Results and Discussion

Under the sorjan based integrated farming systems (total area: 2820 m^2), two years average (2020-21 and 2021-22) the total harvested summer and winter vegetable/spice crops (bottle gourd, brinjal, kangkong, country bean, red amaranth, pumpkin, jackbean, knolkhol, cabbage, potato, spinach, stem amaranth, papaya, tomato, snake gourd, Indian spinach, bangi, chili etc.) was 4368 kg (Table 2). The amount of fruits (guava, malta, mango and pineapple) harvested from the sorjan area was 234 kg. Chewing type of sugarcane (BSRI Akh-42) harvested from sorjan system was 255 kg. Total an average of 165 kg fishes (shoil, boal, sing, koi, magur, tilapia etc.) were harvested from the sorjan canal water. Besides, average production of beef meat 270 kg, milk 6274 litre, duck egg 3972 pieces, fodder 5113 kg and bio-slurry 2325 kg were obtained from the sorjan area.

The two years average (2020-21 and 2021-22) gross returns computed in vegetable and spice crops from the sorjan area was Tk. 66842 (Tk. 237027/ha) (Table 3). The fruit crops provided the gross return Tk. 8430 (Tk. 29894/ha) and sugarcane contributed Tk. 2550 from the sorjan area (Tk. 9043/ha). On the other hand, the average gross returns obtained from milk was Tk. 376431 (Tk. 1334862/ha), duck egg Tk. 39720 (Tk. 140852/ha), fodder Tk. 25565 (Tk. 90656/ha), biogas Tk. 24000 (Tk. 85106/ha) and bio-slurry Tk. 11625 (Tk. 41224/ha) in the existing sorjan area. The total average gross return from vegetables, spices, fruits, sugarcane, fish, beef meat, milk, duck egg, fodder, biogas and bio-slurry was Tk. 875603 (Tk. 2508826/ha). However, gross return obtained from single rice crops was Tk. 110450/ha. The research findings indicated that sorjan based integrated farming systems are more profitable than that of single cropping system. Actually, the sorjan based integrated farming systems research is a long-term (5-10 years) research programme. Therefore, the final recommendation should be made after implementation of the research programme properly.

Table 2. Produces and gross returns from sorjan based integrated farming systems at RARS, Rahmatpur, Barishal (2020-21 and 2021-22)

Name of produces (Sorjan area: 2820 m^2)	Year: 2020-21			Year: 2021-22		
	Harvest (kg/sorjan)	Rate (Tk/kg)	Gross return (Tk/sorjan)	Harvest (kg/sorjan)	Rate (Tk/kg)	Gross return (Tk/sorjan)
Vegetable and spice crops:						
Bottle gourd	553	12	6636	682	12	8184
Brinjal	542	20	10840	603	20	12060
Kangkong	248	12	2976	30	12	360
Country bean	55	20	1090	25	20	500
Red amaranth	288	15	4320	164	15	2460
Pumpkin	482	15	7230	328	15	4920
Jackbean	152	20	3040	50	20	1000
Knolkhol	96	15	1440	65	15	975
Cabbage	95	15	1425	61	15	915
Potato	350	12	4200	358	12	4296
Spinach	79	15	1185	73	15	1095
Stem amaranth	155	12	1860	28	12	336
Papaya	267	15	4005	237	15	3555
Tomato	134	15	2010	285	15	4275
Snake gourd	88	20	1750	37	20	740
Indian spinach	194	15	2910	300	15	4500
Yard long bean	-	-	-	78	15	1170
Sponge gourd	-	-	-	285	15	4275
Ridge gourd	-	-	-	82	15	1230
Ash gourd	-	-	-	78	15	1170
Okra	-	-	-	90	15	1350
Radish (shak)	-	-	-	36	15	540
Radish	-	-	-	82	15	1230
Cucumber	-	-	-	730	15	10950
Cauliflower	-	-	-	87	15	1305
Bangi	37	15	555	-	-	-
Chili	26	60	1560	21	-	1260
Sub-total (Veg & spice)	3840	-	59032	4895	-	74651

Name of produces	Year: 2020-21			Year: 2021-22		
Fruits: Guava	87	30	2610	35	30	1050
Malta	35	80	2800	-	-	-
Mango	-	-	-	70	80	5600
Pineapple	115	10	2300	125	20	2500
Sub-total (Fruit)	237	20	7710	230	-	9150
Sugarcane	350	10	3500	160	10	1600
Fish: Tilapia, punti etc.	258	-	92240	72	-	8640
Beef (Bull)	-	-	-	540	500	270000
Milk (litre)	7622	60	457302	4926	60	295560
Duck egg (piece)	4355	10	43550	3589	10	35890
Fodder	4910	5	24550	5316	5	26580
Biogas	-	-	24000	-	-	24000
Bio-slurry	2400	5	12000	2250	5	11250
Total	**-**	**-**	**723884**	**-**	**-**	**757321**

Conclusion

Sorjan based integrated farming systems could increase the total agricultural productivity through integration of crops (vegetables, fruits, spices and fodder), fisheries, dairy and other enterprises in tidal flooding ecosystem in southern region of Bangladesh. However, the research works should be continued for at least five years for final recommendation.

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Table 3. Gross returns from sorjan based integrated farming systems and single rice crop at RARS, Rahmatpur, Barishal (2020-21 and 2021-22)

Name of produces	Harvested (kg/sorjan area)			Gross return (Tk/sorjan area)			Gross return from sorjan farming systems (Tk/ha)			Gross return from single rice crop (Tk/ha)
	2020-21	2021-22	Average	2020-21	2021-22	Average	2020-21	2021-22	Average	
Vegetables & spices	3840	4895	4368	59032	74651	66842	209333	264720	237027	110450
Fruits	237	230	234	7710	9150	8430	27340	32447	29894	
Sugarcane	350	160	255	3500	1600	2550	12411	5674	9043	
Fish	258	72	165	92240	8640	50440	92240	30638	61439	
Beef meat (Bull)	-	540	270	-	270000	270000	-	957447	478723	
Milk (litre)	7622	4926	6274	457302	295560	376431	1621638	1048085	1334862	
Duck egg	4355	3589	3972	43550	35890	39720	154433	127270	140852	
Fodder	4910	5316	5113	24550	26580	25565	87057	94255	90656	
Biogas	-	-	-	24000	24000	24000	85106	85106	85106	
Bio-slurry	2400	2250	2325	12000	11250	11625	42553	39894	41224	
Total	**-**	**-**	**-**	**723884**	**757321**	**875603**	**2332111**	**2685536**	**2508826**	**110450**

Average price: Vegetables Tk. 16/kg, chili Tk. 60/kg, fruits Tk. 43/kg, sugarcane Tk. 10/kg, fish Tk. 120/kg, beef meat Tk. 500/kg, milk Tk. 60/litre, duck egg Tk. 10/piece, fodder Tk. 5/kg, bio-slurry Tk. 5/kg, biogas Tk. 2000/month

PERFORMANCE OF EARLY VEGETABLE PRODUCTION IN THE CHARLAND AREA

J. RAHMAN, M R ALI AND M M KADIR

Abstract

Vegetable cultivation is a promising economic activity and vegetable consumption is important for human health due to the high nutritional content of vegetables. Vegetables are rich in vitamins, minerals, dietary fiber and several phytochemical compounds. The production of vegetables is insufficient to meet the demand of the ever-increasing population. This research was carried out at Nawvanger char, sadar, Jamalpur 2021-2022 to find out the suitable early sowing and early market for increasing productivity, economic and nutritional development of charland farmers. Treatments included in the experiment were used radish (leaf), jute (leaf), bottle gourd (leaf), amaranth (leaf), cabbage and cauliflower. All of the vegetables were influenced by early sowing and climatic condition and as a result, this approach may be advantageous for charland farmers due to early and high market pricing.

Introduction

The nutrient values of vegetables can vary thousand fold among different varieties of the same food (FAO. INFOODS 2021). Bangladesh is suitable for producing various vegetables (more than 142 types of home-grown and exotic vegetables produced in the country) due to fertile land and environment. Bangladesh retained 3rd position in global vegetables production (FAO, 2021). Vegetables are grown in both winter (mid-December to mid-February) and summer (mid-April to mid-June) seasons in the country. The country has experienced tremendous growth of vegetables production over the last couple of decades mainly due to the higher economic return from vegetables production (Rahman MM et al. 2020) along with the development of improved seeds and technologies. In Bangladesh there are approximately 0.82 million hectares of char land, accounting for 6% of total land area with 36 thousand hectares of new char land being developed every 3-5 years. Farmers in the charland area cultivate a wide range of earlet vegetables in order to maximize market value and nutritional development. Different earley planted vegetable crops have increased their adaptive capacity to mitigate farmers' loss in unfavourable ecosystem such as flooding, drought and erratic rainfall.

Materials and Methods

The experiment was conducted at Nawvanger char, sadar, Jamalpur, Bangladesh 24°57´ north latitudes and 89°55´ east longitudes. The experimental site was of medium high land belonging to the agro-ecological zone Old Brahmaputra Floodplain under Agro-Ecological Zone 9. The experiment was conducted at the during *rabi* 2021-2022 to find out the suitable time for early sowing and early market for increase productivity, economic and nutritional development of charland farmers. Design of the experiment was RCBD with 03 (three) replications having the unit of plot 2m × 2m. BARI Badhacopi-2/Hybrid, BARI Phulcopi-2/Hybrid, BARI Mula-4, Binapatshak-1, BARI Lau-1 and BARI Danta-1 were used as a variety in the experiment. Treatments were included cabbage, cauliflower, radish (leafy vegetable), jute (leafy vegetable), bottle gourd (leafy vegetable) and amaranth (leafy vegetable). Seeds were sown on 19 September, 2021 and harvested on October 22, 2021 to December 07, 2021. Fertilizer was applied in accordance with the fertilizer recommendation guide FRG 2018. Intercultural operations like watering, weeding and spraying insecticides were followed as and when necessary. Collected data were analyzed statistically with the help of Star software and mean separation was done as per LSD test at 5% level of significance.

Results and Discussion

A perusal of data revealed that the entire early sowing vegetables yield was satisfactory in contrast of weather conditions. Amaranth, jute and radish leaf were harvest 30-40 days after sowing which scope in second time sowing if weather favored. Bottle gourd leaf was harvest 40-45 days after sowing which continuing 6-8 times. Cabbage and cauliflower were late harvest than other vegetables in this experiment but these two vegetables production higher than others. Considering gross return, total variable cost gross margin and benefit cost ratio all the vegetables were grown early at charland area in contrast of unfavorable eco-systems such as sudden flood, drought and erratic rainfall. In sudden damage to mitigate production cost and earns handsome money with short duration early leafy vegetables such as amaranth, bottle gourd, jute and radish.

Table 1. Yield and economics of earley vegetable production in the charland area

Treatment	Yield (t/ha)	Gross return (Tk./ha)	TVC (Tk./ha)	Gross margin (Tk./ha)	BCR
Amaranth (leafy vegetable)	7.26	217800	26250	191550	8.3
Bottle gourd (leafy vegetable)	6.93	207900	33750	174150	6.2
Cabbage	15.68	470400	97500	372900	4.8
Cauliflower	14.3	572000	98000	474000	5.8
Jute (leafy vegetable)	8.89	222250	22500	199750	9.9
Radish (leafy vegetable)	8.7	261000	41250	219750	6.3
$LSD_{0.05}$	2.5	-	-	-	-
CV (%)	8.58	-	-	-	-

Radish (leafy vegetable) 30 Tk/kg, Cabbage: 30 Tk/kg, Cauliflower 40 Tk/kg, Jute (leafy vegetable) 25 Tk/kg, Bottle gourd (leafy vegetable) 30 Tk/kg, Amaranth (leafy vegetable) 25 Tk/kg.

Conclusion

In order to maximize market value and nutritional growth, farmers in the Charland area cultivate a wide range of early vegetables. Different earley planted vegetable crops have improved their adaptability to reduce farmer losses in unfavourable ecosystem like flooding, drought and unpredictable rainfall.

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EFFECT OF PLANTING TIME AND EARTHING UP ON SWEET POTATO IN CHAR LAND ECOSYSTEM

J. RAHMAN, M. R. ALI, M. M. RAHMAN AND M. M. KADIR

Abstract

Sweet potato is an important crop that produces starch, dietary fibre, β-carotene, and anthocyanin used as food and for industrial use. This research was carried out at Nawvanger char, sadar, Jamalpur 2020-2021 and 2021-2022 to find out the suitable time for sowing and early market for increase productivity, economic and nutritional development of charland farmers. Treatments included in the experiment were used two management practice normal and earthing up of soil and two sowing time. From two year pooled data sowing dates and management had a significant impact on sweet potato. Different planting times altered normal or earthing up management procedures and as a result this practice may be advantageous for charland farmers due to early market prices.

Introduction

Sweet potato (*Ipomoea batatas* (L.) Lam) is one of the most important tropical edible plants in the world (Zhao, D. et al. 2021). In many countries, it is used as the basic food product due to its high efficiency, abundant nutrients and possibility of growing in various climates. The production and consumption of sweet potato have raised significantly enhancing food security and ecosystem resilience (Ssali et al., 2021). Sweet potato is a nutritionally rich, climate smart crop with good adaptability under low rainfall conditions, poor soils and minimal farm inputs or labor. In Bangladesh, there are about 0.82 million hectares of char land "Charland'' is the Bengali term, its English meaning is "Riverine Island" for mid-channel island that emerges periodically from riverbed as a consequence of accretion. Due to decreasing cultivable land, farmers of char areas (Riverine Island) in Bangladesh have been practicing intercropped garden pea with onion, coriander with onion, sweet gourd with onion, vegetables, pulse and oilseed crops with wheat, different gourds with brinjal are common practice to the farmers of char areas. Sweet potato is the most important tuber crop production in Bangladesh and most area covered by char land. In Bangladesh 56869 acres of land with an annual production of sweet potato 235881 M Ton (BBS, 2020). Farmers of charland area cultivate sweet potato without any special care such as watering, timely sowing or earthing-up. For this case the experiment is undertaken in charland and it may be increase productivity, economic and nutritional development of charland farmers.

Materials and Methods

The experiment was conducted at Nawvanger char, sadar, Jamalpur, Bangladesh 24°57´ north latitudes and 89°55´ east longitudes. The annual average temperature of this district varies from maximum 36.63°C to minimum 9.4°C. Annual average rainfall is 1549.45mm. The experiment was conducted at the during *rabi* 2020-2021 to find out the suitable time for sowing and early market for increase productivity, economic and nutritional development of charland farmers. Design of the experiment was RCBD two factor with 03 (three) replications having the unit of plot 3m × 3m. BARI Misti Alu-8 was used as a variety in the experiment. Earthing up: E_1= Normal/Flat, E_2= Earthing up after 25 of transplanting and Sowing time: S_1= August, S_2= September. 120-36-120-15-6-1.5-1 kg/ha of NPKSMgZnB, all of PSMgZnB and N and K should be applied at 30-35 DAP during earthing up operation (FRG 2018). Intercultural operations like watering, weeding and spraying insecticides were followed as and when necessary. Collected data were analyzed statistically with the help of Statistix 8.0 software and mean separation was done as per LSD test at 5% level of significance.

Results and Discussion

Effect of earthing up

Single fruit weight were recorded at harvest are furnished in table 1. Highest (117cm) was registered under normal management while earthing up was lowest (107cm) at harvest may be cause of soil bulk or free of soil bulk. The data regarding length of fruit are furnished in table 1, significantly highest (16.02) from normal management and lowest (14.92) from earthing up. A perusal of data revealed that the two treatments showed their significant influence on fruit diameter. Significantly highest fruit diameter (14.3cm) was recorded under normal management while earthing up was lowest (13.9cm). The data regarding non-marketable weight were recorded at harvest are arranged in table 1. Significantly highest non-marketable weight (4.9 t/ha) was recorded under earthing up while normal management was lowest (3.87 t/ha) may cause of soil bulk. An appraisal of data table 1 indicated that two management practices exerted their significant consequence on yield. Significantly highest yield (22.44 t/ha) was registered under normal management while earthing up was recorded the lowest (21.65 t/ha).

Effect of sowing time

The data regarding number of single fruit weight are furnished in table 2, significantly highest (115.21gm) from first sowing and lowest (109.42gm) from second. A perusal of data revealed that the two sowing time showed their significant influence on length of fruit. Significantly highest diameter of fruit (14.17cm) was recorded under second sowing while first sowing was lowest (14.06 cm). A perusal of data revealed that two sowing dates showed their significant influence on non-marketable weight and marketable weight because of climatic condition such as rainfall, decreased and increased temperature of crop growing period. An appraisal of data table 2 indicated that sowing time exerted their significant consequence on yield. Significantly highest yield (22.85 t/ha) was registered under first sowing while second sowing was recorded the lowest (21.3 t/ha).

Combined effect of earthing up and sowing time

The data regarding single fruit weight are furnished in table 3, significantly highest (122.9gm) from Normal×First sowing and lowest (106.8gm) from Earthing up×Second sowing. A perusal of data revealed that different combinations showed their significant influence on length of fruit. Significantly highest length of fruit (16.35cm) was recorded under Normal×Second sowing while Earthing up×First sowing was lowest (14.65cm). An appraisal of data table 3 indicated that different combinations exerted their significant consequence on yield. Significantly highest yield (23.79 t/ha) was registered under Normal×First sowing and it was found statistically at par Normal×Second sowing (21.72 t/ha) while Earthing up×First sowing was recorded the lowest (17.04 t/ha).

Table 1. Effect of earthing up on the yield and yield contributing characters of sweet potato in charland area (pooled data)

Earthing up	Single fruit weight(gm)	Length (cm)	Diameter (cm)	Non marketable weight (t/ha)	Marketable weight (t/ha)	Yield (t/ha)
Normal	117	16.02	14.3	3.87	25.43	22.44
Earthing up	107	14.92	13.9	4.9	22.87	21.65
$LSD_{0.05}$	9.96	0.77	0.63	0.55	1.44	0.89
CV (%)	6.66	3.87	3.36	9.48	4.49	2.39

Table 2. Effect of sowing time on the yield and yield contributing characters of sweet potato in charland area (pooled data)

Sowing time	Single fruit weight(gm)	Length (cm)	Diameter (cm)	Non marketable weight (t/ha)	Marketable weight (t/ha)	Yield (t/ha)
First sowing	115.21	15.17	14.06	3.34	26.84	22.85
Second sowing	109.42	15.77	14.17	5.43	21.46	21.3
$LSD_{0.05}$	9.96	0.79	0.63	0.55	1.44	0.89
CV (%)	6.66	3.87	3.36	9.48	4.49	2.39

Table 3. Combined effect of earthing up and sowing time on the yield and yield contributing characters of sweet potato in charland area (pooled data)

Combined effect	Single fruit weight(gm)	Length (cm)	Diameter (cm)	Non marketable weight (t/ha)	Marketable weight (t/ha)	Yield (t/ha)
Normal×First sowing	122.9	15.68	14.1	2.52	28.7	23.79
Normal×Second sowing	112	16.35	14.5	5.23	22.15	21.72
Earthing up×First sowing	107.5	14.65	14.03	4.16	24.97	17.04
Earthing up×Second sowing	106.8	15.19	13.85	5.64	20.77	21.41
$LSD_{0.05}$	14.1	1.13	0.89	0.78	2.04	1.27
CV (%)	6.66	3.87	3.36	9.48	4.49	2.39

Conclusion

According to the study's two year pooled data time of planting and management had a significant impact on sweet potato. Different planting times altered normal or earthing up management procedures and as a result this practice may be advantageous for charland farmers due to early market prices.

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PERFORMANCE OF DIFFERENT ONION VARIETIES IN CHARLAND AREA OF CUMILLA

M. A. H. KHAN, M. RAHMAN AND M.O. KAISAR

Abstract

The experiment was conducted at farmer’s field of charland area under Roghunathpur village of Meghna upazila in Cumilla district during rabi season of 2021-22 to compare the yield performance of BARI released onion varieties against local variety with the aim to replace it by the best one. The onion varieties viz. BARI Piaz-4 and BARI Piaz-6 were compared with local variety.The experiment was laid out in randomized complete block design with three replications. The highest bulb length (5.8 cm), bulb diameter (3.90 cm), individual bulb weight (38.9 g) and yield (16.5 kg/ha) were recorded in BARI Piaz-4 which was statistically similar to BARI piaz-6. BARI Piaz-6 and BARI Piaz-4 were given 40-70% higher yield than the check local variety. So, the local variety might be replaced by high yielding BARI Piaz-4 and BARI Piaz-6 variety.

Introduction

Onion (*Allium cepa*) is an important spice crop in Bangladesh. It is widely cultivated throughout the year. It is a highly cross pollinated crop. It has wide variability especially in bulb shape and size, bulb skin colour etc. In Bangladesh, the area of onion is 1.70 lakh hectare and the total production is 17.04 lakh metric tons with an average yield of 10.05 t/ha (BBS, 2015) which is very low as compared to the world production. The average yield of USA is 41.12 t/ha and India is 12.5 t/ha. The average production of onion in China is 22 million tons, India 12, USA 3, Pakistan 2.0 and Turkey 1.9 million tons. Several factors are involved for low productivity of onion in Bangladesh.Farmers have been cultivating local varieties of onion, those are poor yielder. BARI has developed several high yield potential onion varieties such as BARI Piaz-4, BARI Piaz-6 etc. There is a scope to increase the productivity of onion at charland area through using BARI released onion varieties in their cropping pattern. Hence, the study was undertaken to compare the yield performance of BARI released onion varieties against local variety with the view to replace it by the best one at char land areas.

Materials and Methods

The experiment was conducted at farmer's field of charland area under Roghunathpur village of Meghna upazila in Cumilla district during rabi season of 2021-22. The experiment was conducted with three treatments, i) BARI Piaz-4 ii) BARI Piaz-6 and iii) local. The experiment was laid out in randomized complete block design with three replications. Bulb of onion were planted on 15 December 2021 and harvested on 20 March 2022. The unit plot size was 5.0 m × 2.0 m having plant spacing of 15 cm × 10 cm. The fertilizers were applied in the form of urea, triple super phosphate, muriate of potash, gypsum @ N_{120}, P_{54}, K_{75}, S_{20} Kg/ha and 5 t/ha cow-dung. The entire quantity of cow-dung, P, S, Zn, B and one third of K were applied at the time of final land preparation and the rest K and urea were applied at 25, 50, and 75 days after planting. Irrigation was applied at 30, 50 and 70 days after planting. Fungicide (Ruvral @ 2.5 g/L) was sprayed alternately at 15 days interval starting from 60 days after planting. Data on plant height (cm), number of leaves/plant, bulb length (cm), bulb diameter (cm), individual bulb weight (g) were collected. The recorded data were statically analyzed by using statistix10 software to find the significance of variation resulting from experimental treatments.

Results and Discussion

Yield and yield components of different onion varieties is presented in Table1. Different varieties of onion had significant effect on bulb length, bulb diameter, individual bulb weight and yield (t/ha). The highest bulb length (5.80 cm), bulb diameter (3.90 cm), individual bulb weight (38.9 g) and yield (16.5 (t/ha)) were recorded in BARI Piaz-4 which was statistically similar to BARI piaz-6. The lowest bulb length (4.9 cm), bulb diameter (3.30 cm), individual bulb weight (31.0 g) and yield (9.70 t/ha) was found in local variety.

Table 1.Yield and yield contributing characters of onion at charland area of Meghna upazila under Cumilla district during 2021-22

Treatment	Plantheight (cm)	Leaves/ plant (no.)	Bulb length (cm)	Bulb diameter (cm)	Individual bulb weight (g)	Yield (t/ha)
BARI Piaz-4	33.2	6.5	5.80	3.90	38.9	16.50
BARI Piaz-6	29.7	6.9	5.30	3.80	35.3	13.70
Local	33.6	7.0	4.90	3.30	31.0	9.70
CV(%)	10.2	10.5	5.67	6.00	9.90	7.90
$LSD_{(0.05\%)}$	NS	NS	0.68	0.50	6.62	2.37

Conclusion

From the above findings, it might be concluded that, BARI Piaz-4 and BARI Piaz-6 would be suitable for cultivation in charland area instead of local variety for getting higher yield and income in cumilla region.

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ADAPTATION OF PLUSE AND MUSTARD VARIETIES IN CHARLAND

M.R. ISLAM, A.A.M.M. MUSTAKIM AND M.M. UDDIN

Abstract

The adaptive trial was conducted at charland of the river Pandma, Lakkikunda, Ishurdi during 2021-2022. One mustard, lentil and Pea variety namely BARI sarisha-18, BARI Masur-8 and BARI Motor-3 were demonstrated with two Bigha of land. The tested variety yielded 1.29 t/ha, 2.48 t/ ha and 1.94 t/ha, respectively. Farmers are much interested to grow BARI released varieties.

Introduction

Due to environmental changes crop production techniques should be adapted to overcome the stress condition. Charland crop production mainly depends on rainfed cultivation. The crop suffered from available soil moisture and get stress. Suitable crop varieties which are tolerant to some moisture stress are needed to be studied. Charland is an important area where remains possibility to improve cropping system. Although the farmers' of charland grow some crops like ground nut and some minor cereals like millets but have greater scope of adaptation of BARI released crop varieties. Full package of important crop varieties are needed to adapt at charland for higher productivity and validation of approved technologies. Hence the study is undertaken.

Materials and Methods

The adaptive trial was conducted at charland, Koikunda, Lakkikunda, Ishurdi, Pabna during 2021-2022. It was the developed charland of the river of Padma. The names of selected farmers were Abul Malek, Monirul Islam and Md. Rokon. One mustard, lentil and Pea variety namely BARI sarisha-18, BARI Masur-8 and BARI Motor-3 were demonstrated among the selected farmer fields of Koikunda. with two Bigha of land. The crop varieties were sown on 7 December, 23 and 29 November 2021, respectively. Harvested were done 01, 30 and 29 March 2022, respectively. Crops were sown in residual soil moisture. One irrigation was applied 50 DAS in mustard and no irrigation was applied in lentil and pea crop. Fertilizers were applied as per recommendation for the crops. All fertilizers were applied as basal. Only half N was top dressed in mustard just after irrigation. Yields of the crop varieties were collected as whole plot basis.

Results and Discussion

Yields of mustard, lentil and pea crop varieties have been presented in Table 1. The tested variety of the crops namely BARI sarisha-18, BARI Masur-8 and BARI Motor-3 yielded 1.29 t/ha, 2.48 t/ha and 1.94 t/ha, respectively.

Table 1. Yield performance of mustard, lentil and pea varieties at charland of Padma

Crop	Variety	Sowing time	Harvesting time	Yield (t/ha)
Mustard	BARI sarisha-18	7-12-2021	01.03.2021	1.29
Lentil	BARI Masur-8	23-11-2021	30.03.2022	2.48
Pea	BARI Motor-3	29-11-2021	29.03.2021	1.94

Conclusion

BARI released lentil and pea variety viz., BARI Masur-8 and BARI Motor-3 showed better performance at charland of Padma, Koikunda, Lakkikunda, Ishurdi, Pabna. However, BARI released mustard variety BARI sarisha-18 showed moderate yield. Farmers are much interested to grow BARI released varieties.

PERFORMANCE OF INTERCROPPING LEAFY VEGETABLES WITH SWEET POTATO IN CHAR AREA OF RANGPUR

M.A.I. SARKER, M.S. HASAN, M.M. SHEIKH. M.N. SARKER AND A. K. SAHA

Abstract

The field experiment was conducted at Mohipur char area, Gangachara, Rangpur during *rabi* season of 2020-2021 and 2021-22 to find out suitable combination of sweet potato and leafy vegetables intercropping for higher productivity. Treatments included in the experiment were: T_1 = Sole sweet potato, T_2 = Sweet potato + red amaranth, T_3 = Sweet potato + spinach, T_4 = Sweet potato + raddish and T_5 = Sweet potato + coriander. The maximum root yield of sweet potato was observed in sole crop. Sweet potato equivalent yield (SPEY) of intercropping treatments showed better performance than sole sweet potato. In both the year, the highest SPEY, gross return and net return was observed in T_3 treatment (Sweet potato + spinach). The highest marginal benefit cost ratio was obtained in T_3 and T_2 treatment in 2020-21 and 2021-22, respectively. Thus, Sweet potato + spinach and Sweet potato + red amaranth intercropping would be agronomically feasible and economically profitable for sweet potato + leafy vegetables intercropping system.

Introduction

The sweet potato constitutes the staple diet of tribal population due to hardiness and adaptability into diversified farming system. The yellow or orange fleshed varieties of sweet potato contain high level of B-carotene a precursor of vitamin A and it is reported that weekly overcoming vitamin A deficiency in children, pregnant women and lactating mothers. Sweet potato is an important root crop in Bangladesh. Now, its cultivation area sprayed in char land. A large number of populations are living in char areas and maintaining their livelihood through char based farming systems. Sweet potato is generally grown with wide row spacing about 60 cm, which makes it suitable for intercropping. Intercropping is a way of reducing the risk of complete crop failure and increasing crop productivity. However, relatively few studies have been conducted on intercropping different leafy vegetables with sweet potato. Therefore, the present study was undertaken to evaluate the performance of the intercropping system and to find out a suitable leafy vegetables crop for using as intercrop with sweet potato for higher productivity and economic return.

Materials and Methods

The field experiment was conducted at Mohipur char, Gangachara, Rangpur, during *rabi* season of 2020-21 and 2021-22. Treatments included in the experiment were: T_1 = Sole sweet potato, T_2 = Sweet potato + red amaranth, T_3 = Sweet potato + spinach, T_4= Sweet potato + raddish and T_5= Sweet potato + coriander. The experiment was laid out in a randomized complete block design with three replications and the unit plot size was 4m × 4m. Local variety of sweet potato was used in the experiment. Others crop variety were BARI Lalshak-1, BARI Palongshak-1, BARI Mula-1 and BARI Dhonia-1. The experiment was started 24 November, 2020 and 17 November, 2021. The vine of sweet potato was planting in line and other seeds of intercrop were broadcast. Fertilizers were applied at the rate of 280-170-260-80-12-8 Kg/ha of Urea-TSP-MP-Gypsum-Zinc sulphate-Boric acid for sole sweet potato and intercrop. Half of urea, whole amount of TSP, MP, gypsum, zinc sulphate and boric acid were applied as basal. Remaining urea was top dressed at 20 and 35 days after planting of sweet potato. In intercrop, extra urea (150 kg/ ha) was applied in 2 splits at 20 and 35 DAS to sweet potato. Data on yield contributing characters of sweet potato were taken from randomly selected 5 plants from each plot. Yields of both the crops were taken from whole plot area. Sweet potato was harvested at 2 April, 2021 and 7 April, 2022. On the other hand, intercrops were harvested after 30 to 45 days after sowing in both the year.

The relative yield was obtained by dividing the intercrop yield of a crop with the respective sole crop yield of that crop using the formula (Dewit and Vander Bergh, 1965).

The relative yield of a crop = $\frac{\text{Yield of component crops}}{\text{Yield of sole crop}}$

Sweet potato equivalent yield (SEY) was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Bandyopadhyay (1984) as given below:

Sweet potato equivalent yield = Ys + (Yi×Pi)/ Ps

Where, Ys = Yield of sweet potato, Yi = Yield of intercropped, Pi = Market price of intercropped and Ps = Market price of sweet potato

Results and Discussions

Yield and yield components of sweet potato

Root yield and yield contributing characters of sweet potato during *rabi* of 2020-21 and 2021-22 are presented in Table 1 and all the studied characters observed did not show significant variation. However, numerically the higher root yield (18.12 t/ha and 18.55 t/ha in 2020-21 and 2021-22, respectively) was observed in sole sweet potato (T_1) than that of the other intercropping systems due to no intercrop competition for growth resources like light, nutrients, moisture and space in sole cropping. Such observations are in agreement with the findings of Begum *et al*. (2016). The lowest root yield (16.10 t/ha in 2020-21 and 17.03 t/ha in 2021-22) was recorded in Sweet potato + spinach (T_3). However, root yield in different treatments were attributed by the cumulative effect of yield components.

Table 1. Yield and yield contributing characters of sweet potato in Leafy vegetables + sweet potato intercropping during *rabi* of 2020-21 and 2021-22 at Mohipur char area, Gangachara, Rangpur

Treatment	Plant height (cm)	Branch/ plant (no.)	Roots/ plant (no.)	Weight of root/plant (g)	Root yield (t/ha)
Year : 2020-21					
T_1: Sole sweet potato	75.17	4.40	6.27	434.84	18.12
T_2: Sweet potato + red amaranth	73.03	4.27	5.93	414.64	17.26
T_3: Sweet potato + spinach	72.93	4.13	5.60	398.64	16.10
T_4: Sweet potato + raddish	73.57	4.00	5.80	408.03	16.86
T_5: Sweet potato + coriander	74.60	4.20	6.13	417.21	17.94
LSD $_{(0.05)}$	NS	NS	NS	NS	NS
CV (%)	2.63	9.54	8.76	4.26	7.74
Year : 2021-22					
T_1: Sole sweet potato	73.38	4.53	6.07	441.72	18.55
T_2: Sweet potato + red amaranth	72.37	4.20	5.80	419.81	18.04
T_3: Sweet potato + spinach	73.50	4.60	5.53	407.55	17.03
T_4: Sweet potato + raddish	71.60	4.47	5.47	411.36	17.12
T_5: Sweet potato + coriander	72.55	4.33	5.93	424.12	18.16
LSD $_{(0.05)}$	NS	NS	NS	NS	NS
CV (%)	2.23	7.47	9.34	3.59	5.42

Yield of Intercrops (Vegetables)

In both the year, the highest average yield of intercrops (16.45 t/ha in 2020-21 and 17.04 t/ha in 2021-22) was found in Sweet potato + Radish intercropping system whereas the lowest average yield (1.63 and 1.57 t/ha in 2020-21 and 2021-22, respectively) was found in Sweet potato + Coriander intercropping system (Table 2).

Relative yield

Relative yield determines competitive ability of component crops in intercropping system. Greater value of relative yield showed more competitive ability in intercrop situation compared to its monoculture (Juskiw *et al*., 2000). In 2020-21, the relative yields of sweet potato were 0.95, 0.89, 0.93 and 0.99 when sweet potato was intercropped with red amaranth, spinach, radish and coriander, respectively (Table 2). This indicates that sweet potato yield was reduced by 4.7%, 11.1%, 7% and 1% as compared to sole crop when it was intercropped with red amaranth, spinach, radish and coriander, respectively. In 2021-22, the relative yields of sweet potato were 0.97, 0.92, 0.92 and 0.98 indicates that sweet potato yield was reduced by 2.8%, 8.4%, 7.9% and 2.2% as compared to sole crop when it was intercropped with red amaranth, spinach, radish and coriander, respectively. In both the year, coriander yield was adversely affected and less by growing spinach. The lower relative yield of sweet potato in intercropping indicated that the crop faced competition for space, nutrients, light, and water. The findings are in agreement with that of Hossain *et al.* (2015).

Evaluation of intercrop productivity

Sweet potato - leafy vegetables intercrop productivity was evaluated on the basis of sweet potato equivalent yield (SPEY). Sweet potato equivalent yield (SPEY) of sweet potato - leafy vegetables intercropping showed in Table 2. In the present study, SPEY of all the intercropping systems was higher than sole sweet potato indicating higher productivity of intercropping than sweet potato. In intercropping, the highest sweet potato equivalent yield (30.20 t/ha and 30.76 t/ha in 2020-21 and 2021-22, respectively) was observed in T_3 treatment (Sweet potato + spinach) which was 66.7% in 2020-21 and 65.8% in 2021-22 increased of SPEY over sole sweet potato. The lowest was observed in T_1 (sole sweet potato) in both the year.

Table 2. Vegetable yield, Relative yield of sweet potato and sweet potato equivalent yield (SPEY) as influenced by sweet potato + leafy vegetables intercropping during *rabi* of 2020-21 and 2021-22 at Mohipur char area, Gangachara, Rangpur

Treatment	Vegetable yield (t/ha)	Relative yield of SP (t/ha)	Yield decrease over sole sweet potato (%)	SPEY (t/ha)	% increased of SPEY over sole sweet potato
Year : 2020-21					
T_1: Sole sweet potato	-	-	-	18.12	-
T_2: Sweet potato + red amaranth	5.76	0.95	4.7	23.02	27.04
T_3: Sweet potato + spinach	14.10	0.89	11.1	30.20	66.67
T_4: Sweet potato + raddish	16.45	0.93	7.0	27.83	53.57
T_5: Sweet potato + coriander	1.63	0.99	1.0	21.20	17.00
Year : 2021-22					
T_1: Sole sweet potato	-		-	18.55	
T_2: Sweet potato + red amaranth	10.15	0.97	2.81	28.19	51.97
T_3: Sweet potato + spinach	13.73	0.92	8.39	30.76	65.82
T_4: Sweet potato + raddish	17.04	0.92	7.89	28.48	53.53
T_5: Sweet potato + coriander	1.57	0.98	2.15	21.30	14.82

Market price (BDT/kg): sweet potato = 15, red amaranth = 15, spinach = 15, radish = 10, coriander = 30

Cost and return analysis

Economic analysis is an important tool to evaluate the economic feasibility of intercropping systems was evaluated according to Shah *et al*. (1991). Benefit cost analysis of sweet potato + leafy vegetables intercropping systems are presented in Table 3. Gross return depends on equivalent yield. Among intercropping treatments, the highest gross return (Tk. 453000/ha in 2020-21 and Tk. 461400/ha in 2021-22) was observed in T_3 (sweet potato + spinach) and it was close to T_2 and T_4 owing to higher SPEY. The net return also followed the similar trend of gross return in both the year. Cost of production differed among the treatments. The highest cost of production was recorded in T_3 treatment which was close to T_4 (Sweet potato + radish) due to involvement of higher costs. The highest marginal benefit cost ratio (3.54) was obtained from T_3 (Sweet potato + spinach) in the year of 2020-21 and 3.61 was obtained from T_2 (Sweet potato + red amaranth) in 2021-22. In both the year, sole sweet potato produced lower gross return, net return and marginal benefit cost ratio than other intercropping systems.

Table 3. Economic analysis of sweet potato + leafy vegetables intercropping during *rabi* season of 2020-21 and 2021-22 at char area Rangpur

Treatment	Gross return (Tk./ ha)	Cost of cultivation (Tk./ ha)	Net return (Tk./ ha)	MBCR
Year : 2020-21				
T_1: Sole sweet potato	271800	105500	166300	2.58
T_2: Sweet potato + red amaranth	345300	117040	228260	2.95
T_3: Sweet potato + spinach	453000	128000	325000	3.54
T_4: Sweet potato + raddish	417400	127875	289525	3.26
T_5: Sweet potato + coriander	318000	116050	201950	2.74
Year : 2021-22				
T_1: Sole sweet potato	278250	105500	172750	2.64
T_2: Sweet potato + red amaranth	422850	117040	305810	3.61
T_3: Sweet potato + spinach	461400	128000	333400	3.60
T_4: Sweet potato + raddish	427200	127875	299325	3.34
T_5: Sweet potato + coriander	319500	116050	203450	2.75

Market price (Tk./kg): sweet potato = 15, red amaranth = 15, spinach = 15, radish = 10, coriander = 30

Conclusion

Result revealed that all the intercropping showed better productivity than growing sole sweet potato. Among all the intercropping sweet potato + spinach and sweet potato + red amaranth intercropping found more agronomically feasible and economically profitable in char land area of Rangpur.

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Chalanbeel Area

EFFECT OF MANAGEMENT PRACTICES ON MUSTARD YIELD IN CHALANBEEL AREA

S.S. KAKON, A.A. BEGUM, J.A. CHOWDHURY AND D.A.CHOUDHURY

Abstract

The experiment was conducted at Dobila, Tarash of Shirajgonj in Chalanbeel during the rabi season of 2021-2022 to find out suitable management practices in mustard in Chalanbeel area. The treatments were T_1 = High management practice: Sowing seeds on November 10 + BARI sarisha-14 + fertilizer (HYG) (105-32-40-24-2-1 kg/ha of NPKSZnB) + line sowing (30 cm row to row) + plant protection measures (use of seed treatment, insecticide and fungicide), T_2= Medium management practice: Sowing seeds on November 10 + BARI sarisha-14 +fertilizer (MYG) (60-18-21-10 kg/ha of NPKS) + broadcast + pest management and T_3= Farmers' practice { low management practice : Sowing seeds on November 10 + Tori-7 +fertilizer (FP) (20-40-25 kg/ha of NPKS) + broadcast + no plant protection measure)}. The results revealed that maximum response in yield (1767 kg/ha) was observed with timely sowing (November 10) with complete package. The highest gross return (Tk. 1,06,020/ha), gross margin (Tk. 42360/ha) and benefit cost ratio (2.50) were observed in T_1 treatment, i.e. the high management practice.

Introduction

Chalanbeel is an extensive lowland area in the lower Atrai basin and spreads across Singra and Gurudaspur upazilas of Natore district, Chatmohar, Bhangura, Faridpur upazilas of Pabna district and Ullahpara, Rajgonj and Tarash upazilas of Sirajgonj district. Generally unfavourable ecosystem is less productive and remains fallow in most of the part of the year (BARC, 2013). The existing major cropping pattern under Chalanbeel area is Fallow- Boro-Fallow and hence the land remains fallow in early rabi and kharif season. But the crop productivity could be increased by improving existing cropping patterns through introducing new crops and varieties suitable for the region. High yielding short duration variety along with modern cultivation techniques are the prerequisite for developing improved cropping pattern. At present situation, some farmers of Chalanbeel area are interested to cultivate maize, wheat, garlic and oilseeds crops (like mustard) after receding of water from the soil.

Mustard (*Brassica spp*.) is the major oilseed crop grown in Bangladesh. It is an important source of cooking oil in Bangladesh. Mustard is mainly cultivated as a winter crop and it is grown almost in all the districts of Bangladesh. Rapeseed and mustard occupies 0.336 million hectare (40%) among oil cropped area. Among rapeseed and mustard, *B. campestris is* grown in *75%* of the area and *B. juneea* cover about *25%* of the area. The average national seed yield of rapeseed and mustard is only *739* kg/ha whereas the world average seed yield of rapeseed and mustard is *1575* kg/ha. Annual requirement of edible oil is about *5 lac* metric tons. The internal production of edible oil can meet up only 10-12% of the annual requirement. There are very little scope of horizontal expansion of mustard. So, for increasing mustard production, yield must be increased per unit area. Some of the causes of low yield are related with environmental condition, poor agronomic practices and using local variety. Poor fertility management is one of the most important constrains for this low yield of mustard in our country, Balanced fertilization is a prerequisite for achieving optimum yield potential of high yielding crops. On the other hand, insect pests also affect mustard and cause substantial losses in yield. Most of the farmers presently use chemical fertilizer which increases the production cost as well as the soil is degraded and environment is polluted (Higa, 1991). This crop is efficient in water use and hence requires less water for their growth. However, its yield potentiality varies depending on variety. In most cases, farmers cultivate Tori-7 that yields lower. Whereas BARI already released some short duration high yielding mustard variety. Seed yield and growth decreased gradually with delay in sowing. Sowing time determines the time of flowering, dry matter accumulation, siliqua formation, seed setting, seed yield and oil content of seed (Uddin *et al.*, 1987 and Saran and Giri, 1987). The present investigation was, therefore, undertaken to assess the yield loss of mustard following the principle of omission of single component technology from recommended package.

Materials and Methods

The experiment was conducted at Dobila, Tarash of Shirajgonj in Chalanbeel during the rabi season of 2021-22. The treatments were The treatments were T_1 = High management practice: Sowing seeds on November 10 + BARI sarisha-14 + fertilizer(HYG) (105-32-40-24-2-1 kg/ha of NPKSZnB) + line sowing (30 cm row to row) + plant protection measures(use of seed treatment, insecticide and fungicide), T_2= Medium management practice: Sowing seeds on November 10 + BARI sarisha-14 +fertilizer (MYG) (60-18-21-10 kg/ha of NPKS) + broadcast + pest management and T_3= Farmers' practice { low management practice: Sowing seeds on November 10 + Tori-7 +fertilizer (LYG) (20-40-25 kg/ha of NPKS) + broadcast + no plant protection measure)}. Unit plot size was 20 decimals. Recommended fertilizer packages (FRG, 2018) following the application methods were used for all the crops. The economic indices like gross return, gross margin and benefit cost ratio were also calculated on the basis of prevailing market price of the inputs and outputs (produces).Crop cut was done from an area of one square meter 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 2.

Results and Discussions

Yield and yield components of mustard differed significantly but had no significant variation in plant population of mustard (Table 1). The tallest plant (95.25 cm) was recorded in T_1 treatment and the shortest (68.75 cm) plant was recorded in T_3. Number of siliqua/plant varied significantly in different treatments. The highest number of siliqua/plant was recorded in T_1 (94) and T_3 produced the lowest number of siliqua/plant (45). Similar trend was observed in seeds/siliqua. On the other hand, the minimum number of seeds siliqua^{-1}was recorded in T_3 (14). Thousand seeds weight (seeds size) is a genetically controlled trait. Thousand seed weight was significantly affected by different management practices The highest 1000 seed weight was found in T_1 (3.52 g) which was followed by T_2 (3.42 g).

Seed yield also was significantly affected by different management practices Seed yield of mustard is a function of plant population, siliqua plant^{-1}, seeds siliqua^{-1}and 1000-seeds weight. Recommended package with timely sowing caused significantly increase in seed yield of mustard (Table 3). The highest seed yield of 1767 kg/ha was recorded from timely sowing with recommended packages. In complete package, line sowing was most efficient in improving seed yield of the crop as compared to broadcast. The low yield in broadcast seeding in complete package was due to uneven stand and inefficient utilization of applied nutrients. Lack of proper seeding method under medium management (T_2) reduced the seed yield by 40%. The lowest seed yield was recorded in T_3 treatment (Farmers practice) due to omitting seed treatment good quality variety from recommended package also caused a reduction (52%) in seed yield of mustard.

Table 1. Yield components of mustard as affected by different management practices in Chalanbeel area during *rabi* season of 2021-22

Treat.	Plants/m^2 (no.)	Plant height (cm)	Siliqua /plant (no.)	Seed/siliqua (no.)	1000 seed wt.(g)	Seed yield (kg/ha)	Yield increased over farmers prctices (%)
T_1	54.0	98.25	94	25	3.52	1767.00	109
T_2	59.8	89.75	77	20	3.42	1047.48	24
T_3	55.0	68.75	45	14	2.61	844.25	-
$LSD_{(0.05)}$	NS	12.11	7.52	4.32	0.12	224.9	
CV%	6.48	8,18	6.05	12.26	2.18	10.66	

Cost and return analysis

Cost and return analysis is an important tool to evaluate the economic feasibility of crop production. Benefit cost analysis of mustard production in Chalanbeel area has been presented in Table 2. Gross return and BCR depends on mustard yield. Among the treatments, highest gross return (Tk. 106020.00/ha) and gross margin (Tk. 42360.00/ha) was observed in T_1 treatment (High management practice: Sowing seeds on November 10 + BARI sarisha-14 + fertilizer (105-32-40-24-2-1 kg/ha of NPKSZnB) + line sowing (30 cm row to row) + plant protection measures (use of seed treatment, insecticide and fungicide) and it was close to T_2 (Medium management practice: Sowing seeds on November 10 + BARI sarisha-14 + fertilizer (MYG)(60-18-21-10 kg/ha of NPKS) + broadcast + pest management which was 52% higher than that of farmers practice (Table 2). The highest cost of cultivation (Tk. 42360.00 ha^{-1}) was recorded in T_1 treatment which was close to T_2 due to involvement of higher labor costs for cultivation. Among the treatments, the highest benefit cost ratio (2.50) was obtained from T_1 treatment.

Table 2. Cost and return analysis of mustard as influenced by different fertility during *rabi* season of 2021-2022

Treatment	Yield (kg/ha)	Gross return (Tk./ha)	Total variable Cost (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1	1767.00	106020.00	42360.00	63660.00	2.50
T_2	1047.48	62848.50	35670.00	27178.50	1.76
T_3	844.25	50655.00	30542.00	20113.00	1.66

T_1 = High management practice: Sowing seeds on November 10 + BARI sarisha-14 + fertilizer (HYG) (105-32-40-24-2-1 kg/ha of NPKSZnB) + line sowing (30 cm row to row) + plant protection measures (use of seed treatment, insecticide and fungicide), T_2= Medium management practice: Sowing seeds on November 10 + BARI sarisha-14 +fertilizer (MYG)(60-18-21-10 kg/ha of NPKS) + broadcst + pest management and T_3= Farmers' practice { low management practice : Sowing seeds on November 10 + Tori-7 + fertilizer (LYG)(20-40-25 kg/ha of NPKS) + broadcst + no plant protection measure)}.

Conclusion

Results of the experiment revealed that the highest seed yield of mustard was obtained from timely sowing (November 10) with recommended package. Delay in sowing (20 November) and omitting chemical fertilizer, seed treatment, and plant protection measure from complete package were the production factors limiting seed yield of mustard. Hence, complete recommended package must be followed for getting desirable yield of mustard.

References

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EFFECT OF MANAGEMENT PRACTICES ON POTATO AT CHALAN BEEL AREA

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Abstract

The experiment was conducted at Dobila, Tarash of Shirajgonj in Chalanbeel during the *rabi* season of 2021-2022 to determine optimum management for potato production in chalanbeel area. The treatments were: T_1=Recommended fertilizer dose (180-40-180-20-4-1 kg/ha of NPKSZnB)+ earthing up at 20-25 DAE, T_2=RFD + pre-emergence herbicide (pandimethylene @ 3L/ha) spraying at 5 DAP, T_3=120% RFD + earthing up at 20-25 DAE and T_4 =Farmers' practice (local variety + no earthing up+RFD). The results revealed that maximum response in yield (22.74 /ha) was observed with 120% RFD + earthing up at 20-25 DAE. The highest gross return (Tk. 227433/ha), gross margin (Tk. 95593/ha) were observed in T_3 (120% RFD + earthing up at 20-25 DAE) treatment but the highest benefit cost ratio (1.75) was observed in T_2 (180-40-180-20-4-1kg/ha of NPKSZnB + pre-emergence herbicide (Pandimethylene @ 3L/ha) spraying at 5 DAP) treatment. From the result it could be concluded that RFD 180-40-180-20-4-1 kg/ha of NPKSZnB + pre-emergence herbicide (Pandimethylene@ 3L/ha) spraying at 5 DAP might be suitable for getting maximum yield of potato at chalanbeel area.

Introduction

Chalanbeel is an extensive lowland area under unfavourable ecosystem covering an area of 2.43 million hectares in Bangladesh (Aziz *et al*., 2016). Previous research indicates that there is a possibility of improving productivity of different crops and cropping pattern through adaption of HYV of crops along with their improved production technologies. *Boro* rice is the main crop in beel area. But boro rice require huge amount of water. In this context, boro rice can be replaced by HYV potato, maize, wheat, mustard, garlic, lentil and onion. Previous survey and experience indicated that farmers also grow potato, maize, wheat, mustard, garlic, lentil onion, pea, lathyrus in beel area especially upper side land (*Kandha*) of beel (BARI, 2016). These crops require low water as compared to *boro* rice. Potato (*Solanum tuberosum*) is the most widely grown tuber crop in Bangladesh. It occupies top most position after rice and wheat both in respect of production and consumption (Akhtar *et al*., 1998). Its production unit/area is the highest with maximum output within shortest period of time and generates large number of employment opportunities. *Boro* rice is a risk crop in beel area. Early flooding may damage the *boro* rice. Potato is free from early flooding. Moreover, use of high yielding potato and improved management practices can increase the yield of potato and may save underground water use as compared to *boro* rice cultivation in beel area. Therefore, the experiment was undertaken for adaption of less water requiring HYV potato instead of high water requiring *boro* rice in Chalanbeel area.

Materials and Methods

The experiment was conducted at Dobila, Tarash of Shirajgonj in Chalanbeel during the rabi season of 2021-22. The treatments were: T_1=Recommended fertilizer dose (180-40-180-20-4-1 kg/ha of NPKSZnB) + earthing up at 20-25 DAE, T_2=RFD + pre-emergence herbicide (Pandimethylene @ 3L/ha) spraying at 5 DAP, T_3=120% RFD + earthing up at 20-25 DAE and T_4 =Farmers' practice (local variety + no earthing up + RFD). Unit plot size was 20 decimals. Recommended fertilizer packages (FRG, 2018) following the application methods were used for the crop. Half of N and K and full dose of other nutrients were applied at the time of final land preparation and remaining N and K were applied as top dressed at 30 days after planting (DAP) for all treatments followed by irrigation. Potato (BARI Alu-7 and *Deshal alu*) were planted on 28 November 2021. Crop was harvested on 28 February 2022. A light irrigation was given at 5 DAP for proper emergence. The economic indices like gross return, gross margin and benefit cost ratio were also calculated on the basis of prevailing market price of the inputs and outputs (produces).Crop cut was done from an area of one square meter at three spots from each plot for yield samples in all cases. The collected data were analyzed statistically using MSTAT-C package and means were adjudged by LSD test at 5% level of probability.

Results and Discussion

Plant height, yield components and yield of potato

Plant height, number of tuber/hill, tuber weight/plant and tuber yield of potato were significantly influenced by different management practices (Table 1). The tallest plant (58.0 cm) was found in T_3 (120% RFD+earthing up at 20-25 DAE) treatment followed by T_2 (180-40-180-20-4-1 kg/ha of NPKSZnB + pre-emergence herbicide (Pandimethylene @ 3L/ha) spraying at 5 DAP) and T_1 (RFD-180-40-180-20-4-1 kg/ha of NPKSZnB) + earthing up at 20-25DAE) treatment and the shortest plant (38.47 cm) was found from T_4 (Farmers practices) treatment. The highest number of hill/m^2 (17.97) was recorded in T_4(Farmers' practices) treatment. The highest number of tuber/hill (6.33) was found in T_2 (180-40-180-20-4-1 kg/ha of NPKSZnB + pre-emergence herbicide (Pandimethylene@ 3L/ha) spraying at 5 DAP) which was statistically similar to T_1 (Recommended fertilizer dose(180-40-180-20-4-1 kg/ha of NPKSZnB) + earthing up at 20-25DAE) and T_3 (120% RFD + earthing up at 20-25 DAE) treatment and the lowest (5.33) was observed in T_4 (Farmers practices) treatment. The highest tuber weight/plant (408 g) was observed in T_3 (120% RFD + earthing up at 20-25 DAE) treatment which was statistically similar to T_2 (RFD + pre-emergence herbicide (Pandimethylene @ 3L/ha) spraying at 5 DAP). The highest tuber yield (22.74 t/ha) was found in T_3 (120% RFD + earthing up at 20-25 DAE) which was statistically similar to T_2 treatment and the lowest tuber yield (14.88 t/ha) was recorded in T_4 (Farmers practices) treatment.

Table 1. Yield components and yield of potato as affected by different management practice during 2021-22

Treatment	Plant height (cm)	Hill/m^2 (no.)	Tuber/hill (no.)	Tuber wt./plant (g)	Tuber yield (t/ha)
T_1	54.53	6.39	6.00	387.00	18.91
T_2	55.67	6.43	6.33	392.33	19.90
T_3	58.00	6.45	6.00	408.00	22.74
T_4	38.47	17.97	5.73	120.33	14.88
LSD $_{(0.05)}$	7.14	1.08	0.33	34.24	3.57
CV (%)	6.92	5.80	6.73	5.24	9.34

T_1=Recommended fertilizer dose (180-40-180-20-4-1 kg/ha of NPKSZnB) + earthing up at 20-25DAE, T_2=RFD + pre-emergence herbicide (Pandimethylene @ 3L/ha) spraying at 5 DAP, T_3=120% RFD + earthing up at 20-25 DAE and T_4 =Farmers' practice (local variet y + no earthing up + RFD)

Cost and return analysis

Cost and return analysis is an important tool to evaluate the economic feasibility of crop production. Benefit cost analysis of potato production in Chalanbeel area has been presented in Table 2. Gross return and BCR depends on potato yield. Among the treatments, highest gross return (Tk. 227433/ha) and gross margin (Tk. 95593/ha) were observed in T_3 treatment (120% RFD + earthing up at 20-25 DAE) and it was close to T_2 {RFD + pre-emergence herbicide (Pandimethylene @ 3L/ha) spraying at 5 DAP)} which was 47% higher than that of farmers practice (Table 2). Though T_3 treatment produced the highest yield but the highest cost of cultivation (Tk. 131840/ha) due to higher fertilizer and labor costs involved in this treatment. Among the treatments, the highest benefit cost ratio (1.75) was obtained from T_2 (180-40-180-20-4-1 kg/ha of NPKSZnB + pre-emergence herbicide (Pandimethylene@ 3L/ha) spraying at 5 DAP treatment but the lowest BCR was recorded in T_4 (Farmers' practice).

Table 2. Economic performance of different management practices on potato cultivation during 2021-22

Treatment	Gross return (Tk./ha)	Cost of production (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1	189100	110580	78520	1.71
T_2	199033	113560	85473	1.75
T_3	227433	131840	95593	1.73
T_4	119013	92840	26173	1.28

T_1=Recommended fertilizer dose (180-40-180-20-4-1 kg/ha of NPKSZnB) + earthing up at 20-25DAE, T_2=RFD + pre-emergence herbicide (Pandimethylene @ 3L/ha) spraying at 5 DAP, T_3=120% RFD + earthing up at 20-25 DAE and T_4 =Farmers' practice (local variet y + no earthing up + RFD)

Conclusion

The result revealed that RFD + pre-emergence herbicide (Pandimethylene@ 3L/ha) spraying at 5 DAP) combination might be suitable management practice for getting higher tuber yield and economic return of potato cultivation at chalanbeel area.

PERFORMANCE OF BARI REALIZED MINOR CEREAL CROPS IN ACIDIC SOIL AT MOULVIBAZAR

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Abstract

An experiment was conducted at Regional Agricultural Research Station, BARI, Akberpur, Moulvibazar during the Rabi season of 2021-22 which was belongs to under the Agro-Ecological Zone of Eastern Surma-Kushiyara Floodplain (AEZ 20) and Northern and Eastern Hills (AEZ-29) to evaluate the performances of minor cereal crops at acidic soil condition. The experimental field situated at 24°24/ -24°38′ N latitude and 91°37′-91°37′ E longitude. For Barley, number of days to 50% flowering, 1000-seeds weight and yield/ha were differed significantly but no significant effects were observed on days to maturity, spike length, plant height, dry matter (DM)/Plant, seeds/pike and straw yield/ha. In case of Kaon, days to flowering, plant height (cm), DM/Plant (g), seeds/spike and yield ha^{-1} were differed significantly at acidic soil at Moulvibazar. However, no significant effects were observed on days to maturity, spike length (cm), 1000-grain weight (g), and straw yield (kg/ha). In Sorghum, T_7 (BARI Sorghum-1) was recorded to days to flowering maturity (98 days), days to maturity (126 day), spike length (20.50 cm), plant height (110.51cm), DM/Plant (15.27 g), seeds/spike (475.5 nos),1000-seeds weight (118.66 g), yield/ha (2049.46 kg) and stover yield (9900 kg) at acidic soil at Moulvibazar. In Cheena, T_8 (BARI Cheena-1) was recorded to days to flowering maturity (81 days), days to maturity (104 days), spike length (17.56cm), plant height (57.27cm), DM $Plant^{-1}$ (7.07 g), seeds $Spike^{-1}$ (302.33 nos),1000-seeds weight (5.45 g), yield ha^{-1} (721.46 kg) and stover yield (2863 kg) at acidic soil at Moulvibazar. The yield and yield components of all minor cereal crops were reduced as comp are to other place due to high levels of soil acidity (low soil P^H) which decreased root growth, reduced nutrient availability, and changed crop protection activity. Moreover, Sorghum might be recommended to cultivate on the basis of gross margin, gross return and BCR in the acidic soil at Moulvibazar as well as Sylhet region.

Introduction

Global population is increasing including Bangladesh and thus the demand for cereals are also increasing (Scot and Moebium-Clune, 2017) but a cultivable area in Bangladesh is decreasing (SRD,2013). Moreover, the production of cereals is decreasing in many areas because of climate change (CC) impacts (FAO,2016). Moreover, Soil productivity is declining with continuous chemical fertilizers use (Haque *et al.*, 2019) along with decreased freshwater availability for agricultural production and thus a challenge of sustainable crop production (Faroque *et al.*, 2011). It is estimated that agricultural systems in the world are losing about 75 billion ts of fertile soils each year (Eswaran *et al.*, 2001). Under such situations, it is the responsibility of the scientific community to look for alternate avenues that can help in maintaining food security as well as reducing greenhouse gas (GHG) emissions from agricultural soils. Minor cereals such as proso, pearl, finger, kodo and foxtail can play an important role in food and nutrition security around the globe (Wen *et al.*, 2014). Millets release less GHG in the range of 3218-3358 kg CO2 eq. ha^{-1} (Jain *et al.*, 2016; Wang *et al.*, 2018). Minor cereals, the neglected crops too, can be cultivated under water and nutrient stress conditions. They can be cultivated in semi-arid and arid regions (FAO,2014; Passot *et al.*, 2016). Water and food crises are emerging globally and thus people are suffering from malnutrition. Moreover, they are rich in calcium, phosphorus, potassium and iron (Wang *et al.*, 2018). Such qualities are highly desirable for nutritional security in Bangladesh. Some farmers grow minor cereals in Bangladesh under diverse ecological conditions and under unfavorable ecosystems. We hypothesize that minor cereals would be playing a vital role in future agriculture under a changing climate in Bangladesh. The present investigation was taken along with delineation of production zones, establishing relationships of minor cereal cultivation with selected social character and climatic conditions. Irrigation water and acidic soil are major problem for the production of the major crops at Moulvibazar as well as Sylhet division. So, it can be produced minor cereal crops in to the scarcity of water and acidic soil at Moulvibzar as Sylhet division. Regarding this matter, the experiment was done.

Materials and Method

The experiment was conducted at Regional Agricultural Research Station, BARI, Akberpur, Moulvibazar during the Rabi season of 2021-22 which was belongs to under the Agro-Ecological Zone of Eastern Surma-Kushiyara Floodplain (AEZ 20) and Northern and Eastern Hills (AEZ-29) to evaluate the performances of minor cereal crops at acidic soil condition. The experimental field situated at 24°24/ -24°38′ N latitude and 91°37′-91°37′ E longitude. The soil belongs to the “Khadimnagar” soil series, sandy loam in texture having moderate organic matter content (1.45%), N 0.80%, K 0.07m mol/100g of soil, P was 25 µg/g of soil and S was 10µg/g of soil with pH value 4-5. The treatments of the experiment were 8 (eight) among them 4 of BARI Barley varieties, 2 of BARI Kaon varieties, 1 of BARI Sorghum variety and 1 of BARI Cheena variety. The treatments were as follow: T_1= BARI Barley-6, T_2= BARI Barley-7, T_3=BARI Barley-8, T_4= BARI Barley-9, T_5= BARI kaon-2, T_6=BARI kaon-4, T_6 = BARI Sorghum-1 and T_8=BARI Cheena-1.The experiment was laid out in randomized complete block design with three replications. The unit plot size was 3m × 3m. The seeds of minor cereal crops were sown on 11 November, 2021.Seeds of these minor crops were sown as per treatment specifications. The seed rate of Barley was 120 kg/ha, Kaon 10 kg/ha, Cheena 20 kg/ha, sorghum 10 kg/ha. Seeds of minor cereal crops were sown in rows following row to row distance 20 cm for barley, 25 cm for kaon, 25 cm for chena and 50 cm for sorghum. The plant-to-plant distance was 10 cm for all the crops. Fertilizer nutrients were applied in the plots of the minor cereal crops as per their respective recommended doses and methods (FRG, 2018), which are described below:

Name of the crops	Nutrient rate (FRG, 2018)	Method of nutrient application
Barley	40-14-34-6-1.0 kg/ha N-P-K-S-Zn, respectively	Half of N and all of P, K, S and Zn were applied as basal 3-5 days before seeding. The N was applied as top dress in two equal splits at 30-35 and 55-60 days after sowing followed by irrigation.
Kaon	40-16-28-6-0.7 kg/ha N-P-K-S-Zn, respectively	Half of N and all of P, K, S and Zn were applied as basal 3-5 days before seeding. The N was applied as top dress in two equal splits at 15-20 and 35-40 days after sowing followed by irrigation
Sorghum	60-20-35-6-1.0 kg/ha N-P-K-S-Zn, respectively	Half of N and all of P, K, S and Zn were applied as basal 3-5 days before seeding. The N was applied as top dress in two equal splits at 30-35 and 55-60 days after sowing followed by irrigation.
Cheena	40-14-30-6-0.7 kg/ha N-P-K-S-Zn, respectively	Half of N and all of P, K, S and Zn were applied as basal 3-5 days before seeding. The N was applied as top dress in two equal splits at 15-20 and 35-40 days after sowing followed by irrigation.

Irrigation was applied for one times and other intercultural operations were done as when necessary following the recommended production technologies of the minor cereal crops (BARI, 2020).The crops were harvested when attained to their respective physiological maturity. Data were collected in relation to phenology, yield attributes and yields of the respective crops. Data were analyzed statistically and the mean differences were adjudged with Duncan’s Multiple Range Test (DMRT) following Gomez and Gomez (1984).

Results and Discussion

For Barley, number of days to 50% flowering, 1000-seeds weight and yield/ha were differed significantly but no significant effects were observed on days to maturity, spike length, plant height, dry matter (DM)/Plant, seeds/Spike and straw yield/ha (Table 1) due to Soil acidity which is an important factor negatively affecting crop yield production, especially in areas with water deficiency. Days to flowering 50 % flowering was found higher in T_3 (BARI Barley-8) which were followed by T_1 (BARI Barley-6) and T_2 ((BARI Barley-7) respectively. 1000-seed weight (g) was found higher in T_2 ((BARI Barley-7) which was at par T_1 (BARI Barley-6). Yield/ha was found higher in T_2 ((BARI Barley-7) which was followed T_1 (BARI Barley-6). In case of Kaon, days to flowering, plant height (cm), DM/Plant (g), seeds/Spike and yield/ha were differed significantly at acidic soil at Moulvibazar. However, no significant effects were observed on days to maturity, spike length (cm), 1000-grain weight (g), and straw yield (kg/ha). It recorded that T_5 (BARI kaon-2) had given higher days to flowering (104 days), plant height (105.78 cm), DM/Plant (6.80g), seeds/spike (308 nos) and yield/ha (536.56 kg). In Sorghum, T_7 (BARI Sorghum-1) was recorded to days to flowering maturity (98 days), days to maturity (126 day), spike length (20.50 cm), plant height (110.51cm), DM/Plant (15.27 g), seeds/spike (475.5 nos),1000-seeds weight (118.66 g), Yield/ha (2049.46 kg) and stover yield (9900 kg) at acidic soil at Moulvibazar. In Cheena, T_8 (BARI Cheena-1) was recorded to days to flowering maturity (81 days), days to maturity (104 days), spike length (17.56cm), plant height (57.27cm), DM/Plant (7.07 g), seeds/Spike (302.33 nos),1000-seeds weight (5.45 g), Yield/ha (721.46 kg) and stover yield (2863 kg) at acidic soil at Moulvibazar. In case of barley, T_2 ((BARI Barley-7) produced the highest gross return as well as gross margin (Tk.27582.70 and 6582.70 tk/ha, respectively) and BCR 1.31. For kaon, T_5 (BARI kaon-2) showed the highest gross return and gross margin (Tk. 29648.00 and 8648 tk/ha, respectively) and BCR 1.41. In case of sorghum, T_7 (BARI Sorghum-1) produced the highest gross return and gross margin (Tk. 50889.20 and 29889.20 tk/ha, respectively) and BCR 2.42. In cheena, T_8 (BARI Cheena-1) gave gross return (Tk. 38936.00 tk/ha) and gross margin (Tk. 17936 tk/ha).

Table 1. Plant characters of different minor cereal crops under acidic soil condition

Barley (*Hordeum vulgare*)

Treat ment	Days to 50% flowering	Days to maturity	Spike length (cm)	Plant height (cm)	DM/Plant (g)	Seed/Spike (no.)	1000-seeds wt. (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
T_1	91	114	16.11	77.67	4.33	59.11	88.33	651.85	2104
T_2	89	113	16.78	73.89	4.57	58.67	98.66	722.22	2305
T_3	98	122	15.44	71.11	3.83	46.11	45.66	570.37	2210
T_4	95	111	16.00	73.44	5.30	48.89	41.33	544.44	2183
CV (%)	3.42	2.56	3.78	2.19	2.10	4.35	3.58	4.63	2.73
$LSD_{(0.05)}$	*	NS	NS	NS	NS	NS	*	*	NS

Kaon (*Foxtail millet*) (*Setaria italica*)

Treat ment	Days to 50% flowering	Days to maturity	Spike length (cm)	Plant height (cm)	DM/Plant (g)	seed/Spike (no.)	1000-seeds wt. (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
T_5	104	131.0	19.89	105.78	6.80	307.79	19.66	536.56	2820
T_6	94	130.3	21.89	96.44	5.80	267.46	17.66	451.78	2761
CV (%)	3.89	1.01	3.10	2.90	2.30	34.41	20.63	4.30	5.29
$LSD_{(0.05)}$	*	NS	NS	*	*	NS	NS	*	NS

Sorghum (*Sorghum bicolor*)

Treat ment	Days to 50% flowering	Days to maturity	Spike length (cm)	Plant height (cm)	DM/Plant (g)	seed/Spike (no.)	1000-seeds wt. (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
T_7	98	126	20.50	110.51	15.27	475.5	118.66	2049.46	9900
CV (%)	-	-	-	-	-	-	-	-	-
$LSD_{(0.05)}$	-	-	-	-	-	-	-	-	-

Cheena (Proso millet) (*Panicum miliaceum*)

Treat ment	Days to 50% flowering	Days to maturity	Spike length (cm)	Plant height (cm)	DM $Plant^{-1}$ (g)	seed $Spike^{-1}$(no.)	1000-seeds wt. (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
T_8	81	104b	17.56	57.27	7.07	302.33	5.46	721.46	2863
CV (%)	-	-	-	-	-	-	-	-	-
$LSD_{(0.05)}$	-	-	-	-	-	-	-	-	-

T_1= BARI Barley-6, T_2= BARI Barley-7, T_3= BARI Barley-8, T_4= BARI Barley-9, T_5= BARI kaon-2, T_6= BARI kaon-4, T_7= BARI Sorghum-1and T_8= BARI Cheena-1

Table 2. Economic return of minor cereal crops under acidic soil condition

Minor cereal crops	Treatment	Seed yield (kg/ha)	Stover- yield (Tk./ha)	Gross return (Tk./ha)	Total variable cost (Tk./ha)	Gross margin (Tk./ha)	Benefit cost ratio (BCR)
Barley	T_1	651.85	2305	24918.75	21000	3918.75	1.19
	T_2	722.22	2104	27582.70	21000	6582.70	1.31
	T_3	570.37	2210	22172.95	21000	1172.95	1.06
	T_4	544.44	2183	21238.40	21000	238.40	1.01
Kaon	T_5	536.56	2820	29648.00	21000	8648.00	1.41
	T_6	451.78	2761	25350.00	21000	4350.00	1.21
Sorghum	T_7	1549.46	9900	50889.20	21000	29889.20	**2.42**
Cheena	T_8	721.46	2863	38936.00	21000	17936.00	1.85

Prices: Barley Tk. 35/ kg, kaon Tk. 50/ kg Sorghum Tk. 20/ kg, Cheena Tk. 50/ kg

Conclusion

The experimental results revealed that all the minor cereal crops (barley, kaon, sorghum and cheena,) might be grown at acidic soil but reduced total crop phenology and as well as soil acidity is an important factor which was negatively affected crop yield production, especially in areas with water deficiency. Among the minor cereal crops, Sorghum might be recommended to cultivate on basis of gross return, gross margin and BCR in the acidic soil at Moulvibazar as well as Sylhet region.

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PERFORMANCE OF BARI RELEASED BLACKGRAM VARIETIES IN ACIDIC SOIL OF SEMI HILL VALLEY AT MOULVIBAZAR UNDER RAINFED CONDITION

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Abstract

The experiment was conducted at Regional Agricultural Research Station, BARI, at Moulvibazar during the kharif-II season of 2021-2022 to select blackgram varieties for the Moulvibazar area. Among the varieties, the highest no of pods per plant was recorded in BARI Mash- 4 (48.55) while the lowest (30.55) was in BARI Mash-1. BARI Mash-4produced the highest yield (2.03 t/ha) followed by BARI Mash-3 (1.92 t/ha), and the lowest yield (1.42 t/ha) was observed in BARI Mash-1.

Introduction

Blackgram is one of the most important pulse crops. The family leguminoceae includes about 18000 species, which are characterized by their pods and alternate pinnate or trifoliate leaves (Cobley and Steele,1976).Blackgram is the most important pulse crops in the area and production of pulse crop. In Bangladesh. It stands most important in the consumer preference in the country. Due to rice based cropping pattern, low yield potential, susceptibility to disease the crop has been pushed to marginal and sub marginal lands. Blackgram is the most important pulse crop in area and production in Bangladesh especially in charland area. The inventory of main river char land estimated their total area at 8444km^2 or almost 6% of Bangladesh (FAP 16/19,1993a). In greater sylhet region, farmers usually keep their crop fields fallow in *kharif*-2 season due to scarcity of water and low p^H. Soil P^H and other atmospheric conditions play an important role in germination of blackgram. As a drought tolerant leguminous crop blackgram may be cultivated in this period. BARI has already developed some black varieties,but the farmers of semi hilly area mostly sown in the local cultivar. Now a day's farmers of Bangladesh are very much fascinated to grow high yielding variety along with registant early maturity characters. As a part of this programme was conducted to know the yield performance of blackgram variety cultivar^{-1} in semihilly areas of Moulvibazar.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, Akbarpur, Moulvibazar during the *kharif*-II season of 2021-22 to know the yield performance and popularize BARI blackgram varieties in semi hilly Moulvibazar area. The soil belongs to the "Khadimnagar" soil series sandy loam in texture having moderate organic matter content (1.45%), N 0.80%, K 0.07m mol 100^{-1}g of soil, P was 25 µg/g of soil and S was 10µg/g of soil with P^H value 4-5. Four mustard varieties viz. BARI Mash-1, BARI Mash-2, BARI Mash-3, BARI Mash-4 were sown on 12 September, 2021. Seeds were sown in line with 30 cm line spacing. Unit plot size was 3.0 m × 3.0 m. The experiment was laid out in RCB Design with 3 replications. Fertilizers were applied as basal at 40-85-40-50 kg/ha, of N, $P_2O_{5,}$ K_2O, S, in the form of Urea, TSP, MOP, Zypsum and 10t ha-1 well decomposed cowdung, respectively. Weeding was done at 20 days after emergence of the crop. Grain yield was calculated from the whole plot.Yield contributing characters were taken from 05 randomly selected plant from the middle rows of each plant. Data on different parameters were subjected to analyze of variance and the treatment means were compared by Least Significance Difference (LSD) test.

Results and Discussion

All the BARI released varieties took the same period to initiation stage at 5 DAS and took the 68-73 DAS to attain the physiological maturity. At harvest, all the variety more or less the same in plant height.The highest no. of branches/plant was observed by (16 no.) while the lowest was (11.no)

Yield contributing character and yield of different black gram varieties are presented in table 2. 1000 seed weight. The parameter was not significantly different among the cultivated variety. But, number of pods/plant, pod length, no of seed/pod, plant, population/m' and yield at harvest were significantly different among the variety. The highest no of pods per plant was recorded in BARI Mash-4 (48.55) while the lowest (30.55) was in BARI Mash-1. The highest pod length was recorded in BARI Mash-4 (5.45) while the lowest (4.73) was recorded in BARI Mash-1. The highest (7.05) no of seeds/pod at BARI Mash-1 was observed and the lowest one was 5.93 at BARI Mash-4. The highest no of plant/m was recorded in BARI Mash-4 (41) and the lowest (34.33) was recorded in BARI Mash-2. The highest yield was recorded in BARI Mash-4 (2.0 t/ha) while the lowest (1.42 t/ha) was recorded in BARI Mash-1.

Table 1. Days to the initiation, Days to maturity, plant height, and no of branches/plant of blackgram as influenced by different black gram varieties

Blackgram variety/ cultivar	Days to initiation	Days to maturity	Plant height (cm)	No. of branches/ plant
BARI Mash-1	5.33	68.33	64.10	11.66
BARI Mash-2	5.66	70.33	63.88	14.00
BARI Mash-3	5.66	72.33	63.55	15.66
BARI Mash-4	5.66	73.66	62.33	14.22
CV (%)	12.12	0.81	5.82	9.11
$LSD_{(0.05)}$	1.33	1.15	7.37	2.52

Figure(s) in a column having a common letter or without letter do not differ significantly by LSD

Table 2.Yield and yield component of blackgram as influenced by different blackgram varieties

Blackgram variety	No.of pods/plant	Pod length (cm)	No. of seeds/pod	Plant population/m^2	1000 seed weight (g)	Seed yield (t/ha)
BARI Mash-1	30.55	4.73	7.05	36.66	62.06	1.42
BARI Mash-2	43.77	4.94	6.92	34.33	62.89	1.57
BARI Mash-3	31.99	4.93	6.70	38.66	63.73	1.92
BARI Mash-4	48.55	5.45	5.93	41.00	59.53	2.03
CV (%)	7.9	6.04	3.89	2.62	4.12	2.1
$LSD_{(0.05)}$	6.11	0.60	0.51	1.97	5.11	0.073

Figure(s) in a column having a common letter or without a letter do not differ significantly by LSD

Conclusion

The result revealed that yield performance on the studied varieties was similar except for BARI Mash-4. All the black gram varieties performed better more precisely BARI Mash-4 could be recommended for the Moulvibazar area because of poor management practices, low price availability of its seeds, less risk, and easily grown without modern Technology.

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Production Programme

IMPROVEMENT OF EXISTING CROPPING PATTERN (*ITALI*-JUTE) THROUGH BARI RASUN-JUTE CROPPING PATTERN IN THE CHALAN BEEL AREA

J.A. CHOWDHURY, A.A. BEGUM, S.S. KAKON, M.R. KARIM AND D.A. CHOUDHURY

Abstract

A production program was conducted at the fatmers' field of Chalan beel area under Dobila village of Tarash upazila in Sirajganj district during rabi season of 2021-22 to compare the yield performance of BARI released garlic varieties against local variety with the aim to replace it by the best one for improving the garlic-jute cropping pattern. The garlic varieties, viz. BARI Rasun-3 and BARI Rasun-4 were compared with local variety Itali. BARI Rasun-3 produced maximum yield (12.44 t/ha) and it was 22% higher than local variety Itali. Local garlic variety "Itali" might be replaced by high yielding BARI Rasun-3 variety in garlic-jute cropping pattern to improve the productivity and farmers' income in chalanbeel area of Sirajganj. Use of BARI garlic variety rather than local variety produced higher jute equivalent yield (7.44-6.99 t/ha) which were 23.59 - 16.11% higher. Gross return (Tk. 559200-595200/ha), gross margin (Tk. 351875-387875/ ha) and benefit cost ratio (2.70-2.87) were also higher by using BARI varieties instead of local variety.

Introduction

Garlic (*Allium sativum* L.) is an important spice crop in Bangladesh. Chalan beel area is one of the pocket area of garlic where it is grown after T. *aman*/B. *aman* rice when water recede from the field under zero tillage condition. Farmers have been cultivating local varieties of garlic, those are poor yielder. BARI have released several higher yield potential garlic varieties such as BARI Rasun-1, BARI Rasun-2, BARI Rasun-3 and BARI Rasun-4 etc. There is a scope to increase the productivity of garlic-jute cropping pattern at Chalan beel area through using BARI released garlic varieties in their cropping pattern. So, it is required to fit HYV garlic variety in the existing cropping pattern. If we can introduce HYV BARI garlic variety in the existing jute based cropping pattern in Chalan beel areas, the farmers' will be benefited and productivity will be enhanced. Hence, the study was undertaken to compare the yield performance of BARI released garlic varieties against local variety with the view to replace it by the best one at Chalan beel area in garlic-jute cropping pattern.

Materials and Methods

The experiment was conducted at the farmers' field of Dobila village of Tarash upazila in Sirajganj district during *rabi* season of 2021-22. Garlic variety BARI Rasun-3, BARI Rasun-4, *Itali* (local variety) and Indian Tossa pat were used as treatment variables. The treatments are: V_1= BARI Rasun 3-Jute cropping pattern, V_2= BARI Rasun 4-Jute cropping pattern and V_3= *Itali*-Jute cropping pattern. The experiment was laid out in randomized complete block design with three dispersed replications. The unit plot size was 10m ×2m. The clove of garlic was planted on the muddy soil like rice seedling transplanting followed by covering with rice straw. In both crop, fertilizers were applied in the form of urea, TSP, MoP, Gypsum and zinc sulphate. Well decomposed cowdung @ 5 t/ha was also used. In garlic, 1/3 urea and full amount of other fertilizers were applied in the field before planting. Remaining 2/3 urea was top dressed in two equal installments at 30 and 55 days after planting followed by light irrigation. In case of jute, half of urea and all other fertilizers were applied as basal during final land preparation and remaining urea was top dressed at 45 days after sowing. Plant protection measures and intercultural operations were taken as and when necessary. Data on yield and yield contributing characters were taken and analyzed statistically. The treatment means were compared by using LSD test at 5% levels of significance. For comparison among the crop sequences, the yields of all crops were converted into jute equivalent yield on the basis of prevailing market price of individual crops. The economic indices like gross return, gross margin and benefit cost ratio were also calculated on the basis of prevailing market price of the commodities. Data on required inputs and agronomic management have been presented in Table 1.

Table 1: Data on required inputs and agronomic management for garlic-jute cropping pattern

Parameters	Crop	
	Garlic	Jute
Varieties	BARI Rasun-3, BARI Rasun-4, *Itali*	Indian Tossa pat
Seed rate (kg/ha)	400	6
Sowing method	Line sowing	Broadcast
Spacing (cm)	15 cm × 8 cm	-
Fertilizer dose (N,P,K,S,Zn kg/ha)	100-152-165-20-4	111-15-75-27-4
Date of sowing/planting	15 November 2021	4 April 2022
Date of harvesting (range)	28 March 2022	13 July 2022
Field duration (days)	135	100
Turnaround time (days)	7	

Result and Discussion

Yield and yield component of garlic

Yield and yield component of different garlic varieties have been presented in Table 2. Different varieties of garlic had significant effect on plant height, number of bulb/m^2, single bulb weight, bulb length, bulb diameter, clove no./bulb and bulb yield. The tallest plant (62.77 cm) was recorded in BARI Rasun-3 which was statistically identical with BARI Rasun-4. The shortest plant (40.30 cm) was observed in local variety *"Itali"*. The highest number of bulb/m^2 (99) was obtained from BARI Rasun-3 which was statistically similar with BARI Rasun-4 (96). Similar trend was also observed in case of single bulb weight, bulb length, bulb diameter and number of clove/bulb. Significantly the highest bulb yield (12.44 t/ha) was obtained from BARI Rasun-3 which was statistically identical with BARI Rasun-4 (11.67 t/ha). This result is in agreement with Alom *et al.*, 2017. The lowest bulb yield (10.20 t/ha) was found in local variety *"Itali"*. The highest bulb yield in BARI Rasun-3 was recorded might be due to cumulative effect of its yield components. BARI Rasun-3 and BARI Rasun-4 gave 22% and 15% higher yield than local variety respectively. It was noticeable that BARI Rasun-3 was found resistant to leaf blight disease. .

Table 2. Yield and yield contributing characters of garlic in garlic jute cropping pattern at challan beel (Sirajganj)

Treatment	Plant height (cm)	Bulb/m^2 (no.)	Single bulb wt. (g)	Bulb length (cm)	Bulb dia (cm)	Clove/bulb (no.)	Bulb yield (t/ha)	Yield increased over local (%)
V_1	62.77	99	13.61	4.83	3.90	24	12.44	22
V_2	56.10	96	12.86	4.17	3.37	21	11.67	15
V_3	40.30	90	10.08	3.50	2.60	17	10.20	-
$LSD_{(0.05)}$	7.61	6.70	2.57	0.76	0.62	2.47	0.78	
CV (%)	6.33	3.12	9.29	7.79	8.29	5.14	3.01	

V_1= BARI Rasun 3-Jute cropping pattern, V_2= BARI Rasun 4-Jute cropping pattern and V_3= *Itali*-Jute cropping pattern

Yield of Jute

Yield of jute have been presented in table 3. Fiber and stick yield of jute was not significantly varied among the treatment. Fiber yield of jute was noticed 2.12, 2.33 and 2.40 t/ha in $V_{1,}$ V_2 and V_3 treatment respectively and stick yield of jute was found 5.20, 5.32 and 5.44 t/ha from $V_{1,}$ V_2 and V_3 treatment respectively.

Table 3. Yield of jute in garlic jute cropping patterns at challan beel (Sirajganj)

Treatment	Fiber yield of jute (t/ha)	Stick yield of jute (t/ha)
V_1	2.12	5.20
V_2	2.33	5.32
V_3	2.40	5.44
$LSD_{(0.05)}$	NS	NS
CV (%)	12.76	2.30

V_1= BARI Rasun 3-Jute cropping pattern, V_2= BARI Rasun 4-Jute cropping pattern and V_3= *Itali*-Jute cropping pattern

Jute equivalent yield (JEY)

Jute equivalent yield (JEY) was calculated 7.44, 6.99 and 6.02 t/ha in V_1, V_2 and V_3 treatment respectively (Table 4). JEY was calculated about 23.59 and 16.11% higher when BARI Rasun 3 and BARI Rasun 4 were used respectively in garlic-jute cropping pattern instead of *Itali* variety.

Table 4. Jute equivalent yield (JEY)

Treat.	Bulb yield of garlic (t/ha)	Fiber yield of jute (t/ha)	Stick yield of jute (t/ha)	Jute equivalent yield (JEY) t/ha	Yield (JEY) increased in BARI Garlic -Jute pattern over *Itali* garlic-jute pattern(%)
V_1	12.44	2.12	5.20	7.44	23.59
V_2	11.67	2.33	5.32	6.99	16.11
V_3	10.20	2.40	5.44	6.02	-

Market price: Garlic: Tk. 47.00/kg, Jute: Tk.80.00, Jute stick: Tk.2.00/kg
V_1= BARI Rasun 3-Jute cropping pattern, V_2= BARI Rasun 4-Jute cropping pattern and V_3= *Itali*-Jute cropping pattern

Cost and return analysis

In cost and return analysis, it was calculated that garlic-jute cropping pattern showed better performance when BARI garlic variety was used instead of local variety. The highest gross margin (Tk. 387875/ha) was obtained when BARI Rasun 3 was used in the pattern, which was 28.70% higher than that of *Itali* variety cultivation. Higher BCR (2.87) was also recorded in the same pattern (Table 5).

Table 5. Cost and benefit analysis of the garlic-jute cropping pattern

Treatment	Gross return (Tk./ha)	Cost of production (Tk./ha)	Gross margin (Tk./ha)	BCR	Increased in gross margin (%)
V_1	595200	207325	387875	2.87	28.70
V_2	559200	207325	351875	2.70	21.08
V_3	481600	207325	274275	2.23	-

V_1= BARI Rasun 3-Jute cropping pattern, V_2= BARI Rasun 4-Jute cropping pattern and V_3= *Itali*-Jute cropping pattern
BCR=Benefit cost ratio

Farmers' opinion

Farmers opined that BARI Rasun-3 cultivation instead of local variety in garlic-jute cropping pattern gave the higher yield.

Conclusion

From the above findings it might be concluded that BARI Rasun -3 and BARI Rasun-4 could be fitted for cultivation in garlic-jute cropping pattern in Chalan beel area instead of local variety *"Itali"* for getting higher yield. But BARI Rasun-3 was the best for garlic-jute cropping pattern in chalanbeel area of Sirajganj.

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PERFORMANCE OF HYBRID MAIZE+POTATO INTERCROPPING IN CHALAN BEEL AERA

A.A. BEGUM, J.A. CHOWDHURY, S.S. KAKON, M.Z. ALI, M.R. KARIM, S.T. ZANNAT AND D.A. CHOUDHURY

Abstract

An experiment was conducted at farmers' field in Chalan beel area of Sirajgonj district during the *rabi* season of 2021-2022 to validate the performance of maize+ potato intercropping technology in Chalan beel area. The treatments were: T_1=Hybrid maize (60 cm × 20 cm) sown 10 days after potato planting in between two rows of BARI Alu- 8 (60 cm × 20 cm), T_2=Hybrid maize (60 cm × 20 cm) sown 10 days after potato planting in between two rows of *Deshal alu* (chalan beel local) (60 cm × 10 cm) and T_3=Sole hybrid maize (60 cm × 20 cm). Maize+ potato intercropping showed better performance (maize equivalent yield: 24.94 t/ha and 24.91 t/ha) and gave higher economic return (gross margin: Tk. 421000/ha and Tk. 420250/ha and BCR: 3.08). The yield of sole maize was lower (10.90 t/ha) than maize equivalent yield (24.94 t/ha and 24.91 t/ha) in maize + potato intercroppingsystem. Farmers showed interest to cultivate maize + potato intercrop for higher productivity and return.

Introduction

Chalan beel is an extensive lowland area in the lower Atrai basin and spreads across Singra and Gurudaspur upazilas of Natore district, Chatmohar, Bhangura, Faridpur upazilas of Pabna district and Ullahpara, Rajgonj and Tarash upazilas of Sirajgonj district. Beel (Low land goes under water and remains under water about 4-5 months generally from July to November) areas are under unfavourable ecosystem covering an area of 2.43 million hectares in Bangladesh (Aziz *et al*., 2016). Generally unfavourable ecosystem is less productive and remains fallow in most of the part of the year (BARC, 2013). *Boro* rice is the main crop in beel area. But *boro* rice require huge amount of water. One kg boro rice production requires 5000 litre water (Bouman, 2009). On the other hand maize requires 900 litre water (Bouman, 2009). Consequently, *boro* rice cultivation depleted huge amount underground water resulting bellowing the underground water level. Hence, alternate cropping rather than *boro* rice can save underground water resource as well as environment. In this context, *boro* rice can be replaced by maize + potato intercropping. Previous survey and experience indicate that farmers also grow maize, wheat, mustard, garlic, lentil, onion, pea, lathyrus, potato in beel area especially upper side land (Kandha) of beel (BARI, 2016). These crops require low water as compared to *boro* rice. Our Govt. policy is also pertains to save underground water resource and safe environment. Besides this, *boro* rice is a risk crop in beel area. Early flooding may damage the *boro* rice. Maize + potato intercropping is free from early flooding. Maize + potato intercropping is also higher productive than *boro* rice and may save underground water use as compared to *boro* rice cultivation in beel area. Hybrid maize+potato intercropping is a good proven technology widely practiced in all most all over the country. But this technology has not been studied in chalan beel area. In context, the present production programme was conducted to evaluate the performance of maize + potato intercropping technology at farmers' field in chalan beel area and also for adaption of less water requiring hybrid maize+potato intercropping instead of high water requiring *boro* rice in chalan beel area.

Materials and Methods

The experiment was conducted at the farmers' field in Chalan beel of Sirajgonj district during the *rabi* season of 2021-2022. It belongs to the Lower Atrai Basin (AEZ-5). Maize+potato intercrop covering 1500 m^2 of land. The spacing of potato and maize were maintained 60 cm × 20 cm. There were three treatments such as T_1=Hybrid maize (60 cm × 20 cm) sown 10 days after potato planting in between two rows of BARI Alu- 8 (60 cm × 20 cm), T_2=Hybrid maize (60 cm × 20 cm) sown 10 days after potato planting in between two rows of *Deshal alu* (chalan beel local) (60 cm × 10 cm) and T_3= Sole hybrid maize (60 cm × 20 cm) were used for this production programme. Tubers were planted on 15 November, 2021 and seeds of maize were sown 10 days after potato planting on 25 November, 2021. Fertilizers were applied at the rate of 250-55-115-40-2-1 kg/ha NPKSZnB as urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively (FRG, 2018). One-third of urea and full amount of all other fertilizers were applied at the time of final land preparation. The remaining urea was top dressed in two equal splits at 8-10 leaf stage (30-35 DAS) and taselling stage (50-60 DAS) and mixed thoroughly with the soil as soon as possible for better utilization. Intercultural operations and plant protection measures were taken as and when necessary. Chalan beel local potato was harvested on 01 February 2022 and BARI alu-8 was harvested on 15 February, 2022 and maize was harvested on 10 April 2022.At harvest, yield of both potato and maize were recorded plot wise.

Results and Discussion

Results of hybrid maize+potato intercropping have been given in Table 1 and Table 2. Maize+ potato intercropping showed better performance (maize equivalent yield: 24.94 t/ha and 24.91 t/ha when HYV potato and local potato intercropped with maize, respectively) and gave higher economic return (gross margin Tk. 421000/ha and Tk. 420250/ha and BCR: 3.08). The yield of sole maize was lower (10.90 t/ha) than maize +potato intercropping in terms of maize equivalent yield (24.94 t/ha and 24.91 t/ha).

Table 1. Yield of maize, potato and maize equivalent yield of maize+ potato intercropping at Chalan beel (2021-2022)

Treatment	Tuber yield of potato (t/ha)	Grain yield of maize (t/ha)	Maize Equiv. yield (t/ha)
T_1= Maize + BARI alu-8	25.50	9.64	24.94
T_2= Maize + *Deshal alu*	18.83	9.85	24.91
T_3= Sole maize	-	10.90	-

Table 2. Cost and return analysis of maize +potato intercropping at Chalan beel (2021-2022)

Treatment	Gross return (Tk./ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1= Maize + BARI alu-8	623500	202500	421000	3.08
T_2= Maize + *Deshal alu*	622750	202500	420250	3.08
T_3= Sole maize	272500	100000	172500	2.73

Selling price (Tk./kg): Maize= 25, BARI alu -8= 15, *Deshal alu* (Local)= 20

Farmer's opinion

Farmers showed interest to cultivate maize+ potato intercrop for higher productivity and returns. They also opined that they prefer local cultivar (*deshal alu*) more than HYV.

Conclusion

Results revealed that maize + potato as intercropping maize sown (60 cm × 20 cm) 10 days after planting of potato in between two rows of potato (60cm×20cm) was more profitable than sole maize. The technology should be disseminated through large scale pilot production programme.

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PERFORMANCE OF INTEGRATED WEED MANAGEMENT OF BARLEY

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Abstract

This research was carried out in farmer's field at Nawvanger char, sadar, Jamalpur during 2021-2022 to validate the developed weed management practice in barley. Treatments were included viz., T_1= Herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4DAS + one hand weeding at 35 DAS, T_2= Two hand weeding at 20 and 35 DAS and T_3= No weeding. The yield and yield contributing characters of barley production were influenced by hand weeding or herbicide spraying with hand weeding combination. As a result, Herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4 DAS + one hand weeding at 35 DAS might be a suitable and profitable weed management strategy to address critical period management with farmers spending a lot of time and money for weeding and being scarce during peak season.

Introduction

Barley (*Hordeum vulgare* L.) is the fourth largest cereal crop worldwide in terms of planting areas and has multiple uses, including malting, animal feed and human food (Hong *et al*., 2020). Barley is a versatile cereal grain with varieties that have high protein and low starch grown for animal feed, as well as varieties with high starch and low protein used for malting (Giraldo., 2019). Barley though a minor cereal plays an important role in our agriculture. This crop is usually grown in the marginal and char lands. It is mainly used as fodder and grain is used as industrial raw materials. The area under barley cultivation was recorded as 361 acres (BBS, 2020) which continuously decreased its area. Better yield of a crop depends on many factors. Proper intercultural operations like weeding are one of them. Weed is a serious problem in barley cultivation and that why farmers spending lot of times for weeding. There is a critical growth stage of weeding for each crop. But critical period is not determined yet. Hence determination of critical period is essential. Herbicide may have the capability to suppress the growth of weed. The herbicide consumption in Bangladesh is expected to increase dramatically in future due to labour scarce situation. Farmers spend lot of times and money for weeding. In context, the present investigation was conducted to verify the developed technology in farmers' field.

Materials and Methods

The experiment was conducted in farmer's field at Nawvanger char, sadar, Jamalpur, Bangladesh 24°57´ north latitudes and 89°55´ east longitudes during *rabi* 2021-2022. The experimental site was of medium high land belonging to the agro-ecological zone Old Brahmaputra Floodplain under Agro-Ecological

Zone 9. The unit plot size was 2m×2m. BARI Barley-6 was used as a variety in the experiment. Treatments were included viz., T_1= Herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4DAS + one hand weeding at 35 DAS, T_2= Two hand weeding at 20 and 35 DAS and T_3= No weeding. Seeds were sown on 18 October, 2021 and harvested on February 03, 2022. The crop was fertilized with 80-28-60-12-3.0 kg/ha of N-P-K-S-Zn, respectively (FRG' 2018) in the form of urea-TSP-MoP-gypsum-zinc sulphate and boric acid. Half N and full dose of other fertilizer was applied as basal dose during land preparation. Remaining N fertilizer was top dressed at 55-60 DAS (days after sowing) after irrigation in two equal splits and mixed thoroughly with the soil as soon as possible for better utilization. A light irrigation was given after sowing of seeds for uniform germination. Four irrigations were done depending on soil moisture. Intercultural operations like watering, weeding and spraying insecticides were followed as and when necessary.

Results and Discussion

Yield attributes and yield of barley

Yield attributes and yield of barley have been presented in Table 1. The highest plant, Panicle length, Seeds/panicle, 1000- grain wt. and grain yield (2.17 t/ha) were observed in Two hand weeding at 20 and 35 DAS (T_2) followed by Herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4DAS + one hand weeding at 35 DAS (T_1) and the lowest was observed in No weeding (T_3).

Cost and return analysis

Cost and return analysis has been presented in Table 2. The maximum gross return and gross margin were observed in Two hand weeding at 20 and 35 DAS (T_2). The maximum cost of cultivation was found in Two hand weeding at 20 and 35 DAS (T_2) due to maximum labour cost was engaged in two hand weeding but the maximum BCR was observed in Herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4DAS + one hand weeding at 35 DAS (T_1).

Table 1. Effect of integrated weed management on the yield and yield contributing characters of barley

Treat.	Plant ht. (cm)	Spike length (cm)	Grains/spike (no.)	1000- grain wt. (g)	Grain yield (t/ha)
T_1	80.2	8.82	49.7	30.50	1.95
T_2	86.8	10.5	52.2	33.00	2.17
T_3	75.4	7.0	39.8	24.20	1.18

Table 2.Cost and return of integrated weed management of barley

Treat.	Gross return (Tk./ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	MBCR
T_1	97500	50500	47000	1.93
T_2	108500	57000	51500	1.90
T_3	59000	33750	25250	1.75

T_1= Herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4 DAS + one hand weeding at 35 DAS, T_2= Two hand weeding at 20 and 35 DAS and T_3= No weeding

Selling price (Tk./kg): Barley= 50/-

Conclusion

According to the findings of the study integrated weed management had a considerable impact on grain yield of barley. As a result , Herbicide G-Penda 33 EC (Pendimethylene) @ 3 L/ha spraying at 4 DAS + one hand weeding at 35 DAS might be a suitable and profitable weed management strategy to address critical period management with farmers spending a lot of time and money for weeding and lobor being scarce during peake season

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PRODUCTION PROGRAMMEOF HYBRID MAIZE+SWEET POTATO INTERCROPPING AT CHAR LAND AREA IN RANGPUR AND JAMALPUR

A.A. BEGUM, M.A.I. SARKER AND J. RAHMAN

Abstract

The production programme was conducted at the Mohipur char area, Gangachara, Rangpur and at Nawvanger char, sadar, Jamalpur during *rabi* season of 2021-22 to validate planting system of the component crops in maize + potato intercropping for higher productivity and economic return for the farmers of char land in Bangladesh. Two intercrop combinations viz., (i) maize normal row + one row sweet potato and (ii) maize paired row + two rows sweet potato were evaluated against sole maize crop. At Jamalpur, treatment combination was changed and it was maize paired row + three rows sweet potato were evaluated against maize sole crop. The highest maize equivalent yield, gross return, gross margin and marginal benefit cost ratio were obtained from the maize paired row + two rows sweet potato combination in Rangpur and from maize normal row +one row sweet potato in Jamalpur. The results revealed that Maize + sweet potato intercropping was more productive and profitable than sole maize and ensure food security for resource poor farmers of char land in Bangladesh.

Introduction

In Bangladesh, there are about 0.82 million hectares of char land (Ahmed *et al.*, 1987). Majority of the char families live below the poverty line and have lack money to buy foods from the market. Hence, it is necessary to encourage farmers to adopt innovative integrated crop intensification approaches to increase productivity of their lands. Intercropping is one of the cropping strategies that have been recognized to improve the food security situation and incomes for the farmers (Mahfuza, 2012). Intercropping system becomes more productive and profitable when it is done properly by selecting compatible crops (Begum *et al.*, 2010), spatial arrangements and population density of component crops (Islam *et al*., 2006). The sweet potato (*Ipomoea batatas* L.) is an important tropical crop worldwide, providing starch, beta-carotene, vitamin A, potassium, fibre, anthocyanins for human nutrition, industrial use (Fanta, 2019). Sweet potato is the most important tuber crop production in Bangladesh and most area covered by char land. In Bangladesh 56869 acres of land with an annual production of sweet potato 235881 M Ton (BBS, 2020). On the other hand, maize is spaced crop and cultivated throughout the year, so there is a scope of using this space through growing other crop as intercrop. Its demand especially for poultry feed and fodder is increasing day by day. Generally, char farmers grow hybrid maize and sweet potato in char land area as sole crops. Hybrid maize-sweet potato intercropping is compatible as they possess different photosynthetic pathways, different growth habit and requirement of different growth resources (Islam *et al*., 2007). This system may be popular in char areas for their high yield potential. In that region, Maize + sweet potato intercropping may increase total productivity as well as increase crop diversity instead of sole sweet potato or sole maize. In context, the present production programme was conducted to verify the technology in farmers' field for increasing productivity and for adaption of hybrid maize+ sweet potato intercropping instead of sole sweet potato or sole maize at char land in Rangpur.

Materials and Methods

The production programme was conducted at Mohipur char area, Gangachara, Rangpur and at Nawvanger char, sadar, Jamalpur during *rabi* season of 2021-22. Three combinations of maize-sweet potato intercropping system were evaluated such as: T_1 = Maize normal row (60 cm × 20 cm) + one row sweet potato (60 cm × 30 cm) in between two normal rows of maize (100% MNR: 60% SP), T_2 = Maize paired rows (30 cm / 120 cm /30 cm × 20 cm) + two rows sweet potato (60 cm × 30 cm) in between two paired rows of maize (100% MPR: 40 % SP) and T_3 = Sole maize (60 cm × 20 cm) at Rangpur and at Jamalpur, treatment were: T_1 = Maize normal row (60 cm × 20 cm) + one row sweet potato (60 cm × 30 cm) in between two normal rows of maize (100% MNR: 60% SP), T_2 = Maize paired rows (30 cm / 120 cm / 30 cm × 20 cm) + three rows sweet potato (60 cm × 30 cm) in between two paired rows of maize (100% MPR: 60 % SP) and T_3 = Sole maize (60 cm × 20 cm). The unit plot size was 20 m × 20 m (10 decimal) for each combination in both locations. The hybrid maize (var. Kaberi 50 at Rangpur and NK-40 at Jamalpur) and sweet potato (var. BARI SP-8 at both locations) were used in these demonstrations. Seeds of maize and vines of sweet potato were sown or planted on 17 November, 2021at Rangpur and on 13 October, 2021 at Jamalpur. Sole hybrid maize and intercropping systems were fertilized with 260-55-115-40-4-1 kg/ha of NPKSZnB (FRG, 2018) at both locations. The full amount of P K S Zn B and 1/3 N were applied as basal in the form of triple super phosphate, muriate of potash, gypsum, zinc sulphate, boric acid and urea, respectively. The remaining N was top dressed in two equal splits at 30 and 60 days after sowing/planting (DAS/DAP). Irrigation was given after sowing or planting for proper establishment of crops. Subsequently three irrigations were applied at 30, 60 and 90 DAS/DAP. Two hand weeding were done at 20 and 40 DAS/DAP to keep the crops reasonably weed free. Maize cobs were harvested at physiological maturity stage 20 April, 2022 (154 DAS) at Rangpur and on 06 March 2022 (144 DAS) at Jamalpur. On the other hand, sweet potato was harvested at maturity stage 27 April, 2022 (161 DAP) at Rangpur and on 10 February 2021 (120 DAP) at Jamalpur. Yields of both the crops were taken from whole plot and marginal benefit cost analysis was done in both locations. Maize equivalent yield was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Bandyopadhyay (1984) as given below:

Maize equivalent yield = $Ym + (Ys \times Ps)/ Pm$

Where, Ym=Yield of intercrop maize, Ys =Yield of intercrop sweet potato, Ps=Market price of sweet potato and Pm= Market price of maize

Results and Discussions

Grain yield of maize, root yield of sweet potato and maize equivalent yield

At Rangpur

The results are shown in Table 1. The highest seed yield (8.9 t/ha) was obtained in sole maize which was 8.5% and 4.7% higher than maize normal row + one row sweet potato and maize paired rows + two rows sweet potato intercropping systems, respectively. Numerically, the highest root yield (13.6 t/ha) of sweet potato was found in maize paired row + two rows sweet potato intercropping system and the sweet potato gave 20.4% higher root yield than maize normal row + one row sweet potato intercropping system. Total productivity in terms of maize equivalent yield was the highest (16.66 t/ha) in maize paired row + two rows sweet potato which was 85.9 % and 11.2% higher than sole maize and maize normal row + one row sweet potato, respectively.

The highest maize equivalent yield in this combination was observed because of the higher accumulated seed yield of maize and root yield of sweet potato. This result is in line with the findings of Uddin *et al.* (2006).

Table 1. Grain yield of maize, root yield of sweet potato and maize equivalent yield in maize sole and intercropping systems at Mohipur char in Rangpur during 2021-2022

Treatment	Grain yield of maize (t/ ha)	Root yield of sweet potato (t/ha)	Maize equivalent yield (t/ha)	% increased of MEY over sole maize
Maize normal row + one row sweet potato	8.20	11.3	14.98	67.2
Maize paired rows + two rows sweet potato	8.50	13.6	16.66	85.9
Sole maize	8.96	-	8.96	-

Economic performance

The economic performance of hybrid maize-sweet potato intercropping systems is presented in Table 2. Gross return followed the similar trend to maize equivalent yield. Cost of production differed in different planting systems due to involvement of different variable costs. The highest net return was obtained from maize paired row + 2 rows sweet potato combination (BDT 280800/ha). Though the cost of production of this combination was higher than the sole crop but highest net return was recorded due to the highest gross return. The highest marginal benefit cost ratio (3.06) was also recorded maize paired row + 2 rows sweet potato indicating profitable combination of maize sweet potato intercropping systems. Similar trend was reported by Begum *et al.* (2010) and Islam *et al.* (2014).

Table 2. Benefit cost analysis of sole maize and intercropping system at Mohipur char in Rangpur during 2021-2022

Treatment	Gross return (Tk/ha)	Cost of cultivation (Tk/ha)	Gross margin (Tk/ha)	MBCR
Maize normal row + one row sweet potato	374500	135700	238800	2.76
Maize paired rows + two rows sweet potato	416500	135700	280800	3.07
Sole maize	224000	105500	118500	2.12

Market price (Tk./kg): Maize= 25 and sweet potato =15

At Jamalpur

Results and Discussion

Although total grain yields of maize/sweet potato intercropping were higher than that of sole crop. Another important aspect for maize/sweet potato intercropping is the efficient use of light because of complementary use of space between the maize plants and the sweet potato plants. The complementary effect is also shown for the length of the growth period because their life cycles are different, with the maturity of intercropped. The yield, gross return, cost of cultivation and MBCR of maize/sweet potato are presented in and Table 4. From the Table, it was revealed that gross return per hectare was found higher in maize/sweet potato intercropping system than sole cropping. Maize equivalent yield (MEY) was highest from maize normal row with one row sweet potato (17.87 t/ha) system.

Table 3. Grain yield of maize, root yield of sweet potato and maize equivalent yield in maize sole and intercropping systems at Nawvanger char in Jamalpur during 2021-2022

Treatment	Grain yield of maize (t/ha)	Root yield of sweet potato (t/ha)	Maize equivalent yield (t/ha)	% increased of MEY over sole maize
Maize normal row + one row sweet potato	13.2	4.67	17.87	32.4
Maize paired rows + two rows sweet potato	9.14	5.58	14.72	9.0
Sole maize (60 cm × 20 cm)	13.50	-	13.50	-

Table 4. Benefit cost analysis of sole maize and intercropping system at Nawvanger char in Jamalpur during 2021-2022

Treatment	Gross return (Tk/ha)	Cost of cultivation (Tk/ha)	Gross margin (Tk/ha)	MBCR
Maize normal row + one row sweet potato	536100	90000	446100	6.0
Maize paired rows + two rows sweet potato	441600	105000	336600	4.2
Sole maize	405000	71250	333750	5.6

Selling price (per kg): Maize; 30/- , Sweet potato; 30/-

Farmers' reaction

Farmers of both locations usually cultivate sole maize. Farmers of these areas were interested to cultivate maize - sweet potato intercropping instead of sole maize for higher productivity and economic return. They opined that all the intercrop combinations were so good and take it easily as a new technology for higher productivity and economic return in char land. The by-product of cereal-tuber crops was preferred for animal feed or human nutritional supplementation.

Conclusion

From the result, it could be concluded that Maize + sweet potato intercropping was more productive and profitable than sole maize. So it could be suggested that the farmer of maize growing area would be benefited by Maize paired rows (30cm/120cm/30cm × 20cm) + two rows sweet potato (40cm × 30cm) intercropping system at Rangpur and farmers of Jamalpur would be benefited by Maize normal row (60cm × 20cm) + one row sweet potato (60cm × 30cm) intercropping system.

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PERFORMANCE OF INTERCROPPING SPINACH AND RED AMARANTH WITH BRINJAL

M.Z. ALI, M.A.H. KHAN AND D.A. CHOUDHURY

Abstract

An experiment was conducted at the farmer's field of Baleswar under sadarupazila of Cumilla district during 20121-22 to validate the technology of suitable crop combination of spinach and red amaranth with brinjal for increasing total productivity, economic return and maximize land utilization through intercropping system. Three treatments viz., T_1=3 rows spinach 75% (20 cm row spacing with continuous sowing) in between two row of brinjal 100% (80 cm × 60 cm), T_2=3 rows red amaranth 75% (20 cm row spacing with continuous sowing) in between two row of brinjal 100% (80 cm × 60 cm) andT_3=Sole brinjal (80 cm × 60 cm) were used in the study. Results showed that, different intercropping combination significantly influenced yield and yield contributing characters of brinjal. The yield of brinjal comparatively lower in intercropping but total productivity increased due to additional yield of spinach and red amaranth. All the intercropping combinations showed better performance in terms of brinjal equivalent yield, gross return and benefit cost ratio (BCR) over sole crops. Among the intercropping combinations, 3 row spinach 75% (20cm row spacing with continuous sowing) in between two row of brinjal 100% (80 cm×60cm) was the most feasible and profitable intercropping system in respect of brinjal equivalent yield (35.82 t/ha), gross return (Tk. 7,16400/ha), gross margin (Tk. 4,64400/ha) and marginal benefit cost ratio (2.82).

Introduction

Bangladesh is a densely populated country. Day by day cultivable area is declining due to over growing population, urbanization and industrialization. As a result, our total food demands are increasing but cultivable land area is decreasing. Intercropping is a traditional practice in Bangladesh and it increases total productivity per unit area through maximum utilization of land, labour and growth resources (Ahmed *et al*. 2013; Islam *et al*. 2006; Mahfuza *et al*. 2012). By judicious choice of compatible crops and adopting appropriate planting geometry, inter/intra specific competition may be minimized resulting higher total productivity (Alom-*et al.* 2013). Canopy architecture of tall stature crop regulates the availability of light on under storied crop (Faruque *et al*. 2006). In Bangladesh small farmers constitute 79.4% of our farming community and their cultivated lands are shrinking day by day (MOA, 2014). In that context, intercropping is one of the viable technologies to ensure efficient utilization of their resources for increased production and family income. Intercropping offers the possibility of yield advantage relative to sole cropping through yield stability and improved yield in tropical and sub-tropical areas (Nazir *et al*. 2002; Malik *et al*. 2002; Bhatti *et al*. 2005). Brinjal (*Solanum melongena* L.) is an important vegetable crop is cultivated round the year throughout the country in Bangladesh. It is tall structure, long durated (140-180 days) and wide spaced (80 cm x 60 cm) crop. So, there is a great scopeto cultivate short durated (30-45 days) leafy vegetable like red amaranth and spinach in the inter row space of brinjal could be introduced as intercrop. Leafy vegetable like red amaranth and spinach being short structure quick growing crops can be easily intercropped between two rows of brinjal at early growth stage for getting higher economic return. However, the literature regarding spinach-brinjal and red amaranth- brinjal intercropping is very scarce. Keeping this view in mind, the experiment was undertaken to find out the suitable crop combination of spinach and red amaranth with brinjal for increasing total productivity, economic return and maximize land utilization through intercropping system.

Materials and Methods

A field experiment was conducted at the farmer's field of Baleswar under sadarupazila of Cumilla district during 20121-22. The treatments were: T_1=3 row spinach 75% (20 cm row spacing with continuous sowing) in between two row of brinjal 100% (80 cm × 60 cm), T_2=3 row red amaranth 75% (20 cm row spacing with continuous sowing) in between two row of brinjal 100% (80 cm×60 cm) and T_3=Sole brinjal

(80 cm × 60cm). The trial was set up in a randomized complete block design with three replications. The unit plot size was 4.0 m × 2.4 m. The sole crop of brinjal and intercropped treatments were fertilized with cow dung @ 5 t/ha and 120-31-120-13-3-1.5 kg/ha N-P-K-S-Zn-B in the form of urea, triple super phosphate, murate of potash, gypsum, zinc sulphate and boric acid, respectively. For sole brianjal and intercrop full amount of all other fertilizer except N and K were applied in pit before 1 week of transplanting brinjal. N and K were applied in three equal splits at 21, 40 and 60 days after transplanting (DAT) brinjal as ring method followed by irrigation. Brinjal (var. BARI Begun-8) as main crop and red amaranth (var. BARI Lalshak-1) and spinach (var. BARI Spinach-1) were used as intercrops in this study. The sole crop of brinjal was planted at a spacing of 80 cm x 60 cm. In intercropping system three rows of spinach (75%) and three rows of red amaranth (75%) were intercropped in between two rows of brinjal. After establishment of brinjal seedling (12 days after planting) spinach and red amaranth seeds were sown as per treatments. Brinjal (Thirty days old seedling) was transplanted on 29 November, 2021 and seed of spinach and red amaranth sown on 11 December 2021, respectively. Brinjal was harvested five times and it was harvested on 18 March, 2022, 03 April 2022, 21 April, 2022, 1 May 2022 and 14 May 2022. Spinach and red amaranth were harvested on 21 January, 2022. Four irrigations were done in the experimental field. First was applied at just after transplanting (brinjal) and sowing of the component crops for proper germination. Second, third and fourth irrigation was applied at 45, 60 and 90 days after transplanting (DAT) of brinjal. Weeding was done as per requirement. Sex pheromone trap was used for control of brinjal shoot and fruit borer from active vegetative stage up to fruit developing stage. For brinjal data on yield and yield contributing characters were taken and analyzed statistically. The yield component data of brinjal was taken from 10 randomly selected plants prior to harvest from each plot. For brinjal, spinach and red amaranth at harvest, the yield data was recorded plot wise. The collected data were analyzed statistically using MSTAT-C package and means were adjudged by LSD test at 5% level of probability Brinjal equivalent yield (BEY) was converted by converting yield of intercrops on the basis of market price of individual crop following the formula:

$$\text{BEY} = \text{Yield of intercrop brinjal} + \frac{\text{Yi} \times \text{Pi}}{\text{Price of brinjal}}$$

Where, Yi=yield of intercrops (Spinach/Red amaranth) and Pi=Price of intercrop (Spinach/Red amaranth).

Results and Discussion

Yield and yield contributing characters of brinjal single furit weight (g), number of fruit/plant, fruit length (cm), fruit diameter (cm) and yield of brinjal was significantly influenced due to intercropping spinach and red amaranth with brinjal (Table 1). The highest single fruit weight (88.78 g) was obtained in sole planting of brinjal and the lowest (84.44 g) in T_1 treatment. Similar trend was found in case fruit length and fruit diameter. The highest fruit length (24.65 cm) and fruit diameter (4.35 cm) was recorded in sole brinjal (T_3) treatment and the lowest fruit length (22.45 cm) and fruit diameter (4.05 cm) was recorded in T_1 treatment. The highest brinjal yield (24.2 t/ha) was obtained from sole treatment T_3 (Sole brinjal) and the lowest (18.42 t/ha) in T_1 treatment. The higher fruit yield in sole crop was attributed to more number of fruit/plant and higher single fruit weight. Islam *et al.* (2014) also reported similar result.

Table 1. Yield and yield attributes of brinjal (var. BARI Begun-8), spinach and red amaranth yield under sole and intercropping situation

Treatment	Plant height (cm)	Number of fruit/plant	Single fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield of brinjal (t/ha)	Spinach/Red amaranth yield(t/ha)
T_1	94.73	18.55	84.44	22.45	4.05	18.42	23.2
T_2	95.60	19.35	85.96	23.22	4.15	19.27	14.2
T_3	98.82	20.85	88.78	24.65	4.35	24.2	-
LSD	NS	NS	1.2	1.0	0.22	2.3	
CV (%)	105	11.6	14.2	12.2	9.8	8.9	

Brinjal equivalent yield (BEY)

Brinjal equivalent yield was expressed in total productivity. Brinjal equivalent yield were higher in both intercrops (35.82– 33.27 t/ha) than the sole crop of brinjal (24.2 t/ha) (Table 2). In intercrop combination the higher brinjal equivalent yield (35.82 t/ha) was recorded in T_1 treatment which was followed by T_2 (33.47 t/ha) treatment and the lowest brinjal equivalent yield (24.2 t/ha) was obtained from T_3 treatment (sole brinjal). Ahmed *et al*. (2013) also reported that intercrop combination increase the equivalent yield.

Table 2.Brinjal equivalent yield (BEY), land equivalent ratio (LER) and cost and return analysis of brinjal, spinach and red amaranth under sole and intercropping situation

Treatment	BEY (t/ha)	Gross return (Tk./ha)	Cost of production (Tk./ha)	Gross margin (Tk./ha)	MBCR
T_1	35.82	7,16400	2,52000	4,64400	2.84
T_2	33.47	6,69400	2,55000	4,14400	2.62
T_3	24.2	4,84000	2,20000	2,64000	2.20

Price: Brinjal: Tk. 20/kg. Red amaranth: Tk. 20/kg, Spinach: Tk. 15/kg

Note: T_1=3 row spinach 75% (20 cm row spacing with continuous sowing) in between two row of brinjal 100% (80 cm × 60 cm), T_2=3 row red amaranth 75% (20 cm row spacing with continuous sowing) in between two row of brinjal 100% (80 cm × 60 cm) and T_3=Sole brinjal (80 cm × 60 cm).

Cost and return analysis

Intercropping combination of spinach and red amaranth with brinjal showed higher monetary return than sole crop (Table 2). The highest gross return (Tk.7,16400/ha) was recorded from T_1 treatment which was 48 percent higher than sole brinjal (Table 2). This intercropping combination also gave the higher gross margin (Tk. 464400/ha) and benefit cost ratio (2.84) followed by T_2 treatment with BCR (2.62). The results of increased productivity and returns were consistent with the earlier reports of yield advantage of crop mixture compared to monoculture (Akhteruzzaman*et al.* 1991, Islam *et al.* 2012 and Ahmed *et al*. 2013).

Farmer's opinion

Farmers of these areas were interested to cultivate brinjal – spinach/ red amarnath intercropping instead of sole brinjal for higher productivity and economic return because they could harvest spinach and red amaranth within 31-35 days which would not hampered brinjal growth. They also opined that the intercrop combinations were so good and took it easily as a new technology for higher productivity and economic return.

Conclusion

The results revealed that, both intercropping treatments were productive as compared to sole treatment but T_1 treatment that means 3 row spinach 75% (20 cm row spacing with continuous sowing) in between two rows of brinjal 100% (80 cm × 60 cm) intercrop combination was more productive and profitable in respect of brinjal equivalent yield and monetary return.

PRODUCTION PROGRAMME OF INTERCROPPING GARDEN PEA WITH SORGHUM IN ACIDIC SOIL AT MOULVIBAZAR

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Abstract

A production program was conducted at the farmer's field of Narayonpur, Uttormajdihi, Srimongal, Moulvibazar during the Rabi season of 2021-2022 to validate the performance of Sorghum + garden pea intercropping technology. There were two treatments such as T_1= Sorghum normal row (60cm×10cm) + two rows garden pea (20cm × 10cm) and T_2= Sole Sorghum (60cm×10cm). Sorghum + garden pea intercropping showed better performance (Sorghum equivalent yield: 21.35 t/ha) and gave a higher economic return (gross margin Tk. 324500 /ha and MBCR: 4.17). The yield of sole Sorghum was lower (3.50 t/ha) than Sorghum equivalent yield (21.35 t/ha) in Sorghum + garden pea intercropping. Farmers showed their interest to cultivate Sorghum + garden pea intercrop for higher productivity and economic return.

Introduction

The production programme or block demonstration is one of the simplest and most popular ways of technology dissemination and farmer's motivation. Bangladesh is an overpopulated country with a small land area where food demand is very high. In order to produce more food within a limited area, one of the most important options is to increase the cropping intensity and produce two or more crops over the same piece of land. On the other hand, a good number of farmers can see the technology practically through the process and the growers can decide their future tasks and plan. With this view, the Agronomy Division, BARI, Gazipur with the help of Regional Agricultural Research Station (RARS), Akbarpur, Moulvibazar conducted a production program of Sorghum + garden pea intercropping at acidic soil in a farmer's field. Higher productivity from intercropping depends on judicious choice of component crops, suitable planting system or proportion of component crops (Islam *et al*., 2006). Sorghum is an unbranched and erect cereal crop grown with wide spacing. Several short-duration and short stature vegetables like garden pea may be grown in association with sorghum. Sorghum grain is as nutritious as other cereal grains which contain about 11% water, 340 k.cal of energy, 11.6% protein, 73% carbohydrate, and 3% fat by weight (Thimmaiah, 2002; Taylor *et al*., 2006; Yan *et al*., 2012). Garden pea is a very popular vegetable rich in different nutrients. It contains about 68g of water, 127 k.cal of energy, 7.4g protein, 24g carbohydrate and 26g calcium per 100 grams edible portion. Generally, legumes in association with non-legumes help not only in the utilization of the nitrogen being fixed in the current growing season but also help in residual nutrients build-up of the soil (Kakraliya *et al*., 2018). Legumes allow the sequestration of carbon (1.42 Mg C ha^{-1} $year^{-1}$) in soils and induce the conservation of fossil energy inputs in the system (Kakraliya *et al*., 2018). This production program was conducted to increase yield and economic return and to increase cropping intensity in acidic soil of Moulvibazar as well as Sylhet division.

Materials and Methods

The production programme was conducted at farmer's fields of Narayonpur, Uttormajddi, Srimongal, and Moulvibazar which was near to Regional Agricultural Research Station, Akbarpur, Moulvibazar during the Rabi season of 2021-22 which belonged to under the Agro-Ecological Zone of Eastern Surma-Kushiyara Floodplain (AEZ 20) and Northern and Eastern Hills (AEZ-29). The experimental field was situated at 24°24/ -24°38′ N latitude and 91°37′-91°37′ E longitude. The soil belongs to the "Khadimnagar" soil series, sandy loam in texture having moderate organic matter content (1.45%), N 0.80%, K 0.07m mol/100g of soil, P was 25 µg/g of soil and S was 10µg/g of soil with pH value 4-5. The production program was conducted at the farmer's field of Narayonpur, Uttormajddi, Shreemogol, Moulvibazar during the *The Rabi* season of 2021-2022. Sorghum + garden pea intercropping covering 15 decimals of land. There were two treatments such as T_1= Sorghum normal row (60cm × 10cm) + two rows garden pea (20cm × 10cm) and T_2= Sole Sorghum (60cm × 10cm). Sorghum (var. BARI Sorghum-1) and garden pea (var. BARI Motorshuti-3) were used for this production programme. Seeds were sown on 24 November 2021. Dolomite was used @ 2 ts/ha before sowing seed. Both seeds were treated with provax @ 3g kg^{-1} of seed. Fertilizers were applied at the rate of 120-48-75-30-3- 1 kg ha^{-1} of N, P, K, S, Zn, B as Urea, Triple Super Phosphate (TSP), Muriate of Potash (MoP), Gypsum, Zinc sulphate and Boric acid for intercrop. One-third of N, the whole amount of TSP, MoP, gypsum, zinc sulphate, and boric acid were applied as basal. The remaining 2/3 N was top dressed at 25 and 45 days after sowing (DAS) of sorghum. In intercrop, extra N (40 kg ha^{-1}) was applied in 2 splits at 20 and 35 DAS to garden pea. Intercultural operations and plant protection measures were taken as and when necessary. Garden pea was harvested on 7-10 January, 2022 and sorghum was harvested on 20 April, 2022.

Results and Discussion

Results of Sorghum + garden pea intercropping have been given in Table 1 and Table 2. Sorghum + garden pea intercropping showed good performance (maize equivalent yield: 21.35 t/ha) and gave a better economic return (gross margin Tk. 324500 /ha and MBCR: 4.17). The yield of sole Sorghum was lower (3.50 t/ha) than Sorghum + garden pea intercropping in terms of Sorghum equivalent yield (21.35 t/ha).

Table 1. Yield of Sorghum, garden pea and Sorghum equivalent yield of Sorghum + garden pea intercropping during *rabi* 2021-2022

Treatment	Green pod yield of garden pea (t/ha)	Grain yield of Sorgum (t/ha)	Sorghum Equiv. yield (t/ha)
T_1= Sorghum + garden pea	6.25	2.60	21.35
T_2= Sole Sorghum	-	3.50	3.50

Table 2. Cost and return analysis of Sorghum + garden pea intercropping at Akberpur (2021-2022)

Treatment	Gross return (Tk. /ha)	Cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	MBCR
T_1= Sorghum + garden pea	427000	102500	324500	4.17
T_2= Sole Sorghum	70000	50000	20000	1.40

Selling price (Tk./kg): Sorghum= 20, garden pea=60

Farmer's opinion

Farmers showed their interest to cultivate Sorghum + garden pea intercrop for higher productivity and economic returns.

Conclusion

Results revealed that Sorghum (60cm×20cm) + two rows garden pea (20cm×10cm) as intercropping was more profitable than sole Sorghum. The technology might be disseminated through large-scale pilot production programme in the area of Moulvibazar.

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PRODUCTION PROGRAM OF INTERCROPPING GARDEN PEA WITH HYBRID MAIZE IN ACIDIC SOIL AT MOULVIBAZAR

A.A. BEGUM, M. SHAHEENUZZAMN, M.R. KARIM AND D.A. CHOUDHURY

Abstract

A production program was executed by RARS, Moulvibazar at the farmer's field of Giasnagor, Sadar, and Moulvibazar during the Rabi season of 2021-2022 to validate the performance of Hybrid maize + garden pea intercropping technology. There were two treatments such as T_1= Maize normal row (60cm × 20cm) + two rows garden pea (20cm×10cm) and T_2= Sole Maize (60cm × 20cm). Maize + garden pea intercropping showed better performance (maize equivalent yield: 15.26 t/ha) and gave a higher economic return (gross margin: Tk. 230720 Tk./ha and MBCR: 3.20). The yield of sole maize was lower (7.50 t/ha) than maize + garden pea intercropping in terms of maize equivalent yield (15.26 t/ha). Farmers showed interest to cultivate Maize+ garden pea intercrop for higher productivity and return.

Introduction

The production program is the simplest and most popular way of technology dissemination and farmer's motivation in specific circumstances. It improves the opportunity of exchanging prospects and constraints to achieve goals and objectives, views, and ideas as well as sharing experiences among researchers, extension personnel, and farmers (Annual Research Report, 2021). On the other hand, a good number of farmers looked to new technology practically low cost but higher income, greater knowledge, and improved channel of communication with the consumers (Rahaman *et al.*, 2021).The production programme can contribute to an economically efficient for a specific area and the financial viability for farmers, while improving environmental performance and which are socially acceptable. With this view, RARS, Akberpur, Moulvibazar conducted a production program of Hybrid maize + garden pea intercropping in acidic soil. *Soil* acidification threatens dryland crop production in the *soils* of the entire Sylhet region in Bangladesh. The advantages of legume cereal^{-1} intercrops are often assumed to arise from the complementary use of N sources by intercropping with legumes because intercropped legumes can meet their N demand due to the complementarities between symbiotic N_2 fixation, soil N acquisition, and intercropped cereals uptake of more N from the soil than they stand in sole cropping (Bedoussac *et al*, 2010 and Musa *et al*, 2012). This is of particular interest for developing low-input and sustainable cropping systems. In addition, legume maize (*Zea mays* L.) intercropping has higher land use efficiency, lower water consumption, and more ecological and environmental benefits compared to a cereal-cereal intercropping (Siddique *et al*, 2001; Li *et al*, 2011). Maize+garden pea is an important intercrop technology. But this intercropping has not been introduced at all to the acidic soil of farmers' fields.

Therefore, it is imperative to validate and introduce the performance of Maize+ garden pea intercropping technology at acidic soil of farmers' fields in Moulvibazar districts.

Materials and Methods

The Production programme was conducted at the farmer's field of Giasnagor, Sadar, Moulvibazar which was near to Regional Agricultural Research Station, Akbarpur, Moulvibazar during the *Rabi* season of 2021-22 which belonged to the Agro-Ecological Zone of Eastern Surma-Kushiyara Flood plain (AEZ 20) and Northern and Eastern Hills (AEZ-29). The experimental field was situated at 24°24′ -24°38′ N latitude and 91°37′-91°37′ E longitude. The soil belongs to the "Khadimnagar" soil series, sandy loam in texture having moderate organic matter content (1.45%), N 0.80%, K 0.07m mol $100g^{-1}$ of soil, P was 25 µg g^{-1} of soil and S was 10µg g^{-1} of soil with P^H value 4-5. Maize + garden pea intercrop covering 15 decimals of land. The spacing of maize in Maize + garden pea intercropping was maintained at 60 cm × 20 cm and two rows of garden pea were maintained in between two rows of Maize. There were two treatments such as T_1= Maize normal row (60cm × 20cm) + two rows garden pea (20cm × 10cm) and T_2= Sole Maize (60cm × 20cm). Hybrid maize (var. BARI Hybrid maize-16) and garden pea (var. BARI Motorshuti-3) were used for this production program. Seeds were sown on 22 November 2021. Fertilizers were applied at the rate of 250-55-115-40-2-1 kg ha^{-1} N-P-K-S-Zn-B in the form of Urea, TSP, MoP, Gypsum, Zinc sulphate and Boric acid, respectively. One-third of urea and the full amount of all other fertilizers were applied at the time of final land preparation. The remaining urea was top dressed in two equal splits at the 8-10 leaf stage (30-35 DAS) and tasseling stage (50-60 DAS) and mixed thoroughly with the soil as soon as possible for better utilization. Intercultural operations and plant protection measures were taken as and when necessary. Garden pea was harvested on 7 and 14 January 2021 and maize was harvested on 18 March 2022.

Results and Discussion

Results of Hybrid Maize + garden pea intercropping have been given in Table 1 and Table 2. Maize + garden pea intercropping showed better performance (Maize equivalent yield: 15.25 t/ha) and gave a higher economic return (gross margin Tk. 230720 Tk./ ha and MBCR: 3.20). The yield of sole maize was lower (7.50 t/ha) than maize + garden pea intercropping in terms of maize equivalent yield (15.25 t/ ha).

Table 1. Yield of maize, garden pea, and maize equivalent yield in maize + garden pea intercropping

Treatments	Garden pea pod yield (t /ha)	Grain yield of maize (t/ ha)	Maize Equiv. yield (t/ ha)
T_1= Maize + garden pea	3.16	6.64	15.26
T_2= Sole maize	-	7.50	7.50

Table 2. Cost and return analysis of maize + garden pea intercropping

Treatments	Gross return (Tk. /ha)	Cost of cultivation (Tk./ ha)	Gross margin (Tk./ ha)	MBCR
T_1= Maize + garden pea	335720	105000	230720	3.20
T_2= Sole maize	165000	100000	65000	1.65

Selling price (Tk. kg^{-1}): Maize= 22, garden pea = 60

Farmers' opinion

Farmers showed interest to cultivate Maize + garden pea intercrop for higher productivity and economic returns.They also demand BARI Motorshuti-3 seeds in due time.

Conclusion

Results revealed that Maize normal row (60cm×20cm)+two rows garden pea (20cm×10cm) intercropping was more profitable than sole maize in acidic soil. The technology might be disseminated through a large-scale pilot production programme.

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PRODUCTION PROGRAM OF INTERCROPPING GARDEN PEA WITH HYBRID MAIZE IN KHAGRACHORI

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Abstract

A field experiment was conducted at farmer’s field of hill valleys in Khagrachori during the *Rabi* season 2021-2022 to validate the potentiality of BARI developed intercrop technology. Three intercrop treatments were evaluated against sole hybrid maize. There were four treatments viz., T_1: Hybrid maize normal row (MNR) (60cm × 20cm) + 3 rows garden pea (15cm × 10cm), T_2= MNR (60cm × 20cm) + 2 rows garden pea (20cm × 10cm) T_3= MNR (60cm × 20cm) + 1 row garden pea (60cm × 10cm). T_4=Sole Hybrid maize (60cm × 20cm). Yield of hybrid maize was not reduced significantly due to intercrop situation. Among intercrops, hybrid maize + two rows garden pea was the best in terms of maize equivalent yield (15.57 t/ha) followed by hybrid maize normal row + 3 rows garden pea. Similar trend was observed in case of gross return and gross margin. The results revealed that all the intercrop technologies were suitable for farmers’ field. Among those hybrid maize+2 rows pea showed the best performance in terms of maize equivalent yield and economic return.

Introduction

Intercropping is an age-old practice of farmers in Bangladesh. They practice it for getting more profit as well as to minimize risk of total crop failure. Hybrid maize becomes popular to the farmers for high yield potentiality. At present maize is a very popular and multi uses cereal crop. Besides, the climate of Bangladesh is suitable for maize cultivation. The rate of seed germination and seedling growth of maize are very slow in winter season due to prevailing low temperature. Farmers grow maize as a sole crop at the hilly area of Khagrachori. In that area fodder for livestock and poultry feed is acute problem. Every year a huge amount of maize grain is required as feed and fodder for poultry and livestock sector and most of them imported. Maize is a long duration crop which takes about five months so, short duration crops like pea proved suitable and profitable for intercropping with hybrid maize in the research station. Vegetable are the main component of human food that supplies proteins, carbohydrates, fats, vitamins and minerals. However, these intercrop technologies are to be disseminated among the farmers in the country. Hence, this experiment was conducted in the farmers’ field to evaluate the potentiality of those intercrop technologies.

Materials and Methods

The experiment was conducted in a farmer's field of hill valleys in Khagrachori during the *rabi s*eason, 2021-2022. Four developed intercrop technologies were evaluated against sole hybrid maize. There were four treatments viz., T_1=Hybrid maize normal row (MNR) (60cm × 20cm) + 3 rows garden pea (15cm × 10cm), T_2= MNR (60cm×20cm) + 2 rows garden pea (20cm × 10cm) T_3= MNR (60cm × 20cm) + 1 row garden pea (60cm×10cm). T_4=Sole Hybrid maize (60cm × 20cm). The experiment was laid out in a randomized complete block design (RCBD) with with three dispersed (farmer's field) replications. The unit plot size was 12 m × 8 m. Hybrid maize (var. BARI Hybrid Maize-9) and garden pea (var. BARI motorshuti- 3) were used in this experiment. Garden pea and maize were sown on November 27, 2021. Fertilizer dose (260-55-40-4-1 kg/ha NPKSZn) were applied for sole hybrid maize and intercrop treatments. The full amount of P K S Zn and $^1/_3$ N were applied as basal in the form of triple super phosphate, muriate of potash, zinc sulphate and urea, respectively. The remaining N was top dressed in two equal splits at 30 and 50 days after sowing (DAS). Irrigation was given after sowing/planting for proper establishment of crops. Subsequently three irrigations were applied at 30, 60 and 90 DAS. Two hand weeding were done at 20 and 40 DAS to keep the crops reasonably weed free. Yield components of all the crops were taken from randomly selected 10 plants from each plot. The component crop was harvested in 12-16 February 2022 and Maize harvested from 09-15 April 2022 and yields were taken from whole plot. Equivalent yields were computed using the formula of Bandyopadhaya (1984). Economic analysis was also done.

Results and Discussion

Yield and yield attributes

From the results it is revealed that grain yield of maize was not significantly reduced by intercrop combination, the highest grain yield (9.57 t/ha) was obtained from sole maize that was statistically similar to T_2 (9.56 t/ha) treatment (Table 1). Grain yield of hybrid maize reduced in different intercrop technologies. Yield of different companion crops have been shown in Table 2. Total yield in terms of maize equivalent yields (MEY) were different in different intercrop treatments. Maize equivalent yields in all intercrop technologies were higher than sole maize. Among intercrop technologies, the highest maize equivalent yield 15.57 t/ha was recorded from T_2 (Maize+2 rows of garden pea) intercropped combination (Table 2) followed by hybrid maize normal row + 3 rows pea (14.57 t/ha). The lowest equivalent yield 9.57 t/ha was obtained from T_5 (sole Maize).

Cost and return analysis

Cost and return analysis (Table 3) revealed that the highest gross return (Tk.311400 /ha), gross margin (Tk.196400/ha) and MBCR (2.71) was obtained from intercrop combination T_2 (Maize + 2 rows garden pea) and the lowest was observed in T_4 (sole Maize) (Tk.191400/ha, Tk. 101400/ha and 2.12, respectively).

Farmer's opinion

Short duration vegetable (garden pea) intercrop with maize was found as a profitable practice though they faced some difficulties performing different intercultural operations. Therefore, they can earn extra income easily without hampering the main crop (Maize) and could help to meet up the vegetable requirement of the family.

Conclusion

Results revealed that Maize normal row (60cm × 20cm) + two rows garden pea (20cm × 10cm) intercropping was more profitable than sole maize in farmers' fields of Khagrachari. The technology might be disseminated through a large-scale pilot production programme.

Table 1.Yield components and yield of hybrid maize in maize + garden pea intercropping systems at Khagrachori during *Rabi* season of 2021-2022

Treatments	Plant height (cm)	Grains/cob (no.)	1000- grain wt. (g)	Grain yield (t/ha)
T_1= MNR + 3 rows garden pea	225.39	408.12	316.81	9.47
T_2= MNR + 2 rows garden pea	222.62	402.79	319.79	9.56
T_3=MNR + 1 row garden pea	224.43	406.56	315.85	9.42
T_4= Sole maize	224.89	407.23	317.23	9.57
LSD $_{(0.05)}$	7.57	6.46	3.19	0.06
CV (%)	4.18	6.99	5.29	4.71

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Table 2. Yield of garden pea and maize equivalent yield of maize + garden pea intercropping systems in farmer's field of Khagrachori during *Rabi* season of 2021-2022

Treatments	Green pod yield of garden pea (t/ha)	Maize equivalent yield (t/ha)
T_1= MNR + 3 rows garden pea	4.5	14.57
T_2= MNR + 2 rows garden pea	4.8	15.57
T_3=MNR + 1 row garden pea	2.9	13.21
T_4= Sole maize	-	9.57
LSD $_{(0.05)}$	0.21	-
CV (%)	5.34	-

Table 3. Cost and return of maize + garden pea intercropping systems in farmer's field of Khagrachori during *Rabi* season of 2021-2022

Treatments	Gross return (Tk/ ha)	Cost of cultivation (Tk/ ha)	Gross margin (Tk/ ha)	MBCR
T_1= MNR + 3 rows garden pea	291400	110000	181400	2.65
T_2= MNR + 2 rows garden pea	311400	115000	196400	2.71
T_3=MNR + 1 row garden pea	264200	135000	129200	1.96
T_4= Sole maize	191400	90000	101400	2.12

Price (Tk/kg): maize -20.00, and pea-60

INTERCROPPING PEA WITH HYBRID MAIZE IN KUSHTIA

S.S. KAKON, J. A. MAHMUD, J.A. CHOWDHURY, A.A. BEGUM AND D.A. CHOUDHURY

Abstract

The production programme was conducted at the farmer's field of Kushtia sadar upazila , during *rabi* season of 2021-22 2022 to evaluate the performance of maize + garden pea intercropping technology.in farmer's field and its economic performance. Two treatment combinations viz., maize normal row + two rows garden pea were evaluated against maize sole crop. The highest maize equivalent yield, gross return, net return and benefit cost ratio were obtained from the maize normal row + two rows garden pea combination . The highest MEY (17.55 t/ha) ,gross return (TK. 526500 /ha) and gross margin (TK. 384150/ ha) were obtained from T_2 (maize normal row + two rows garden pea) treatment .The results revealed that maize + garden pea combination might be suitable for increasing productivity than sole maize production and ensure food security for resource poor farmers of Bangladesh.

Introduction

Bangladesh is the most densely populated country of the world. Demographic pressures and increasing urbanization Bangladesh's agricultural land is becoming insufficient for cultivation food crops. Maize is spaced crop and cultivated throughout the year, so there is a scope of using this space through another crop as intercrop. Field pea is also cultivated in rabi season and it is a short statured crop. Its demand especially to the urban people is increasing day by day. Peas are an excellent source of protein, fiber, minerals and vitamins. Garden pea can play an important role to overcome our national protein and fiber deficit. So pea may be intercropped with maize under variable pea population, which may increase total productivity as well as increase diversity. Hence, the experiment has been undertaken the developed pea and hybrid maize intercropping in farmer's field.

Materials and Methods

The experiment was conducted at Kushtia sadar during the rabi season 2021-2022.The variety of hybrid maize was Singenta-7720 and the variety of field pea was BARI Motorshoti-3. The intercrop combinations were Maize normal row (60 cm×25 cm) + two rows pea. The crop was fertilized with 250-55-115-40-3-1 kg N-P-K-S-Zn-B /ha along with 5.0 t/ha of cowdung. One third of urea and full amount of all other fertilizer were applied at the time of final land preparation. The remaining urea was applied in two equal spilt at 8-10 leaf stage (35 DAS) and taselling stage (55 DAS). Both maize and field pea seed were sown on 25 November, 2021. The crop was irrigated twice after fertilization at 35 and 55 DAS. Weeding, earthing up and other intercultural operations were done as per requirement. Green field pea was harvested time to time from 27 January to 10 February, 2022 and maize was harvested on 25 April, 2022. The yield of both crops was recorded and analyzed statistically.

Results and Discussion

Yield and economic performance of maize under intercropping system is shown in Table 1. The grain yield of maize in intercropped combination ranged from 9.85 to 12.35 t/ha. Intercrop combination produced the highest maize equivalent yield than sole maize. From maize equivalent yield, about 42% higher yield advantage was found from intercropping system over the sole maize cultivation. The highest MEY (17.55 t/ha) ,gross return (TK. 526500 /ha) and gross margin (TK. 384150/ ha) were obtained from T_2 (Maize normal row + two row pea) treatment treatment. Intercrop maize with pea get higher productivity and economic return.

Table1. Yield and economic performance of maize singenta-7720 with pea intercrop at Kushtia during 2021-22

Treatment	Yield (t/ha)	Pod yield of pea (t/ha)	MEY (t/ha)	Gross return (Tk. /ha)	Total variable cost (Tk. /ha)	Gross margin (Tk./ha)
T_1: Sole maize	12.35		12.35	370500	125360	245140
T_2: Maize + two row pea	9.85	3.85	17.55	526500	142350	384150

Price (TK/ Kg): Maize: 30.00, Green field pea: 60.00

Farmer`s reaction

Farmers showed interest in cultivation of maize intercropped with field pea for higher economic return. According to the farmer's opined of those area cultivation of two crops in the same piece of land is a profitable practice. They are interested in cultivating hybrid maize with garden pea as intercropping due to higher productivity.

Conclusion

Based on findings, it may be concluded that hybrid maize with garden pea intercropping system suitable combination for higher productivity and economic return.

INTERCROPPING BUSH BEAN WITH MAIZE UNDER DIFFERENT PLANTING SYSTEM

J.A. CHOWDHURY, G. PAUL, A.A. BEGUM, S.S. KAKON, AND D.A. CHOUDHURY

Abstract

A field experiment was conducted to evaluate the suitability and economic performance of BARI Bushbean intercrop with BARI Hybrid Maize at farmer's field of hill valleys in Khagrachori during the *rabi* season, 2021-2022. Two treatments viz. T_1: Sole Maize (60cm × 20cm) and T_2: Maize (60cm × 20cm) + two rows of Bushbean (20cm × 10cm) were used for the experiment. The results revealed that Maize-Bushbean combination did not influence yield and yield contributing characters of maize as compared to sole maize. The intercropping combination performed better in terms of maize equivalent yield, gross return and marginal benefit cost ratio (MBCR) over sole crops.

Introduction

Bangladesh is a overpopulated country with a small land area where food demand is very high. In order to produce more food within a limited area, one of the most important options is to increase the cropping intensity, producing two or more crops over the same piece of land. Intercropping gives the opportunity to use the land more efficiently where the choice of compatible crops with minimum inter-specific competition is the most important factor. Maize is second most important cereal crop of Bangladesh. Popularity of Maize cultivation is increasing day by day. Most of the farmers of the farmers grow Maize as a sole crop in Khagrachori. Maize is a long duration crop. In that case, farmers can easily cultivate different short duration vegetables with Maize. Bushbean is a popular vegetable in Khagrachori as well as Chattogram region. Its pod is consumed as vegetables and seed as khashya which can be easily incorporated with maize as intercrop of short duration. Hence, the present experiment was conducted to increase yield and economic return of farmers and improve the productivity of existing cropping pattern.

Materials and Methods

The experiment was conducted in a farmer's field of hill valleys in Khagrachori during the rabi season, 2021-2022. Two treatments viz., T_1= Sole Maize (60cm × 20cm) and T_2=Maize (60cm × 20cm) + two rows of Bushbean (20cm×10cm) were used for the experiment. It was laid out in randomized complete block design (RCBD) with three dispersed (three farmer's field) replications. The unit plot size was 12 m×8 m. Hybrid Maize (BARI Hybrid Maize-9) and Bushbean (BARI Jharsheem-2) were used as testing material. For maize, spacing was 60cm×20cm and two rows of Bushbean maintaining spacing (20cm×10cm). Both seeds were sown on 7 December, 2021. Fertilizers were applied @ 260-60-110-40-5-1.5 kg N-P-K-S-Zn-B ha-1 for sole maize and intercropping. One third urea and full amount of all other fertilizers were applied as basal at final land preparation. The rest urea was applied as top dress in two equal splits at 8 leaves and tasseling stages. Two times weeding and earthing up were done after each top dress. The crop was irrigated at 20-40-70 and grain filling stage. The component crop was harvested in 12-16 February 2022 and Maize harvested from 09-15 April 2022. At harvest, the yield and yield attributes were recorded and analyzed statistically.

Results and Discussion

Yield attributes and yield

From the results it is revealed that grain yield of Maize was not significantly influenced by intercrop combination, highest yield (9.56 t/ha) was obtained from Maize sole that was statistically similar to Maize yield (9.47 t/ha) at treatment T_2 (Maize+Bushbean) (Table 1). The highest Maize equivalent yield 13.37 t/ ha was recorded from T_2 (Maize+Bushbean) intercropped combination (Table 2). The lowest equivalent yield 9.39 t/ha was obtained from T_2 (sole Maize).

Cost and return analysis

Cost and return analysis revealed that highest gross return (267400 Tk./ ha), net return (177400 Tk./ ha) and BCR (2.98) was obtained from intercrop combination T_2 (Maize+Bushbean) over T_1 (sole Maize) (Tk.187800/ ha, Tk.119800/ ha and 2.76, respectively).

Farmer's opinion

Maize with short duration intercrop (Bush bean) was found as a profitable practice though they faced some difficulties performing different intercultural operations. Therefore, they could earn extra income easily without hampering the main crop (Maize) and could help to meet up the vegetable requirement of the family.

Conclusion

Results revealed that Maize normal row (60cm×20cm) + two rows bushbean (20cm×10cm) intercropping was more profitable than sole maize in farmers' fields of Khagrachari. The technology might be disseminated through a large-scale pilot production programme.

Table 1. Yield and yield contributing characters of maize and bushbean under intercrop combinations at Khagrachori during the year of 2021-2022.

Treatments	Plant height (cm)	Grains/ cob	1000 grain wt. (g)	Maize yield (t/ha)	Vegetable yield (t/ha)
T_1= Maize + Bushbean	225.39	408.12	316.81	9.47	3.33
T_2= Maize as sole	222.62	402.79	319.79	9.56	-
CV (%)	4.18	1.99	1.29	0.71	-
LSD $_{(0.05)}$	7.57	6.46	3.19	0.06	-

Table 2. Equivalent yield and economics of Maize and intercrops at Khagrachori during the year of 2021-2022.

Treatments	Maize equivalent yield (t/ha)	Gross return (Tk /ha)	Cost of cultivation (Tk/ ha)	Gross margin (Tk/ ha)	MBCR
T_1= Maize + bushbean	13.37	267400	90000	177400	2.98
T_2= Sole maize	9.39	187800	68000	119800	2.76

Price (Tk. Kg^{-1}): Maize- 20.00; Bushbean- 60.00

PERFORMANCE OF INTERCROPPING OF CHILI WITH MAIZE IN HILL VALLEYS OF KHAGRACHARI

G. PAUL, M.A.A. MALEK AND M.R. AHMAD

Abstract

An intercropping experiment was conducted at farmers' field at hill valleys in Khagrachori during the *Rabi* season, 2021-2022 to verify the potentiality of hybrid maize-chilli intercropping system. Two treatments viz., T_1=Maize normal row (60cm × 20cm) + one row chilli (60cm × 50cm)-Improved practice and T_2= Sole Maize (60cm × 20cm)-Farmers' practice were used in the experiment. Grain yield of hybrid maize reduced in intercropping systems but the reduction was not significant. The highest maize equivalent yield (12.97 t/ha), gross return (Tk 262000/ha) and benefit cost ratio (2.91) were recorded in maize normal row + 1 row chili planting system. The results revealed that intercropping system was productive and profitable than sole maize in the farmers' field of hill valleys in Khagrachori.

Introduction

Bangladesh is an over populated country with a small land area where food demand is very high. In order to produce more food within a limited area, one of the most important options is to increase the cropping intensity, producing two or more crops over the same piece of land. Intercropping gives the opportunity to use the land more efficiently where the choice of compatible crops with minimum inter-specific competition is the most important factor. Maize is second most important cereal crop in Bangladesh. Popularity of maize cultivation is increasing day by day. Most of the farmers grow maize as a sole crop in Khagrachori. Maize is a long duration spaced crop. In that case, farmers can easily cultivate different short duration spices with maize. Chilli is a popular spices crop in Khagrachori as well as Chattogram region. Its fruit is consumed as spices which can be easily cultivated with maize as intercrop. Hence, the present experiment was conducted to increase yield and economic return of farmers and improve the productivity of existing cropping pattern.

Materials and Methods

The experiment was conducted in a farmer's field of hill valleys in Khagrachori during the *Rabi* season, 2021-2022. Two treatments viz., T_1: Maize normal row (60cm × 20cm) + one row chilli (60cm × 50cm)-Improved practice and T_2: Sole Maize (60cm × 20cm)-Farmers' practice were used in the experiment. It was laid out in randomized complete block design (RCBD) with three dispersed (three farmer's field) replications. The unit plot size was 12 m × 8 m. Hybrid Maize (var. BARI Hybrid maize-9) and chilli (BARI Morich-2) were used as testing materials. Both seeds were sown on 22 November, 2021. Fertilizers were applied @ 260-60-110-40-5-1.5 kg N-P-K-S-Zn-B ha^{-1} for sole maize and intercropping. One third urea and full amount of all other fertilizers were applied as basal at final land preparation. The rest urea was applied as top dress in two equal splits at 8 leaves and tasseling stage. Two times weeding and earthing up were done after each top dress. The crop was irrigated at 20, 40, 70 DAS and grain filling stage. The component crop chilli was harvested in 23-27 February 2022 and maize was harvested from 09-15 April 2022. At harvest, the yield and yield attributes were recorded and analyzed statistically.

Results and Discussion

Yield and yield attributes

From the results it was revealed that grain yield of maize was not significantly influenced by intercrop. The highest grain yield (9.33 t/ha) was obtained from sole maize T_2 that was statistically similar to maize yield (9.12 t/ha) at treatment T_1 (Maize+Chilli) (Table 1). The highest Maize equivalent yield 13.10 t/ha was recorded from T_1 (Maize+Chili) intercropped combination (Table 2). The lowest equivalent yield 9.12 t/ha was obtained from T_2 (sole Maize).

Cost and return analysis

Cost and return analysis revealed that the highest gross return (Tk.262000/ha), gross margin (Tk.172000/ ha) and MBCR (2.91) was obtained from intercrop combination T_1 (Maize+Chili) over the T_2 (Sole Maize) (Tk. 182400/ ha, gross marginTk.108400/ ha and MBCR 2.46, respectively).

Farmer's opinion

Maize with short duration intercrop (Chilli) was found as a profitable practice though they faced some difficulties in intercultural operations. Therefore, they can earn extra income easily without hampering the main crop (Maize) and could help to meet up the spices requirement of the family.

Conclusion

Results revealed that improve practice or Maize normal row (60cm × 20cm) + one row chilli (60cm × 50cm) intercropping was more profitable than farmers' practice (sole maize) in farmers' fields of Khagrachari. The technology might be disseminated through a large-scale pilot production programme.

Table 1. Yield contributing characters and yield of maize and green chilli yield of intercrop combinations at Khagrachori during *Rabi* season of 2021-2022

Treatments	Plant height (cm)	Grains/cob (no.)	1000- grain wt. (g)	Grain yield of maize (t/ha)	Green chilli yield (t/ha)
T_1= Maize + chilli	212.39	401.12	312.81	9.12	3.10
T_2= Sole maize	211.62	402.79	315.79	9.33	-

Table 2. Equivalent yield, cost and return of maize + chilli intercrops at Khagrachori during *Rabi* season of 2021-2022

Treatments	Maize equevalent yield (t/ha)	Gross return (Tk/ha)	Cost of cultivation (Tk/ha)	Gross margin (Tk/ha)	MBCR
T_1= Maize + chili)	13.10	262000	90000	172000	2.91
T_2= Sole maize	9.12	182400	74000	108400	2.46

Price (Tk./kg): Maize- 20.00; chilli- 60.00

PERFORMANCE OF ONION-JUTE CROPPING PATTERN AT BEEL AREA OF FARIDPUR

M.A.K. MIAN, A.A. BEGUM, S.S. KAKON, J.A.CHOWDHURY AND D.A. CHOUDHURY

Abstract

Experiment was conducted at Mongler beel (Boalmari, Faridpur) to evaluate the performance the technology (Onio-Jute cropping pattern). Onion-Jute and Onion-B. *aman* rice were found as the most productive cropping patterns with better economic benefit at Monglar beel area (Faridpur). Farmers' are interested to adopt in these improved cropping patterns in the beel area. They will get more economic returns.

Introduction

Onion is a major spices crop in Bangladesh. *Boro* rice-Falllow is the major cropping pattern at beel area of Faridpur. Previous research indicated that Onion-Jute cropping patter could be grown successfully instead of *Boro* rice-Falllow cropping pattern in Beel area of Faridpur. Farmers' were interested to cultivate crops in Onion-Jute cropping pattern. This pattern is more profitable as compared to sole *boro* rice cultivation There is a need to validate the cropping of Onion-Jute in farmers field in that location of Faridpur. Therefore, the pattern of Onion-Jute cropping was designed to validate in farmers' field of Faridpur.

Materials and Method

Experiment was conducted at Mongler beel (Boalmari, Faridpur) to evaluate the performance the technology (Onio-Jute cropping pattern). The trial was conducted in RCB design with five replications. Treatments (cropping patterns) of Experiments were as follows: T_1=Onion-Jute,
T_2=Onion-(broadcast *aman*) B. *aman* rice, T_3= Lathyrus- B. *aman* rice, T_4=Fallow-*Boro* rice
The crops were sown/planted/transplanted in season timely. Fertilizer, irrigation, weeding and other management were done as per recommendation of each crops. Crops were harvested at maturity. Relevant data was collected carefully and analyzed accordingly. Economic evaluation was done for each cropping pattern. Farmers' opinion about improved (new) cropping patterns was recorded and reflected in the report.
Rice equivalent yield (REY) and Production efficiency (PE) were calculated as follows.
Rice equivalent yield (REY): (Yield crop ×price of crops)/price of rice
Production efficiency (PE): REY/365

Results and Discussion

Bulb yield of onion (20.89-21.07 t/ha) were good in T_1 and T_2 at Monglar beel, Faridpur (Table 1). Jute fiber and stick yield were 4.93 t/ha and 6.02 t/ha respectively in T_1 (Table 2). Lathyrus yield was 1.68 t/ha and broadcast *aman* (B.*aman*) rice grain yield was 2.47 t/ha in T_3 while B.*aman* rice grain yield was noticed lower (1.42 t/ha) in T_2 (Table 1). Pulse crop like lathyrus inclusion in the cropping pattern (T_3) enhanced yield of B.*aman* rice. Similar results has been described by Ayesha (2021). *Boro* rice grain yield was observed 4.93 t/ha in T_4 (Table 2). Rice equivalent yield (REY: 16.84 t/ha) and production efficiency (PE:46.14 kg/ha/day) were computed higher values in Onion-Jute cropping pattern (T_1) followed by Onion-B.*aman* (T_2) rice cropping pattern while the lowest value was observed in Fallow-*Boro* rice cropping pattern T_4 (Table 2). The results indicated that inclusion of non- rice crops in the rice based cropping system increased productivity. Productivity increased 208%, 165% and 9% respectively in T_1, T_2 and T_3 respectively over T4 (Fallow-*Boro* rice) cropping pattern. Economic evaluation was shown in Table 3. Higher gross return (Tk.572560/ha), gross margin (Tk. 193710/ha) were calculated in T_1 followed by T_2 (Table 3). T_3 and T_4 showed higher BCR but with lower gross return and gross margin. Lower gross return and gross margin was happened in T_3 and T_4 because of lower productivity. On the contrary, higher BCR was occurred in T_3 and T_4 due to low production cost involvement in T_3 and T_4 As compared to other cropping patterns. T_3 and T_4 cropping patterns were not encouraging because of lower productivity and lower economic returns although they showed higher BCR (1.54-1.67) than other cropping patterns. However, Onion-Jute and Onion-B. *aman* rice were found as the most productive cropping patterns with better economic benefit over existing cropping pattern.

Table 1. Yield performance of crops in cropping patterns at Monglar beel), Faridpur (2021-2022)

Treatment (Cropping pattern)	Onion	Lathyrus	Rice	
	Onion bulb yield (t/ha)	Seed yield (t/ha)	*Boro* rice/ B.*aman* rice grain yield (t/ha)	*Boro* rice / B.*aman* straw yield (t/ha)
T_1=Onion-Jute	21.07	-	-	-
T_2=Onion-B. *aman* rice	20.89	-	1.42	2.38
T_3=Lathyrus-B. *aman* rice	-	1.68	2.47	2.87
T_4=Fallow-*Boro* rice	-	-	4.93	6.02

Table 2. Yield performance of crops in cropping patterns at Monglar beel), Faridpur (2021-2022)

Treatment (Cropping pattern)	Jute		Rice equivalent yield (t/ha)	PE (kg/ha/day)
	Jute fiber yield (t/ha)	Jute stick yield (t/ha)		
T_1=Onion-Jute	4.93	6.02	16.84	46.14
T_2=Onion-B. *aman* rice	-	-	14.49	39.70
T_3=Lathyrus-B. *aman* rice	-	-	5.98	16.38
T_4=Fallow-*Boro* rice	-	-	5.46	14.96

Table 3. Cost and return analysis of cropping pattern at Monglar beel), Faridpur (2021-2022)

Treatment (Cropping pattern)	Gross return (Tk./ha)	Cost of production (Tk./ha)	Gross margin (Tk./ha)	BCR
T_1=Onion-Jute	572560	378850	193710	1.51
T_2=Onion-B. *aman* rice	492660	332800	159860	1.48
T_3=Lathyrus-B. *aman* rice	203320	121740	81580	1.67
T_4=Fallow-*Boro* rice	185640	120860	64780	1.54

Table 4. Market price of crops, straw and input in the cropping patterns at Monglar beel), Faridpur (2021-2022)

Sl. No.	Crops/straw	Price (Tk./kg)	Price (Tk./t)
1	Onion bulb	20	20000
2	*Broro* rice grain	34	34000
3	*Broro* rice straw	3	3000
4	B.*aman* rice grain	38	38000
5	B.*aman* rice straw	3	3000
6	Jute Fibre	75	75000
7	Jute stick	2	2000
8	Lathyrus seed	60	
Input			
9	Labour	450.00/day	-
10	Urea	18.30/kg	-
11	TSP	26.00/kg	-
12	MoP	15.00/kg	-
13	Gypsum	12.00/kg	-
14	Zinc Sulphate	230.00/kg	-
15	Boric Acid	250.00/kg	-
16	Tillage	1000/33 decimal	-
17	Irrigation	1500/33 decimal	-
18	Potato seed	32.00/kg	-
19	Mustard seed	80.00/kg	-
20	*Boro* rice seed	40.00/kg	-
21	Jute seed	200.00/kg	-
22	Onion seed	3000.00/kg	-
23	Lathyrus seed	60.00/kg	-

Conclusion

Onion-Jute and Onion-B. *aman* rice were found as the most productive cropping patterns with better economic benefit at Monglar beel area (Faridpur). Farmers' are interested to adopt in these improved cropping patterns in the beel area. They will get more economic returns.