Cereal Crops

WHEAT

1. CHARACTERISTICS OF BORDER IRRIGATION FOR WHEAT IN CLAY SOIL

B. R. Khan. M. N. Molla, M. Mainuddin, M. H. Rashid and M. Maniruzzaman

Irrigation water with 5.5 1/s was applied to wheat at a border strip with width of 10 m in a clay soil with 0.43 percent bed slope, at vegetative growing stage (28 DAE). The average soil moisture upto rooting depth (35 cm) was 18.77 percent, Potential Application Efficiency depth at Low Quarter (PRELQ) and Application Efficiency at Low Quarter (AELQ), both excluding side seepage were 82.92 percent and 68.19 percent, respectively for a length of 98 m.

AT maturity stage, 5.191/s was applied when average soil moisture for rooting depth (65 cm) was 20.76 percent. PELQ and AELQ were 89.15 percent and 79.12 percent, respectively for a length of 68 mm. Advance ratio was 0.084 and 0.15 for Trial 1 and 2, respectively when time of opportunities at lower and was considered at 1 m upstream. In both situations high PELQ, indicates border designs are suitable. Further trials with different discharges are needed for making suggestion on border size. Tentatively, it can be suggested that 80 m length is acceptable to both situation.

2. RESPONSE OF WHEAT TO IRRIGATION

K. C. Roy

A study was conducted at the Regional Agricultural Research Station, Jessore during the rabi season of 1994-95 to determine the best irrigation scheduling of wheat. A total of seven treatments including rainfed (control), pre-sowing and post-sowing irrigations were taken. Measured quantity of irrigation water was applied in various critical growth stages. Grain and straw yields varied significantly among the treatments. The highest yield of 4.03 t/ha was obtained with 3 irrigations amounting to 171mm water. There was no significant difference in yield between 2 and 3 irrigations. The increase in yield for irrigated treatments over control treatment varied between 26 to 49 percent. Combined analysis of 2 years data also shows the same trend. The benefit cost ratio of wheat cultivation ranged between 1.64 and 2.26.

3. IRRIGATION SCHEDULING OF WHEAT BASED ON FAO-DEVELOPED CROPWAT PROGRAM

K.C. Roy

A study was conducted at the Regional Agricultural Research Station, Jessore during the rabi season of 1994-95 to compare different irrigation schedules of wheat based on the FAO-developed CROPWAT program. Irrigation management conditions were varied to estimate the crop production under rainfed and different irrigated regimes. Climatic, soil and crop data were used as input to the program. The program gives exact time and depth of water to apply for different options and yield reduction along with other outputs. Grain yield varied significantly among different treatments. The highest yield of 3.74 t/ha was obtained with 3 irrigations amounting 277 mm water. There was no significant difference in yield between 3 and 4 irrigations. The model-predicted yield agreed well with the observed yield.

4. IRRIGATION REQUIREMENT OF WHEAT UNDER DIFFERENT SOIL TYPES AND AGRO-CLIMATIC CONDITIONS

M. A. K. Mridha, M. H. Rashid, M. S. Islam and M. S. Alam

Wheat (variety: Kanchan) was tested with five irrigation levels in silty clay loam soil at Joydebpur, sandy loam soil at Nashipur and silty loam soil at RARS, Jessore during 1999-2000 and 2000-2001. During 1999-2000, 4 irrigations at Joydebpur, 4 irrigations at Dinajpur, and 3 irrigations at Jessore produced the highest yield of 3.74 t/ha, 3.53 t/ha and 4.40 t/ha, respectively. During 2000-2001, the highest yield of 3.74 was obtained under 4 irrigations at Joydebpur, 3.67 t/ha under 4 irrigations at Dinajpur and 3.81 t/ha under 5 irrigations at Jessore. Farmers usually apply 1-2 irrigations to wheat which result in low yield (1.1-2.7 t/ha). For optimum yield (3-4.5 t/ha) wheat requires 3 to 4 irrigations with 50 to 60 mm water at each time. Irrigations to be applied at 20, 40, 60 and 80 days after sowing (DAS) in case of 4 irrigations while it should be at 20, 50 and 75 DAS in case of 3 irrigations.

5. INTERACTION EFFECT OF IRRIGATION LEVELS AND FERTILIZER DOSES ON WHEAT PRODUCTION

M. S. Islam M. A. K. Mridha, M. S. Alam and M. S. Rashid

The experiment was conducted at the central farm of Bangladesh Agricultural Research Institute, Joydebpur during 1999-2000 and 2000-2001. Four irrigation levels (viz. 1,2,3 and 4 numbers) with three different fertilizer doses, low, medium and standard were applied in different combinations to know the interaction effects on wheat production. It was observed that the 4 numbers of irrigation with standard dose of fertilizer produced higher yields (4.49 t/ha in 1999-2000 and 4.94 t/ha in 2000-2001) than any other combinations. It was also found that at low irrigation level increased doses of fertilizer did not produce higher yield of wheat. This indicates that the main reason for national low yield of wheat is the inadequate soil water or low level of irrigation.

6. DETERMINATION OF IRRIGATION SCHEDULING FOR WHEAT SEEDED BY PTOS

M. A. Hossain, M. I. Hossain and M. Badruzzaman

A study was conducted to generate information about the optimum timing of irrigation and the quantity of water required for a good yield of wheat. The study was conducted during the rabi season 2000-2001 and 2001-2002 at the Wheat Research Centre, Nashipur Dinajpur. Irrigation water was applied by different amounts and at different growth stages of the crop. In the first year, treatment T_7, receiving 4 irrigations and 170 mm water, produced the highest yield (4.17 t/ha) but in the second year, treatment T_6, receiving 180 mm water produced the highest yield (4.24 t/ha) of wheat. From two years results, it was observed that four irrigations with 170-180 mm water produced good yield (4.17 t/ha) to 4.24 t/ha) of wheat in Dinajpur region.

7. EVALUATION OF IRRIGATION EFFECTIVENESS OF DIFFERENT BED WIDTHS FOR WHEAT CULTIVATION

M. A. R. Akanda, M. S. Islam, M. A. Hossain and M. Abdullah

An experiment was conducted at the research field of Bangladesh Agricultural Research Institute, Gazipur, during the rabi seasons of 2001-2002 and 2002-2003. Two bed-widths viz., 40 and 60 cm with furrow width 30 cm were tested along with farmers' practice for wheat cultivation to determine the irrigation effectiveness. The highest yield, 3.94 t/ha and 3.36 were obtained from 40 cm bed width during the first and second year, respectively. About 18 percent water was saved by this practice over that of the border irrigation method (farmers' practice). The average gross margin of Tk. 16715 per ha and benefit cost ration of 2.37 were obtained from 40 cm bed plantation.

8. DETERMINATION OF YIELD RESPONSE FACTORS OF WHEAT

M. S. Alam, M. A. Hossain and M. Abdullah

Yield response factors at vegetative and grain formation stages of wheat (Variety: Protiva) were experimentally determined in clay loan soil in Rajshahi and Joydebpur. The were found 0.18 at vegetative stage and 0.46 and 0.45 at yield formation stage in Rajshahi and Joydebpur, respectively. Using these values along with the potential yield and stage wise crop evapotranspiration, the relationships between the crop evapotranspiration and the expected yields were obtained as-

$Y_v = 3.36+0.009\ ET_{av}$; $50mm <= ET_{av<=83mm}$ and

$Y_{yf} = 2.22+0.0214\ ET_{af}$; $53mm <= ET_{af} <= 88mm$ for Rajshahi and

$ET_a = 2.76+0.0075\ ET_{ay}$; $48< ET_{ay} <= 80$ and

$ET_{af} = 1.82+0.02\ ET_{af}$ $47 <= ET_{af<}=78$ for Joydebpur

Where, Y_v is the expected yield (t/ha) for water deficit in vegetative stage, y_{y6} the expected yield (t/ha) for water deficit in yield formation stage, ET_{av} and ET_{af} are the crop evapotranspiration in mm at vegetative and yield formation stages, respectively.

9. PERFORMANCES OF SOME WATER CONVEYANCE METHODS FOR WHEAT CULTIVATION

K. K. Sarker, P. K. Malaker, I. Hossain, M. S. Islam, A. Hossain, S. K. Biswas and M. A. R. Akanda

The study was conducted to evaluate the performance of four irrigation systems using BARI flow diversion device, border irrigation, traditional hose pipe and flooding irrigation system on total water supply, seasonal water use, water saving, field irrigation efficiency and water use efficiency for wheat during rabi season of 2007-2008. The study was carried out at Wheat Research Centre (WRC), Nashipur, Dinajpur. The soil was sandy loam having average bulk density 1.52 gm/cc, field capacity 22%, and organic matter 1%. Irrigation scheduling and application rates of irrigation water for wheat were applied based on effective cumulative pan evaporation (CPE) adjusted for rainfall at the ratio of IW:ECE was 0.85 under the irrigation regimes of crown root initiation (17-21 DAS) + booting stage (45-50 DAS) + early grain filling stage (75-80 DAS). Total seasonal water, field irrigation efficiency and water productivity using BARI flow diversion device were 248 mm, 91 % and 2.2 kg m^{-3}, respectively. Using border irrigation, seasonal water use was found 271 mm and field irrigation efficiency and water productivity were 81% and 2.0 kg m^{-3}, respectively. Those using traditional hose pipe were found 257 mm, 86% and 2.0 kg m^{-3}, respectively. Seasonal water use was found 289 mm in flooding irrigation system. Field irrigation efficiency and water productivity in this method were 70% and 1.6 kg m^{-3}, respectively. Water could be saved up to 23%, 8% and 14% using BARI flow diversion device, border irrigation and traditional irrigation systems, respectively, compared to that in flooding irrigation, method.

10. WATER REQUIREMENT IN ZERO TILLAGE AND BED PLANTING METHOD FOR WHEAT CULTIVATION

K. K. Sarker, I. Hossain, P. K. Malaker, A. B. M. Rahman, M. S. Islam and M. A. R. Akanda

The experiment was conducted to determine irrigation scheduling on the basis of cumulative pan evaporation (CPE). Irrigation water was applied to wheat using IW: CPE ratios of 0.60, 0.85 and 1.10 applied at 17- 21 DAS, 45-50 DAS and 75-80 DAS, respectively. The study was carried out at Wheat Research Centre (WRC), Nashipur, Dinajpur. It was found that tillage was the minimum but maximum grain of wheat was responsive to optimum irrigation as well as irrigation at IW: CPE of 0. 85 and 1.10 level of three and two time's irrigation, respectively. A total of 217and

201mm seasonal water use at IW: CPE of 0.85 and 1.10 application three and two time's irrigation was used in maximum wheat yield under zero tillage method, respectively. But 224 and 209 mm seasonal water at IW: CPE of 0.85 and 1.10 applied three and two time's irrigation was used in maximum wheat yield under bed planting method, respectively.

11. VALIDATION OF DRAS MODEL FOR WHEAT

P. K. Sarkar, S. K. Biswas, M. Alam and S. Hossain

The study was conducted in collaboration with and financial support of Center for Environmental and Geographic Information Services (CEGIS) to validate the irrigation water scheduling of Drought Assessment (DRAS) model for wheat. The performance of the model was compared with the results that obtained from the BARI recommended irrigation schedule. The experiment was carried out during the years of 2005-06 through 2007-08 at two agro-ecological zones. The locations included Jamalpur and Barind area of Rajshahi. Six different irrigation treatments including one rainfed with three replications were considered for this study. In respect of grain yield, BARI recommended irrigation practice performed comparatively better at Jamalpur (3.642 t/ha on average). The model based treatment T_3 (Application of NIR as per DRAS model base on reported value) yielded the highest (3.598 t/ha on average) at Rajshahi. However, the yields from all irrigated treatments were very close to each other. From three years study, the model performance was found quite satisfactory for irrigated wheat cultivation in this country. In respect of water productivity, the model performed almost similar to the traditional practice at Jamalpur. It performed comparatively better at Rajshahi region. Hence, it can be concluded that, irrigation water was used more efficiently at Barind area by the treatments recommended by the model.

12. DETERMINATION OF CROP CO-EFFICIENT VALUES OF WHEAT BY LYSIMETER STUDY

M. S. Islam and M. A. R. Akanda

The crop coefficient values of 0.42, 0.78, 1.13 and 0.48 were determined for initial, development, mid-season and late season stages of wheat (variety: Sourav). The values differed slightly from those calibrated by Islam (2004) for Bangladesh. As the lysimeter provides control environments, the values determined by this method are most dependable and recommended for estimating crop water requirement of wheat in Bangladesh.

13. OPTIMUM WATER USE IN CONSERVATION AGRICULTURE FOR WHEAT CULTIVATION

K. K. Sarker, E. Haque, A. Z. Sarkar, M. S. Islam and P. K. Sarkar

The experiment was conducted in conservation agriculture with zero till drill, PTOS, bed planting and farmer's practice tillage method under the basis of different irrigation levels at Wheat Research Centre (WRC), Nashipur, Dinajpur. Irrigation water was applied in different tillage methods under 5 irrigation levels at different growth stages. The treatments included I_0 (No irrigation), I1 (17-21 DAS), I_2 (17-21 DAS+50-55 DAS), I_3 (17-21 DAS+50-55 DAS+75-80 DAS) and I_4 (17-21 DAS+35-40 DAS+50-55 DAS+75-80 DAS), respectively. It was found that the sowing cost of wheat was reduced using these methods from that of the farmer's practice. Seasonal water use was less in PTOS than other tillage methods. The effect of tillage was significant on grain yield. Higher grain yields were obtained from PTOS, bed planting and zero tillage than farmer's practice. There was no significant difference within the interaction effect of tillage methods and irrigation. The effect of irrigation level was found highly significant on grain yield. Grain yield was increased with the increase of irrigation up to three irrigations. Water use efficiency was increased as the

number of irrigation was decreased. On average 33, 43, 53 and 51 percent of higher yields were obtained than that farmer's practice at one, two, three and four irrigation levels, respectively.

14. OPTIMUM WATER AND FERTILIZER USE FOR WHEAT PLANTED ON RAISED BED

P. K. Sarkar, A. J. Mila, A. Khatun and S. Pervin

The study was carried out in the experimental field of Irrigation and Water Management Division, BARI, Gazipur with a view to evaluate the interactive impact of irrigation and fertilizer on wheat (cv. BARI Gom 24) cultivated on raised bed. Irrigation scheduling based on pan evaporation was not found very effective in comparison to the recommended interval based irrigation scheduling. Comparatively more irrigation water was required for this method without increasing grain yield. The highest grain yield (4.700 t/ha) was obtained from the treatment irrigated thrice at three growth sensitive stages with an optimum fertilizers dose. One irrigation at the most critical growth stage (17-21 DAS) was found very effective in respect of water productivity. Reduced fertilizer doses gradually decreased the grain yields in all cases.

15. OPTIMUM WATER USE IN CONSERVATION TILLAGE FOR WHEAT CULTIVATION

P. K. Sarkar, S. K. Biswas and A. J. Mila

The study was conducted at the research field of the Irrigation and Water Management Division, BARI, Gazipur during the season of 2012-2013 with a view to evaluate the interaction of different tillage methods with different soil water regimes on wheat (cv. BARI Gom-24) growth and production. A significant response of wheat to different tillage methods and irrigation schedules was observed. Among the different tillage methods, performance of raised bed method applying three irrigations was relatively better yielding the highest (4.373 t/ha). In respect of irrigation, since three irrigations at three different critical growth stages were applied in I_3 treatments, better yields were obtained from those treatments. In respect of water productivity (WP), the I_1 (irrigated only once at CRI stage) treatments performed better giving a relatively higher WP values since a reasonable yield were obtained applying less irrigation water.

16. PERFORMANCE OF ADVANCED WHEAT GENOTYPES UNDER DIFFERENT LEVELS OF SALINITY

M. A. R. Akanda, M. A. Hossain, S. K. Biswas and N. C. Barma

This study was conducted in plastic pots at BARI, Gazipur during 2012-2013 and 2013-2014, respectively. 8 (eight) wheat genotypes and 2 (two) varieties were considered for trial during 2012-2013. 4 (four) levels of salinities i.e. 4dS/m, 8dS/m, 12dS/m and 16dS/m were considered for irrigation water. Among the ten genotype/varieties, 5 (five) of them i.e. BARI Gom-25, BAW-1146, BAW-1147, BAW-1150 and BAW-1157 performed well up to salinity of 12dS/m in the first year. These 5 (five) genotypes may be considered for further trial for screening best one against salinity in 2013-2014. During 2013-2014, among the four genotype/varieties, 2(two) of them i.e., BAW-1147and BAW-1157 performed well up to salinity of 12dS/m. BAW-1146 was not considered for trial due to the non-availability of the seed.

17. CALIBRATION AND TESTING OF AQUACROP MODEL FOR WHEAT CROP IN BANGLADESH CONDITION

M. S. Rahman, S. K. Biswas, M. A. R. Akanda and P. K. Sarkar

Prediction of crop yields is very much important to optimize irrigation under limited available water for enhanced sustainability and profitable production. Food and Agriculture Organization (FAO) of the United Nations has recently addressed this need by providing a yield response to water simulation model (AquaCrop). This model is already parameterized for different crops including wheat. In this study, AquaCrop was locally calibrated and tested for wheat crop (variety: BARI Gam-24) with several treatment variables of irrigation: T_1= full irrigation as the control, T_2= water stress at flowering stage, T_3= water stress at flowering and grain formation stage, T_4= water stress at tillering and flowering stage and T_5= water stress at crown root initiation and tillering stage. The field experiment was conducted in the research field of IWM Division Research Field, BARI, Jodebpur, during winter season of 2011-2012. Model parameters that were calibrated using the field experiment data included conservative parameters which are given specific but can or may be cultivar specific, parameters which are dependent on environment and /or management, and parameters which are cultivar specific. The conservative parameters were held constant and the calibrated model was evaluated by test simulations. The simulation results showed a reasonably accurate prediction of the final aboveground biomass within 11% of the measured value. The predicted wheat grain yield values were within 16% of measurements except in the treatment of water stress at flowering stage, with errors up to 19.03%.

18. ASSESSMENT OF CLIMATE CHANGE IMPACT ON WHEAT AND MAIZE PRODUCTION IN BANGLADESH USING INFOCROP MODEL

M. A. Hossain, M. M. Rahman, A. F. M. Tariqul Islam, S. K. Biswas and A. R. Akanda

Climate has been changing due to natural forcing. Climate factors such as temperature, rainfall, atmospheric carbon dioxide, solar radiation, etc. are closely linked with agricultural production. Rice, wheat and maize production would be major concern in recent years due to changing climatic conditions. Simulation study has been conducted to assess the climate change impacts on wheat and maize production in the major wheat and maize growing areas of Bangladesh and the effects of climate changes on the yield of wheat and maize have been assessed using crop growth model InfoCrop. The simulation was carried out to predict the yields of wheat and maize under different climatic trends of temperature and carbon dioxide concentration. The effect of temperature on the yield of wheat that is negative while of CO_2 is positive but temperature plays dominant role. Prediction was also made to predict the climate change impacts of wheat yields based on historical and IPCC climate change scenarios. From the simulation studies, it is found that wheat yield decreases from 3438 kg/ha in 2020 to 3125 kg/ha in 2050 and from 3358 kg/ha in 2020 to 2850 in 2050 kg/ha for historical and IPCC climatic change scenarios, respectively in Dinajpur region of Bangladesh. For this period the wheat yields decrease by 9.1% for historical trend and decreases by 15.12% for IPCC trend.

19. RESPONSE OF WHEAT TO IRRIGATION IN SALINE SOILS OF COASTAL AREAS

A. R. Akanda, S. K. Biswas, S. Mondal, A. Saleh and Zofer

The study was conducted at the farmer's field of Kulia in Debhata upazilla of Shatkhira during the rabi season of 2013-2014 to study the response of wheat to irrigation in saline soils of coastal areas. The experiment consisted of four irrigation treatments, i.e, irrigation at initial vegetative stage (farmer's practice T_1), one irrigation at CRI stage T_2, two irrigations each at CRI and booting stages T_3 and three irrigations each at CRI, booting and grain fillings stages T_4. The results revealed that irrigation lead a significant positive effect on the growth, yield and yield contributing

parameters of wheat. Grain yield of wheat was found to be increased with increasing frequencies of irrigation. The highest yield (4.08 t/ha) was obtained from treatment T_4, receiving 3 irrigations at CRI, booing and grain filling stages, where as, the lowest (3.02 t/ha) was found in treatment T_1 (farmer's practices) irrigated only at CRI stage. The water productivity was the highest (2.60 kg/m^3) when irrigation water was applied at only CRI stage while the lowest (1.93 kg/m3) was attained from treatment T_4 where three irrigations were applied. The soil salinity was found to be gradually built up from 2.49 dS/m - 7.25 dS/m with increasing evaporation and temperature.

20. RESPONSE OF WHEAT TO SUPPLEMENTAL IRRIGATION WITH SALINE WATER IN COASTAL AREAS

A. R. Akanda, S. K. Biswas, K. K. Sarker, A. J. Mila and A. Rahaman

An experiment was conducted at the Agricultural Research Station, Benarpota, Shatkhira, Bangladesh Agricultural Research Institute during rabi season of 2013-2014 and 2014-2015 to investigate the response of wheat to supplemental irrigation with saline water in coastal areas of Bangladesh. Two different sources of saline water, viz., best available fresh groundwater (BAW) and canal water, were used for irrigating wheat. Three irrigations given at crown root initiation (CRI), booting, and grain filling stages with BAW (T_1, control); two irrigations given at CRI, and booting stages with BAW (T_2); one irrigation at CRI stage with BAW (T_3); three irrigations at CRI and booting stage with BAW, and at grain filling stages with moderately saline canal water (T_4) were applied in the study. Wheat was irrigated with BAW and moderately saline canal water according to the treatments. Salinity of BAW (groundwater) over the years ranged from 2.8 to 4.3 dS/m while salinity of canal water ranged from 4.6 to 6.4 dS/m. Grain yield and yield contributing parameters like spike per square meter, number of grains per spike, and 1000-grain weight varied significantly with number and amount of irrigation water applied. But insignificant variation in yield and yield contributing parameters between treatment T_1 and T_4 was attributed due to the water quality not due to the number and amount of irrigation water. From two years average, the highest grain yield of 4.42 was obtained from treatment T_1 insignificantly followed by T_4 with the yield of 4.05 t/ha while the lowest (2.96 t/ha) was obtained from T_1 that received only one irrigation at CRI stage. Slight variation in grain yield between T_1 and T_4 implied that irrigation with saline canal water at the grain filling stage had little detrimental effects on the growth and yield attributing characters of wheat. Irrigation with saline ground water had almost no effect on increasing soil salinity; rather it helped to decrease soil salinity. On the other hand, canal water irrigation slightly increased soil salinity and consequently grain yield was slightly deceased. A significant difference in yield between two irrigations with BAW and three irrigations-two with BAW and one with canal water indicate that moisture that moisture stress was more harmful than salinity stress. Therefore, along with marginally saline ground water, moderately saline canal water can be used for supplemental irrigation to wheat where fresh water is limited.

21. FIELD TRIAL OF SCREENED ADVANCED WHEAT GENOTYPES/LINES IN SALINE SOIL

A. R. Akanda, S. K. Biswas, A. Rahaman and N. C Barma

A field trial was conducted at the Agricultural Research Station, Benarpota, Satkhira of Bangladesh Agricultural Research Institute during rabi season of 2014-2015 to evaluate the performances of selected three wheat genotypes in saline soil at field condition in coastal areas of Bangladesh. The treatments of the experiment include: T_1 = BAW - 1147, T_2 = BAW - 1157 and T_3 = BARI Gom - 25. Medium saline canal water (4.6-6.8 dS/m) was used for irrigating crops. The highest grain yield (4.86 t/ha) was obtained from BAW- 1157 wheat genotypes comparing to other two genotypes BAW-1147 and BARI Gom-25. The soil salinity levels at different growth stages was found ranging from >2 dS/m to <11 dS/m. The genotype, BAW-1157 performed the best in terms of yield and water productivity under the saline condition.

22. IMPACT OF IRRIGATION WATER SALINITY ON GROWTH, YIELD AND WATER USE OF WHEAT

S. K. Biswas and A.R. Akanda

Water and soil salinity are important factors determining crop growth and yield, especially, in the saline soils. A field experiment was conducted at the experimental field of IWM division of Bangladesh Agricultural Research Institute, Gazipur during December- March, 2014-2015 and 2015-2016 to investigate the effect of irrigation water salinity on the growth, yield components and yield of wheat. Irrigation with four fixed levels of salinity (4, 7, 10 and 13 dS/m) and one varying levels (salinity increased as plant grow older) of saline water were compared with fresh water (<0.5 dS/m) irrigated (control) treatment. All the growth and yield components were found negatively affected by irrigation with different levels of saline water. The decreases of growth and yield parameters were not significant up to the salinity of 7 dS/m. Beyond this, a strong negative effect was observed on almost all growth and yield contributing parameters like plant height, rooting density, leaf area index, spike length, spikelet per spike, number and weight of grain per spike, 1000- grain weight and biomass yield. In all cases, the highest values were recorded in control and the lowest were recorded in higher levels of salinity (for 13 dS/m in the first year and 16 dS/m in the second year). Irrigation with saline water of 4 dS/m and fresh water gave identical results in term of growth, yield and yield contributing parameters. Over the years, the highest grain yields of 5.14 and 4.29 t/ha were found in the control treatment and low salinity treatment in the first and second season, respectively, while the lowest yields of 3.58 and 3.03 t/ha were found in the high salinity treatments. On an average, compared to the low salinity level, medium (10 dS/m) and high salinity (13 dS/m) levels reduced the grain yield by 20.65 and 31.72% and biomass yield by 20.1 and 33.0%, respectively. Whereas varying levels of salinity reduced the grain yield only by 10.24% and biomass yield by 15.88%. The water uses by the crop ranged from 204 to 258 mm in the first season and 212 to 283 mm in the second season with maximum in no salinity treatment and minimum in high salinity treatment. Applying varying level of salinity gave almost similar results in terms of growth, yield and yield components with 7 dS/m salinity level. This treatment gave the highest water productivity of 1.70 and 1.88 kg/m^3 in the first and second seasons, respectively, with 223 and 243 mm of total water use. Therefore, irrigation with low saline water at the early growth stages and higher salinity water at the later stages might be a good option for growing wheat in saline environment.

23. EFFECT OF DEFICIT IRRIGATION TO WHEAT ON RAISED BED

R. Zaman, A. R. Akanda, S. K. Biswas and M. R. Karim

The experiment was conducted during the rabi season, 2015-16, at the Regional Agricultural Research station of BARI, Ishurdi, Pabna to find out the water requirements of wheat on raised bed and to relate soil moisture content with the progression of the crop season. This study consists of the treatments, T_1 = Irrigations up to 100% FC at CRI, booting and grain filling stages (flat land), T_2 = Irrigations up to 100% FC at CRI, booting and grain filling stages on raised bed, T_3 = Irrigations up to 80% FC at CRI, booting and grain filling stages on raised bed and T_4 =Irrigations up to 60% FC at CRI, booting and grain filling stages on raised bed. The experiment was laid out in a RCB design with three replications. The result showed that a significant effect of irrigation treatments on plant height, spike per m^2, grains per spike and grain yield. The highest grain yield (4.91 t/ha) was obtained from treatment T_2, irrigations up to 100% FC at CRI, booting and grain filling stages on raised bed which used 301 mm of seasonal water over irrigation up to 100% FC at same stages on flat land where 308 mm of seasonal water was used. On raised bed, highest grain yield (4.14 t/ha) was obtained with 80% deficit irrigation at the expense of 288 mm of water. However, irrigation up to 60% of field capacity used a seasonal water of 277 mm and produced yield of 3.38 t/ha with no significant difference with that irrigated at 80% of FC. On comparing raised bed to flat land wheat yield at full irrigation condition increased about 19% to 23.68% with 10.31% saving of irrigation water. With 20% deficit irrigation, the use of water was reduced by 22.86% while yield was increased 4.28%. But at 40% of full irrigation, water use was reduced by

about 29.14% whereas the yield was decreased by about 14.86%. The rate of daily evaporation was found to vary directly with the rise of temperature and decrease in humidity during the crop season.

MAIZE

24. IRRIGATION REQUIREMENT OF MAIZE

B. R. Khan M. S. Alam, M. M. Hossain and D. K. Parh

Irrigation requirement of maize applied at different growth stages was studied at Regional Agricultural Research Station, Jamalpur, during the Rabi-season of 1991-92. The highest grain yield (7.10 t/ha) was recorded with two irrigations application, one each at silking and grain-filling stages added with a rainfall at knee-high stage. The treatment with no irrigation produced the lowest yield (4.16 t/ha).

25. RESEARCH ON MAIZE FOR IRRIGATION BASED ON CLIMATOLOGICAL APPROACH

K. C. Roy, T. M. K. Anwar, M. Mainuddin and S. Islam

A study was undertaken to determine the optimum ratio of irrigation water applied to cumulative pan evaporation in maize. The experiment was conducted during the rabi seasons for 3 years at Joydebpur and for 2 years at Ishurdi with different ratios of irrigation water applied to cumulative pan evaporation. The season 1991 -92 concluded the study period. A fixed depth of 50 mm water was applied in each irrigation throughout the growing season. From the study, the ratio 0.75 is recommended for irrigation scheduling of maize. The water requirement for the crop ranged 350-400 mm.

26. EFFECT OF WATER LOGGING ON MAIZE

M. S. Islam, M. S. Alam, M. A. K Mridha and M. H. Rashid

Three durations, 24,48 and 72 hours of water logging condition at each of three different stages of growth, 16, 46 and 86 days after emergence, along with normal drainage practices were tested for yield and yield contributing characters of maize (Variety: Barnali) in clay loam soil of Joydebpur and in sand clay loan soil at RARS, Hathazari during 1996-97 irrigation season, In both the locations, treatment $T_1$with normal drainage and irrigation (3 irrigations at different stages) produced the highest yield (6.28 t/ha at Joydebpur and 5.38 t/ha at Hathazari) and treatment T_4 with 72 hours water logging produced the lowest yield (4.45 t/ha at Joydebpur and 3.46 t/ha at Hathazari) Plant height (205 cm at Joydebpur and 173.6 cm at Hathazari), ear height (95.9 cm at Joydebpur and 89.80 cm at Hathazari), number of cobs per plant (1.26 at Joydebpur and 1.22 at Hathazari), biomass (355.7 gm at Joydebpur and 300.7 gm at Hathazari) were also the highest in T_4 At Joydebpur, it received a total irrigation water application of 152 m along with an effective rainfall of 112 mm. Similarly, at Hathazari, applied water was 137 mm along with an effective rainfall of 120 mm. For both the locations, water logging for 72 hours in all stages were found harmful to maize production, Yield has found to decreases with the increased duration of water logging. The highest reduction of yield was 29.14% in Joydebpur and 35.69% in Hathazari for 72 hours of water logging.

27. MAIZE YIELDS AS AFFECTED BY NUMBER AND TIMING OF IRRIGATION

S. K. Biswas, P. K. Sarkar and K. C. Roy

A field experiment was conducted at the Regional Agricultural Research Station, Jessore during the rabi season of 200-2001 and 2001-2002 with three maize cultivars viz.; BARI maize-6, Barnali and Pacific-11 to study their response of different numbers and timing of irrigation on the yields. The highest grain yield was obtained from the treatment with 4 irrigations throughout the growing seasons followed by the treatments with no irrigation each at grain filling. silking knee-high and seedling stages for all the cultivars. Percentage of yield reduction due to no irrigation at the different stages was found the highest for the variety, Pacific-11 produced the highest grain yield of 9.75 th/ha when irrigation at 20, 40, 70 and 75 days after sowing (DAS) with 351 mm of water. For the same irrigation sequences and timing BARI maize and Barnali produced 7.11 and 6.81 t/ha, respectively.

28. IRRIGATION SCHEDULING OF HYBRID MAIZE USING CROPWAT COMPUTER PROGRAM

K. C. Roy, P. K. Sarkar, M. A. K. Mridha and M. A. Hossain

An experiment was conducted to determine the irrigation scheduling of hybrid maize during the rabi season, 2001-2002 using the computer program CROPWAT. Irrigations were given at different depletions (60, 80 and 100%) of readily available moisture (RAM) as well as at 25, 50, 75 and 90 days after sowing (DAS). Besides, no irrigation treatment and a 25 days fixed interval treatment were also tested in the study. The treatment irrigated up to field capacity of 25, 50,75 and 90 DAS produced the highest yield (8.04 t/ha) with 322 mm of water for 4 irrigations. The treatment T_6, irrigated five times at fixed interval of 25 days gave 7.99 t/ha of yield with 318 mm water application. From the study it reveals that four irrigations each at 25, 50, 75 and 90 days after sowing is the proper irrigation scheduling for the cultivation of maize.

29. DETERMINATION OF CROP CO-EFFICIENT OF HYBRID MAIZE BY LYSIMETER STUDY

M. S. Islam and M. A. Hossain

The crop coefficient values at initial, development, mid-season and late season of hybrid maize (variety: BARI Hybrid maize-1) were determined as 0.38, 0.87 1.36 and 0.175, respectively, under this study at Joydebpur. These locally determined values for a high yielding variety of maize differed to some extent from those recommended by FAO. The corresponding FAO values are 0.4, 0.80, 1.15 and 0.70. FAO values are the generalized ones recommended for use worldwide but those determined by this study are location specific. Another reason may be the use of specific variety of hybrid maize in this experiment. However, locally determined values are preferred to those for generalized values to estimate location specific crop ET.

30. EFFECT OF IRRIGATION AND FERTILIZER LEVELS ON THE YIELD OF BARI- HYBRID MAIZE

M. S. Islam, S. K. Biswas, M. A. R. Akanda, A. T. M. A. Islam Mondal and S. Hassan

In a study at the farms of Joydebpur (2006-2007 and 2007-2008) and Ishurdi (2006-2007) of BARI, the interactive effects of irrigation and fertilizer on the yield of BARI Hybrid Maize 3 were assessed. Four irrigation levels i.e., water application up to 50, 75, 100 and 125% of depleted soil moisture from field capacity and three fertilizer doses, N_{250} P_{60} K_{120} Mg_{10} Zn_5 B_2 kg/ha, N_{125} P_{60} K_{60} S_{30} Mg_{10} Zn_5 B_2 kg/ha and N_{375} P_{60} K_{180} S_{30} Mg_{10} Zn_5 B_2 kg/ha were tested. The interaction between irrigation level and fertilizer doses show that irrigation up to 100% of depleted soil moisture and

N_{250} P_{60} K_{120} M_{10} Zn_5 B_2 kg/ha of fertilizer doses was found the best combination producing 7.59 t/ha and 9.77 t/ha of grain yields in silty clay loam soil of Joydbepur and clay loam soils at Ishurdi, respectively. However, no significant difference was observed among the levels of irrigation and doses of fertilizers in Joydebpur but significant difference was found in yields at Ishurdi. Due to adequate rainfall in Joydebpur, no irrigation effect on yield was obtained among the irrigation levels.

31. CULTIVATION OF MAIZE USING REGULATED DEFICIT IRRIGATION IN LYSIMETER

P. K. Sarkar, D. K. Roy, M. Rahman, and M. S. Rahman

The study was undertaken to determine the water use efficiency of maize (cv. BARI Hybrid maize 5) under deficit irrigation practice and to identify crop growth stages during which the crop can withstand water stress with limited effect on yield. The results showed that variation in timing and amount of irrigation had a reasonable impact on grain yield. The stem-elongation stage was found as the most sensitive to water stress. On the other hand, water deficit during the early and maturity stage had a limited effect on yield. Stressing at the heading stage (treatment T_3) resulted the highest yield reduction. Water productivity was observed the lowest (1.58 kg/ m^3) for the same treatment (treatment T_3) and the highest (2.46 kg/ m^3) for the treatment T_2 (stress at the stem elongation stage). Although the maximum yield (11.25 t/ha) was obtained from the treatment T_1 fulfilling entire crop water requirement, deficit irrigation can be an effective practice for higher yield (as much as 11.04 t/ha) imposing stress at the stem elongation stage (mid-season) and thus irrigated areas can be increased in water resources limiting situations.

32. RESPONSE OF MAIZE GENOTYPES TO DIFFERENT LEVELS OF SOIL SALINITY USING SALINE WATER IRRIGATION

M. S. Rahman, M. M. Rohman, P. K. Sarkar, M. A. R. Akanda and M. R. Molla

In this study, twenty five maize genotypes (CZ 3, CZ 10, CZ 12, CZ 19, CZ 24, CZ 26, CZ 27, CZ 28, CZ 29, CZ 30, CZ 31, CZ 32, CZ 33, CZ 35, CZ 36, CZ 37, CML 159, CML 206-1, CML 216, CML 251, CML 376-1, CML 395, CML 456, CML 470 and CML 496) were tested for their salt tolerance at different degree of soil salinity: 4 dS/m (T_2), 8 dS/m (T_3), 12 dS/m (T_4) and16 dS/m (T_5). A non saline treatment (T_1) was undertaken as a control. The survivality, growth and yield of the genotypes are gradually decreased by increasing soil salinity. All maize genotypes were found to be salt tolerant at 4 dS/m salinity level and yields were more or less similar to non saline treatment. Some maize genotypes (CZ 28, CZ 29, CZ 33 and CZ36) were found to be high salt tolerant (up to16 dS/m) though the yields were lower than that of non-saline treatment.

33. EFFECT OF IRRIGATION BY URBAN WASTEWATER ON MAIZE YIELD AND SOIL HEALTH

S. K. Biswas, M. S. Rahman, M. A. R. Akanda, P. K. Sarkar, and I. Hossain

A field experiment was conducted in peri-urban area of Rajshahi during the winter season of 2011-2012 to investigate the suitability and effect of urban wastewater for irrigating maize crop. There were five treatments of irrigation and fertilizer doses with three replications: T_1: fresh water irrigation with full standard fertilizer doses, T_2: wastewater irrigation with zero fertilizer doses, T_3: wastewater irrigation with half of standard fertilizer doses, T_4: wastewater irrigation with three fourth of standard fertilizer doses and T_5: wastewater irrigation with full standard fertilizer doses. No significant yield differences were found among the treatments of fresh water-irrigation with full fertilizer doses, wastewater irrigation with three fourth of fertilizer doses, and wastewater irrigation with full fertilizer doses (T_1, T_4 and T_5). Water quality parameters like pH, NO_3-N, N, P, K, S, Zn, Na, Ca, Mg, Cu, Fe and Mn of urban wastewater did not exceed the limit of standards for

agricultural use to comply with WHO, FAO, DoE and GoB guidelines. On the other hand, EC, TDS, and B levels were found to be ranged from slight to moderate variations from the standards for irrigation. The nutrients of N, P, K, Zn and B added into the soil through wastewater irrigation ranging from 24% to 99% of standard fertilizer doses. The soil properties like OM, EC, N, P, K, S and B, were found to be increased to a considerable level in the wastewater-irrigated soil (T_2-T_5) including erratic changes in pH, Fe, Mn, Zn and Cu level. However, the use of urban wastewater for irrigation with reduced fertilizer management can be a profitable option for maize cultivation.

34. EFFECT OF IRRIGATION LEVELS ON SEED QUALITY AND YIELD OF MAIZE

A. Khatun, A. R. Akanda, Rokunuzaman, M. Amiruzzaman and A. Nessa

The experiment was conducted at the experimental field of IWM Division, BARI, Gazipur during 2013 to 2015 and RARS Ishurdi during 2013-2014 to 2014-2015 to investigate the response of irrigation to seed quality and seed production of hybrid maize. Parental lines of BARI Hybrid Maize-9 (BIL79 x BIL28) were sown in isolation (time) maintaining ratio of four female rows alternate with two male rows (4:2). Male rows were sown in two different dates for synchronization. Four levels of irrigation were selected for the experiment. The irrigation levels were T_1: Two irrigations each at the vegetative (50-60 DAS) and grain filling (110-120 DAS) stages, T_2: Two irrigations each at silking (80-90 DAS) and grain filling (110-120 DAS) stages, T_3: Three irrigations each at vegetative, silking, and grain filling stages, and T_4: Four irrigations each at pre- vegetative (20-25 DAS), vegetative, silking, and grain filling stages. The results showed that most of the yield contributing parameters were found higher in treatment T_4. The treatment T_4 gave the highest seed yield both male (8.21 t/ha) and female (4.17 t/ha) at Joydebpur and (8.163 t/ha) and (5.87 t/ha**)** at Ishurdi, respectively. Vegetative stage was the critical stage to irrigation. Better seed quality was found in treatment T_4 with four irrigations in terms of germination percentage and seeding vigour.

35. CULTIVATION OF MAIZE USING REGULATED DEFICIT IRRIGATION

P. K. Sarkar, A. Khatun and S. K. Biswas

The study was undertaken to study the water productivity of maize (BARI Hybrid Maize- 5) under deficit irrigation practices and to predict crop growth stages during which the crop can withstand water stress with limited effect on yield. The results showed that variation in timing and amount of irrigation had a reasonable impact on grain yield. The stem-elongation stage (30-35 days after sowing) was not found very sensitive to water stress. Water stress at maturity stage also had a limited effect on yield. Imposing water deficit at the heading stage (60-70 days after sowing, treatment T_3) resulted to the highest yield reduction. Water productivity was observed the lowest (1.88 kg/m^3) for the same treatment and the highest (2.62 kg/m^3) for the treatment T_4 (stress at the grain filling stage). The highest yield (8.003 t/ha) was obtained from the treatment T_1 which was fully irrigated (four irrigations at four growth stages). On the other hand, a slightly low yield (7.930 t/ha) was obtained from the treatment T_2 (three irrigations at three stages except stem elongation). This result implies that omitting irrigation or a slight stress at the stem elongation stage is not very harmful in respect of grain yield.

36. EFFECT OF IRRIGATION AND MULCH ON THE YIELD OF MAIZE IN SOUTHERN AREAS OF BANGLADESH

S. S. A. Kamar, M. A. R. Akanda and M. S. Uddin

This study was conducted at the farmer's field of Babugong Upazilla, Barisal during the year of 2014-2015 and 2015-2016 to determine the effect of irrigation sequences and straw mulch on the yield of maize. The experiment consisted of two factors: irrigation and mulch. The irrigation

treatments were placed in the main plot as: I_1: Farmer practice, I_2: One irrigation at 4 leaf stage, I_3: Two irrigations each at 4 leaf stage and 8-10 leaf stage, and I_4: Three irrigations each at 4 leaf stage, 8-10 leaf stage and tasseling stage. The subplot treatments were: M_1: No mulch, M_2: Mulch with 1 cm thickness, M_3: Mulch with 2 cm thickness, and M_4: Mulch with 3 cm thickness. The variety of test crop was BARI hybrid Maize-9. I_4 (Three irrigations each at 4 leaf stage, 8-10 leaf stage and tasseling stage) produced the highest plant height (274.3 cm) stating that plant height is directly proportional to water availability but the quantity must not exceed the optimal quantity. From two year observations, I_3M_3 (Two irrigations each at 4 leaf stage and 8-10 leaf stage with 2cm thick mulch) produced the highest number of grain per cob and 100-grain weight. The highest grain yield and biological yield were also obtained from I_3M_3 over two years of observations. Among all treatments, I_3M_3 (Two irrigations each at 4 leaf stage and 8-10 leaf stage with 2cm thick mulch) produced the highest BCR (1.70).

37. EFFECT OF ALTERNATE WETTING AND DRYING FURROW IRRIGATION ON THE YIELD AND WATER PRODUCTIVITY OF MAIZE

K. K. Sarker, A. R. Akanda, S. K. Biswas, M. F. Bazzaz, M. N. Islam and A. Barman

A new method of irrigation was used to investigate the effect of alternate furrow irrigation on crop performance, seasonal crop water use (SCWU), water productivity (WP), and nutrient uptake concentration in grain of maize (BARI hybrid maize-9) at Irrigation and Water Management research field, BARI, Gazipur and at Agricultural Research Station, BARI, Dinajpur during the year of 2014-2015 and 2015-2016. The field experiments were laid out in randomized complete block design in spilt plot with nine treatments replicated thrice. The treatments were accommodated by three irrigation levels and the same number of irrigation methods (Irrigation water applied to 100% (I_1), 80% (I_2) and 60% (I_3) field capacity. (Alternate wetting and drying furrow irrigation (AWDFI), fixed wetting and drying furrow irrigation (FWDFI) and traditional furrow irrigation(TFI) methods, respectively, denoted by M_1, M_2 and M_3). Results showed that AWDFI produced similar grain yield compared to TFI with almost 37% reduction in irrigation water when irrigated to 100% FC. The interactive effect of irrigation levels and methods had significant effect on dry matter (DM) and grain yield productions among the treatments while the same level of irrigation produced insignificant difference between the treatments, AWDFI (M_1) and TFI (M_3) methods. AWDFI (M_1) and TFI (M_3) obtained significantly better dry matter and grain yield compared to the FWDFI (M_2) method. On an average, AWDFI and TFI produced around 8.13 t/ha and 8.10 t/ha, respectively, in Gazipur and 9.74 and 9.98 t/ha in Dinajpur, respectively, over two years (2015 and 2016) when irrigation water was applied to 100% field capacity. AWDFI saved 37, 34 and 31% seasonal crop water use (SCWU) at Gazipur and 32, 29 and 24% SCWU at Dinajpur compared to TFI over two years of 2015 and 2016, when irrigation water was applied to 100, 80 and 60% FC, respectively. WP was substantially improved by AWDFI. WP was higher around 38% in Gazipur and 31% in Dinajpur in AWDFI system than TFI over two growing seasons of 2015 and 2016when irrigating with 100% FC.The micronutrients (N, P, K. S, Ca, Mg) and micronutrients (B, Zn, Cu, Fe, Mn) concentrations in maize grain were found similar trends in the methods of AWDFI, FWDFI and TFI when irrigated with the three irrigation levels of I_1 (100% FC), I_2 (80% FC) and I_3 (60% FC), respectively. AWDFI (M_1) has been found effective and water-saving irrigation techniques which improves water productivity without insignificant yield reduction and have the potentiality to be used in drought prone areas where maize production is highly dependent on irrigation.

Pulse Crops

LENTIL

38. EVAPOTRANSPIRATION FORM LENTIL

B. R. Khan M. N. Molla, M. Mainuddin and M. H. Rashid

Lentil (lens culinaris), variety Utafala, was treated with four different practices of irrigation in the newly constructed BARI lysimeter at Joydebpur, Gazipur in the order to find out the actual evapotranspiration (ET) requirement of the same. The total ET for the season was 180 mm. for a yield of 0.923 t/ha and a maturity period of 98 days. At this watering, dry mater production was 2.047 t/ha. The water use index (WUI) for the yield was 5.13 kg/ha mm. The crop was watered at 21 days interval. Due to rainfall only two irrigations were necessary. The highest production was only 0.995 t/ha with a total water use of 372 mm. reducing WUI to 2.67 kg/ha-mm. Higher rates of water uptake were observed at the 6^{th} and the 14^{th} weeks after emergence. The first stage appeared to be dominated by the higher physiological necessity of the crop whereas the next one by the higher atmospheric demand. Crop coefficients (kc) referred to both pan evaporation (EP) and potential evapotranspiration (PET, Hargreaves) were close to each other. The average Kc well acceptable to both the references was the highest (1.45) during 28 to 42 days after emergence (DAE). The average figures for the 1^{st}, 2^{nd} 3^{rd} 3-weeks periods were 0.35, 1.09, 0.47 and 0.82, respectively. The average seasonal Kc (acceptable to both the systems) was estimated to be 0.70.

39. IRRIGATION REQUIREMENT OF LENTIL

B. R. Khan, M. A. Ahad and S. Islam

Lentil (Lens culinaris) of variety, Utfala was treated with 3 irrigation treatments. The yield was unsatisfactory. There were no statistically significant 0.05% level) variations in yield among the treatments. However, the highest yield 0.40 t/ha) was obtained by only one irrigation applied at 42 days after emergence (DAE). The next highest was in one irrigation applied at 21 DAE. The water use index estimated from soil moisture depletion of top 30 cm soil and estimated effective rainfall index 3.37 kg/ha-mm was the highest no irrigation.

CHICKPEA

40. EVAPOTRANSPIRATION FROM CHICKPEA

B. R. Khan, S. Islam and M. A. Ahad

Chickpea (Cicer arietinum) of variety Nabin was treated with four different practices of irrigation in the lysimeter tanks at Joydebpur in order to find out the actual evapotranspiration (ET) requirement of the same. The total ET for the seasons was 265 mm for a yield of 2.09 t/ha, which was found in irrigation with 35 days interval. The maturity period was 118 days at this watering, dry matter production was 3.89 t/ha. The water use index (WUI) for the yield was 7.88 kg/ha-mm. The crop was watered only upto the flowering stage (55 DAE). The highest production was 2.3 t/ha with a total water use of 3.4 mm, reducing WUI to 7.56 kg/ha-mm. Higher rates of water uptake were observed around 70 to 84 DAE and again during 91 to 98 DAE in treatment T_1, watering every 14 days interval. The first stage appeared to be dominated by the higher physiological necessity of the crop, whereas the next one by higher atmospheric demand. Crop coefficients (k) referred to U. S. Class A Pan, Hargreaves and penman methods were not much varied. An average K. applicable to all methods was taken as 0.73.

41. DETERMINATION OF YIELD OF CHICKPEA AS A FUNCTION OF IRRIGATION WATER AND TIME OF APPLICATION

M. A. Hossain, M. S. Alam, M. A. Bhuyia and M. S. Akhter

Five irrigation application sequences along with a no irrigation practice were tested for chickpea (Cicer arientinum) in silty clay loam soil of BARI farm, Joydebpur. One irrigation at post sowing and another at flowering stage up to 50% and 25% of depleted soil moisture produced 1.65 and 1.36 t/ha yield for a seasonal water use of 138 and 82.4 mm in 2003-2004 and 2004-2005, respectively. The lowest yield of (1.18 and 0.75 t/ha) of the crop was obtained from no irrigation sequence in first and second years, respectively. However, irrigation applied at vegetative stage up to 50% and 25% of depleted soil moisture in addition to one post sowing irrigation produced 1.55 t/ha and 1.21 t/ha of yield, respectively, requiring 125 mm and 81.4 mm water.

COWPEA

42. RESPONSE OF COWPEA TO IRRIGATION

M. A. K. Mridha and M.H. Rashid

The experiment was conducted to find out the amount and timing of water required to grow cowpea (Genotype: HAF-43, BARI Falon-1) in clay loam soil at Joydebpur during the dry season of 1994-95. It had seven irrigation treatments, at different growth stages, having three replications. Under Joydebpur conditions, 3 to 4 irrigations were required for good yield. Non-irrigated crops could not survive without at least an irrigation around pre-flowering stage (85-90 DAE). The highest amount of irrigation water required was 282 mm for the yield of 1.22 t/ha. Yield and yield contributing characters varied significantly with different level of irrigations.

43. IRRIGATION REQUIREMENT OF COWPEA

M. A. K Mridha, M. H. Rashid and B. R. Khan

The experiment was conducted to find out the irrigation requirement of cowpea (Variety> HAF-43 BARIFALON-1) in silty clay loam soil at Joydebpur and sand clay loam soil at Hathazari during 1995-96 and 1996-97 irrigation seasons. It had four treatment including the one with no irrigation (control) and four replications. Irrigations was given at two different stages, vegetative and pre-flowering. Best yield was obtained with only one irrigation at pre-flowering stage (80 days after emergence, DAE) Yield increased with one irrigation at vegetative stage (40 DAE) was less than that with one irrigation at pre-flowering stage by 12.60%. At Joydebpur, the highest amounts of irrigation water (146 mm in 1995-96 and 118 mm in 1996-97) were applied in T_4 which produced the second highest yields of 1375 kg/ha in 1995-96 and 1790 kg/ha in 1996-97. At Joydebpur, the highest yields of 1448 kg/ha and 2277 kg/ha were obtained in where irrigation applications of 90 mm and 68 mm, respectively were made. Similarly, at Hathazari, the highest amounts of irrigation water (80 mm in 1995-96 and 83 mm in 1996-97) were applied which produced the second highest yields of 1558 kg/ha in 1995-96 and 1575kg/ha in 1996-97 where irrigation water of 46 mm in 1995-96 and 45 mm in 1996-97 were applied.

Oilseed Crops

MUSTARD

44. RESPONSE OF MUSTARD TO IRRIGATION AT DIFFERENT STAGES OF GROWTH

M. A. R. Akanda, M. S. Islam, B. R. Khan and M. R. I. Mondal

The experiment was conducted to find the critical growth stages of Mustard (Brassica napus) responsive to irrigation and the amount of irrigation water required by one advanced napus line of Mustard in silty loan soil of Jessore and grey terrace soil of Joydebpur during the dry seasons of 1992-93 and 1993-94. There were seven treatments along with control having three replications seed yield significantly varied with irrigation treatments for both the years and locations. But in 1993-94, the other agronomic characters like branches/plant, siliqua and 1000 seed wt. were also significantly varied with irrigations. Averaged over both locations and years, the treatment with 3 irrigations, one each at vegetative, flowering and siliqua filling stages (T_1) produced the highest yields (1217 kg/ha). The yields reduced with reduction of irrigation number. This was followed by two irrigations, one each at flowering and siliqua filling stages. This treatment (T_1) had also the highest yield in every location and year. In Jessore and Joydebpur, the yields were 804 and 746 Kg/ha, respectively, in 1992-93. In 1993-94, the corresponding yields were 1633 and 1684 Kg/ha. The plots with no irrigation had the lowest yields for both the years and locations (in Jessore, 157 and 418 kg/ha and in Joydebpur, 1833 and 391 kg/ha). The seed yield for both the location in the 1992-93 were much lower than the average yield because of infestation with aphids and sterility problem, the maximum average water received for two years by the crop was 163.0 mm at Jessore and 252.0mm at Joydebpur.

45. EVAPOTRANSPIRATION FROM MUSTARD

B. R. Khan M. S. Islam and M. R. I. Mondal

Mustard (Brassica Campestris) of variety SS-75 was treated with four different practices of irrigation in the lysimeter tanks at Joydebpur in order to find out the actual evapotranspiration (ET) requirement of the same. The total ET for the season (91 days) was 210 mm for a yield of 2.12 t/ha, which was found in irrigation with 28 t/ha. The water use index (WUI) for the yield was 8.24 kg/ha-mm. This treatment received only two irrigations. The crop was irrigated up to the flowering to pod filling stage (64 DAE) On an average 28 to 65 DAE (8 Now. to 15 Jan.) was found to have higher ET, 2.5 to 3 mm/day. Crop coefficients (k_c) referred to U. S. Class A Pan, Hargreaves and Penman methods are presented in graph. Average K_c for the whole season were .82, 83, 85 and 1.03 referred to pan evaporation, ET_c (hargreaves), ET_c (Penman) and ET_c (Penman-Monteith), respectively. Kes for the higher ET period (28 to 65 DAE) were 0.98, 0.98, 1.07 and 1.26 as referred to Pan evaporation, ET_c (Hargreaves), ET_c Penman), and ET_c (Penman-Monteith), respectively.

46. COMPARATIVE STUDY ON THE STRIP SIZES OF BORDER IRRIGATION IN MUSTARD

M. A. R. Akanda, M. S. Islam, B. R. Khan and M. R. I. Mondal

The experiment was conducted with 4 border-strip sizes at the central research station, Joydebpur during the dry seasons of 1992 and 1993-94 to see their effects on water application efficiency and the overall productivity of Mustard. The highest yields (1041 kg/ha in 1992-93 and 880.0 kg/ha in 1993-94) were obtained in the strip size, 5 x 20 m. The average application efficiencies were also higher (78% and 84%), in this treatment, than any other treatment both the years. The lowest

yields (856.0 kg/ha in 1992-93 and 550.0 kg/ha in 1993-94) were found in the strip size, 13 x 20 m. This treatment received the highest amount of water (308 mm) with the least application efficiency.

47. LYSIMETER STUDY ON THE EFFECT OF SUBSURFACE WATER LEVELS ON MUSTARD PRODUCTION

M. A. K. Mridha, M. S. Islam, M. S. Alam and M. M. Hossain

The experiment was conducted at the central farm of Bangladesh Agricultural Research Institute, Joydebpur during 1999-2000 and 2000-2001. Three different depths to artificial groundwater /subsurface water level viz., 30 cm, 45 cm and 60 cm were maintained in three lysimeter tanks. Another lysimeter tank was kept as a control. Altogether four lysimeter tanks were used for this study. Measured quantity of water was applied every day in each tank except the control treatment to maintain the same water level. Also measured quantity of irrigation water was applied at 25, 35, and 55 days after sowing to all the lysimeter tanks. Highest yield (1.94 t/ha in 1999-2000 and 1.88 t/ha in 2000-2001) were obtained in the treatment where the depth to water level was 30 cm (T_1). Results show that subsurface water level even at 30 cm below the ground surface did not create water logging or drainage problem to mustard, rather it contributed towards crop water requirement. In other words, closer was the groundwater level from soil surface, higher was the yield. This study shows that mustard can be grown in the low lying areas with shallow depth to groundwater level, even at 30 cm below the ground surface.

48. WATER REQUIREMENT AND WATER USE EFFICIENCY OF MUSTARD UNDER SPRINKLER IRRIGATION

A. J. Mila, M. A. R. Akanda, S. K. Biswas, P. K. Sarkar and S. Pervin

This study was conducted at the experimental field of IWM Division, BARI, Gazipur to investigate the water requirement and water use efficiency of mustard using sprinkler irrigation. There were six irrigation treatments, each replicated thrice in a randomized complete block design (RCBD). Sprinkler irrigation method was used in treatment T_1-T_5 and basin irrigation method was used in treatment T_6. The results showed that plant height and yield were significantly influenced by different irrigation treatments. Other yield contributing characters such as no. of pods per plant, seeds per pod, branches per plant, plant population per m^2 and 1000 seeds weight varied with the irrigation but were not statistically significant. The highest seed yield (1.39 t/ha) was obtained from the treatment T_6 (irrigation at vegetative, pre-flowering and pod formation stages) and the second highest yield (1.38 t/ha) was obtained from the treatment T_4 (irrigation at vegetative and pod formation stages). The lowest seed yield (0.83 t/ha) was obtained from the treatment T_3 (irrigation only at pod formation stage). The vegetative stage was the critical stage to irrigation for mustard. The highest amount of seasonal water requirement (142.00 mm) was used in treatment T_6 while the lowest amount (96.00 mm) was used in treatment T_1. The highest water use efficiency (13.3 kg /ha-mm) was found in treatment T_1 while the lowest (7.30 kg/ha-mm) was found in treatment T_3. The benefit cost ratio (BCR) of sprinkler irrigation and basin irrigation method was 1.44 and 2.13, respectively. The results suggest that sprinkler irrigation method may not be economically feasible for mustard cultivation.

49. RESPONSE OF WATER STRESS CONDITION OF MUSTARD DUE TO CLIMATIC VARIABILITY AND CHANGE

M. S. Rahman, M. A. R. Akanda, S. K. Biswas, P. K. Sarkar and A. Khatun

Scarcity of water is going to be the most severe constraint for the development of agriculture in Bangladesh. Under this condition, the necessity of using the available water economically and efficiently is unquestionable. The objectives of the study were to identify crop growth stages during which the crop can withstand water stress with limited effect on yield and to determine a

suitable irrigation option against drought for sustainable production. The results showed that variation in timing and amount of irrigation had a reasonable effect on grain yield. The mid-season stage of mustard was the most sensitive to water stress. On the other hand, water stress during the early and late stage had a limited effect on yield. Although, the highest yield (2.67 t/ha) was obtained from the treatment fulfilling entire crop water requirement with a seasonal water use of 367 mm. The lowest yield (1.85 t/ha) was obtained from treatment T_4 with water stress at mid stage (22 DAS and 75 DAS) requiring the seasonal water use of 310 mm. Deficit irrigation can be an effective practice for higher productivity and thus irrigated areas can be increased under water resources limiting situations.

50. RESPONSE OF MUSTARD TO IRRIGATION IN SALINE SOILS OF COASTAL AREAS

A. R. Akanda, S. K. Biswas, S. Mondal A. Saleh and Zofer

The experiment was conducted at the farmer's field of the village, Kulia village in Debhata upazilla of Shatkhira district during the rabi season of 2013-2014 to investigate the response of mustard in saline soils of coastal areas. There four irrigation treatments, i.e., irrigation at initial vegetative stage (farmer's practice) T_1, one irrigation at pre-flowering stage T_2, one irrigation at pod formation stage, T_3 and two irrigations each at pre-flowering and pod formation stage T_4. Although no significant variation was observed among irrigation treatments for the growth parameters but grain and straw yield of mustard were found to be increased with increasing frequencies of irrigation. The highest yield (1.52 t/ha) was achieved from treatment T_4, receiving two irrigations each at pre-flowering and pod formation stages while the lowest (1.42 t/ha) was obtained from farmer's practice (T_1). The highest water productivity (145 kg/m^3) was obtained from treatment T_2 that received irrigation at pre-flowering stage while the lowest (1.19 kg/m^3) was obtained from treatment T_4 that received two irrigations at pre-flowering and pod formation stages. The salt built-up was minimal at the time of sowing and gradually increased during the later growth stages in all the treatments.

GROUNDNUT

51. RESPONSE OF GROUNDNUT TO IRRIGATION GIVEN AT DIFFERENT GROWTH STAGES

M. A. R. Akanda, M. S. Islam and Md. Jahangir Alam

The experiment was conducted in sandy loam soil of the Regional Agricultural Research Station, Jamalpur, during the rabi seasons of 1985-86 and 1986-87 with groundnut cultivars DA-1 and DG-2 to study their response to irrigation(s) at different growth stages. Out of 8 treatments, irrigation give at pre-flowering stage produced the highest pond yields of 2517 kg/ha in 1985-86 and 3058 kg/ha in 1986-87. The treatment used 133 mm water in 1985-86 and 1986-87, respectively. The control treatment (no irrigation) produced the lowest pond yield in both the yeas. No significant difference in plant highest and pods per plant was found among the treatments.

Interaction between variety and treatment showed that DA-1 was found to produce the highest pod yields (2659 kg/ha in 1985-86 and 3166 kg/ha in 1986-87) when irrigated at pre-flowering stage. In both the years, the control treatment (no irrigation) was found to produce the lowest pod yields.

52. PERFORMANCE OF GROUNDNUT UNDER FURROW AND CHECK BASIN IRRIGATION

M. A. R. Akanda, M. H. Rashid and M. Shoeb Hassan

Field experiments with furrow and check basin irrigation methods along with control (no irrigation) were carried out in silty clay loam soil at the Regional Agricultural Research Station (RARS), Jessore during the three consecutive rabi seasons of 1988-89 to 1990-91. These experiments were conducted on Zingha Badam, a newly released variety of groundnut. Between the two methods, the furrow method performed better than the check-basin method during three years of experiment in respect of yield and yield contributing parameters with almost same amount of irrigation water received by check basin method. The yield produced by furrow method during three years were 3507 kg/ha, 3494 kt/ha, and 3668 kg/ha, respectively. All the yield contributing characters followed the similar trend with the yield obtained. The highest rainfall (1125 mm) was recorded during the cropping season of 1990-91.

53. RESPONSE OF GROUNDNUT TO DIFFERENT LEVELS OF IRRIGATION

S. Pervin, M. A. R. Akanda, A. J. Mila, P. K. Sarkar and M. S. Rahman

An experiment was conducted at the research field of Irrigation and Water Management Division, BARI, Gazipur during the rabi seasons of 2010-2011 and 2011-2012 to determine an appropriate irrigation schedule for optimum yield and to find out the critical stage to irrigation for groundnut. There were five irrigations treatments; each replicated thrice in a randomized complete block design (RCBD). The results showed that in the first year, plant height, number of branches per plant, seeds per plant, pods per plant, 100 pods weight and yield were varied significantly among the different treatments. But in the second year, plant height and 1000 seeds weight were significantly varied. Other yield contributing parameters were statistically non-significant in both the years. In the first year the highest yield (2.10 t/ha) and the lowest yield (1.30 t/ha) were obtained in the treatments T_1 (no water stress) and T_5 (water stress at flowering and pod formation stages), respectively. Whereas, in the second year, the highest (1.65 t/ha) and lowest (1.34 t/ha) yields were obtained in the treatments T_5 and T_3, respectively. Flowering and pod formation stage were the critical stages in the first year but in the second year, flowering stage was the critical stage. The highest and lowest seasonal water (329 mm and 209 mm) including an effective rainfall of 164 mm were used in the treatments T_1 and T_5, respectively for the first year whereas in the second year, these values were obtained 204 mm and 124 mm in the same treatments including an effective rainfall of 68 mm, respectively. The highest benefit cost ratio (1.55) was found in treatment T_5 while the lowest (1.04) was obtained from treatment T_1 in the second year. This trend also prevailed in the first year.

54. EFFECT OF WATER STRESS ON THE YIELD OF GROUNDNUT

S. Pervin, M. S. Rahman, P. K. Sarkar, S. K. Biswas, A. J. Milla and A. Khatun

Scarcity of water is the most severe constraint for development of agriculture in Bangladesh. Under this condition, the need to use the available water economically and efficiently is unquestionable. The objectives of the study were to identify crop growth stages during which the crop can withstand water stress with limited effect on yield and a suitable irrigation options against drought for sustainable production. The results showed that variation in timing and amount of irrigation had a reasonable impact on groundnut grain yield. The late season stage of groundnut was the most sensitive to water stress in Joydebpur location for the given soil and weather condition. On the other hand, water stress during the early and mid-stage had a limited effect on grain yield. Although maximum yield was obtained from the treatment fulfilling entire crop water

requirement, deficit irrigation can be an effective practice for higher water productivity, and thus irrigated areas can be increased in water resources limiting situations.

SESAME

55. IRRIGATION WATER REQUIREMENT OF SESAME

M. A. K. Mridha and B. R. Khan, M. S. Rashid and P. Podder

An experiment was conducted to find out the amount and timing of irrigation required to grow sesame in clay loam soil of Joydebpur during the dry season of 1994-95. It consisted of four treatments of irrigation given at different growth stages with four replications. The treatments were: No irrigation (T_0) and irrigation at vegetative (T_1), flowering (T_2) or pod filling (T_3) stages. Yield and yield contributing characters except 1000 grain weight varied significantly among different treatments. Yield of sesame in treatments T_0, T_1 and T_2 were statistically similar due to rainfall. However, treatment T_3 produced the highest yield (1445 kg/ha). This treatment was significantly better than all others and required 196 mm of irrigation water.

56. EFFECT OF WATER-LOGGING AT FLOWERING TO POD-FILLING STAGE OF SESAME

B. R. Khan M.S. Islam M. A. R.Akanda and M.R.I. Mondal

The effect of water logging flowering to pod-filling stage of sesame was studied in BARI lysimeter. There was not any remarkable difference in yield and other agronomic characters for water logging for durations of 12, 24 and 36 hours. However, the colour of the plants with 36 hours' water logging turned pale immediately after water logging but gradually recovered afterwards. The total water consumed by the crops was 1308 mm.

57. EFFECT OF WATER LOGGING ON SESAME

M. A. K. Mridha, B. R. khan, M. H. Rashid, and P. Podder

The experiment was conducted to determine the effect of water logging of various durations at different growth stages. On production of sesame (variety: T-6) at Joydebpur during the dry season of 1994-95. The experiment consisted of eleven treatments each having three replications. Late vegetative and flowering stages were found very sensitive to water logging. More than 12 hours' water logging at these stages reduced the yield by 33 to 35%. Effect of water logging for 12 hours' duration at both late vegetative and flowering stages were statistically similar to that of 48 hours at pod filling stage.

58. SESAME CULTIVATION WITH DIFFERENT DRAINAGE SYSTEMS

M. S. Alam, M. S. Islam and M. A. K. Mridha

An experiment was conducted at BARI, Joydebpur and RARS, Jessore to find out the varietals performance of sesame under different drainage systems during the kharif season of 2002. Three varieties, T-6, BARI Till-2 and Till-3 were tested under two types of drainage systems. The highest seed yields (1129-58 kg/ha at Joydebpur and 867.77 kg/ha at Jessore) were obtained from drainage across the lower end of the plot with bed and furrow having row spacing, 45 cm (D_2) From the interaction effect between treatment and variety, it is seen that the above treatment in interaction with the variety, BARI Till-3 produced the highest seed yield (1286.25 kg/ha). From this study, sesame has been found to produce better yields when provided with good drainage system.

59. EFFECT OF DURATION OF WATER LOGGING OF CROP STAND AND YIELD OF SESAME

P. K. Sarkar and S. Hossain

The study was conducted at the research field of IWM Division, BARI, Gazipur, during the rabi season of 2007-2008 with a view to evaluating the effect of water logging of different durations on the production of two sesame varieties (BARI Til 2 and BARI Til 3). A significant response of sesame on water logging and its duration was observed. Seed yields were reasonably decreased (39.41 % for BARI Til 2 and 53.20 % for BARI Til 3, respectively) for 24 hours' continuous water logging. Higher rate of yield loss with duration of water logging was observed for BARI Til 3 than that of BARI Til 2.

SUNFLOWER

60. RESPONSE OF SUNFLOWER TO IRRIGATION GIVEN AT DIFFERENT GROWTH STAGES

M. A. K. Mridha, M. H. Rashid, T. M. K. Anwar and P. Podder

The experiment was conducted to find out the critical growth stages(s) of sunflower (DS-1) in relation to irrigation for good yield in clay loam soils of Joydebpur and Regional Agricultural Research Station (RARS), Ishurdi during the dry season of 1994-95. There were eight treatments (including a control one) each replicated thrice. Yield of sunflower varied significantly among the treatments. In both the locations, the treatment with 3 irrigations, one each at vegetative (25 days after emergence, DAE), heading (45 DAE), and grain-filling (65 DAE) stages produced the highest yield (1600 Kg/ha at Joydebpur and 2790 Kg/ha at Ishurdi). Irrigation water required for the highest yield at Joydebpur was 342 mm and at Ishurdi, 254.6 mm. There was a high variation in yield between Joydebpur and Ishurdi locations due to variation of soil type and fertility.

61. ESTIMATION OF CROP CO-EFFICIENT VALUES OF SUNFLOWER BY LYSIMETER STUDY

A. J. Mila, A. R. Akanda and S. K. Biswas

The experiment was conducted on sunflower (Variety: BARI Surjomukhi-2) crop during the month of mid- November to mid-March in a lysimeter (dimension: 1m×1m×1m size) to measure the daily evapotranspiration of the crop (ETc) and crop coefficient (Kc) value from 2014 to 2015 at Irrigation and Water Management Division, Bangladesh Agricultural Research Institute, Gazipur. The study was conducted using from four types of irrigation intervals 10, 15, 20, and 25 days allowing drainage from four lysimeter tanks. Irrigation at 15 days interval produced highest yield and was considered suitable for estimating ETc and Kc. Seasonal highest ETc was found at 265.01mm. The kc values of sunflower at initial, development, mid-season and late season were found to be 0.70, 1.49, 1.95, and 0.50. These values were found higher than the values recommended by FAO. ETo was estimated by CROPWAT using climate data and location information. The variations might be due to location, climate and environmental factors.

62. EFFECT OF DEFICIT IRRIGATION ON GROWTH AND YIELD OF SUNFLOWER

A. J. Mila, A. R. Akanda, M. A. Rahman and M. H. Rashid

This experiment was conducted at the research field of Irrigation and Water Management Division, BARI, Gazipur, and Agricultural Research Station, Benarpota, Satkhira during the rabi season of 2013-2014 and 2014-2015 with BARI Surjomukhi-2. There were nine irrigation treatments, each replicated thrice in a randomized complete block design with additional spare plot. Furrow irrigation method was used. It was found that deficit irrigation (DI) was reduced plant growth such as plant height, leaf no./plant, root length density, canopy coverage, biomass and grain yield compared to full irrigation. About50 and 30% water was saved to produce 2.18 and 2.52tha^{-1} yield by applying $DI_{60\%}$ up to FC at vegetative and pre-flowering stage in Gazipur and Satkhira which had increased water productivity (WP) and profit Each irrigation was done to replenish the depleted soil moisture from field capacity depleted. It was also observed that pre-flowering stage was the critical stage to deficit irrigation. From this study, it can be recommended that cultivation of BARI Surjomukhi-2 is suitable in saline and non-saline regions in terms of yield and oil content at $DI_{60\%}$ at vegetative and pre-flowering stage compared to full irrigation (FI).

SOYBEAN

63. EFFECT OF OVER- WATERING ON SOYBEAN

M. S. Islam, M. A. Fazal and M. H. Rashid

Out of 20-25, 30-35 and 40-45 hours' saturation durations at vegetative, poding and pod filling stages of soybean (variety: PB-1), the first and last ones were found to produce 16.39% and 7.65% lower yields, respectively, than that of 30-35 hours' saturation duration, in grey terrace soil of Joydebpur. It indicated that 20-25 hours' saturation duration was not enough to supply adequate moisture to plants at the specified stages of growth. On the other hand, 40-45 hours' saturation duration was found long enough to create water stagnation at the root zone and thus, reduced the yield considerably. However, the intermediate one, 30-35 hours' duration, was found favorable rather than harmful for plants to produce the highest yield (1.83 t/ha). Pod filling stage of growth was found less harmful to yields for 44.50% to 89.00% over watering. However, irrigation up to field capacity throughout the season produced 31.88% lower yield than that irrigated with 66.99% over watering at different growth stages.

64. DETERMINATION OF CROP CO-EFFICIENT VALUES OF SOYBEAN BY LYSIMETER STUDY

A. J. Mila, A. R. Akanda and K. K. Sarkar

The experiment was conducted during 2015-2016 crop season on soybean (variety BARI Soybean-6) from mid-November to the last week of March in a lysimeter (dimension: 1 m X 1 m X 1 m size) installed in the experimental field of Irrigation and Water Management Division of BARI which measured the daily evapotranspiration (ET_c) of soybean. The crop coefficient (K_c) value was then determined with the help of this ETc values in conjunction with reference crop evapotranspiration for the location and the crop growth stages. The study was conducted with four levels of irrigation at an interval of 10, 15, 20, and 25 days allowing drainage within and adjacent of four lysimeter tanks. Irrigation at 15 days interval produced the highest seed yield and was considered to be suitable for estimating ET_c and K_c. Seasonal highest ET_c was found at 371.18 mm. The reference crop evapotranspiration was estimated from climatic data using the Software, CROPWAT. The K_c values of soybean at initial, development, mid-season and late season were found to be 0.67, 1.46, 1.59, and 0.62. These values were found somewhat higher than the value

recommended by FAO. The Kc values determined under this study are location specific and it is quite understandable that the global average values should differ from these values.

Tuber Crops

POTATO

65. IRRIGATION REQUIREMENT OF POTATO

B. R. Khan, M. A. Fazal and M. M. Rashid

An experiment was fielded at Potato Research Sub-Centre, BARI, Munshiganj to determine the optimum water requirement of potato. A potato variety, Diamant was treated with 7 irrigation regimes. Three irrigations, one each at stolonization (35 days after planting, DAP) amount equaling 75 percent pan evaporation (PE) of the preceding 15 days. tuberization (45 DAP) equaling 100 percent PE of the preceding 10 days and bulking (60 DAP) equaling 75 percent PE of the preceding 15 days. produced the best yield (17.7 t/ha). Total water used (water from irrigation, rainfall and soil moisture depletion) in this treatment was 112 mm, irrigation water along being 70 mm. The crop was harvested as early as at 74 DAP, due to the attack of late blight. Where the crop harvested at 90 DAP, the total water used would have been 137 mm as it is estimated. All treatments received an estimated effective rainfall of 49 mm. However, the differences in yields under the different treatments were not statistically significant at 5 percent level. Further works are needed for any better inference.

66. STUDY ON THE EFFECT OF DROUGHT TO POTATO VARIETIES

M. S. Islam S. Akhter and M. H. Rashid

The experiment was conducted at Joydebpur during the Rabi (dry) season of 1991-92 with four potato cultivars-Diamant, Cardinal, KS and Heera. Three treatments-stress at 30-35 DAS and continued upto harvest, stress at 50-55 DAS and continued upto harvest and irrigation at 50% DAS and continued upto harvest and irrigation at 50% depletion of available soil moisture (ASM) were tested. Due to rainfall, no significant difference among the treatments were found.

67. EFFECT OF SOIL MOISTURE STRESS ON POTATO VARIETIES

M. S. Islam, A. K. M. A Habib, B. R. Khan and M. Zakaria

The experiment was conducted at Joydebpur during the rabi season of 1992-93 with four potatoes Cultivars-Cardinal, Diamant, Heera and KS (Kupri Sundari). The experiment was undertaken to find the drought (water stress) tolerant varieties under Bangladesh condition. There were three treatments including control, having four replications, Diamant was least affected among the varieties (reduction of yield by 17%) when stress started from 50 days after sowing. Heera was most affected (yield reduction of 66%) when stress started from 30 days after sowing.

68. RESPONSE OF POTATO TO IRRIGATION AT DIFFERENT GROWTH STAGES

M. Hossain

An experiment was conducted to study the effect of irrigation on potato at different growth stages at Regional Agricultural Research Station (RARS), Jamalpur during the dry season of 1993-94, Irrigations applied at 20 days after planting (DAP), tuberization stage (45 DAP) and bulking stage (60 DAP) produced higher yield than any other combination. Irrigation equaling 150% pan

evaporation accumulated from the preceding irrigation day was better than 100% pan evaporation accumulated for the same interval. First irrigation at 20 DAP was better than either at 10 DAP or at 35 DAP (stolonization stage)

69. THE USE OF COMPUTER PROGRAM FOR IRRIGATION SCHEDULING OF POTATO

P. K. Sarkar and S. K. Biswas

A field experiment was conducted at the Regional Agricultural Research Station, Jessore during the period from December 1999 to March 2000. It was designed to compare the yield and yield contributing characters of the potato variety " Heera" under different irrigation schedules based on the FAO developed CROPWAT Computer program. Irrigation management conditions varied to estimate the crop production under rainfed and different irrigation regimes. Irrigation water was applied as per output of the CROPWAT program and measured amount of irrigation water was applied directly to the experimental plots. The yield contributing characters were influenced markedly with timing and depth of irrigation. Irrigation showed significant effect of plant height, foliage coverage, stems per hill and tuber yield. The increase in tuber yield due to various irrigation treatments over control ranged from 130% to 227%. The highest yield of 16.86 tons per hectare was obtained when irrigation was applied at 70% depletion of the available moisture content. Six irrigations amounting 250 mm of water was applied to obtain that yield. The highest water use efficiency was observed in T_7 and the lowest water use efficiency was found in treatment T_1.

70. INTERACTION EFFECT OF IRRIGATION WATER AND FERTILIZER DOSES ON THE PRODUCTION OF POTATO

M. S. Islam, M. A. K. Mridha, M. S. Alam and M. S. Rashid

Interaction of three irrigation intervals, 14 (T_1), 21 (T_2) and 28 (T_3) days, with three different fertilizer doses high (F_1), medium (F_2) and low (F_3) were tested on potato (variety: Cardinal) in silty clay loam soil of Joydebpur during 1999-2000 and 2000-2001. The highest yields of 28.76 t/ha and 17.67 t/ha and 17.67 t/ha were obtained in the irrigation treatment T_1 (14 days intervals) with high fertilizer dose, F_1 in 1999-2000 and 2000-2001, respectively. The lowest yields of 16.08 and 12.50 t/ha were found from irrigation treatment T_3 (28 days interval) with low dose of fertilizer (F_3) application in 1999-2000 and 2000-2001, respectively. Total water received by the treatment T_1, T_2, and T_3 were 364, 273 and 182 mm in 1999-2000 and 355, 268 and 185 mm in 2000-2001. The maximum benefit cost ratio (2.34) was found in the treatment T_1 irrigated 14 days interval with high fertilizer dose N_{150} P_{60} K_{150} S_{20} Zn_4 Kg per hectare. The highest marginal rate of return was 556.55 percent in the same treatment. In potato cultivation irrigation at 14 days interval with high fertilizer dose was found to be the best practice to produce potato economically.

71. STUDY THE EFFECT OF IRRIGATION INTERVAL AND REGIME ON THE YIELD AND SCAB INFESTATION OF POTATO

M. A. Hossain, M. A. T. Masud and M. S. Rahman

Experiment was conducted with potato variety, Diamant, in the farm of Regional Agricultural Research Station, Jamalpur during Rabi seasons of 2004-2005 and 2005-2006 to investigate the yield and scab infestation under different irrigation frequencies and quantities. Three irrigation intervals i.e. 7, 12 and 17 days along with three levels of water quantities equaling 50, 100 and 150% of depleted soil moisture were tested for yield and scab infestation of potato tubers. It was observed in 2004-2005 that irrigation interval of 12 days and watering at 100% depletion of soil moisture produced the highest fresh and total yields of 24.64 t/ha and 27.56 t/ha, respectively, whereas irrigation interval of 7 days and watering at 150% of depleted soil moisture produced the

lowest fresh and total yields (21.68 t/ha and 25.98 t/ha, respectively). In 2005-2006, the total and fresh yields (27.41 t/ha and 26.27 t/ha, respectively) were not found statistically different from those obtained under water application of 150% and irrigation interval of 12 days. The scab infestation was observed the highest, 4.30 and 2.97 t/ha for water application of 150% depleted soil moisture and 7 days irrigation intervals in the first and second years, respectively. This indicates that scab disease is more susceptible to frequent over irrigation.

72. DETERMINATION OF CROP CO-EFFICIENT VALUES OF POTATO BY LYSIMETER STUDY

M. A. R. Akanda, M. S. Rahman, M. S. Islam and M. Hossain

The crop coefficient values of 0.25, 0.62, 0.70 and 0.23 were determined for initial, development, mid-season and late season stages of potato (variety: BARI ALU-7, Diamant). The values are different slightly from the FAO recommended values (FAO, 1977). As the lysimeter provides control environments, the values determined by this method are most dependable and recommended for estimating crop water requirement of potato in Bangladesh.

73. CALIBRATION AND TESTING OF AQUACROP MODEL FOR POTATO CROP IN BANGLADESH CONDITION

M. S. Rahman, M. Salehin, P. K. Sarkar, M. A. R. Akanda and A. U. Haque

Predicting yield is increasingly important to optimize irrigation under limited available water for enhanced sustainability and profitable production. Food and Agriculture Organization (FAO) of the United Nations has recently addressed this need by providing a yield response to water simulation model (AquaCrop). This model is already parameterized for different crops including potato. In this study, AquaCrop was locally calibrated and tested for potato crop (variety: Diamant) with several treatment variables of irrigation: full irrigation as the control, water stress at stolonization stage, water stress at tuberization stage and water stress at bulking stage. The field experiment was conducted in the research field of Bangladesh Agricultural Research Institute (BARI), Jodebpur, during winter season of 2010-2011. Model parameters that were calibrated using the field experiment data included conservative parameters which are given specific but can or may be cultivar specific, parameters which are dependent on environment and /or management, and parameters which are cultivar specific. The conservative parameters were held constant, and the calibrated model was evaluated by test simulations. The simulation results showed a reasonably accurate prediction of the final aboveground biomass within 9% of the measured value. The predicted tuber yield values were within 15% of measurements, except in the treatment of water stress at stolonization stage, with errors up to 19.031%. The simulated pattern of canopy progression and biomass accumulation over time were close to measured values, with Willmott's index of agreement for all the cases being $\geq$0.985 for canopy cover, and $\geq$0.989 for biomass. Accelerated senescence of canopy due to water stress was difficult to simulate accurately. The model closely predicted the trend in soil water content, but overestimated soil moisture for the three water stress treatment cases. From the first year study, the calibrated model seems to have performed well for potato crop in Bangladesh condition.

74. EFFECT OF IRRIGATION ON YIELD AND QUALITY OF PROCESSING POTATO VARIETIES

A. J. Mila, A. R. Akanda, B. C. Gosshami, S. Pervin and N. C. Sheel

This study was conducted at the research field of Irrigation and Water Management Division, BARI, Gazipur, to obtain more information about the effect of irrigation on yield and quality of BARI Alu-25 (Asterix) and BARI Alu-28 (Lady Rosseta during the robi season of 2012-13 and 2013-14. There were six irrigation treatments, each replicated thrice in a randomized complete block design (RCBD). Furrow irrigation method was used. Yield of tubers increased with

irrigation rate as a result of more tubers per plant and large tubers but the percent of malformed tubers also increased. The variety BARI Alu-25 along with three irrigations each at, stolonization, tuberization, and bulking stage and the other one two irrigations each at, stolonization or tuberization along bulking stage were found better to produce the highest yield than other treatments in the first year. In contrast, in the next year, two irrigations i.e., stolonization or tuberization and bulking stage were found better yield than other interactions. The stolonization and tuberization stages were the critical stage to irrigation for processing potato cultivation. BARI Alu-25 produced higher yield and biomass than BARI Alu-28. The highest WU (169.34 mm) and WP and the (31.72 kg/m^3) were found in treatment V_1T_6 and V_2T_2 in the first year whereas in the next year, highest WU (190.74 mm) and WP (24.42 kg/m^3) were found in treatment V_1T_6 and V_2T_2. Treatments soil moisture variation within two varieties was more in the next year compared to the first year. BARI Alu-28 produced maximum canopy coverage than BARI Alu-25. Financial feasibility of BARI Alu-25 along with two irrigations i.e. (stolonization and bulking stage) was found better than other treatments. BARI Alu-25 is suitable for producing French fry and BARI Alu-28 is suitable for chips. The variety BARI Alu-28 with two irrigations given each at tuberization and at bulking stage was found better quality (considering TSS, Specific gravity, DM, and Starch) than other treatments.

75. EVALUATION OF WASTEWATER AS A SOURCE OF N, P, K FOR POTATO CULTIVATION

S. K. Biswas, P. K. Sarkar, S. C. Mondal, and A. R. Akanda

A set of field experiments was conducted at the farmer's field in Terokhada, Rajshahi city during 2011 – 2013 to identify the right dose of N-P-K fertilizers for potato (Diamant, BARI Alu-7) production by irrigation with municipal wastewater (hereafter called wastewater). The experiment was designed in a randomized complete block with five treatments and three replications. The treatments of each experiment had five different levels of particular nutrient (N= 0, 120, 150, 180, 210; P= 0, 8, 12, 16, 20; K = 0, 60, 80, 100, 120 kg-ha) under investigation while other major nutrients were kept at the recommended dose. The varying levels of nitrogen and phosphorus had significant influence on growth and yield variables, and yield of potato. The tuber yields of potato increased to attain their maximum values up to nitrogen rate of 150 kg/ha and phosphorus rate of 12 kg/ha beyond this tuber yield decreased. The omission of N and P reduced all the growth and yield variables as well as the yield of potato. The reduction in the growth and yield variables due to the omission of P was less than that due to the omission of N. Unlike N and P, the higher doses of K showed no significant effect on the growth and yield of potato. Though K-omission plots produced significantly the lowest biomass and tuber yields among the five treatments, they were identical with the plots that received varying doses of K (60 - 120 kg/ha). However, for all cases, the maximum yield does not obtain with the maximum fertilizer application. This fact is more conspicuous for N and P fertilizers than K fertilizer. Regression analysis indicates that N-P-K of 137-14-72 kg/ha can be a balanced dose for potato production by irrigation with wastewater.

SWEET POTATO

76. STUDY THE EFFECT OF DROUGHT ON THE YIELD OF DIFFERENT SWEET POTATO CULTIVARS

M. S. Islam, M. A. Mannan and M. K. Rahman

The experiment was conducted at Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during the rabi season of 1991-92. Results show that neither the drought treatment nor the variety drought treatment nor the variety has significant effect on the marketable yield of sweet potato. The untimely heavy rainfall might be responsible for such effects. However, significant difference was found for varieties on the non-marketable yield of sweet potato, No significant on dry matter

percentage of tubers and vines. Higher water uses by the controlled treatment did not produce any significant difference in yield and dry matter percentage of sweet potato which might be due to rainfall at two critical growth stages (stolonization and bulking).

77. EFFECT OF MOISTURE STRESS ON THE YIELD OF DIFFERENT SWEET POTATO CULTIVARS

M. S. Islam, A. K. M. A Habib, BIRKhan and M. Zakaria

The experiment was conducted at Joydebpur during the rabi season of 1992-93 with four potatoes Cultivars-Cardinal, Diamant, Heera and KS (Kupri Sundari). The experiment was undertaken to find the drought (water stress) tolerant varieties under Bangladesh condition. There were three treatments including control, having four replications, Diamant was least affected among the varieties (reduction of yield by 17%) when stress started from 50 days after sowing. Heera was most affected (yield reduction of 66%) when stress started from 30 days after sowing.

78. RESPONSE OF SWEET POTATO TO IRRIGATION METHODS AND INTERVALS

M. S. Islam and M. GM. Rasul

The experiment was conducted at Regional Agricultural Research Station, Jessore, during rabi seasons of 1992-93, with the sweet potato variety, Tripti. Irrigation in furrows, at an interval of 21 days, produced the highest marketable and non-marketable (33.07 t/ha and 7.52 t/ha) yields of sweet potato. One irrigation in border produced the lowest marketable and non-marketable (42.04 t/ha and 6.14 t/ha) yields. However, no significant differences were found in dry matter percentages of tubers among the treatments. The treatments producing highest and lowest yields used 372 and 254 mm water, respectively, in a season.

Vegetable Crops

WINTER TOMATO

79. STUDY ON THE COMPARATIVE PERFORMANCE OF LOW COST DRIP FURROW AND BORDER IRRIGATION FOR TOMATO CULTIVATION

M. S. Islam M. A. R. Akanda, M. H. Rashid and M. M. Haque

Two Drip systems-one with P.V.C pipe and the other with used medical saline delivery tube together with traditional border and furrow systems were used to irrigate tomato (variety: Manik) at RARS, Jessore, during the rabi seasons of 1990-91 and 1991-92. The drip system with "used saline tube" produced the highest marketable fruit yield (64.79 t/ha), no. of fruits per plant (22), weight of fruit per plant (1.45 kg) and cull yield (7.7 t/ha) during 1990-91. Benefit cost ratio (RCR) was the highest (1.78) for drip system with "used saline delivery tube" and the lowest (1.19) for furrow systems. But in 1991-92 there were no significant differences in characters considered for the treatments except marketable fruit yield. In 1991-92 the drip system with "PVC pipe" produced the highest marketable fruit yield (17.7 t/ha). The furrow system gave the lowest marketing yield in both the years. The benefit cost ratio was found the highest (0.70) for PVC dripper and the lowest (0.35) for furrow method. Unusual heavy shower was responsible for low yield of crop in 1991-92 and thus, the BCR for each of the methods was found less than 1.0.

80. EFFECT OF IRRIGATION REGIMES AND INTERVALS ON THE GROWTH AND YIELD OF TOMATO

M. S. Islam, M. A. Fazal and M. A. I. Bokshi

Four intervals and three levels (regimes) of irrigation were tried in tomato (variety, Ratan) cultivation at Joydebpur during 1994-95 season to find their effects on yield, physical parameters and attack of virus. Out of the selected irrigation intervals, one with 35 days was found to produce the lowest fruit yield (38.35 t/ha) but enhanced the highest virus attack (33.46%). On the other hand, irrigations at 14 days interval produced the highest fruit yield (55.66 t/ha) with the least (27.28%) virus attack. This implies that 35 days irrigation interval produced sufficient moisture stress in plants that subsequently became too weak to prevent themselves from virus attack. Irrigation regimes were found also to have no effect on fruit yield and cull yield. However, no effect on plant height, diameter of fruits and attack of virus was observed. Interactions between 14 days interval and irrigation upto field capacity produced the highest fruit yield (56.64 t/ha) using 132.86 mm irrigation water whereas 35 days interval and irrigation amount equaling 75% of depleted water produced the lowest fruit yield (37.71% t/ha) using 117.91 mm irrigation water.

81. EFFECT OF IRRIGATION APPLICATION METHODS ON THE YIELD OF TOMATO

M. S. Alam, M. S. Islam, M. A. K. Mridha and M. H. Rashid

Three irrigation methods, viz., Ridge and furrow (M_1), Bed and furrow (M_2) and Check basin (M_3) were tested on tomato (variety: Ratan) in a silt clay loam soil of Joydebpur during the Rabi seasons of 1999-2000 and 2000-2001. The same quantity of irrigation water was applied in each plot at 12 days interval. The highest yields of 46.42 and 63.21 t/ha were obtained in the same treatment (M_1) in both the years. The lowest yields 40.60 and 51.06 t/ha were also found in the same treatment (M_2) in 1999-2000 and 2000-2001, respectively. The fruit wt./plant were found the highest (1.00 kg in 1999-2000 and 1.35 kg in 2000-2001) in treatment M_1. Total irrigation water received by each treatment was 319 mm including 76 mm effective rainfall in 1999-2000 and 325 mm with no rainfall in 2000-2001. The maximum benefit cost rations of 3.96 and 4.00 and the highest gross margins of Tk. 175300.00/ha and Tk. 237200.00/ha were found in treatment (M_1), in 1999-2000 and 2000-2001, respectively. The marginal rate of return was, 1228 and 1869.23 percent in 1999-2000 and 2000-2001, respectively. In tomato cultivation 12 days interval of irrigation with ridge and furrow method of water application was found to be the best among the selected methods for tomato cultivation.

82. PERFORMANCE EVALUATION OF FERTIGATION ON TOMATO CULTIVATION

M. A. K. Mridha, M. S. Alam and K. C. Roy

Fertigation by drip irrigation system appeared technically feasible and economically viable for tomato cultivation. In the study the highest tomato yield (85 t/ha) was found in drip fertigation method with 110 kg N/ha and the lowest yield (62 t/ha) in farmers practice with 250 kg/ha of nitrogen. The system saved 46% water and 40% urea over traditional furrow system of irrigation in the study at Joydebpur. The incremental benefit cost ration was as high as 2.29 over the traditional furrow method. Thus, the drip fertigation method seems profitable when used at its potential level of command area for high value horticultural crops.

83. DETERMINATION OF CROP COEFFICIENT VALUES OF TOMATO BY LYSIMETER STUDY

M. S. Islam, N. A. Hossain, M. A. Bhuyia and M. A. R. Akanda

The crop coefficient values as 0.46, 0.83, 1.08 and 0.86 were determined at initial, development, mid-season and late season stages of tomato (variety: BARI Tomato-3). These locally determined values of tomato were found to remain within the FAO recommended ranges of 0.4-0.5 for initial stage, 1.05-1.25 for mid season stage and 0.8-0.95 for late season stage. However, the value at development stage (0.83) was found to slightly exceed the FAO range, 0.7-0.8, by some margin. This might be due to the effect local soil and temperature as well as crop variety on crop ET. However, locally determined values are always preferred to the generalized values for the estimation of crop ET.

84. PERFORMANCE EVALUATION OF FERTIGATION ON TOMATO CULTIVATION

M. A. R. Akanda, M. Abdullah, and M. A. Rashid

Fertigation system appeared technically feasible and economically viable for tomato cultivation. This is the third year study conducted in IWM research field, BARI, Joydebpur. The highest tomato yield (72.60 t/ha) was obtained in fertigation with fertilizer doses N_{100} P_{50} and K_{80} kg/ha. The yield of tomato during 2003-2004 was lower than that of 2001-2002 due to severe virus infestation but the yield was higher than the last year. However, the yield trend among the treatments remained the same. The treatment with N_{100} kg/ha performed better in all the years. The system also saved about 46% of irrigation water, 60% of urea and 36% of MP over traditional furrow irrigation system. The incremental benefit cost ratio was 2.83 over the traditional farmers' practice. Thus, the fertigation seems profitable for tomato cultivation as well as for high value horticultural crops.

85. ON-FARM TRIAL OF FERTIGATION ON TOMATO

M. A. R. Akanda, M. S. Rahman, M. A. Hossain and M. Abdullah

A fertigation trial on tomato was conducted during 2003-2004 and 2004-2005 at Taratpara, Gazipur, one of the projuktee villages of BARI to evaluate the performance of fertigation at farmers' level in terms of technical and economic feasibility over the traditional system. The highest tomato yield (50.87 t/ha) was obtained in fertigation method with fertilizer doses N_{100} P_{100} K_{80} kg/ha which was an increase about 22.4% over the control. However, the overall tomato yield was very much lower than the potential. This was due to severe virus infestation to the crops. The system saved 58% of urea, 36% of MP and about 48% of irrigation water over the traditional furrow irrigation system. The highest incremental benefit cost ration (1.79) was also obtained from the fertigation treatment with N_{100} P_{50} K_{80} kg/ha over the furrow irrigation system.

86. DEMONSTRATION AND POPULARIZATION OF DRIP AND FERTIGATION TECHNOLOGY ON LATE TOMATO IN PANCHAGAR DISTRICT

S. K. Biswas, M. A. R. Akanda, M. Alam and M. S. Islam

Fertigation system appeared technically feasible and economically viable for tomato and brinjal cultivation. This On-farm trial was done in two farmers' fields of Boda upzilla of Panchagar district during 2005-2006. The highest tomato yields (25.62 t/ha and 24.13 t/ha) were obtained in drip irrigation applied at an alternate day with fertilizer doses N_{100} P_{100} K_{80} kg/ha. For both the fields, the farmers' practice (furrow irrigation) produced the lowest yields (15.60 and 16.50 t/ha)

with higher doses of fertilizer. The yield was comparatively lower due to virus infestation to crops. The fertigation system saved nearly 60% of Urea 36% of MP and 40-50% of irrigation water. The incremental rate of return from late tomato was 1.70 and 1.61.

87. EFFECT OF DIFFERENT LEVELS OF DRIP IRRIGATION AND MULCHES ON THE YIELD OF TOMATO

S. K. Biswas, M. A. R. Akanda, M. S. Rahman and M. A. Rashid

Drip irrigation at an alternate day (control), three and four days intervals with and without mulch were tested to study their effects on yield, economic return and water use efficiency of tomato (cv: BARI Tomato-3) during three consecutive rabi seasons from 2004-2005 and 2006-2007 at the central research station, BARI, Gazipur. The yield and yield contributing characters varied significantly under paddy straw and polythene mulch for all levels of irrigations over the control treatment (without mulch). In the first year, the highest tomato yield (83.72 t/ha) was obtained from the treatment mulched with paddy straw with drip irrigation at 4 days interval but in the second and third years, the highest marketable fruit yields were recorded in polythene mulch treatment with the same irrigation interval. Considering three years' average, polythene mulch with irrigation 4 days interval produced higher yield than that of straw mulch. The highest water use efficiency (474.69 kg/ha/mm) was also obtained in this treatment with an average irrigation of only 149.33 mm which saved 45-56% water over the control. The lowest fruit yields were obtained from un-mulched treatment, irrigated at 4 days interval. The highest incremental BCR (6.52) was found from straw mulch and 3.38 from polythene mulch.

88. EFFECT OF DRIP IRRIGATION WITH DIFFERENT LEVELS OF MICRO-NUTRIENTS ON FRUIT QUALITY AND YIELD OF WINTER TOMATO

M. A. R. Akanda, M. A. Rashid and K. N. Mazidul Hossain

Drip irrigation at 3 days intervals along with mulch and different levels of macro and micronutrients were tested to study their effects on yield, economic return of tomato (CV: BARI Tomato-3) during the rabi season of 2007-2008 at the central research station, BARI, Gazipur. The yield and yield contributing characters of tomato varied significantly under different levels of micronutrients. The highest marketable fruit yields (59.27 t/ha) were recorded in treatment T_2 with fertilizer doses N_{100} P_{100} K_{100} $B_{1.5}$ Zn_2 Mg_2 kg/ha. The cull yield (10.51 t/ha) was also the lowest in this treatment. The cull yield was the highest (20.20 t/ha) in treatment T_1 where no micronutrients were used along with NPK. It reveals that use of micro nutrients along with NPK under fertigation has a good effect on quality fruits of tomato. The overall tomato yield was much lower than the potential due a heavy shower on February 19, 2008 and also for virus infestation. Lot of fruits were damaged and graded as unmarketable due to heavy rains. The seasonal water used by the treatments was same i.e. 370 mm including a seasonal effective rainfall of 105mm. The highest BCR (3.66) was also found from high yielder treatment T_2.

89. REGIONAL ADAPTATION OF FERTIGATION ON WINTER TOMATO

A. F. M. T. Islam, P. K. Sarkar and M. A. R. Akanda

A fertigation trial on winter tomato was conducted at OFRD site, Pabna to evaluate the adaptability of fertigation at northwest region of Bangladesh in terms of technical and economic feasibility over traditional irrigation system. Two fertigation treatments including one farmer's traditional practice during the winter seasons of 2009-10 and 2010-11were used in the study. The highest marketable yield of tomato (58.19 t/ha) was obtained from treatment T_2 (applying irrigation water alternate day incorporating fertilizer doses of N_{100} P_{100} K_{80} kg/ha) while the lowest yield (51.06 t/ha) was obtained from T_1 (traditional system with fertilizer doses N_{205} P_{100} K_{125} kg/ha with 10 days interval application of irrigation water). The yield from fertigation method (treatment T_2) was about 14% increase over the control. The fertigation system saved 52% urea,

36% of MP and about 50% of irrigation water over the traditional furrow irrigation system. A benefit cost ratio 3.19 was predicted for fertigation system based on the treatment T_2.

90. ON-FARM TRIAL OF FERTIGATION ON TOMATO AND BRINJAL IN BARIND AREA OF RAISHAHI

M. A. R. Akanda, A. Rahman and M. S. Islam

Fertigation system appeared technically feasible and economically viable for tomato and brinjal cultivation. This on-farm trial was done in Barind area of Godagari upzilla in Rajshahi district in collaboration with on-farm research division of BARI during 2005-2006 and 2006-2007. The highest tomato yields of 52.96 t/ha and 35.14 t/ha were obtained in drip irrigation at an interval of 3 days with fertilizer doses N_{100} P_{100} K_{80} kg/ha during 2005-2006 and 2006-2007, respectively. The highest brinjal yield of 34.17 t/ha in 2005-2006 and 20.17 t/ha in 2006-2007 were also obtained from the study area. The lowest yields of 38.17 t/ha and 21.23 t/ha for tomato and 27.02 t/ha and 14.68 t/ha for brinjal were obtained in furrow irrigation with higher doses of fertilizer in both the years. The fertigation system saved 50-55% of Urea, 35-36% of MP and 48-50% of irrigation water. The incremental rate of returns was 2.85 for tomato and 2.54 for brinjal in 2005-2006 and the same were 2.43 for tomato and 1.67 for brinjal in 2006-2007. From the two year's average, the incremental rate of returns was found 2.13 for tomato and 2.76 for brinjal.

91. EFFECT OF MUNICIPAL WASTEWATER IRRIGATION WITH DIFFERENT DOSES OF FERTILIZER ON YIELD AND BIOLOGICAL QUALITY OF LEAFY VEGETABLES

S. K. Biswas and A.R. Akanda

An experiment was conducted at the sub-urban area of Rajshahi city during February−May, 2014 to determine the appropriate fertilizer dose for cultivation of leafy vegetables (e.g. Indian spinach), and to evaluate the microbiological quality of vegetables under municipal wastewater (as referred to wastewater) irrigation. The experiment consisted of five treatments−25, 50, 75 and 100% recommended fertilizer dose (RFD), in combination with irrigation by wastewater, and 100% RFD in combination with irrigation by fresh water, as control. In general, harvest was found higher in the wastewater-irrigated plot with higher doses of fertilizer. Application of 50% RFD in combination with wastewater produced statistically identical crop attributes and fresh yield with that of application of 100% RFD in combination with irrigation by fresh water, indicating that 50% of fertilizer requirement can be minimized by irrigating with wastewater without any compromise in the yield. Increase in fertilizer dose to 75% RFD or 100% RFD had little effect on increasing the yield. A high bacterial contamination with fecal coliforms, total coliforms, total bacterial aerobic counts and Escherichia coli was observed in fresh Indian spinach irrigated with municipal wastewater. However, the crop was not contaminated with pathogenic bacteria of the Salmonella species. Therefore, the hygienic aspects of wastewater irrigated crops, especially for vegetable crops, require more attention to sanitary problems.

92. PERFORMANCE STUDY OF ALTERNATE WETTING AND DRYING FURROW IRRIGATION FOR TOMATO CULTIVATION

K. K. Sarker, A. R. Akanda, D. K. Roy, S. K. Biswas and M. A. Goffar

The field experiment was conducted for two years at BARI, Gazipur during the rabi seasons of 2013-2014 and 2014-2015 to assess a new irrigation method of alternate wetting and drying furrow irrigation (AWDFI) for tomato cultivation. The field experiment was laid out in Randomized Block Design (RBD) with six treatments replicated thrice. Irrigation was applied by alternate wetting and drying furrow irrigation (AWDFI), fixed wetting and drying furrow irrigation (FWDFI) and traditional furrow irrigation (TFI). Each irrigation method was divided into two levels of irrigation to 100% field capacity (FC) and 80% FC at each application. The results of the

study showed that dry matter of the tomato plant and marketable yield of tomato were not found to differ significantly between the treatments of AWDFI and TFI. However, there were better than FWDFI when irrigation water was applied at same irrigation levels. Marketable yield of tomato was similar between the treatments of AWDFI and TFI, when irrigated at 100% FC. AWDFI produced higher marketable yield by 7.86% than TFI when irrigated at 80% FC. Cull yield was higher by 15.79% and 5.9% in TFI than AWDFI system when irrigated 100% and 80% FC, respectively. The most important result was that AWDFI saved irrigation water by 37.8% and 35% (on average) compared to TFI without significant reduction in yields at the irrigation level of 100 % and 80% FC, respectively. Field water use efficiency was improved by 37% and 40% (on average) in AWDFI system compared to TFI when irrigation water was applied to 100% and 80% FC, respectively. The quality parameters (Total soluble solid and pulp) content of tomato fruits at harvest were found greater in AWDFI system than TFI at the same levels of irrigation. The benefit-cost ratio (BCR) and unit production cost (UPC) (Tk per kg of tomato) of the treatment AWDFI was attained similar to the treatment of TFI when irrigated with 100% FC. BCR was found greater and UPC was attained lower in AWDFI compared to TFI and FWDFI, respectively when irrigated with 80% FC., BCR was found higher in AWDFI by 2.8%, 8.6% and 11.4%, 10.2% (on average) than that of TFI and FWDFI when irrigated with 100% and 80% FC, respectively. AWDFI produced lower UPC (Tk per kg of tomato) compared to TFI and FWDFI by 2.8%, 8.9% and 23.3%, 12.8% when irrigated with 100% and 80% FC, respectively. However, AWDFI is a way to save water for tomato production. This new method may be feasible in drought prone areas where water and water supply methods are limited to irrigation for crop cultivation.

SUMMER TOMATO

93. DEVELOPMENT OF NUTRIENT AND WATER MANAGEMENT PACKAGE FOR SUMMER TOMATO CULTIVATION UNDER CONTROLLED ENVIRONMENT

A. R. Akanda, M. A. Hossain, S. K. Biswas, K.K. Sarkar and G. M. A. Halim

Fertigation has been found technically and economically feasible for tomato cultivation in winter as well as in summer season. Use of different levels of micronutrients has a significant effect on the yield and fruit quality of tomato and mulch can minimize the irrigation frequency due to soil moisture conservation. Considering this hypothesis, this experiment was undertaken with different levels of fertilizers under drip irrigation to develop a nutrient and water management package for summer tomato (BARI hybrid tomato-8) cultivation in silty clay loam soils of BARI, Gazipur. The study was conducted in consecutive there kharif II season of 2012, 2013 and 2014. Three levels of fertilizers, i.e. N_{100} P_{55} K_{120} $B_{1.0}$ $Zn_{4.0}$ $Mg_{4.0}$ kg/ha, N_{100} P_{70} $B_{2.0}$ $Zn_{6.0}$ $Mg_{8.0}$ kg/ha and N_{100} P_{55} K_{120} kg/ha (control) were considered under drip irrigation applied at 2 days interval. The treatments were arranged with mulch and without mulch. Rice straw was used as a mulching material. The treatment (T_4) with fertilizer doses N_{100} P_{55} K_{120} $B_{1.0}$ $Zn_{4.0}$ $Mg_{4.0}$ kg/ha with straw mulch produced the highest marketable yield of summer tomato (40.98 t/ha, 33.02 t/ha and 33.46 t/ha) with minimum cull yield in all the years. The lowest yield (30.96 t/ha, 24.85 t/ha and 26.45 t/ha) was obtained from the treatment T_3 having no use of micronutrients and mulch. The mulched treatments received, respectively, 297, 289 and 310 mm of seasonal water ins 1st 2nd and 3rd years whereas the non-mulched treatments received 315 mm, 338 mm and 321 mm of seasonal water in the 1st, 2nd and 3rd year, respectively. The highest average BCR (3.71) was found in high yielding treatment in all the years along with average highest water productivity of 12.0 kg/m^3.

94. PERFORMANCE EVALUATION OF FERTIGATION SYSTEM ON SUMMER TOMATO

M. A. R. Akanda, M. S. Rahman, M. Shahabuddin Ahamed and M. S. Islam

Fertigation was found technically and economically feasible for tomato cultivation in winter. Considering this hypothesis, experiment was conducted with summer tomato (BARI Hybrid

Tomato–4) having 4 fertigation and 2 irrigation levels. The fertilizer levels were N_{250} P_{95} K_{125} kg/ha, N_{150} P_{95} K_{75} kg/ha, N_{100} P_{95} K_{50} kg/ha and N_{75} P_{95} K_{35} and the irrigation levels were- drip irrigation at 2 days interval and drip irrigation at 3 days interval during 2005-2006 and 2006-2007 seasons. In the second year, the highest marketable yield of summer tomato (30.98 t/ha) was obtained from the fertigation treatment with fertilizer doses of N_{75} P_{95} K_{35} kg/ha irrigated at 3 days interval. In the first year, the highest marketable yield of summer tomato (32.42 t/ha) was also obtained from the same treatment. The lowest yield of 19.12 t/ha and 14.28 t/ha were obtained from the treatment with recommended fertilizer doses N_{250} P_{95} K_{125} kg/ha irrigated at 2 days interval in the first and second year, respectively. The highest yielder treatment received 195 mm of seasonal water including an effective rainfall of 25 mm in the second year study. The BCR was found 3.22 in highest yielding treatment (N_{75} P_{95} K_{35}) in 2006 and 3.3 in the previous year. The average benefit cost ratio was 1:3.11.

95. EFFECT OF DRIP IRRIGATION WITH DIFFERENT LEVELS OF MICRO-NUTRIENTS ON FRUIT QUALITY AND YIELD OF SUMMER TOMATO

M. A. R. Akanda, M. S. Ahmad and K. M. Hossain

Fertigation was found technically and economically feasible for tomato cultivation in winter as well as in summer. Considering this hypothesis and for quality fruit production an experiment was conducted with summer tomato (BARI hybrid tomato–4) having 4 fertigations with different levels of NPK and micronutrient (B, Z_n and M_g) and 2 irrigation levels during kharif-1 season of 2007. The fertilizer levels were N_{100} P_{100} K_{120} kg/ha, N_{100} P_{100} K_{120} B_1 Zn_4 Mg_4 kg/ha, N_{100} P_{125} K_{140} kg/ha and N_{100} P_{125} K_{140} B_2 Zn_6 Mg_8 kg/ha and the irrigation levels were- drip irrigation at 2 days interval and drip irrigation at 3 days interval. The highest marketable yield of summer tomato (35.90 t/ha) was obtained from the fertigation treatment T_3 with fertilizer doses of N_{100} P_{100} K_{120} B_1 Zn_4 Mg_4 kg/ha irrigated at 2 days interval. The cull yield was also the lowest (2.53 t/ha) in this treatment. The lowest yield of 22.0 t/ha with 3.72 tons of cull yield was obtained from the treatment T_5 with fertilizer doses N_{100} P_{125} K_{140} kg/ha irrigated at 2 days interval. No micronutrients were used in this treatment. So, use of micronutrients with NPK showed a significant effect on quality fruits as well as yield of summer tomato. The highest yielder treatment received 270 mm of seasonal water including an effective rainfall of 35 mm during the crop season. The highest BCR (3.66) also was found the highest yielding treatment T_3.

96. EFFECT OF DRIP IRRIGATION WITH DIFFERENT LEVELS OF MICRO-NUTRIENTS ON YIELD AND QUALITY OF SUMMER TOMATO

M. A. R. Akanda, M. Shahabuddin Ahamed, Kh. Mazidul Hossain and M. S. Rahman

Fertigation was found technically and economically feasible for tomato cultivation in winter as well as in summer season. Considering this hypothesis and for quality fruit production, an experiment was conducted with summer tomato (BARI hybrid tomato– 4) having 4 fertigation treatments with different levels of NPK and micronutrient (B, Z_n and M_g) and 2 irrigation levels during kharif-1 seasons of 2007, 2008 and 2009. The fertilizer levels were N_{100} P50 K_{120} kg/ha, N_{100} P50 K_{120} B_1 Zn_4 Mg_4 kg/ha, N_{100} P75 K_{140} kg/ha and N_{100} P75 K_{140} B_2 Zn_6 Mg_8 kg/ha and the irrigation levels were- drip irrigation at 2 days interval and drip irrigation at 3 days interval. The average highest marketable yield (29.97 t/ha) was obtained from the fertigation treatment T_3 with fertilizer dose of N_{100} P_{50} K_{120} B_{10} Zn_{40} $Mg_{4.0}$ kg/ha irrigated at 2 days interval for the last three years. The average cull yield was also the lowest (2.77 t/ha) in this treatment. In respect of fruit quality parameters, TSS, Vitamin-C and β carotene content was also found the highest in this treatment. The average lowest marketable tomato yield (18.04 t/ha) was obtained from T_1 irrigated at 2 days interval and the highest cull yield (5.17 t/ha) was obtained from treatment T_2 (N_{100} P_2O_5 $_{50}$ K_{120} kg/ha) irrigated at 3 days interval where no micronutrients were used. The highest yielder treatment received an average of 300.0 mm of seasonal water and produced the highest BCR

(3.12). The results showed that use of micronutrients along with NPK had a significant influence on the yield and fruit quality of summer tomato.

97. DEVELOPMENT OF NUTRIENT AND WATER MANAGEMENT PACKAGE FOR SUMMER TOMATO CULTIVATION UNDER CONTROLLED ENVIRONMENT

M. A. R. Akanda, M. A. Hossain, S. K. Biswas and G. M. A. Halim

Fertigation was found technically and economically feasible for tomato cultivation in winter as well as in summer season. Use of different levels of micronutrients had a significant effect on the yield and fruit quality of tomato. Considering this hypothesis, this experiment was undertaken with different levels of fertilizers under drip irrigation to develop a nutrient and water management package for summer tomato (BARI hybrid tomato-8) cultivation in sandy clay loam soils of BARI, Gazipur during kharif-1 season of 2012. Three levels of fertilizers, i.e. N_{100} P_{55} K_{120} $B_{1.0}$ $Zn_{4.0}$ $Mg_{4.0}$ kg/ha, N_{100} P_{70} $B_{2.0}$ $Zn_{6.0}$ $Mg_{8.0}$ kg/ha and N_{100} P_{55} K_{120} kg/ha (control) were considered under drip irrigation applied at 2 days interval. The treatments were arranged with mulch and without mulch. Rice straw was used as a mulching material. The treatment (T_4) with fertilizer doses N_{100} P_{55} K_{120} $B_{1.0}$ $Zn_{4.0}$ $Mg_{4.0}$ kg/ha with straw mulch produced the highest marketable yield of summer tomato (40.98 t/ha) with minimum cull yield. The lowest yield (30.96 t/ha) was obtained from the treatment (T_3) having no micronutrients and mulch use of micronutrients and mulch showed a significant difference in yield. All the mulched treatments received 297 mm of seasonal water. The non-mulched treatments received 297 mm of seasonal water. The highest BCR (4.22) was found in high yielding treatment T_4.

BRINJAL

98. PERFORMANCE EVALUATION OF FERTIGATION ON BRINJAL CULTIVATION

M. A. R. Akanda, M. Abdullah and M. A. Rashid

Fertigation appeared technically feasible and economically viable for brinjal cultivation. A fertigation experiment was conducted with brinjal (variety: BARI Begun-4) during the rabi seasons of 2002-2003 and 2003-2004 at the central research station, BARI, Gazipur. The highest marketable brinjal yield (53.67 t/ha) was obtained in fertigation with fertilizer doses N_{110} P_{30} K_{60} kg/ha which was 28.77% increase yield over control (41.68 t/ha). The yield of the current season was somewhat lower than that of previous year (56.09 t/ha) due to infestation of plants with bacterial wilt. But the yield trends among the treatments remained the same. Furrow irrigation treatment received the highest amount of seasonal water use (442mm). The system saved 35% of urea, 49% of MP and 48.7% of irrigation water. The highest incremental BCR (2.02) was also obtained from fertigation method with fertilizer doses N_{110} P_{30} K_{60} kg/ha. Last year it was 2.75 in the lest year

99. DETERMINATION OF CROP CO-EFFICIENT VALUES OF BRINJAL BY LYSIMETER STUDY

M. A. Hossain, M. A. R. Akanda, M. S. Islam and M.S. Alam

The crop coefficient values of 0.42, 0.80, 1.30 and 0.93 were determined for initial, development, mid-season and late season stages of brinjal (variety: BARI Begun-4). These locally determined values of brinjal were found to remain within the FAO recommended ranges of 0.4-0.5 for initial stage, 0.7-0.8 for development stage and 0.8-0.95 for late season stage. However, the value at mid season stage (1.30) was found to slightly exceed the FAO range, 1.05-125, by some margin. This might be due to the effect of local soil and temperature as well as crop variety on crop ET.

However, locally determined values are always preferred to the generalized values for the estimation of crop ET.

CABBAGE

100. EFFECT OF DIFFERENT SOIL MOISTURE STATUS ON THE YIELD OF CABBAGE

M. S. Islam, M. A. Hossain and M. S. Ahmed

For better crop yield, it is necessary to irrigate an upland crop at a certain depletion level of available soil water. In this experiment, efforts were made to find out this depletion level for the yield of cabbage (variety: Provati) in sandy clay loam soil, Hathazari. Results shown that irrigation at 60 percent depletion of available soil moisture produced the highest yield (55.83 t/ha) of cabbage. The seasonal water uses were 189.0 mm in 1989-90 and 198.0 mm in 1990-91 for this treatment.

101. EFFECT OF DIFFERENT METHODS OF IRRIGATION OF THE GROWTH OF CABBAGE

M. M. Hossain and G. M. A. Halim

An experiment was conducted with different methods of irrigation like ridge and furrow, bed and furrow, and border irrigation on the growth of cabbage at Regional Agricultural Research Station, Jamalpur during the rabi season of 1992-93. All three methods were observed to effect similarly on yield and other characters of cabbage growth except head diameter. Head diameter was found significantly higher in border irrigation (21.7 cm) than in ridge and furrow irrigation (20.7 cm) and similar with bed and furrow irrigation (21.2 cm).

102. EFFECT OF DIFFERENT METHODS OF IRRIGATION ON THE GROWTH OF CABBAGE

M. Hossain and G. M. Halim

An experiment was conducted with three methods of irrigation, viz., ridge and furrow, bed and furrow, and border to cabbage at Regional Agricultural Research Station, Jamalpur, during the dry season of 1993-94. All the three methods had similar effect on yield and other growth characters except on outer leaves per plant. Yield in irrigated treatment was significantly better than in non irrigated one.

CAULIFLOWER

103. DETERMINATION OF CROP CO-EFFICIENT VALUES OF CAULIFLOWER BY LYSIMETER STUDY

M. S. Rahman, P. K. Sarkar, M. A. R. Akanda and S. Pervin and A. J. Mila

The crop coefficient values of 0.48, 0.95, 0.91 and 0.75 were determined for initial, development, mid-season and late season stages of cauliflower (cv: Snow white). These values differed slightly from the FAO recommended values (0.75-1.05) (FAO, 1977). Since the crop co-coefficient of a crop is location and environments specific the values determined by this method are recommended for estimating crop water requirement of cauliflower in similar conditions of Bangladesh.

GARDEN PEA

104. IRRIGATION SCHEDULING FOR GARDEN PEA

M. A. Bhuyia, G. M. A. Halim M. S. Alam, M. A. Hossain and S. K. Biswas

The study was conducted during the rabi seasons of 2003-2004, 2004-2005 and 2005-2006 at the research field of IWM Division, BARI, Joydebpur, Gazipur. In order to generate information about the optimum timing of irrigation as well as the quantity of water required for better yield of garden pea, 4 irrigation treatments (irrigation at 5, 10, 15 and 20 days interval) and a control treatment (no irrigation) were selected for this study. The highest yields (7.32 t/ha and 4.50 t/ha) were obtained by applying 214 mm and 175 mm water at 10 days intervals with four irrigations during the rabi season of 2003-2004 and 2004-2005, respectively. But in 2005-2006, the highest yield (7.18 t/ha) was obtained by applying irrigation at 5 days interval. But it had no significant difference with treatment T_2 (6.67 t/ha). The second highest yield of 6.63 t/ha was obtained from 3 irrigations at 15 days interval by applying 151 mm irrigation water and 3.43 t/ha was obtained from 7 irrigations at 5 days interval by applying 225 mm of irrigation water during the rabi season of first and second year, respectively. The lowest yield was obtained from the control treatment (T_1) in all the years. The benefit cost ratio (BCR) was found 5.32 by applying irrigation at 10 days interval. From the three years study it implies that irrigation at 10 days interval appears suitable for garden pea production.

CAPSICUM

105. EFFECT OF DRIP IRRIGATION WITH DIFFERENT LEVELS OF MICRO-NUTRIENTS ON FRUIT QUALITY AND YIELD OF CAPSICUM

M. A. R. Akanda G. M. A. Halim, M. A. Rashid and K. M. Hossain

The experiment was conducted in a poly house of Horticulture Research Centre of BARI, Gazipur during the rabi season of 2007-2008. The night temperatures within the poly shed was maintained between 15^0-17^0C for favorable condition. Drip irrigations were used in the study. The highest yield (14.56 t/ha) of capsicum was obtained from (T_2) using a fertilizer dose, N_{100} P50 K_{80} B_1 Zn_4 kg/ha and irrigated by drip method at 2 days interval. The size and shape of fruits were also attractive and marketable in this treatment. The cull yield was also the lowest (0.46 t/ha) in this treatment. Compared to this treatment, the fertilizer dose of N_{100} P75 K_{120} B_2 Zn_4 kg/ha produced the lowest marketable yield (9.93) and the highest cull yield (1.05 t/ha). The seasonal water used for capsicum was 385mm through drip system. The highest benefit cost ratio (BCR) 5.44 is observed from treatment T_2 and the lowest (3.68) from T_4. Balanced application of micronutrients along with NPK found a good effect on fruit quality as well as yield of capsicum. So, capsicum cultivation under controlled environment with drip system by using balanced doses of micronutrients is very much profitable with its growing demand.

RADISH

106. EFFECT OF IRRIGATION AT DIFFERENT GROWTH STAGES OF THE SEED AND ROOT YIELD OF RADISH

M. A. R. Akanda, M. M. Hoque and B. R. Khan

The experiment was conducted in a silty loam soil at Regional Agricultural Research Station, Jessore during the rabi seasons of 1991-92 and 1991-93. A popular variety of radish, Tasakisan was selected to see the effect of irrigation applied at different stages of growth on the root and seed yield. Irrigation at an interval of 15 days had the highest root yield (51.4 t/ha in 91-92 and 59.1 t/ha in 92-93), both the years, among all bother irrigation treatments. Irrigation (s), only at 15 and/or 30 days after emergence (DAE), had the lowest root yield (39.4 t/ha in 91-92 and 42.1 t/ha in 92-93). One irrigation at 15 DAE had the lowest seed yield during both 91-92 (750 kg/ha and 92-93 (610 kg/ha). The root yield yields were significantly (at 5% level) better with 3 to 4 irrigations, with 15 days interval started either at 15, 30 or 45 DAE than lesser and/or later irrigations. However, seed yield was the best (also significantly better than all other yields) when irrigated with 15 days interval from emergence through harvest. For a good yield (amount 58 t/ha), 2 to 3 irrigations at 15 days interval (started at 30 or 45 DAE) are sufficient. Further increase in irrigation did not increase yield significantly. However, for seed yield irrigation each 15 days throughout the field duration is necessary. It required 312 to 364 mm of irrigation water to produce 1095 to 837 kg of seed per hectare.

PUMPKIN

107. IRRIGATION SCHEDULING FOR PUMPKIN

M. S. Islam, M. A. Hossain, M. A. T. Masud and S. K. Biswas

An experiment was conducted at the research field of IWM Division, BARI, Joydebpur, during the rabi seasons of 2003-2004 to 2005-2006 to find out the interval and quantity of irrigation required for optimum yield of pumpkin. Five different irrigation options with a non-irrigated (control) one were used to see their effects on the yield of pumpkin. In first and second year, the highest yields, 17.29 and 19.72 t/ha, respectively, were obtained from the treatment, $T_{3,}$ irrigated at 10 days interval. But in the third year, the highest yield (15.40 t/ha) was obtained by applying irrigation at 5 days interval with no significant difference from treatment T_3 irrigated at 10 days interval. In the first year, the second highest yield (15.50 t/ha) was obtained from the treatment irrigated at 15 days interval whereas in the second year, the treatment irrigated at 5 days interval gave the second highest yield (15.50 t/ha). However, the lowest yields of 11.60, 13.11 and 7.67 t/ha were recorded in the non-irrigated treatment in the first, second and third years, respectively. The seasonal water used by the treatment producing the highest yield were 346, 399 and 610 mm including effective rainfall of 22, 19 and 0mm in the first, second and third year, respectively. However, from the economic analysis of three years average data, the highest benefit cost ratio was found 3.06 by applying irrigation at 10 days interval. Thus, irrigation at 10 days interval is suitable for optimum pumpkin production.

BOTTLE GOURD

108. IRRIGATION SCHEDULING FOR BOTTLE GOURD

M. A. Hossain, M. A. T. Masud and M. S. Rahman

An experiment was conducted at the research field of IWM Division, BARI, Gazipur during the rabi seasons of 2004-2005, 2005-2006 and 2006-2007 to find out the irrigation interval and amount of irrigation water needed for optimum yield of bottle gourd (BARI advanced line, BG-8-3-1-1-1-11-12). Six different irrigation options including a non-irrigated one (control) were used. The highest yield was obtained as 36.11 t/ha, 21.57 t/ha and 33.02 t/ha by applying irrigations at 5 days interval amounting 667.0 mm water with 13 irrigations, 426.0 mm of water with 11 irrigations and 502.0 mm of water with 9 irrigations in 2004-2005, 2005-2006 and 2006-2007, respectively. The second highest yield was obtained as 28.45 t/ha,18.17 t/ha and 31.12 t/ha by applying irrigations at 10 days interval amounting 485.0 mm, 339.0 mm and 428.0 mm water with 7, 6 and 5 irrigations, respectively. From the study, irrigation at 5 days interval was found suitable for optimum yield of bottle gourd.

BITTER GOURD

109. RESPONSE OF DIFFERENT LEVELS OF IRRIGATION AND MULCHING TO BITTER GOURD CULTIVATION

M. A. Hossain, A. R. Akanda, S. K. Biswas and M. A. T. Masud

An experiment was conducted at the research field of Irrigation and Water Management (IWM) Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during the kharif-1 season of 2013 and 2014 to find out the interval and quantity of irrigation water required with mulch and without mulch for the potential yield of bitter gourd. Eight different irrigation options with mulch and no mulch were used to see their effects on the yield of bitter gourd. The highest yield (15.31 t/ha and 5.09 t/ha) was obtained from treatment T_6 which received 4 and 3 irrigations at 14 days interval with mulch in the 1^{st} and 2^{nd} year, respectively followed by the treatment T_7 (13.13 t/ha) irrigated at 21 days interval with mulch receiving 3 irrigations in the year 2013 and the treatment T_8 (4.40 t/ha) irrigated at 28 days interval with mulch receiving 2 irrigations in the year 2014.The lowest yield (6.07t/ha and 2.10 t/ha) was obtained from treatment T_4 (28 days interval without mulch) in the year 2013 and 2014, respectively. The seasonal water used by the high yielded treatment (T_6) were 220 mm and 260 mm during the 1st and 2nd year respectively. The non-mulched treatments received higher amount of water use than mulched treatments. The highest BCR also obtained from the treatment T_6 irrigated at 15 days interval with mulch.

110. EFFECT OF MUNICIPAL WASTEWATER IRRIGATION WITH DIFFERENT DOSES OF FERTILIZER ON YIELD AND BIOLOGICAL QUALITY OF LEAFY VEGETABLES

S. K. Biswas and A.R. Akanda

An experiment was conducted at the sub-urban area of Rajshahi city during February−May, 2014 to determine the appropriate fertilizer dose for cultivation of leafy vegetables (e.g. Indian spinach), and to evaluate the microbiological quality of vegetables under municipal wastewater (as referred to wastewater) irrigation. The experiment consisted of five treatments−25, 50, 75 and 100% recommended fertilizer dose (RFD), in combination with irrigation by wastewater, and 100% RFD

in combination with irrigation by fresh water, as control. In general, harvest was found higher in the wastewater-irrigated plot with higher doses of fertilizer. Application of 50% RFD in combination with wastewater produced statistically identical crop attributes and fresh yield with that of application of 100% RFD in combination with irrigation by fresh water, indicating that 50% of fertilizer requirement can be minimized by irrigating with wastewater without any compromise in the yield. Increase in fertilizer dose to 75% RFD or 100% RFD had little effect on increasing the yield. A high bacterial contamination with fecal coliforms, total coliforms, total bacterial aerobic counts and Escherichia coli was observed in fresh Indian spinach irrigated with municipal wastewater. However, the crop was not contaminated with pathogenic bacteria of the Salmonella species. Therefore, the hygienic aspects of wastewater irrigated crops, especially for vegetable crops, require more attention to sanitary problems.

Fruit Crops

MANGO

111. EFFECT OF IRRIGATION BY DIFFERENT METHODS AT DIFFERENT REPRODUCTIVE STAGES ON THE YIELD OF MANGO

K.C. Roy, M. Biswas, M. N. Alam and M.S. Islam

A study was undertaken in Mango Research Centre, Chapainawabgonj to test the performance of different methods of irrigation on mango production and to find the critical reproductive stage (s). Flood, modified basin and drip irrigation methods were used to irrigate mango trees. Irrigation was applied at flowering, at pea and at flowering and pea stages of mango. Trees selected for the experiment were more or less of the same age and size. Initial fruit setting varied significantly. Fruit dropping and average weight of fruits did not differ significantly. From the first year result, no conclusion in respect of the best method of irrigation and best time of irrigation could be drawn.

JACKFRUIT

112. EFFECT OF IRRIGATION AT DIFFERENT GROWTH STAGES OF JACKFRUIT AT THE FARMERS' FIELD

M. A. R. Akanda, M. A. Hossain, M. A. Satter, M. S. Rahman and A. K. Azad

This study was conducted at the farmers' field of village Vangnahati, Sreepur of Gazipur district to determine the effect of irrigation as well as to identify the critical stages for irrigation to jackfruit during 2002-2003, 2003-2004, 2004-2005 and 2005-2006. The yield contributing characters varied significantly among the irrigation treatments. The yield trends for all the years were somewhat similar. The highest annual return/tree was obtained from the tree irrigated at 15 days interval and the lowest was obtained from no irrigation (control) during all the study years. From the four years' study, it may be commented that nearly 3-4 times higher yield could be obtained from irrigated trees than the non-irrigated trees. The number of fruits and unit fruit weight were higher in irrigated trees than those of the control during all the years. The same trend was also observed during all the years. It might be due to presence of sufficient moisture at the root zone during flowering and fruit setting stages of the trees irrigated at 15 days interval. The critical stage for irrigation to Jackfruit was found from bloom through fruit development.

GUAVA

113. OFF-SEASON PRODUCTION OF GUAVA BY DRIP IRRIGATION

M. A. R. Akanda, M. A Hossan, M. S. Rahman, Mr. Modan Gopal Saha and M. Abdullah

This study was conducted at the guava orchard of IWM Division, BARI, Gazipur to investigate the effectiveness of drip irrigation for off-season production of guava during 2003-2004 and 2004-2005. Although, the saplings were planted in May 2002, it became in first fruiting stage during 2003-2004. The highest off-season yield/tree (7.15 kg) was obtained from treatment T4 irrigated by drip system with 100% pruning of flowers in the main season during 2004-2005. The yield was higher than the last year (2003-2004). However, the yield trends among the treatments for both the years were somewhat similar. But practically, the annual guava yield/tree was higher in T6 irrigated in ring basin method with pruning of 50% of flowers in the main season. The net economic return was also the highest (Tk. 161.38) in treatmentT_4.

PAPAYA

114. PERFORMANCE EVALUATION OF FERTIGATION ON PAPAYA CULTIVATION

M. A. Hossain, M. S. Alam, M. N. Islam and M. S. Islam

Fertigation appeared technically feasible and economically viable for papaya cultivation. A fertigation experiment was conducted with papaya (variety: BARI papaya-1) in 2005 at the research field of IWM Division, BARI, Gazipur. The highest papaya yield (53.92 t/ha) was obtained from fertigation with 50% less N and P fertilizers, which was 118% increase in yield over the control (24.65 t/ha). Ridge and furrow irrigation treatment (farmer's practice) received the highest amount of irrigation water (420 mm), whereas drip system received only 52 mm water. The highest BCR (4.24) was obtained in fertigation treatments whereas it was 1.93 for furrow irrigation.

LITCHI

115. EFFECT OF IRRIGATION AT DIFFERENT GROWTH STAGES ON THE YIELD AND QUALITY OF LITCHI GROWN IN FARMERS' FIELD

M. S. Rahman, M. A. R. Akanda, M. A. Hossain and M. R. Shamim

The study was conducted at the farmers' field of village Paragaon, Harinal of Gazipur district to determine the effect of irrigation as well as to identify the critical stages for irrigation and quality on yield and yield parameters of litchi during 2005-2006 and 2006-2007. The yield contributing characters varied significantly among the irrigation treatments. The yield trends for all the years were somewhat similar. The highest litchi yield (35.62 & 42.26 kg/tree) during 2005-2006 and 2006-2007, respectively, as well as the annual economic return (Tk. 3442.00 and Tk. 4395.00 per/tree) were obtained from the treatment irrigated at 15 days interval. The lowest yield and annual return were found from non-irrigated tree (control) during all the study years. The number of fruits and unit fruit weight were higher in irrigated trees than that of non-irrigated trees. It might be due to sufficient moisture at the root zone during flowering and fruit setting stages.

116. EFFECT OF IRRIGATION ON THE YIELD AND QUALITY OF LITCHI

F. Akter, A. R. Akanda, M. Roknuzzaman, M.P. Haque, M. Amin and M. Dhar

The study was conducted at RARS, Hathazari, Chittagong and RARS, Ishwardi, Pabna during 2013-2014 and 2014-2015 to determine the effect of irrigation on yield and quality of litchi as well as to identify the critical growth stages to irrigation. In Hathazari, yield and yield contributing characters varied significantly among the treatments. The average litchi yields of two years ranged from 17.50 kg/plant to 45.40 kg/plant. The lowest average yield (17.50 kg/plant) was obtained from the T_1 (Non- irrigated tree) and the highest average yield 45.40 kg/plant) was found from T_4 (irrigated at flowering and fruit setting stages). The highest amount of irrigation water (290 mm) was used by the highest yielder T_4 at 2014-2015. This was 349mm in 2013-2014. The economic return/tree was also the highest (Tk. 3861) from the irrigated trees T_4 in 2014-2015. In Ishwardi, the average litchi yields of two years ranged from 28.49 kg/plant to 52.77 kg/plant. The lowest average yield (28.49 kg/plant) was obtained from T_1 (Non- irrigated tree) and the highest average yield (52.77 kg/plant) was found from T_4 (irrigated at flowering and fruit setting stages). The highest amount of irrigation water (267 mm) was used by the highest yielder treatment T_4 in 2014-2015 and it was 349mm in 2013-2014.The economic return/tree was also the highest (Tk. 11607) from the irrigated trees (T_4) in 2014-2015.

WATERMELON

117. EFFECT OF DIFFERENT METHODS OF IRRIGATION ON THE YIELD OF WATERMELON

K. C. Roy and M. H. R. Sheikh

A study was undertaken to determine the best method of irrigation for watermelon. The experiment was conducted during the rabi season of 1992-93 at RARS, Jessore, Pitcher, ring-basin, flood and furrow methods of irrigation were conducted. Due to excessive rainfall, variation in the treatments could not be made. The highest yield of 30.52 t/ha was obtained in pitcher irrigation though it was not significantly different from other treatments.

118. RESPONSE OF WATERMELON TO IRRIGATION IN SALINE SOILS OF COASTAL AREAS

A. R. Akanda, S. K. Biswas, S. Mondal A. Saleh and Zofer

This study was conducted at the farmers' field of Amtali, Barguna to investigate the effects of irrigation on yield and yield components of watermelon (Citrullus lanatus) in coastal saline area of Bangladesh, during January - April, 2014. Irrigations at 5, 10, 15 days interval were compared with farmers' practice irrigation that received a total three irrigations throughout the growing season. The electrical conductivity of canal water used to irrigation watermelon was ranged from 2.6 to 3.4 dS/m. The growth and yield of watermelon responded positively to different irrigation intervals. The frequently irrigated treatment produced the bigger size and higher number of watermelon per plant. Small size fruit and less number of fruits per plant were obtained in farmers' practice (control) treatment. The highest fruit yield of watermelon (37.7 t/ha) was obtained from the treatment plots where irrigation water was applied at 5- days intervals. The second highest yield (33.67 t/ha) was obtained in 10-day interval irrigated plots. Farmers' practice treatment that received irrigation at 25 days interval produced the lowest yield of 20.47 t/ha. Though the yield and total water use (455 mm) was found the highest in 5-day intervals irrigated plots, the water productivity was found to be the highest when irrigation water was applied at 10 days interval while the lowest (1.93 kg/m3) was attained from control treatment. The soil salinity was found to be gradually increased from 2.0 dS/m - 8.52 dS/m with minimum at sowing time and maximum at harvest. Frequent irrigation helped to decrease soil salinity considerably.

MUSKMELON

119. DETERMINATION OF IRRIGATION SCHEDULING FOR MUSKMELON

M. A. Hossain, M.A.T. Masud and M.S. Rahman

An experiment was conducted at the research field of Regional Agricultural Research Station (RARS), Rahmatpur, Barishal, during the rabi season of 2006-07 to find out a suitable irrigation schedule for optimum yield of muskmelon. The highest yield (29.81 t/ha) was obtained from the treatment irrigated at 10 days interval followed by the treatment irrigated at 5 days interval (28.22 t/ha). From the study, it implies that irrigation at 10 days interval was most suitable for muskmelon production.

STRAWBERRY

120. PERFORMANCE OF FERTIGATION ON THE YIELD AND QUALITY OF STRAWBERRY

S. Pervin, M. A. R. Akanda, M. M. Rahman and M. S. Islam

The interactive effects of irrigation and fertilizers on the yields of BARI strawberry-1 and FA-016 were assessed at the central research station, Joydebpur during the rabi season of 2012-2013. Two drip irrigation levels i.e., alternate day and two days interval and three fertilizer doses $N_{110}K_{110}P_{40}S_{25,}$ $N_{90}K_{90}P_{40}S_{25}$ and $N_{70}K_{70}P_{40}S_{25}$ with two different strawberry varieties were tested. Soluble fertilizers like N and MoP were applied with water through drip irrigation system. First irrigation and fertilizer application were done at 30 and 32 days after transplanting (DAP), respectively. The cumulative effects of irrigation water, fertilizer doses and varieties are noticed that the lowest fertilizer dose ($N_{70}K_{70}P_{40}S_{25}$), alternate day irrigation and FA-016 strawberry variety produced highest yield and it might be suitable for strawberry cultivation in Joydebpur but it required longer cropping season (100.33 days) than that of BARI strawberry-1. Regarding the quality, BARI strawberry-1 obtained high TSS but produced low P^H and Vitamin-C as compared to the FA-016 variety. The seasonal water use varies from 422.0-607.0 mm for a good yield (176.44-761.60 gm/plant) in Joydebpur under normal rainfall condition. The highest benefit cost ratio was seen in the variety of FA-016 (9.79) than that of BARI strawberry-1 (3.38) utilizing with alternate day irrigation and low fertilizer doses in both variety.

121. PERFORMANCE OF FERTIGATION SYSTEM ON STRAWBERRY CULTIVATION

A. R. Akanda, K. K. Sarker, S. K. Biswas, M. R. Shamim and S. Pervin

Proper utilization and uniformity of water and fertilizer are usually considered to improve the water and fertilizer management systems. Therefore, this study was carried out to assess the fertigation system on the yields of advanced strawberry line FA-016 at the IWM Research Field, BARI, Joydebpur, Gazipur during the two rabi seasons of 2013-2014 and 2014-2015. Two drip irrigation levels i.e., drip irrigations at two and three days interval and three fertilizer doses $N_{110}K_{100}P_{40}S_{25}$kg/ha, $N_{75}K_{75}P_{40}S_{25}$ kg/ha and $N_{50}K_{50}P_{40}S_{25}$ kg/ha were tested. Soluble fertilizers like urea and muriate of potash were applied with water through drip system. Fertigation was done in four times at different growth stages of the crop. On average, growth parameters of strawberry were influenced insignificantly by different levels of irrigation and fertilizer application among the treatments. On average, the treatment T_2 (Drip irrigation at 2 days intervals with moderate fertilizer dose of N_{75}, P_{40}, K_{75}, and S_{25} kg/ha) produced the highest marketable fruits yield (11.53

t/ha) while the minimum marketable fruit yield (10.39 t/ha) was found in treatment T_6 where irrigation was applied at 3 days intervals with lowest fertilizer dose of N_{50}, P_{40}, K_{50}, and S_{25} kg/ha. The quality parameters (pH, total soluble solids, vitamin A and percentage of total sugar) were found almost similar among the treatments. The seasonal water use varied from 10.5-16.8cm throughout the growing period. The mean water productivity was varied from 7.62-8.51kg/m^3. On an average, the highest net margin (Tk. 17,98,102/ha) and benefit-cost ratio (**6.01**) was obtained from treatment T_2 where irrigation water was applied at 2 days' intervals with moderate fertilizer dose of N_{75}, P_{40}, K_{75}, and S_{25} kg/ha. Proper amount of irrigation water with an optimum (N_{75}, P_{40}, K_{75}, and S_{25} kg/ha) fertilizer dose produced highest yield and consequently increased the net margin and benefit-cost ratio.

MANDARIN

122. GROWTH, YIELD AND QUALITY OF MANDARIN AND SWEET ORANGE AS INFLUENCED BY DIFFERENT METHODS AND LEVELS OF IRRIGATION

A. Khatun, A. R. Akanda and M.J. uddin

The experiment was conducted at RARS, Akbarpur, Moulovibazar on existing orchard to investigate the effect of different methods and levels of irrigation on the growth, yield and quality of mandarin and sweet orange. from December 2013 to April 2016. Kamala lines 26,27and BARI Malta-1 were used as the test crops. The experiment was conducted with 6 years (orange) and 4 years (sweet orange) old plantation. The four treatments were distributed in a randomized complete block design with four replications. The plant spacing was 4mx4m for orange and 3.5mx3.0m for sweet orange. The treatments were T_1: Rain fed, T_2: Irrigation applied at 10 days interval by ring basin method, T_3: Irrigation applied at 15 days interval by ring basin method, T_4: Irrigation applied through drip system at 3 days interval. Measured amount of water was applied to each plant at several intervals to maintain the soil moisture content at the root zone up to field capacity. In irrigated orange and sweet orange plants, growth was found better than non-irrigated plants. The result revealed that most of the parameters were higher in treatment T_4 where drip irrigation was applied. The highest (1553 kg/ha) and the lowest (501 kg/ha) yields of orange were obtained from treatments, T_4 and T_1, and in sweet orange, 8449 kg/haand2335 kg/ha, from the treatments T_4 and T_1, respectively. The highest yield was obtained from treatment T_4, (Drip irrigated treatment) which resulted in higher water productivity (5.55 kg/m^3 for orange and 12.83 kg/$m^3$for sweet orange) but the minimum values were obtained from ring basin irrigation method (2.43 kg/m^3 for orange and 6.49kg/$m^3$for sweet orange). The higher BCR was also observed in drip irrigated treatment (T_4).

SWEET ORANGE

123. GROWTH AND YIELD OF SWEET ORANGE AS INFLUENCED BY TIMING OF FERTILIZER APPLICATION AND METHOD OF IRRIGATION

A. R. Akanda, K. K. Sarker, M. R. Shamim, M.G. Shaha and A. Khatun

This study was carried out at the experimental field of Irrigation and Water Management Division, Bangladesh Agricultural Research Institute, Gazipur to determine the appropriate timing of fertilizer application and the irrigation method on the growth and yield of sweet orange during 2013-2016. The experiment was designed with five treatments and five replications. The treatments were: T_1 = Rainfed (normal practice), T_2 = Irrigation at 10 days interval by ring basin method (November-May) with recommended fertilizers applied two times in a year, T_3 = Irrigation

at 15 days interval by ring basin method (November-May) with recommended fertilizers applied four times in a year, T_4= Drip irrigation at five days interval (November-May) with fertilizer application at two months interval, T_5 = Drip irrigation at five days interval (November-May) with fertilizer application at once in a month. Results of this study indicated that the plant height and stem diameter were observed greater in treatment T_4 than other treatments. Yield contributing parameters (fruit length and diameter) and total yield were found to have almost similar trend of T_2, T_3, and T_4 but higher than T_1 and T_5. The treatment T_4 with drip irrigation at five days interval with fertilizer application at two months interval performed better in plant growth than other treatments. Seasonal irrigation water use was lower in treatment T_4 and T_5 than T_2 and T_3 in each year. Drip or ring basin method could be an irrigation strategy for sweet orange cultivation due to better plant growth, number of fruits, fruits length and diameter, yield and water use.

Spices Crops

ONION

124. IRRIGATION SCHEDULING FOR ONION

M. S. Islam, B. R. Khan and M. H. Rashid

The experiment was conducted to see the effect of irrigation on the production of onion (cv. Thaherpuri) at Joydebpur during the rabi season of 1994-95. The experiment had five different irrigation treatments and a non-irrigated control treatment. The experiment was laid out in a randomized complete block design with three replicates. The highest bulb yield (10.50 t/ha) was obtained from 3 irrigations applied at each of 20, 40 and 60 DAT. The lowest yield (3.83 t/ha) was obtained without any irrigation. The maximum water applied (160mm) was in treatment containing irrigations at 20, 40, 60 and 80 DAT but the yield was less (9.94 t/ha) as compared to the maximum. There was no significant difference between these two treatments at 5% level. Irrigation at 80 DAT seems unnecessary and even harmful.

125. EFFECT OF IRRIGATION ON ONION PRODUCTION

S. K. Biswas, P. K. Sarkar and M. H. Rashid

An experiment was conducted at the Regional Agricultural Research Station, Jessore during the rabi season of 1999-2000. It was designed in RCBD to compare the yield and yield contributing characters of onion (cv. Faridpuri) under different irrigation schedules. Measured amount of irrigation water was applied directly to the experimental plots. Although yield contributing characters were not influenced markedly. Yield was significantly influenced by timing and depth of irrigation. The per cent increase over control in bulb yield due to irrigation range from 101. 97 per cent to 178.04 per cent. The highest yield was 9.017 t/ha when five irrigation amounting 265 mm of water was applied. The water use efficiency of 77.21 kg/ha/mm was obtained in control treatment and decreased with the increase of water use.

126. EFFECT OF IRRIGATION FREQUENCY AND FUNGICIDE SPRAY ON THE DISEASE INFESTATION OF ONION

S. K. Biswas, M. A. Bhuyia, M. A. R. Akanda and M. Rafiuddin

An experiment was conducted to find out the level of disease infestation by different levels of irrigation and fungicide spray on the bulb yield of onion during the rabi season of 2002-2003. Four irrigation levels, no irrigation (I_1), irrigation at 10 days interval ($I_{1)}$ 20 days interval ($I_{2)}$ and 30 days interval ($_3$) (I_4) with 4 spray schedules, no spray (F_1), one spray at 40 days after planting (F_2), two sprays each at 40 and 55 days after planting (I_1), and three sprays each at 40, 55 and 90 days after planting (I_4) were used in the experiment. Disease severity, yield and yield attributes varied

significantly (p=0.05) between sprayed and unsprayed, and irrigated and non-irrigated treatments, respectively. The disease severity between sprayed and unsprayed plots ranged 2.50to4.17 for I_1, 2.5 to 4.33 for I_2, 3.00 to 4.33 for I_3 and 2.0 to 3.30 for I_4, respectively. In irrigation treatments, the highest (scale: 3.50) level of disease infestation was observed in I_1 (no irrigation) and the lowest (scale: 2.87) in I4 (irrigation at 30 days interval) while in spray treatments, it was the highest (scale 4.16) in F_1 (no spray) and the lowest (scale: 2.5) in F_4 (three spray). Interaction between irrigation and spray show that the disease infestation was the highest (scale: 2 in I_4 F_4.

127. DETERMINATION OF CROP CO-EFFICIENT VALUES OF ONION FOR SEED PRODUCTION

A. R. Akanda, M. A. Hossain, S. K. Biswas and S. A. Mallick

A field experiment was conducted with BARI Piaz-1 to determine crop co-efficient values for seed production with lysimeter at the IWM Research field, BARI, Gazipur. The crop coefficient values of 0.68, 0.93, 1.23 and 0.78 were determined for initial, development, mid-season and late season stages of onion (variety: BARI Piaz-1) for seed production. These locally determined values of onion were found within the FAO recommended ranges. The value of K_c for the late season stage (0.78) varied slightly from the recommended values. Since this was a location specific experiment, a little variation in experimentally determined values of K_c from the recommended values (0.85-0.9) was observed. This might be due to the effect of local soil and climatic as well as crop variety on crop ET. However, locally determined values are always preferred to the generalized values for the estimation of crop ET.

128. STUDY THE EFFECTIVENESS OF FLOW DIVERSION DEVICE FOR ONION IRRIGATION

S. K. Biswas, M. A. R. Akanda and M. S. Islam

The experiment was carried out to study the effectiveness of BARI developed flow diversion device for irrigation to onion. The performance of the device was compared with farmers' practice (flood irrigation) and broad bed furrow irrigation system. The treatment irrigated with flow diversion device produced the highest yields (6.64 and 9.23 t/ha, respectively) over the years. The water productivity was also found the highest (4.17 and 5.39 Kg/m^3) in this treatment. However, the lowest yields (5.49 and 8.02 t/ha) and the lowest water productivity (3.13 and 4.09 Kg/m^3) were recorded in the farmers' practice in the first and second years, respectively. The lowest amount of irrigation water (151 mm) was received by the highest yielder treatment.

129. PERFORMANCE STUDY OF LOW COST SPRINKLER IRRIGATION SYSTEM FOR ONION CULTIVATION

M. S. Islam, M. M. Hossain, F. R. Khan and M. A. Hossain

The experiment was conducted at Spices Research Centre, Bogra during the rabi seasons of 2004-2005 and 2005-2006 to test the performance of low cost sprinkler for onion irrigation. It was compared with farmers practice (flood irrigation with 20 days interval). A non-irrigated treatment was also set as a control. In both the years, the highest bulb yields (9.96 and 22.52 t/ha) and water productivities 5.50 and 6.26 kg/m^3 were obtained from the treatment irrigated with low cost sprinklers. The bulb yields increased 46.04% and 29.29% over the farmers' practice during the first and second years, respectively. The water required for sprinkler irrigation was 162 mm in 11 applications including 20mm water for plant establishment while 176 mm of irrigation water was required for farmers' practice in three applications.

130. EFFECT OF IRRIGATION LEVELS ON THE SEED YIELD OF ONION

S. K. Biswas, D. K. Roy, P. K. Sarkar, A. Khatun and M. A. R. Akanda

This study was executed at the experimental field of IWM Division, BARI, Gazipur to investigate the effect of irrigation on onion seed yield. There were six irrigation treatments: T_1= Irrigations at vegetative, bolting, flowering and seed formation stages, i.e., no stress, T_2= Stress at vegetative stage, T_3= Stress at bolting stage, T_4= Stress at flowering stage, T_5= Stress at seed formation stage, and T_6= Irrigations at vegetative and flowering stages (Farmers practice). The results showed that most of the growth and yield contributing parameters like umbel diameter, effective floret per umbel, seed yield per plant and 1000- seed weights were significantly influenced by different irrigation treatments. Other growth parameters such as, plant height, number of flower stalk per plant, length of scape and diameter of scape varied with the irrigation but the variations were not statistically significant. The highest yield (1110.89 and 1067.58 kg/ha in the first and second year, respectively) was observed from the treatment receiving irrigations at four different growth stages while the treatment in which stress was imposed at flowering stage produced the lowest seed yield (897.70 and 846.55 kg/ha in the first and second year, respectively). Water productivity was observed the highest (0.45 kg/m^3) in treatment T_5 while the lowest (0.38 kg/m^3) was observed in treatment T_4. The highest benefit-cost ratio (3.69) was obtained from treatment T_1 while the lowest (2.93) was obtained from treatment T_6. The results suggest that irrigation at the flowering stage may be considered critical for onion seed production.

131. DETERMINATION OF CROP CO-EFFICIENT VALUES OF ONION FOR SEED PRODUCTION

M. A. R. Akanda, M. A. Hossain, S. K. Biswas and S. A. Mallick

A field experiment was conducted with BARI Piaz-1 to determine crop co-efficient values for seed production with lysimeter at the IWM Research field, BARI, Gazipur. The crop coefficient values of 0.68, 0.93, 1.23 and 0.78 were determined for initial, development, mid-season and late season stages of onion (variety: BARI Piaz-1) for seed production. These locally determined values of onion were found within the FAO recommended ranges. The value of K_c for the late season stage (0.78) varied slightly from the recommended values. Since this was a location specific experiment, a little variation in experimentally determined values of K_c from the recommended values (0.85-0.9) was observed. This might be due to the effect of local soil and climatic as well as crop variety on crop ET. However, locally determined values are always preferred to the generalized values for the estimation of crop ET.

132. EFFECT OF DEFICIT IRRIGATION AND MULCH ON ONION SEED PRODUCTION

S. K. Biswas, D. K. Roy and A. R. Akanda

The effects of deficit irrigation and mulch on seed yield, water use and water productivity of onion was studied through a field experiment conducted in 2012 - 2013 and 2013 - 2014 winter season at the experimental field of Bangladesh Agricultural Research Institute, Gazipur. Eight treatments comprising of four levels of irrigation regimes (irrigating up to 40, 60, 80, and 100% soil moisture deficit (SMD)) and two levels of mulching (no-mulch and rice straw) were tried. Surface irrigation was used and the crop was planted on beds. Water applied per irrigation, soil moisture contents before and after irrigation was monitored throughout the season while the growth, yield parameters and yield of onion seed were recorded. Deficit irrigation and mulch had significant effect on yield of onion seed. The seed yield ranged from 1040 to 1566 kg/ha in the first year and from 1082 to 1623 kg/ha in the second year, with minimum in treatment of 40% DSM without mulch and maximum in full irrigated mulch treatment. The seed yields of the treatments irrigated up to 80% DSM were not statistically different from those that were fully irrigated (up to100% DSM). Analyses of results showed that irrigating onion up to 40% DSM reduced seed yield by about 30%.

Applying water up to 60% of DSM caused a yield reduction of about 19%. However, irrigating onion up to 80% of DSM reduced seed yield by less than 4%. Results also revealed that water use of onion crop were largely influenced by the depths of water applied rather than mulching. On average, total water use ranged from 177 to 262 mm with minimum in mulch treatment of 40% DSM and maximum in full irrigated treatment. Total water used by the mulch treatments was only 5.08% lower than that of the non-mulched treatments. While difference in total water applied between mulched and non-mulched treatments was 7.2%. Mulching with rice straw did significantly improve the water productivity of the onion seed crop. The water productivity was found to be the highest (0.71 kg m^{-3}) in the mulched treatment that received irrigation up to 80% DSM with total water use of 220 mm. This treatment also produced near to the highest yield with 22% saving of irrigation water. BCR obtained under deficit irrigated (up to 80% DSM) mulched treatment (5.17) was comparable with that of full irrigated-mulched treatment (5.21). Therefore, in terms of yield, water saving and economics, irrigating up to 80% DSM with mulch gave the best result for seed production of onion.

133. YIELD AND WATER PRODUCTIVITY INDICES OF ONION UNDER SPRINKLER IRRIGATION

S. K. Biswas, A. Khatun, A. J. Mila, P. K. Sarkar and M. A. R. Akanda

A field study was conducted in the experimental field of IWM Division, BARI, Gazipur during December to March of 2011 – 2012 and 2012 – 2013 to investigate the effect of different irrigation regimes on growth, bulb yield and water use pattern of onion. The water – yield relationship has been developed for onion with different irrigation regimes under sprinkler irrigation to quantify crop water productivity functions (CWPF) for optimum use of irrigation water. Seven irrigation regimes were: T_1 - Surface irrigation where crop was irrigated at 15 days interval; T_2 – Sprinkler irrigation at 60% of ETc; T_3 – Sprinkler irrigation at 80% of ETc; T_4 – Sprinkler irrigation at 100% of ETc; T_5 – Sprinkler irrigation at 120% of ETc; T_6 – Sprinkler irrigation at 140% of ETc; T_7 – Sprinkler irrigation at 160% of ETc. Marginal water productivity (MWP) and elasticity of water productivity (EWP) were calculated using the relationship between bulb yield and seasonal evapotranspiration (SET). A continuous increasing trend in growth parameters and yield was recorded with the increase in SET up to 140% ETc. However, with further increase in SET the same was decreased. Though SET requirement for maximum yield (21.7 and 15.47t ha^{-1}) was 249 and 271 mm but the highest water productivity (WP) of 9.22 and 6.58 kg m^{-3} was attained with relatively low SET of 202 and 189 mm in the first and second year, respectively. In terms of bulb yield and WP, sprinkler irrigation found superior over the surface (conventional) one. Sprinkler irrigation with 140% ETc found most suitable for bulb yield. However, WP was found highest in sprinkler irrigation with 100% ETc and then declined with the increase in ETc. Hence, in water constraint situation, 100% ETc would be the most appropriate irrigation level for onion production with sprinkler irrigation system. This study also confirmed that critical levels of SET needed to obtain maximum bulb yield or WP, could be obtained more precisely from the knowledge of MWP and EWP.

134. EFFECT OF DEFICIT IRRIGATION AND MULCH ON ONION SEED PRODUCTION

S. K. Biswas, D. K. Roy and A. R. Akanda

The effects of deficit irrigation and mulch on seed yield, water use and water productivity of onion was studied through a field experiment conducted in 2012 - 2013 and 2013 - 2014 winter season at the experimental field of Bangladesh Agricultural Research Institute, Gazipur. Eight treatments comprising of four levels of irrigation regimes (irrigating up to 40, 60, 80, and 100% soil moisture deficit (SMD)) and two levels of mulching (no-mulch and rice straw) were tried. Surface irrigation was used and the crop was planted on beds. Water applied per irrigation, soil moisture contents before and after irrigation was monitored throughout the season while the growth, yield parameters

and yield of onion seed were recorded. Deficit irrigation and mulch had significant effect on yield of onion seed. The seed yield ranged from 1040 to 1566 kg/ha in the first year and from 1082 to 1623 kg/ha in the second year, with minimum in treatment of 40% DSM without mulch and maximum in full irrigated mulch treatment. The seed yields of the treatments irrigated up to 80% DSM were not statistically different from those that were fully irrigated (up to100% DSM). Analyses of results showed that irrigating onion up to 40% DSM reduced seed yield by about 30%. Applying water up to 60% of DSM caused a yield reduction of about 19%. However, irrigating onion up to 80% of DSM reduced seed yield by less than 4%. Results also revealed that water use of onion crop were largely influenced by the depths of water applied rather than mulching. On average, total water use ranged from 177 to 262 mm with minimum in mulch treatment of 40% DSM and maximum in full irrigated treatment. Total water used by the mulch treatments was only 5.08% lower than that of the non-mulched treatments. While difference in total water applied between mulched and non-mulched treatments was 7.2%. Mulching with rice straw did significantly improve the water productivity of the onion seed crop. The water productivity was found to be the highest (0.71 kg m^{-3}) in the mulched treatment that received irrigation up to 80% DSM with total water use of 220 mm. This treatment also produced near to the highest yield with 22% saving of irrigation water. BCR obtained under deficit irrigated (up to 80% DSM) mulched treatment (5.17) was comparable with that of full irrigated-mulched treatment (5.21). Therefore, in terms of yield, water saving and economics, irrigating up to 80% DSM with mulch gave the best result for seed production of onion.

GARLIC

135. RESPONSE OF GARLIC TO DIFFERENT LEVELS OF IRRIGATION

P. K. Sarkar, S. K. Biswas, M. S. Rahman, A. J. Mila and D. K. Roy

More information about current soil water level and future water use allow irrigators to improve irrigation scheduling decisions, make better use of limited water and increase net returns. A study was conducted in the research field of IWM Division, Gazipur during the 'rabi' seasons of 2008-2010 with a view to evaluate the effect of different irrigation options on garlic (cv: BARI Rashun-1) growth and production. A significant response of garlic to number, amount and timing of irrigation was observed. Among eight treatments, T_5 (irrigation at 7 days interval) produced the highest yield (7.633 t/ha). The second highest yield (7.600 t/ha) was obtained from the treatment T_6 (irrigation at 10 days interval). The highest BCR was predicted to be 3.62 with a total water use of 320 mm. Based on the results obtained for two years, the farmers may be advised to irrigate garlic at 7 to 10 days interval in silty loam soil to produce a profitable yield.

136. EFFECT OF IRRIGATION ON GARLIC PRODUCTION

B. R. Khan, M. S. lslam and M. A. Hossain

An experiment was carried out in a randomized complete block design with four treatments and three replications at Joydebpur during the Rabi season of 1994-95, to find out the effect of irrigation on the production of garlic (local variety). The treatments were irrigations at 10, 20 and 30 days intervals after sowing. Irrigation at 10 days interval produced the highest yield (4.59 t/ha) with the application of 472 mm water.

137. DETERMINATION OF CROP CO-EFFICIENT VALUES OF GARLIC BY LYSIMETRIC STUDY

S. K. Biswas, M. A. Hossain and A. R. Akanda

An experiment was conducted during November to March of 2013–2014 to determine the water requirement and crop coefficient of garlic using a drainage lysimeter. A reference evapotranspiration (ETo) was simulated with a software, CROPWAT, during garlic growing season. Results showed that crop coefficient values (Kc) at initial, development, mid-season and late season stages were 0.51, 0.87, 1.04 and 0.61, respectively. Though these locally determined values of garlic were differed marginally with that determined by researchers for other regions of the world, but it was comparable. This might be due to the effect of local soil and temperature as well as crop variety on crop ET. However, locally determined values are always preferred to the generalized values for the estimation of crop ET.

138. GROWTH, YIELD AND WATER PRODUCTIVITY OF GARLIC UNDER SPRINKLER IRRIGATION

S. K. Biswas, M. A. Hossain and A. R. Akanda

A field study was conducted in the experimental field of IWM Division, BARI, Gazipur during November to March of 2013 – 2014 and 2014 – 2015 to investigate the effect of different irrigation regimes on growth, bulb yield and water use pattern of garlic under sprinkler irrigation system. The water – yield relationship has been developed for garlic with different irrigation regimes under sprinkler irrigation to quantify crop water productivity functions (CWPF) for optimum use of irrigation water. Six irrigation regimes were: T_1 - Surface irrigation where crop was irrigated at 15 days interval; T_2 – Sprinkler irrigation at 40% of ETo; T_3 – Sprinkler irrigation at 60% of ETo; T_4 – Sprinkler irrigation at 80% of ETo; T_5 – Sprinkler irrigation at 100% of ETo; and T_6 – Sprinkler irrigation at 120% of ETo. Marginal water productivity (MWP) and elasticity of water productivity (EWP) were calculated using the relationship between bulb yield and seasonal evapotranspiration (SET). A continuous increasing trend in growth parameters and yield was recorded with the increase in SET to 100% ETo. However, with further increase in SET the same was decreased. In the first year, SET requirement was 254 mm for obtaining maximum yield of 9.10 t/ha while in the following year, SET was 240 mm with maximum yield of 6.43 t/ha. But in both the years, the highest water productivity was achieved with relatively low SET values. The highest water productivity (WP) of 3.76 kg/m^3 and 3.03 kg/m^3 was achieved with SET values of 211 mm and 191 mm, respectively, in the first and second year. In terms of bulb yield and WP, sprinkler irrigation found superior over the surface (conventional) one. Sprinkler irrigation with 100% ETo found most suitable for bulb yield of garlic. However, WP was found the highest in sprinkler irrigation with 80% ETo and after that declined with the increase in ETo. Hence, in water constraint situation, 80% ETo would be the most appropriate irrigation level for garlic production with sprinkler irrigation system. This study also confirmed that critical levels of SET needed to obtain maximum bulb yield or WP, could be obtained more precisely from the knowledge of MWP and EWP.

CHILLI

139. EFFECT OF WATER LOGGING ON CHILLI (CAPSICUM ANNUM L.)

M. Shariful Islam, M. S. Alam, M. A. K. Mridha and M. H. Rashid

Three water logging durations (24, 48 and 72 hours) provided at each of the three stages (25, 55 and 75 days after transplanting, DAT) along with normal irrigation and drainage practice were experimented on chill (local) in the clay/loam soil of BARI central farm, Joydebpur during the

1996-97 rabi season. Water logging at 55 |DAT for 72 hours' duration was found harmful to the highest extent (yield reduction of 46.62%). Yield reduction was directly proportional to the water logging duration. Chilli plants at 55 DAT stage was very much sensitive to water logging. Treatment T_1 with normal irrigation (irrigation at 10 days interval) and drainage produced the highest yield of 4.44 t/ha. Fruit length (68.96 mm) and diameter (7.75 mm) were also found higher in this treatment. It had a total irrigation water application of 180 mm along with an effective rainfall of 118 mm.

140. SCREENING OF SUMMER CHILI LINES AGAINST WATER-LOGGING

M. A. R. Akanda, M. N. A. Chowdhury, S. A. Mallik, R. Ara and M. K. Uddin

The study was conducted at SRC, Shibgonj, Bogra with 7 (seven) summer chilli lines along with BARI Morich-1 as check during kharif season of 2010 and 2011 to screen out water logged tolerant chilli lines and to find out the critical stages of summer chilli line to water-logging. Three durations of water-logging viz. 4, 8 and 12 hours were done at flowering and fruit setting stages. Irrespective of stages for water- logging, the results showed that the survivality of the tested entries decreased with the increase of duration of water logging. The fruit setting stage was found to be more sensitive to water-logging compared to flowering stage. Among the tested entries and irrespective of duration of water-logging, E_1 performed the best at flowering stage while E_5 showed the best performance at fruit setting stage in both the years. In addition to those lines E7 (C-612) also showed better performance in respect of water-logging and yield during this year. The interaction effect showed that the highest fresh yield of chilli (15.67 t/ha) was obtained from E_1 x T_1 (4 hours' water logging during flowering stage) while the second highest fresh yield (14.86t/ha) was obtained from E_1 x T_1 (4 hours' water logging in fruit setting stage). The total water used at 4, 8 and 12 hours of water logging was 89, 102 and 118mm, respectively during flowering stage. In the fruit setting stage, the amounts were 78, 91 and 104mm for 4, 8 and 12 hours' water logging, respectively.

Non-Commodity

141. EFFECT OF WASTEWATER IRRIGATION ON CROP YIELD AND SOIL HEALTH

M. S. Rahman. M. A. R. Akanda, M. S. Hassan and S. Noor

An experiment was conducted at the farmer's field of Horian, Rajshahi during the rabi season of 2008-2009 to evaluate the effect of wastewater irrigation on wheat (Tricicum aestivum) yield ans soil health. Three irrigations by both fresh and wastewater were applied at 20, 35 and 60 days after sowing, and fertilizer doses were full dose (N_{170} P_{40} K_{82} $Zn_{1.75}$ B_1 kg/ha), half dose (N_{85} P_{20} K_{41} $Zn_{0.875}$ kg/ha), one fourth dose ($N_{42.5}$ P_{10} $K_{20.5}$ $Zn_{0.438}$ kg/ha) and zero dose of recommended standard doses. The highest grain yield (3.45 t/ha) of wheat was obtained from the wastewater-irrigated treatment with full recommended fertilizer dose (T_1) produced the second highest yield (3.41 t/ha). Besides, the wastewater- irrigated treatment of full recommended fertilizer dose produced the highest straw yield (7.89 t/ha). But, the highest net return (13,168 tk/ha) and benefit-cost ration (1.39) were obtained from the wastewater-irrigated treatment with half of recommended fertilize4r dose (T_4). Wastewater (sugar-mill effluent together with domestic wastewater) quality parameters, such as P^H, NO_3-N N, P, K, S, Zn, Na, Ca, Mg, Cu, Fe and Mn did not exceed the limit of standards for agricultural use to comply with WHO, FAO, DoE, and GoB guidelines. On the other hand, EC, TDS, and Boren level were found to be ranged from slight to moderate variations from the standards for irrigation. Wastewater irrigation provides significant amounts of nutrients into the soil which reduces the need for costly fertilizer inputs. The nutrients N, P, K, Zn and B were added into the soil through wastewater irrigation to the amount of 48 kg/ha, 33 kg/ha, 0.21 kg/ha and 1.83 kg/ha, respectively which were equivalent to 28%, 27%, 40%, 12% and 183% of recommended fertilizer doses (N_{170} P_{40} K_{82} $Zn_{1.75}$ B_1 kg/ha), respectively. Besides, the considerable amount of S, Na, Ca and Mg, and small amount of Cu, Fe and Mn were

entered into the wastewater-irrigated soil. No similar residual effect of pesticides (i.e., Diazinon, Fenitrothion, thion, Malathion and Quinalphos) were found in the wheat grains of the wastewater-irrigated treatments (T_2-T_5). The application of wastewater to crop field can improve some physical and chemical properties of soil. Results showed that the soil properties (i.e. OM, EC, P, K, S, B, Ca and Mg) were found to be increased in a considerable level in the waste water-irrigated soil (T_2-T_5), whereas no consistent changes occurred in the P^H, Fe, Mn, Zn, Cu and total-N level, as compared to freshwater-irrigated soil (T_1). However, the combined use of waste water irrigation and reduced fertilizer management can be a profitable or suitable option for crop cultivation.

142. DETERMINATION OF YIELD RESPONSE FACTORS OF BORO RICE IN RAJSHAHI REGION

M. S. Alam, M. A. Hossain and M. Abdullah

Yield response factors at vegetative and grain yield formation stages of Boro rice (Variety: BR-28) were experimentally determined in clay loam soil in Rahshahi. The values were found 0.60 and 0.28 at vegetative and at grain formation stages, respectively. Using these values along with the potential yield and stage wise crop evapotranspiration, the relationships between the crops evapotranspiration and the predicted yields were obtained as-

$Y_y = 1.5 + 0.011\ ETa_y$;119mm <= ET_a <=199 mm and

$Y_{ya} = 2.68 + 0.005\ ETa_{yf}$;122mm <= ETa_{yf} <=203 mm

Where, Y_v is the expected yield (t/ha) for water deficit in vegetative stage, Y_{y6} the expected yield (t/ha) for water deficit in grain formation stage, ET_{ay} and ET_{ayf} are the actual crop evapotranspiration in mm at vegetative and at grain formation stages, respectively.

143. ADAPTATION TO WATER STRESS CONDITION OF CROP DUE TO CLIMATIC VARIABILITY AND CHANGE

M. S. Rahman, P. K. Sarkar, M. A. R. Akanda, A. Khatun and S. K. Biswas

Scarcity of water is the most severe constraint for development of agriculture in Bangladesh. Under this condition, the need to use the available water economically and efficiently is unquestionable. The objectives of the study were to identify crop growth stages during which the crop can withstand water stress with limited effect on yield and a suitable irrigation options against drought for sustainable production. The results showed that variation in timing and amount of irrigation had a reasonable impact on grain yield. The mid-season stage of mustard was the most sensitive to water stress. On the other hand, water stress during the early and late stage had a limited effect on yield. Although maximum yield was obtained from the treatment fulfilling entire crop water requirement, deficit irrigation can be an effective practice for higher productivity and thus irrigated areas can be increased in water resources limiting situations.

144. DESIGN AND CONSTRUCTION OF A LYSIMETER FOR STUDY OF EVAPOTRANSPIRATION OF DIFFERENT CROPS

B. R. Khan, M. Mainuddin and M. N. Molla

Bangladesh Agricultural Research Institute (BARI) does not have any big Lysimeter of set of Lysimeters to measure evapotranspiration (ET) of different crops directly and accurately. Hence, it was felt necessary to design and construct some permanent Lysimeters in different localities of Bangladesh so that basic research on ET requirement of different crops can be carried out with better precision. After careful studies of the available related literature, a set of four lysimeters have been designed and constructed. It has got two modes of operation, on supplying water from top of lysimeters and the other maintaining constant water level at different depth of soil as required by the experiment without irrigation from top. It will be put into use from the coming Rabi season.

145. WATER MANAGEMENT STUDY UNDER BURIED PIPE DISTRIBUTION SYSTEMS

M. H. Rashid, M. A. K. Mridha

A total of 8 buried pipe schemes of Tangail Agricultural Development Project (TADP) ware selected under the study to average water loss in pipeline and earthen channel were 0.52 lps/100 m and 6.81 lps/100 m, respectively by inflow-outflow method. However, the loss by tank test method was found to be buried pipe system was around 92 percent over that in earthen channel. However, the command area under buried pipe system was found much less than the potential. This was due to own fuel system practice, low pump discharge, low pumping hours, inefficient operation and management works, inefficient extension works and inappropriate credit systems.

146. EVALUATION OF THE IMPACT OF IMPROVEMENTS MADE TO FOUR DEEP TUBE WELL IRRIGATION SYSTEMS

M. H. Rashid, R. K. Das and M.Z. Uddin

Based on the results and recommendations of the bench mark study conducted in 1988-89 irrigation season, an improvement programme was designed and implemented at four deep tubewell schemes in 1989-90 and 1991 seasons. Manikgonj and Ghior schemes ware improved with properly designed compacted earth channels; Saturia and Dhamrai schemes were improved with the combination of compacted earth channel and partial buried pipe system. Necessary control structures were constructed at all schemes. After improvement of the distribution systems operational procedures and other management practices, conveyance loss was decreased by 25 to 57 percent, block rotational system was being practiced, equity of water supply was improved and adequacy of water application was increased by 13 to 27 percent, Command area was increased by 13 to 20 percent at Ukiara and Baparipara, respectively. Due to the use of only block rotation, command area con be increased by 13 to 22 percent. Analyses also showed that with total saved water, command area can be increased by 66 percent at Ukiara and 120 percent at Khatra-2.

147. PROBABLE USES OF FARM-PONDS IN BANGLADESH

M. H. Rashid, N. N. Karim, M. S. Islam and M. A. Fazal

The goal of food self sufficiency will require the full and wise use of all available water resources. Proper water management on the farm increases and sustains agricultural production, Incorporation of local ponds into deep tubewell irrigation systems may be a strategy of such water management. Survey of ponds near by them that would be incorporated into the systems. Supplemental irrigation with pond water is found profitable even when water depth falls below 1.9m and having no deep tubewell facility. The highest net return can be obtained from the combined uses of pond for fish-cum-duck culture and irrigation (by whole seasons buffer storage in case of boro rice) by manually lifting on cash cost basis.

148. DETERMINATION OF GROUNDWATER FLUCTUATION AND AQUIFER PARAMETERS IN BARI CENTRAL FARM

M. S. Islam and M. H. Rashid

At the farm of Bangladesh Agricultural Research Institute, Joydebpur, 10 observation wells were installed in 1985 to monitor the static ground water level. The maximum depth to static water level was found 11.8 m in 1987 and the minimum 6.8 m in 1986.A permanent depletion of 1.0 m was

observed in 1989 and 90. From 5 years' record it is seen that the possible recharge starts from May. Values of Transmissivity and storage co-efficient were found 1059 m2/day and 0.0006 respectively indicating a poor aquifer which is confined in nature. Since the distance between the production wells 3 and 4 l of 5 is less than 300 m, interaction between them causes reduced discharge when both are in operation simultaneously. The highest rainfall was recorded in 1988 as667.4 mm in May. The aquifer was fully recharged in 1986-88.

149. BURIED PIPE DISTRIBUTION SYSTEMS FOR IRRIGATION

M. H. Rashid, M. A. K. Mridha

A number of buried pipe water distribution systems have so far been installed in Bangladesh through different organizations like Rural Development Academy (RDA), Bangladesh Agricultural Research Institute (BARI), Tangail Agricultural Development Project (TADP) Barind Integrated Area Development Project (BIAD) and Mott MacDonald International (MMI), But a systematic study for the evaluation of their performance is yet lacking. Therefore, this study was undertaken to fill that gap to some extent. Different construction Materials viz. non reinforced cement concrete, reinforced cement concrete, plastic (uPVE/PVC) and asbestos cement were used for pipe construction. TADP has shown that the Jointing of the type in-situ cement sand mortar bending to cover a jute bandage soaked in cement sand mortar banding to cover a jute bendage soaked in cement slurry is a better Jointing method. The system cost/ha was Tk. 7000.00, Tk. 11115.00 and Tk. 12000.00 by TADP, MMI and BIAD, respectively. The maximum average head loss was found 0.53 tps/100 m for 230 mm pipe in Chulabar and the minimum 0.10 tps/100 mm for 280 mm pipe in Shaplapara schemes.

150. INVESTIGATIONS OF NEW TECHNOLOGIES FOR MINOR IRRIGATION

M. H. Rashid and M. A. Fazal

This study was undertaken to provide a properly researched and documented information base for assistance in planning in the early stages of National Minor Irrigation Development project. Central (Dhaka and Gazipur) parts of the country were the selected areas for this study. A market survey was conducted at Dhaka and Bogra to obtain the cost and availability of pumping equipments. Static water levels of STWs were measured in April at different upazilas of Dhaka and Gazipur Districts to prepare contour map. Socio-economic survey and STW contractors survey and northwest to assess the demand of farmers for DSSTWS and FMTWs and also to see the ability of STW contractors for FMTW drilling. Market survey indicates that costs of available pumping equipments are not widely varied in the two markets and diameter of maximum PVC pipes are below standard. Static water level survey indicates that Dhaka and Gazipur districts need the development of Force Mode Tubewells (FMTWs). Socio-economic survey indicates that farmers demand has relation to the affordability. Average command area of STW and benefit obtain by irrigating average command area were found to be 8.2 acres and Tk. 36,000 respectively at central and 9.9 acres and Tk. 44,500/- at northwest, respectively. Contractors survey indicate that STW contractors` are interested in FMIW drilling but in some areas 10-12" diameter drilling by hand percussion method is not possible.

151. A STUDY ON RECHARGE AND DEPLETION CHARACTERISTICS OF AQUIFERS IN COMILLA REGION

M. H. Rashid, M. Moniruzzaman and M. A. B. Kamal

One of the four Components of the Groundwater Resources Investigation Program financed by World Bank was sited at Comilla Sadar Upazila to assess the present as well as the future development potential of the groundwater resources in the area. The aquifer characteristics and properties were determined through litho logical investigations and pumping test data analysed. Groundwater level was monitored in different observation wells which were installed at

representative locations of the Upazila. Nine years (1982-1990) water level data were analyzed both graphically and analytically to determine the nature of rise and fall of groundwater levels over the years. Groundwater recharge was assessed by different methods and it has been observed that the rejection of recharge during late monsoon when the aquifer is full to its capacity. The relationship of the Gumti river with groundwater reservoir in the area was determined using the water levels of four observation wells installed on the two banks and the river stages. For further development of groundwater resources economically an approximate tubewell zoning map was prepared. A well spacing equation was developed to calculate appropriate well spacing so as to optimize groundwater utilization within safe yield. Groundwater quality of Comilla region was evaluated in respect of its use in agriculture. The annual safe yield of groundwater was estimated for average rainfall condition by a hydrological balance and was found to be 739 mm (212.83 million cubic meter, MCM) with an allowable water level fluctuation on 14.88 mm.

152. USE OF LOCAL PONDS FOR RAIN WATER HARVESTING AND BUFFER STORAGE FOR DEEP TUBEWELL IRRIGATION SYSTEMS

M. H. Rashid, M. S. Islam and N. N. Karim

Many investigators indicated the potentiality of uses of farm ponds in irrigation in Bangladesh. Accordingly, this study was undertaken to study on test the technical feasibility and economical viability of maximizing the uses of the available water resources and the pumping units through utilizing the existing ponds. Three ponds one at BARI Central Farm, one at Telipara and the other Teknngpara on Joydepur were selected for intensive study. Soil characteristics, pond capacity water losses from the ponds were determined at each study site. Pump discharge, conveyance loss, time of buffer storage and additional command area from the use of ponds were also measured. Additionally, command area from the use of ponds was also measured. Additionally, survey was conducted in several districts of determination to the present level of farm pond utilization, prospects and problems of their utilization etc. The average bulk density varied from 1.28 to 1.63 gm/cc, particle density varied from 2.15 to 2.33 gm/cc and porosity varied from 27.44% at the study sites. Soil types were mainly clay which was suitable for water preservation.

From the three years data (July/88-June/91), it was observed that the total loss exceeded the total annual rainfall and hence there was a net loss in all the three ponds under study. The evaporation loss was always higher than the seepage and percolation losses. Highest pond water storage was available at the end of monsoon and lowest at the end of dry season.
The usable capacity of ponds at BARI Central Farm, Telipara and Teknagpara were 14138, 3604 and 8596 cubic meters and the corresponding pump discharges were 49.28,39.36 and 39.09 1/s. respectively. The survey result indicated that area of the ponds varied between 0.092 and 0.185 ha with depth 3 to 4 m. At the present situation, maximum utilization of ponds were for fish culture and domestic purposes.

Unusual pond-water hydraulics, inadequate water storage during dry season, unawareness of the owners about the various pond utilization and benefits there from, lack of cultivable lands near pond sites, inconvenient conveyance system and inconvenient distribution system are major factors presently constraining utilization of local ponds.

Possibility of runoff water harvest and its extent depend on the topography (relative position) of pond bed, banks and surrounding fields. Survey results show that runoff water harvest is not possible for all ponds under the present conditions. However, with some modification (eg. re-design, re-excavation of ponds and levee construction) it is possible to harvest runoff water in most of the ponds. It should be also mentioned that in normal rainy year ponds in most area of the country are refilled with rain falling directly on the ponds and pond banks.

There is a good possibility of incorporation most of the local ponds in tubewell irrigation systems, fish culture, duck farming and domestic uses. Command area can be increased with the use of ponds and which is directly proportional to the size of the pond.
Ponds in which water depth falls below 1.90 lm in any time and no DTW is available to pump in only supplemental irrigation is profitable. Fish-cum duck culture is found more profitable than fish culture. When water depth in the ponds remains at least 1.9 m throughout the year. The combined utilization of the ponds for irrigation with manual lifting and fish-cum-duck culture is technically feasible and economically viable (by whole season buffer storage) on cash cost basis. The combined pond water utilization by early stored water is also economically profitable even where the DTW is not available for whole season buffer storage.

Since pond water hydraulics varies from place to place, location specific study in different agro-ecological zones of the country should be undertaken. Particularly, in Barind areas, this type of study is very essential. Therefore, this of similar projects (s) should be undertaken in different locations.

153. EVALUATION AND EXTENSION OF DIFFERENT MANUAL PUMPS IN THE FARMERS FIELD

M. H. Islam, M. H. Rashid, M. S. Hossain and P. K. Saha

Three types of manual pumps-Treadle, Rower and 4-cylinder BARI pumps were installed in farmers field at Mirkamari, Shahapur and Diarshahapur under Ishurdi Upazila, Wheat, cabbage, brinjal, potato, radish and some other winter crops were irrigated in 1990-91 Rabi season. The discharge ranges of Treadle, Rower and 4-cylinder BARI pumps were recorded as 30-63,57-60, and 98-149 t/m respectively at field conditions, and the pump wise benefit cost ratios were obtained as high as 3.67, 3.46 and 2.67 on full cost basis respectively. Farmers showed keen interest to use full cost basis respectively. Farmers showed keen interest to use Treadle pump for its ease in operation as well as its good discharge, ease of operation and profitability Treadle pump can be extended to the farmers in other locations of the country for irrigation wheat, watermelon and winter vegetables.

154. DESIGN, FABRICATION AND TESTING OF FLOW MEASURING DEVICE FOR CHANNEL FLOW

M. S. Islam and B. R. Khan

A flow measuring device for channel flow was designed, fabricated and tested at Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, in 1991-92. Preliminary test results showed that the maximum capacity of the device to measure the flow rate was 430 1/min (7.171 ps). The gear ratio was very small to count the revolutions of dial-needle when the flow rate exceeded 120 1/min. This created a problem in calibrating the dial for volumetric measurement of water. So this year, gear ratio has been changed to 1:1000. The fitting of the propeller shaft at the base of the device has been improved with some modification of bearing setting. The number of blades of the propeller has also been reduced to three from four.

155. EVALUATION OF THE EXISTING ON-FARM WATER MANAGEMENT PRACTICES FOR UPLAND CROPS IN SOME SELECTED LOCATIONS

B. R. Khan and M. S. Islam and S. Islam

The experiment was undertaken to evaluate the existing water management practices for upland crops in some selected locations of Bangladesh. For want of fund, on-spot study of the existing systems could not be made. Instead, letters were sent to a number of Thana Agricultural Officers inquiring about the present irrigation practices. Pieces of information were received from nine locations, percentages of irrigated land were 67, 80, 75, and 29 for wheat, potato, mustard, tomato

and chilli, respectively. The corresponding average yields for irrigated condition were 2.95, 13.8, 1.11, 15 and 0.5 t/ha, respectively. Most of the farmers irrigate their wheat at least 3 times. Lentil is not irrigated at all. Farmers of the reported Locations in Gopalganj are not aware of the benefit of irrigations in mustard crop. Farmers of a reported location of Naogaon are not aware of the benefit of irrigating wheat and mustard.

156. LYSIMETER STUDIES OF ET PRODUCTION FUNCTIONS FOR CDP CROPS

B. R. Khan, M. M. Hossain, M. H. Rashid, M. S. Islam and M. Rahman

This project, funded by Canadian Executing Agency of Crop Diversification Programme, Ministry of Agriculture, Bangladesh, was undertaken to improve capability, within BARI's Irrigation and Water Management Division, of conducting studies on actual evapotranspiration to develop economical water management practices for CDP crops. A set of lysimeters with four field tanks, each with 10X10 surface area and 90cm effective soil depth and one access chamber has been constructed at Regional Agricultural Research Station, Jamalpur, Bangladesh. In the first year of construction, 1994-95, Mustard (Brassica Napus), variety BARI Sharisha-8 (NAP-8509), was treated with four different practices of irrigation in the lysimeter tanks in order to find out the actual evapotranspiration (ET) requirement of the crop. The total seasonal (89 days) ET was 227 mm for a grain yield of 1.72 t/ha and dry matter production (shoot only) of 7.37 t/ha, for the treatment with 28 days irrigation interval. The water use index (WUI) for the yield was 6.75 kg/ha-mm. This treatment received only 4 irrigations. The last irrigation was applied on the day just 5 days before harvest (90 DAE). On an average, higher ET, approximately 3.25 mm/day was observed during the period from 21 to 42 DAE (9 december to 30 December 1994). Crop coefficients (K_c) in reference to U.S. Class A Pan and ET_0 calculated by Hargreaves equation are presented in graph. Average Kc values for the whole season were 0.9 and 0.76 and for higher ET period (21 to 42 DAE) were 1.17 and 1.05 as referred to pan evaporation and ET_0 (Hargreaves), respectively.

157. STUDY OF GROUNDWATER LEVELS FOR IRRIGATION IN SELECTED AREAS OF JESSORE REGION

K. C. Roy

The study of groundwater level is very crucial in today's irrigated agriculture in Bangladesh since in many areas groundwater levels decline to such an extent that manual and centrifugal pumps cannot lift water toward the end of the rabi season. Before making a conclusion on the decline of groundwater level perpetually and over exploitation, it is necessary to monitor it. In view of the above, a study was undertaken to monitor the groundwater levels in three randomly selected observation wells in Jessore, Magura and Meherpur districts. Hydrographs of observation wells and rainfall were made and analyzed. From the study it was concluded that groundwater levels were not perpetually declining, that the lowest groundwater levels were well within the suction limits of manual and centrifugal pumps and that the groundwater resources of the region are not over exploited.

158. SUITABILITY OF TREADLE PUMPS FOR NON-RICE CROP IRRIGATION

M. S. Islam

Motorized pumps have not been very much used for non-rice crop cultivation, On the other hand, treads have been used, to some extent, in many places for these crops, Thus, the present study was undertaken to do financial analysis of irrigation crop production using treadle pumps. Study results show that due to irrigation yields of potato, maize and sunflower were increased by 100, 160 and 107%, respectively. The study also revels that even after repayment the cost of treadle pump, the net profit was increases by Tk. 16000/- acre for potato, Tk. 5800/acre for maize and Tk. 780/ acre for sunflower. Resides, greater quantity of dry matter was also produced under irrigation, which

can be used as feed or fuel. Since pump cost has been fully paid in the first year, from second year onward net profit is expected.

159. ASSESSMENT OF IRRIGATION AND WATER MANAGEMENT ACTIVITIES IN DIFFERENT HILLY REGIONS OF BANGLADESH

M. S. Islam, M. S. Shariful Islam, M. S. Alam, and M. H. Rashid

The study was conducted in hilly areas of Srimongol, Kamalgonj and Sadar thana of Moulovibazar district; Ramgarh, Manikchari, Matiranga and Sadar thana of Khagrachari district. Raikhali and Sadar Thana of Rangamati district; Bokshigonj Thana of Jamalpur district and Haluaghat Thana of Mymensingh district. It was found that no definite cropping pattern was followed in hills and valleys of the study areas. However, in plans, T. Aman-Vegetables cropping pattern were found. Chharas (perennial streams are the main source of irrigations water in hilly regions LLPs are used to irrigate crops in plains and to some extent in valleys. But in plains, 25% of total irrigated land watered by LLPs. The rest are irrigated by indigenous methods, like don, swing basket, pitcher or can. Usually. furrow and basin methods of water application were used by construction cross dam. Due to unpredictable heterogeneous and discrete aquifer system, groundwater could not be developed in the hilly areas. Chharas can be developed as water storage reservoir where form water can be used for irrigation either by gravity flow or by pumping. There are opportunities to introduce improved irrigation technologies and water management practices in the hilly areas. particularly for horticultural crops and trees.

160. DESIGN, FABRICATION AND TESTING OF A FLOW DIVERSION DEVICE

M. S. Islam, M.A. Hossain, M. A. Bhuiya and M. Abdullah

A flow diversion device was designed, fabricated and tested in the Irrigation and Water Management Division of Bangladesh Agricultural Research Institute. The device was made of mild steel pipes, reducers and flanges. It divided the pump flow of 9.02 I/s first into two flow rates, each of which was, again, divided in to two flow rates. The entire pump flow was made to pass through at 7.62 cm inlet of the device. The discharge of the pump was bifurcated into two equal flows. When each of these smaller flows was allowed to pass through the nest diversion sequence, it was split into two flows to pass through 2.54 cm. diameter pipes. Thus, initial flow was finally split in to four flows. The device first split pump flow (9.02 1/s and 2.33 & 2.18 1/s was observed after the second split of each 4.51 1/s flow. The devices are capable of delivering water to 4 pieces of crop fields simultaneously thus providing irrigation facilities to more farmers at a time. Further, due to small flow rates, there is a little possibility of soil erosion and uprooting of tender plants. Present price of the device is Tk.3000/- but if it is fabricated on a large scale, the price will come down to only Tk.1500.00

161. IMPACT ON ENVIRONMENT AND SOCIO-ECONOMICS OF BARIND IRRIGATION PROJECT

M. A. R. Akanda, M. S. Islam M. N. Islam and M. S. Alam

The Barind Integrated Area Development Project is a remarkable successful area development project. Although, the project has mostly positive impacts on socio-economic and environment has still got some negative impacts. Some of these are, decrease of surface water sources for irrigation due to fish culture, declination of groundwater table and out break of mosquito carried disease. Above all, the multidimensional nature of the project and its effective implementation have

contributed a lot towards overall development of the area, allevation of poverty and in reversal of environmental degradation.

162. ASSESSMENT OF WATER PRODUCTIVITY FOR SHALLOW TUBEWELLS IN DIFFERENT LOCATIONS OF BANGLADESH

M. A. R. Akanda, M. N. Islam, M. Abdullah, S. A. Mallik and M. A. Hossain

An assessment on water productivity of shallow tubewell irrigations for different crops were done at some of the groundwater exploitation regions, Bogra, Rangpur, Kurigram, Nilfamari, Netrakona and Comilla of Bangladesh. This study was done with questionnaire survey among tubewell owners and farmers and some field investigations like, discharge measurement, fuel consumption etc were done. The overall water productivity of some major crops, like, Boro rice, wheat, maize, potato, banana and vegetables under shallow tubewell irrigation were assessed. The highest water productivity for Boro rice (0.37 kg/m^3) was obtained in Comilla followed by Bogra (0.32 kg/m^3) but for potato it was the highest (18.44 kg/m^3) in Bogra. The overall water productivities for the above mentioned crops were found higher in Comilla, Bogra and Rangpur. Vegetables and upland crops irrigation with STW is more profitable than rice irrigation for both farmers and tube-wells owners in most of the areas.

163. ADAPTIVE CROP AGRICULTURE INCLUDING INNOVATIVE FARMING PRACTICES IN COASTAL ZONE

M. S. Islam, M. A. R. Akanda, A.M. Ibrahim, A. Hossain I. H. Haque and M. Shahidul Islam

The study was conducted in Benarpota farm of BARI and in farmers' fields of Satkhira Sadar upazilla. The soil of Benarpota farm is highly saline. Normally, T. Aman is grown in wet season when the soil salinity remains 2.0 dS/m or less. During the dry season, the salinity usually goes beyond 12 dS/m. But tomato was found to give a good yield (42.03 t/ha) under drip irrigation in raised bed with straw mulch. Flat bed without mulch and can irrigation produced the lowest yield (19.46 t/ha). In farmers' field okra produced the highest yields (9.65 t/ha, 10.31 t/ha) from can irrigation in raised bed with mulch at different locations. The significant variations in yield contributing characters of the selected crops were not found due to heavy rainfall. However, in all the cases raised bed with mulch produced the highest yields of okra.

164. DEVELOPMENT OF INTEGRATED SALINITY MANAGEMENT TECHNIQUES FOR THE COASTAL ECO-SYSTEM OF BANGLADESH

M. S. Islam, M. A. R. Akanda, M. N. Islam A.T. M. A. Islam, Mondal and M. Amin

The project study was done to evaluate the performance of tomato, chili and watermelon under different planting and irrigation techniques and compared the results with those obtained from farmers' practice in the saline soils of Charmajid, Noakhali during the rabi season of 2006-2007. Among the planting techniques, raised bed and flat bed with and without mulch were used. Plantation in flat beds without irrigation and mulch represented the farmers' practice. Simultaneously, promising options were also demonstrated in the saline soils of the neighboring areas. Besides, survey was conducted adjacent to the project site during the same period to estimate the economic return from the tomato cultivation. Tomato produced the highest yield (69.18 t/ha) in raised bed with mulch and irrigated by drip method. The highest net return per ha over total cost basis was Tk. 2,93,816.00 with BCR 3.42 (over total cost basis) for the same sequence of irrigation and planting technique. However, the lowest yield (16.96 t/ha), net return (Tk. 42,725.00 per ha) and BCR (1.72) were obtained from flat land plantation without mulch and

irrigation. Similar trends in yield, net return and BCR were also obtained from watermelon cultivation. In this case, the yield was 34.07 t/ha, net return was Tk. 86,055.00 per ha and BCR was 2.02. In farmers' practice, the corresponding values were 14.72 t/ha, Tk. 23,435.00 per ha and 1.47 respectively. Chili cultivation in saline soil gave the net return of Tk. 1,35,020.00 per ha with a BCR of 2.91 when planted in raised bed with mulch and irrigated by manual pump. This finding was somewhat different from that obtained in farmers' field. In demonstration fields, the highest yield of tomato was 53.24 -57.86 t/ha and watermelon yield, 35.98-36.93 t/ha from the drip irrigated treatments in raised beds with mulch. The net return from tomato varied from Tk. 1,98,176.00 to Tk. 2,25,896.00 per ha. and BCR 2.63- to 2.86. The net return from watermelon varied from Tk. 95,605.00 to Tk. 1,00,355.00 and from BCR 2.13 to 2.19 but the second highest BCR was obtained from manual pump irrigation, which varied from 2.33 to 3.14 for tomato and from 1.93 to 2.03 for watermelon. The soil salinity during plantation in tomato field was 3.77-3.85 dS/m in December which increased rapidly to even about 8.40 dS/m in March in flat bed without irrigation and mulch. However, the salinities in raised beds with mulch and drip irrigation could be possible to keep within the reasonable limit (3.77-5.24 dS/m) throughout the season. The intensity of soil salinity in the project site was comparatively lower in this year than the previous year due to early rainfall during the irrigation season. The salinity values in drip irrigation treatments were 4.27-4.60 dS/m in January, 5.00-5.15 dS/m in February and 5.10-5.25 dS/m in March. Other treatments were found to have comparatively higher values of soil salinity (upto 8.4 dS/m). Similar situations were also observed for watermelon and chili. Thus, drip irrigation in mulched raised bed is suitable for profitable cultivation of tomato, watermelon and chili in saline areas of Noakhali. Rain water harvesting in the study area has been found economically profitable for fish culture as well as irrigation during the dry season. According to by the farmers, the drip irrigation in raised bed with mulch performed better but irrigation by manual pump in raised bed with mulch is more suitable for adoption.

165. REMEDIATION OF SALINE WASTELANDS THROUGH PRODUCTION OF RENEWABLE ENERGY, BIOMATERIALS AND FODDER

M. S. Islam, M. A. R. Akanda, M. N. Islam and M. A.T.M. Islam Mondal

Bangladesh Agricultural Research Institute (BARI) is involved in all work packages (WPs) from WP1 to WP7. Under WP1, BARI is mandated to conduct a pot trial of exotic and local tree species to screen out suitable species for biomass, energy supply and pulp production under saline environment. The institute is also involved in collecting specific information on soil, water and plant from the existing saline pilot sites at Kuakata and Khajura in the coastal region under WP2. The institute is assessing and providing data and information needed to characterize and describe the eco-physiological conditions for the production of biomass in agro-forestry systems in saline areas under WP3. Under WP4, BARI is also participating in cooperation with other consortium members contributing to categorization and mapping of total saline areas in Bangladesh based on criteria that have been established by the consortium. Under WP5, BARI was supposed to send one junior scientist to the University of Utrecht, the Netherlands, for six months with the objective of involvement in the definition and analysis of the biomass supply chains, while at the contributing valuable information on this subject from the case study areas. Under WP6, BARI is contributing from its experience to describe two case studies focusing on the implementation of bio-saline agro-forestry. It will also suggest required policy initiatives and recommendations to the Government and policy makers to promote potentials of salt-affected soils. Finally, it will provide inputs and help in the development of a project webpage/site and updating of the information under WP7.

BARI has already constructed a poly house along with the experimental setup where the pot trials were conducted. Five species under 2nd set of pot trial i,e *Acacia tortolice, Acacia ampliceps, Acacia salicina, Tamarix articulata* and *Conocarpus lancifolius* were planted in pots with 5 replications in November 2008 under four salinity levels (5 dS/m, 10 dS/m, 15 dS/m and 20 dS/m). The pot soil and its nutrient status have been analyzed in the Soil Science laboratory of BARI. Salinity of soil and drainage water are being monitored at 3 months interval. The growth data of

the plants are being monitored at 3 months interval. The plants had been harvested on 08 December, 2009 to estimate their biomass, nutrient content, ash, Na and Cl content. The ash, Na and Cl content have been analyzed in the soil science laboratory of Bangabandhu Shiek Mozibur Rahman Agricultural University, Salna, Gazipur.

In case study areas of Kuakata and Khajura, 163 plants of 5 different plant species have been selected based on plant growth and density. The plant growth data, soil and water salinity (both for surface and groundwater) are being monitored at 6 months interval under WP_2. Under WP_3 to WP_7, the data/ information/ maps on coastal boundary, surface water bodies, digital maps on hydrology, soil salinity, land use, soil class, data on groundwater quality, groundwater declination, land topography and other irrigation information have already been collected from different organizations, like, CEGIS, WARPO, BADC, SRDI and Geological Survey of Bangladesh. These have already been sent to the Acacia Institute at Utrecht University. According to their requirement, data have been provided. Technical and financial reporting is being made on regular basis.

166. EFFECTS OF URBAN WASTEWATER IRRIGATION ON CROP YIELD AND SOIL HEALTH

M. S. Rahman, S. K. Biswas, M. A. R. Akanda, P. K. Sarkar, M. H. Rashid and I. Hossain

A field experiment was conducted in Rajshahi region during the winter season of 2010-2011 to investigate the suitability and effect of urban wastewater for irrigating maize and potato crop. There were five treatments of irrigation and fertilizer doses with three replications: T_1: fresh water irrigation with full standard fertilizer doses, T_2: wastewater irrigation with zero fertilizer doses, T_3: wastewater irrigation with half of standard fertilizer doses, T_4: wastewater irrigation with three fourth of standard fertilizer doses and T_5: wastewater irrigation with full standard fertilizer doses. No significant yield differences were found among the treatments of fresh water-irrigation with full fertilizer doses, wastewater irrigation with three fourth of fertilizer doses, and wastewater irrigation with full fertilizer doses (T_1, T_4 and T_5). Water quality parameters like pH, NO_3-N, N, P, K, S, Zn, Na, Ca, Mg, Cu, Fe and Mn of urban wastewater did not exceed the limit of standards for agricultural use to comply with WHO, FAO, DoE and GoB guidelines. On the other hand, EC, TDS, and B levels were found to be ranged from slight to moderate variations from the standards for irrigation. The nutrients of N, P, K, Zn and B added into the soil through wastewater irrigation ranging from 23% to 100% of standard fertilizer doses both in maize and potato. The soil properties like OM, EC, P, K, S, B, Ca and Mg were found to be increased to a considerable level in the wastewater-irrigated soil (T_2-T_5) including erratic changes in pH, Fe, Mn, Zn, Cu and total-N level. However, the combined use of urban wastewater irrigation and reduced fertilizer management can be a profitable option for maize and potato crop cultivation.

167. GROUNDWATER STATUS AND NET RECHARGE IN GAZIPUR AREA

P. K. Sarkar, D. K. Roy, M. S. Rahman, A. F. M. T. Islam and A. Khatun

Demand of ground water for agriculture, industrial and drinking water is increasing with the increase of population. Large scale groundwater exploitation is causing alarming depletion of ground water table with the consequence of irreversible environmental impact. Under this context, management of ground water should consider both the quality and quantity issues in integrated manner. This study was conducted to investigate the groundwater fluctuation pattern in Gazipur district using observation well data during 1997-2007. Three observation wells at different location of the Gazipur Sadar upazilla were randomly selected for data collection. From the study it may be concluded that groundwater levels are rapidly declining and the levels are already beyond the suction limits of manual and centrifugal pumps. The groundwater resources of this region are overexploited. From November to February/March there is scanty or no rainfall. Annual recharge was found much less in comparison to the withdrawal and the aquifer was never fully replenished throughout the study period. Consequently, a gradual decline in static water level was observed in

this region. The level is much more below than the suction limit. In some areas the maximum groundwater level was observed below 30 m during dry period.

168. ASSESSMENT OF GROUNDWATER RECHARGE AND USES IN PANASI (PABNA-NATORE-SIRAJGONJ) IRRIGATION PROJECT

A. F. M. T. Islam and P. K. Sarkar

Quantification of the rate of natural ground water recharge is a pre-requisite for efficient ground water resource management. The groundwater recharge potentiality in PANASI project area was studied based on groundwater level (GWL) fluctuation and rainfall data during the year 2001 to 2010. In this experiment, an attempt has been made to determine groundwater fluctuation, recharge and to derive an empirical relationship to determine ground water recharge in the project area. From this study it is seen that there were variations in water table fluctuation and groundwater recharge from year to year which varied from 1.91 m to 7.07 m and from 210 mm to 525 mm respectively. The GWL is not declining continually i.e. the rise and fall of GWL do not follow any definite pattern. Results proved that the maximum ground water level goes beyond the suction limit of STWs, so the operation of manual and centrifugal pumps were in danger during the study period in case of Pabna and Natore district. On the other hand, in case of Sirajgonj those pumps could lift water in the dry seasons. The average recharge based on GWL fluctuation was calculated 358 mm/ season where as the average maximum allowable abstraction, considering the groundwater level to lie within the suction limit of the STW, was 306 mm/season. These indicate that within suction limit the maximum abstracted water could be replenished by monsoon season rainfall recharge. Finally, an equation was derived to get recharge from monsoon season rainfall where GWL data are unavailable.

169. ASSESSING HEALTH, LIVELIHOODS, ECOSYSTEM SERVICES AND POVERTY ALLEVIATION IN POPULOUS DELTAS (ESPA)

M. A. R. Akanda, S. K. Biswas, A. F. M. Saleh, A. S. Jofer and M. S. Mondol

Trial-1. Response of Different Levels of N to the Growth and Yield of Boro Rice in Saline Prone Areas

The field experiment was carried out at the clay saline soils of ARS, Benerpota, Shatkhira to observe the effect of different levels of Nitrogen on the growth, yield and Biomass for Boro rice (BRRI Dhan-47). 5 (five) levels of N viz. 25%, 50%, 75%, 100% and 125% of recommended doses including a control (0%). The grain yield was not varied significantly among the treatments. This might be the rich of organic matter in the soil. The primary data on physiological growth and yield were generated those will be used as model inputs.

Trial-2. Performance of Boro Rice under Different Levels of Saline Water Irrigation

The study was conducted at the sandy clay loam soil of IWM Divisional Research field at BARI, Gazipur during the rabi season of 2012-2013 with Boro rice (BRRI Dhan-28) to generate the primary physiological data of rice under different salinity stress conditions at different growth stages and to determine the impact of salinity of biomass and yield of rice. Five (5) levels of saline water viz. 3dS/m, 6dS/m, 9dS/m, 12dS/m and variable salinities at different stages were imposed as irrigation. The water salinity was created artificially with a mixture of Nacl and Cacl2. The highest grain yield (6.49 t/ha) was found in treatment T_3 irrigated with saline water of 3dS/m

which is almost like non-saline. The lowest grain yield (0.66 t/ha) was found in the treatment of 12dS/m salinity. So, the effect of salinity stress on the yield of Boro rice was obtained from this trial which will be used as the input of agricultural model.

170. COORDINATED PROJECT ON WATER MANAGEMENT FOR ENHANCING CROP PRODUCTION UNDER CHANGING CLIMATE: BARI COMPONENT

P. K. Sarkar, A. R. Akanda, S. K. Biswas, M. Roknuzzaman, S. C. Mondol and F. Akhter

This is a two years' project aims to develop a feasible methodology for improving irrigation performance through better water management and raising the efficiency of water use in the study areas. The work comprises a number of different experiments dealing with different aspects with a view to achieve the overall goal. The field work was initiated with a base line survey and it was conducted at three study regions (Dinajpur, Rajshahi and Chittagong districts) during October-November 2011. The existing farming system and adaptation techniques to climate change were assessed through an extensive field survey. The specified selected locations were Birganj upazila under Dinajpur, Godagari upazila under Rajshahi and Hathazari upazila under Chittagong district, respectively. Based on the survey results, a few location specific promising cropping patterns were selected in respect of the project aim. As per selected patterns, the further project activities were conducted. Important climatic parameters like temperature, rainfall, humidity, sunshine hours and relative humidity were considered as the influencing factor on agriculture. A long term (30 years) data set on those parameters for the study areas were collected under the experiment 1 from the Bangladesh Meteorological Department. The MAKESENS software was used for data analysis. An extensive study was conducted on irrigation scheduling of rice and other important location specific non-rice crops for optimum yield and water use under the experiment 2. Long term groundwater level data from some selected observation wells were collected under the experiment 4 from the Bangladesh Water Development Board (BWDB). Those data were also analyzed using the same software. Groundwater level data were also collected directly from a few selected observation wells in the study areas. Water samples are being collected from different sources used for irrigation in the study areas under the experiment 5 and is duly being analyzed in the laboratory to test the suitability for irrigation. Second year's activities are going on and different field/ laboratory data collection is on progress. The results obtained from those field studies are discussed in detail at the respective sections. At the end of the project period a detailed report will be prepared as per prescribed PCR format.

171. COMPARATIVE STUDY ON YIELD AND WATER USE BY DIFFERENT CROPPING PATTERNS IN BARIND AREA

S. K. Biswas, M.A. Salam and A. R. Akanda

Experiments on rice based cropping systems for sustainable crop production were conducted at the Barind area of Rajshahi during 2013-15 in Randomized Complete Block Design with three replications. Four different cropping patterns with seven principal crops of that region viz: Musatrd-Boro-T.Aman, Wheat-Mung-T.Aman, Potato-Mung-T.Aman and Chickpea-Mung-T.Aman were compared to evaluate their comparative profitability in terms of yield, water use and economics. Three irrigation practices were tried for each crop in a pattern. The treatments were: for wheat- irrigation at CRI (T_1), at CRI and booting (T_3), and at CRI, booting and grain filling (T_3) stages; for mustard- irrigation at vegetative, at vegetative and flowering, and at vegetative, flowering and pod formation stages; for potato- at stolonization and tuberization (T_1), at stolonization and bulking (T_2), and at stolonization, tuberization and bulking stages (T_3), for mungbean- pre-sowing (PI), PI and at vegetative, and at PI, vegetative and flowering stages; for chickpea- no irrigation, irrigation at early vegetative, and at vegetative and flowering stages, for

T.Aman- alternative wetting and drying (AWD) method with 20 cm (T_1), 25 cm (T_2) and 30 cm (T_3) depth; and for Boro rice- Farmers' practice (ponding up to 3-5 cm), (AWD) method with 20 cm (T_2), and 30 cm (T_3) depth. As yield of different crops in a particular cropping sequence varied, rice equivalent yield (REY) also varied with the different irrigation treatments. In all patterns, except Potato-Mung-T.Aman, rice equivalent yield was found the highest under T2 irrigation regime. It ranged from 11.44 t/ha in Chickpea-Mung-T.Aman to 13.37 t/ha in Wheat-Mung-T.Aman cropping sequence. In Potato-Mung-T.Aman pattern, the highest REY of 29.48 t/ha was found in T3 irrigation treatment. Though the trend of total water use was found higher in rice dominant patterns than non-rice dominant cropping patterns, the trend of water productivity (WP) was reverse.`In Mustard-Boro-T.Aman pattern, TWU varied from 1554 to 1977 mm whereas it varied from 890 to 927 mm in non-rice dominant patterns. WP ranged from 2.78 to 3.31 kg/m3 in Potato-Mung-T.Aman pattern, from 1.27 to 1.45 kg/m^3 in Wheat-Mung-T.Aman pattern and from 1.21 to 1.27 kg/m^3 in Chickpea-Mung-T.Aman cropping pattern. While it ranged from 0.61 to 0.75 kg/m3 for rice dominant Mustard-Boro-T.Aman cropping pattern. The relative degree of utilization of soil water storage was greatest in chickpea (83%), followed by wheat (67%), mustard (62%) and potato (61%). Among the patterns, on average over irrigation management, the highest gross margin and the BCR (Tk.309585/ha and 2.26) were obtained from Potato- Mung-T.Aman and the lowest values (Tk. 65755/ha and 1.52) were obtained from Mustard-Boro-T.aman cropping sequence. Therefore, inclusion of non-rice rabi crops instead of boro rice can significantly reduce the irrigation requirements in dry season without having any adverse effect on farm's income.

172. DEVELOPMENT OF APPROPRIATE WATER MANAGEMENT PRACTICES FOR INCREASING CROP WATER PRODUCTIVITY IN SALINE AREA

A.R.Akanda, S.K. Biswas and M.A. Rahaman

A study was conducted during 2014-2015 at ARS, Benarpota, Satkhira with the two most common and intensive cropping patterns viz. Mustard (BARI Sharisa- 14) - Boro (BR Dhan-47) - T.Aman (BINA Dhan- 7) and Wheat (BARI Gom- 25) - Mung (BARI Mung- 6)-T.Aman (BINA Dhan- 7) of that area and compared to evaluate their comparative profitability in terms of yield and water use. Four different irrigation treatments were tried for different crops in a pattern. The treatments were: for wheat- Farmers' practice (T_1), irrigation at CRI (T_2), at CRI and maximum tillering (T_3) and at CRI, maximum tillering and flowering (T_4) stages; for mustard- Farmers' practice, irrigation at pre-flowering, at pod formation and at pre-flowering and pod formation stages; for mungbean- Farmers' practice, irrigation at vegetative, at flowering, and at vegetative and flowering stages; for T.Aamn- no irrigation, irrigation at booting, at grain filling, and at booting and grain filling stages; and for Boro rice- Farmers practice (ponding up to 3-5 cm), alternative wetting and drying (AWD) method with 20 cm(T_2), 30 cm (T_3) and 40 cm (T_4) depth. Rice equivalent yield (REY) varied with different irrigation treatments. In Mustard-Boro-T.Aman cropping pattern, rice equivalent yield was found the highest of 13.43 t/ha under T_2 irrigation regime. While the lowest REY of 12.86 t/ha was obtained in treatment T_4. On the other hand, in Wheat-Mung- T.Aman cropping pattern, the highest REY of 15.61 t/ha was obtained from T_4 irrigation regime and the lowest was from Treatment T_2. Total water use and water productivity (WP) were found lower in non-rice dominant pattern Wheat-Mung-T.Aman than rice dominant pattern Mustard-Boro-T.Aman pattern. Total water use varied from 1372 mm to 1720 mm with minimum in treatment T_4 and maximum in control treatment T_1 under Mustard-Boro-T.Aman pattern. In contrast, TWU was found the highest (1072 mm) in irrigation regime T_4 and the lowest was found in the most deficit treatment T_2 (836 mm) in Wheat-Mung-T.Aman pattern. In Mustard-Boro-T.Aman pattern, WP was ranged from 0.76 to 0.94 kg/m^3 with the lowest in T_1 and the highest in T_4. While in Wheat-Mung- T.Aman pattern, WP ranged from 1.44 for T_3 to 1.49 for T_1 in kg/m^3. Between the two patterns, the highest gross return (Tk. 93850/ha), gross margin (Tk. 48980/ha) and BCR (2.04) was realized by Wheat-Mung- T.Aman cropping sequence with T_4 water regime closely followed by treatment T_3. Though irrigation regime T_4 gave the best result in terms of yield and profitability, considering the water scarcity in saline areas the irrigation treatment T_3 can also be suggested for farmers.

173. TECHNICAL AND ECONOMICAL FEASIBILITY OF SOLAR PUMP IRRIGATION FOR CROP CULTIVATION IN COMPARISON WITH OTHER POWER SOURCES

K. K. Sarker, A. R. Akanda, M. A. Hossain and M.A. Rashid

Solar powered water pumping system plays an important role in irrigation and water management. It is necessary to compare the economic and technical feasibility for crop production to develop data base for irrigation experts, policy makers, farmers and private entrepreneurs and water management. Therefore, this study was undertaken to assess the technical and economic analysis of solar, diesel and electric powered water pumping for irrigation at different locations in Bangladesh. Primary and secondary data were collected through field survey, monitoring and questionnaire survey in 2015 and 2016. A total of 12 samples for solar powered irrigation system, 2 samples for solar powered irrigation with household electrical-grid supply system, 4 samples for electric powered irrigation pump systems and 4 samples for diesel powered irrigation pumping system were randomly selected for this study. Other information was gathered from national and international experiences, and related past literatures. Five case studies (two solar powered, two electric powered and one diesel powered irrigation system) were randomly selected for details economic analysis to assess and compare the benefit cost ratio (BCR), internal rate of return (IRR) and net present value (NPV). The survey study indicated that the cost of pumped irrigation water using panels of solar photovoltaic cells with accessories was between Tk 2,413,010 and Tk 5,500,000 with the panel capacity range from 4.2 kW to 14kW. In contrast, diesel powered pumping units of capacities between 2.98 KW and 4.48 KW cost Tk 25,000–Tk 35000.The costs of electricity powered pumps of capacities, 3.73 KW to 18.65 KW cost Tk 120,000 – Tk 1,000,000. The highest gross margin was estimated from electric powered irrigation compared to solar and diesel powered irrigation system for various crops cultivation, while lower gross margin was estimated from diesel powered irrigation pumps due to lower gross irrigated area for crop production. Among the case studies, BCR was found 0.10 and 0.05 in solar powered irrigation and solar powered irrigation with household electrical-grid supply system, respectively. IRR and NPV were found negative which indicates that these systems are not economically profitable. BCR, IRR and NPV were found highest 1.39, 44% and Tk. 2,00,511 in electric powered irrigation (centrifugal pump) system compared with other power sources, which indicates that this system is profitable. Based on existing farmers' field condition, as is evident by now, solar powered irrigation pumping systems require high initial costs. However, an economic evaluation of solar powered system could be considered in future for its multipurpose uses such as, solar-cum-diesel powered irrigation pumping system for crop production and drinking water supply, electrification to villages for providing lighting, fans and lighting at street, water supply for fish culture and other community services like as telecommunication.

174. SUSTAINABLE CROP PRODUCTION IN DROUGHT AND SALINE COASTAL AREAS OF BANGLADESH UNDER CHANGING CLIMATE

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This project, funded by Bangladesh Climate Change Trust Fund, was undertaken to develop the suitable water management practices based on major cropping patterns in saline and drought prone areas of Bangladesh under climate change situation. The coastal districts selected for conducting cropping pattern based experiments were Barguna, Khulna and Satkhira, and the drought prone districts were Kushtia, Rajshahi and Rangpur. Every crop in major cropping patterns of that area received four different water management practices varied according to crops. From the experiments conducted during 2014-2015, it was seen that non-rice dominant cropping pattern had lower water use with higher water productivity. In salt prone areas, both rice equivalent yield and water productivity were found higher in T_2 water management sequence where modest amount of water was applied through irrigation. In drought prone areas, though the higher WP was obtained mostly from T_2 irrigation management, the highest rice equivalent yield (REY) was obtained from T_4 irrigation practices where higher amount of water was applied through irrigation. In saline

prone area, Tomato-Jute-T.Aman had the highest REY and WP (54.60 t/ha and 5.73 kg/m^3) followed by Tomato-T.Aus-T.Aman (41.51 t/ha and 2.85 kg/m^3) and Watermelon-T.Aus-T.Aman (38.21 t/ha and 2.74 kg/m^3) cropping patterns obtained under T_2 water regime. Total water use was found the lowest in Mustard-Mung-T.aman and Wheat-Mung-T.aman patterns. The highest water use pattern was Mustard-Boro-T.Aman with the lowest water productivity of 0.72-0.86 kg/m^3. On the other hand, in drought areas, the highest REY and WP (56.60 t/ha and 3.94 kg/m3) were obtained in Tomato-T.Aus-T.Aman. Total water use was also found higher in this pattern and ranged from 1437 mm to 1780 mm depending on irrigation management. In general, TWU was lower in non-rice dominant pattern than rice dominant pattern. REY and WP were increased drastically when some non-rice crops like tomato, potato, watermelon and even jute were included in the pattern. Among the pattern, the highest gross margin and the BCR (Tk. 649704/ha and 3.21) were obtained from Tomato- Jute-T.Aman under T_4 water management and the lowest values (Tk. 57604/ha and 1.44) were obtained from Wheat-Mung-T.aman cropping sequence under T_2 water management in saline prone area. While in the drought prone area, the highest gross margin and the BCR (Tk. 751102/ha and 4.28) were obtained from Tomato-T.Aus-T.Aman in T_3 water management and the lowest values (Tk. 43520/ha and 1.39) were obtained from Chickpea-Mung-T.aman cropping sequence in T_1 water management. In both the areas, not a particular water management option was suitable for a particular crop and/or cropping sequences for getting higher yield and profit as well.