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BAU CAMPUS, MYMENSINGH-2202
BANGLADESH

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FOREWORD

I am delighted to know that the Annual Research Report 2011-12 of the Institute is going to be published. During this period, the Institute made significant contributions on technology generation and its transfer throughout the country, capacity building through national and international collaborations.

The research activities of the Institute were carried out under eleven research divisions. During this period, 12 crop varieties were released viz., two varieties of rice (Binadhan-9 and Binadhan-10), two varieties of groundnut (Binachinabadam-5 and Binachinabadam-6), one variety of sesame (Binatil-2), two varieties of soybean (Binasoybean-1 and Binasoybean-2), two varieties of lentil (Binamasur-5 and Binamasur-6) and one variety of tomato (Binatomato-7). Binadhan-9 is an aromatic long fine grain rice variety suitable for aman season. Binadhan-10 is a salt tolerant variety to the tune of 10-12 dS/m. Binachinabadam-5 and Binachinabadam-6 are also salt tolerant which can tolerant upto 8 dS/m salinity during flowering till harvest stages.

A substantial progress has been made towards the development of new crop varieties. Some significant features of the developed lines are elucidated here as; the mutant $KD_5$18-150 showed 40.06% higher grain yield (average 3.62 t ha^{-1}) than mother Kalizira and 22.65% than the existing aromatic rice BRRI dhan34 in different sub-stations of BINA as well as in different farmers' field across the country. Two rice lines *viz.*, Ciherang *sub1* and Samba Mahsuri *sub1* were found promising for submergence tolerant, early maturing and minikate type for T. aman season. Two mutant lines of mungbean; N_3J-305 and E_4I-915 were found consistent in respect of seed yield over locations which matured six days earlier than Binamoog-7 and Binamoog-8. In another study against salinity, two rice genotypes; NERICA-1 and PBRC-37 showed relatively better performance in respect of yield and yield attributes up to 12 dS/m. On the basis of nitrate reductase activity of Binatomato-6, 150 kg N ha^{-1} was found sufficient for normal plant growth and development if urea is applied frequently in 20 days interval. A black seeded mutant line SM-12 of sesame was identified as high yield potential; two lines (BAU-S/80 and BAU-S/109) of soybean were found early maturing with higher seed yield; two lentil lines (LM-75-4 and LM-132-7) were found very promising for seed yield and consumers' preferred characteristics; three summer tomato mutant lines (TM-131, TM-134 and TM-219) were found to be promising in respect to fruit yield, shape and size.

Fertilizer recommendations were made on some elite mutant lines of mustard, soybean, sesame, salt tolerant rice and Binapatshak. In a study, about 20% increased yield was found using PGPR biofertilizer in the field condition of boro season at Mymensingh.

In pest management, advanced selected lines of rice, pulses, oilseeds, tomato and onion were discriminated for resistance apart from bio-control and irradiation aided control measures. Mutants/lines of rice, pulses, oilseeds, tomato and jute were also evaluated for tolerance to their major insect pests and some mutants found to show tolerance against insect pests. Resource management for higher water productivity and water use efficiency together with water requirement and irrigation scheduling of BINA developed crop varieties were assessed. A water saving cropping pattern was also developed for the drought prone Barind area of Chapai Nawabganj district, Magura and Mymensingh district as well. Trend of long-term climatic parameters and water table were also evaluated and its predictions were made for year-round crop planning. For yield maximization through better crop management, population density, early and late sowing potentials of advanced selected lines/varieties of rice, oilseeds, pulses and tomato were also performed and reported. Two genotypes of rice (Binadhan-9 and Kalozira) were evaluated under three transplanting date (August 01, August 10 and August 20) and found best time as August 01 for better yield. Three advance lines/varieties of soybean (BAU S/70, AVRDC 78 and Binasoybean-1) were assessed under different row spacing (20, 25 and 30 cm) and 20-25 cm line sowing produced more yield (2.55-2.79 tha^{-1}). Two genotypes of sesame (Binatil-1 and Binatil-2) were evaluated under three row spacing (15, 20 and 25 cm) and 15-20 cm row spacing found better for maximum yield (1.08-1.15 $t\ ha^{-1}$).

In order to take the BINA crop varieties to the end users and attain maximum benefit from them, a good number of training programmes for the farmers, BADC, DAE and NGO personnel, field days and demonstrations were carried out. Besides this, BINA scientists supervised considerable number of M.S. and Ph.D. students of BAU, Mymensingh.

It is hoped that the report would be useful for scientists, planners, policy makers and those who have academic interest as well. I am grateful to the members of the Publication Committee for their efforts in bringing out the report in time.

(Dr. M A Sattar)
Director General

PREFACE

Bangladesh Institute of Nuclear Agriculture is an Agriculture Research Institute which has been using nuclear techniques in agriculture research since 1975. Now the Institute has become one of the reputed national institute and its exposure is gradually increasing internationally. The institute always has updated its annual research programme under changing climate & needs of the country. The scientist of the institute are trying also to devote themselves in full concentration developing new varieties and generating the non commodity technologies. I feel very happy for the success of the scientists of our institute to develop short duration (120-125 days) an aromatic fine long slender grain rice with an average grain yield 3.75 tons per hectare. This variety opens the potentiality of cultivating robi crops in the occupied land area by the existing local aromatic variety having life cycle of 150-160 days. In this year we could make release of a salt tolerant variety Bindhan-10 (tolerant upto 10-12 dS/m) which can be easily cultivated in at least one third area in the southern zones with a yield potential of 5.02-5.5 t ha^{-1}. This variety can be grown also in non-saline condition throughout the country with more yield potential (7.5-8.5 t ha^{-1}).

There are many potential mutant lines of different crops which are being in advanced stages and awaiting for release process. Among them the rice mutant line RM(1)-200(C)-1-17 produced 200-990 kg ha^{-1} higher yield than BRRI dhan28. These are other rice mutant line RM(2)-50(C)-2-1 produced 8.58 t ha^{-1} yield in boro season which was 1.35 t ha^{-1} more yield than its parent BRRI dhan29. The rice mutant line RM(2)-40(C)-4-2-4 took the shortest period to mature in T. aman season (119 days) and produced all most alike yield as BRRI dhan49. The jute mutant O$_{91}$/90/72-3 produced 8-10% higher fiber and 25-30% higher stick yield than the parent O-9897. Four mutant lines of wheat immerged as saline tolerant 6-12 dS/m. Two rapeseed mutants MM-51 and MM-63 have been identified with higher seed yield and short duration (1700 and 1800 kg ha^{-1}, 78-82 days). A sesame mutant line (SM-10-04) has performed better in different locations in respect of seed yield (1500-1700 kg ha^{-1}. Two soybean lines (BSUS-70 and AVRDC-78) have been selected for higher yield (2500-2800 kg ha^{-1}). Two chickpea genotype P-70 and CPM-860 have been selected for bolder seed size and higher seed yield. Three AVRDC tomato mutant lines TM-8, TM-14 and TM-17 and one Cherry type mutant line TM-19 have been selected for higher yield. In addition to that one summer mutant line (TM-219) was found to be promising in respect of fruit yield (38.5 t ha^{-1}), shape and size. Three onion mutants had significantly higher dry bulb yield than BARI Piaj-3 and BARI Piaj-8, had also lower weight loss on storing for one month.

Research on soil fertility restore and production of Plant Growth Promoting Rhizobacteria (PGPR), Phosphate Solubilizing Bacteria (PSB) are in progress, needs further evaluation in on farm and regional condition. Irrigation scheduling research for different mutants are also in progress under changing climate and soil condition. Cropping pattern research including the BINA short duration varieties are carried on to increase the cropping intensity. Development of economically and severely affective pest tolerant mutants of different crops are in progress also.

Regarding technology transfer activities like block demonstration, DAE personnel and farmers training and field days, production and distributions of seeds of different varieties to different stake holders are being carried out also successfully.

I feel proud to congratulate our scientists for their keen interest, hardworking and great devotion for research. Thanks to all concerned who put their all sincere endeavors to prepare the document. Any constructive suggestions for the improvement of this annual report would be highly appreciated.

Dr. M. A. Salam
Director (Research)

BINA’S OBJECTIVES

To develop high yielding and better quality crop varieties using both mutation and conventional breeding techniques.

To assess the fertilizer status of the soils of Bangladesh and efficiency of utilization of applied nutrients by crop plants using radioisotopic techniques.

To develop means of water use efficiency for optimization of crop yields through radioisotopes and radiation techniques.

To evolve control measure against major pests and diseases of crop plants.

To assist national and international research programmes through cooperative support.

To provide facilities to students of the Bangladesh Agricultural University for carrying out research leading to Masters and Ph.D. degree in Agriculture.

To arrange training programmes for the research scientists on the peaceful use of atomic energy in agriculture.

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PLANT BREEDING DIVISION

RESEARCH HIGHLIGHTS

Rice

The aromatic long fine grain rice line RC-43-28-5-3-3 has been released as Binadhan-9 in the 77th meeting of National Seed Board held on 15Th May 2012. It is suitable for T. aman season. It produces higher yield (3.0-4.15 t ha^{-1}) than its parent Kalizira and the check BRRI dhan38; and matures 23-25 days earlier. For its shorter culm length it does not lodge. The mutant RM(1)-200(C)-1-17 produced 233-1333 kg and RM(1)-200(C)-1-17 produced 200-990 kg higher yields than BRRI dhan28 at 6 out of 9 locations when transplanted after harvest of long durated mustard/rapeseed during 2nd week of February to 1st week of March. The maturity of the mutant lines was 3-5 days earlier than BRRI dhan28. The mutant line RM (2)-50(C)-2-1-1 produced 8.58 t ha^{-1} yield in boro season which was 1.35 t ha^{-1} more yield than its parent BRRI dhan29 and matured 4 days earlier. In contrast, in T. aman season it produced 7.72 t ha^{-1} yield which was 2.06 t ha^{-1} higher than the check variety BRRI dhan49 and matured 5 days earlier. Interestingly, the mutant RM(2)-40(C)-3-1-7 appeared as aromatic in the boro season, although produced statistically at par yield with its parent and matured 12 days earlier. Moreover, 4 other mutants were selected in boro season that matured 8-10 days earlier and produced statistically at par yield with their parent BRRI dhan29. The mutant RM(2)-40(C)-4-2-4 took the shortest period to mature in T. aman season, only 119 days, and produced statistically indifferent yield with BRRI dhan49. Thirty four F_5 lines have been selected for higher aroma with long fine grains and higher iron contents. To select for higher yielding deep water rice M_2 bulk population of Mousar and M_1 population of Luxmi digha have been grown.

Jute

The mutant O_{97}/90/72-3 produced 8-10% higher fiber and 25-30% higher stick yields than its parent O-9897.

Wheat

Four mutant lines produced significantly higher yields through maintaining higher population in the saline soil of Satkhira than the check variety Pradip. Germination of wheat hardly affected by soil salinity $\leq$ 6.0 dS/m while yield up to 12 dS/m.

Mustard/Rapeseed

Two rapeseed mutants (MM-51 and MM-63) have been identified with higher seed yield and short duration (1700 and1800 kg ha^{-1}, 78-82 days). Two mustrad lines (RC-4 and RC-9) have been identified with higher seed yield and short duration (1400 and1500 kg ha^{-1}, 75-80 days). In addition, some M_6 and M_5 mutant lines of mustard and rapeseed have been selected with higher seed yield potential. These lines also need further evaluation.

Groundnut

Three mutants derived from Dacca-1 and two mutants from PK-1 produced significantly higher yields than their respective parents. Three *Cercospora* leaf spot tolerant lines that having significantly higher yield than the parents, Dacca-1 and Zhingabadam have also been selected.

Sesame

A mutant line (SM-10-04) has performed better in different locations in respect of seed yield (1500-1700 kg ha^{-1}). The capsules and leaves are hairy which can resist insect infestation. Application will be done to NSB for registration this line as variety. In addition there are some other mutants in advanced generations (M_8 and M_9) for evaluation.

Soybean

Two lines (BAUS-70 and AVRDC-78) have been selected for higher yield (2500-2800 kg ha^{-1}). Seven mutant lines have been selected which gave higher than their mother varieties, Sohag and BARI soybean-5.

Mungbean

MBM-3-07-Y performed well in respect of seed coat colour, grain yield and tolerant to *Cercospora* leaf spot disease at different agro-ecological zones. Some promising mutants have been selected for earliness, grain yield and tolerance to diseases which will be tested in different yield trial.

Chickpea

Two genotypes P-70 and CPM-860 have been selected for bolder seed size and higher seed yield. Application will be made to NSB for registration as a variety. Some desirable mutant lines/plants have been selected for earliness, bolder seed size and higher seed yield at Barind area.

Lentil

LM-75-4, LM-185-2 and LM-132-7 mutant lines were found promising for seed yield (Av. wt. 2315, 2058 and 2221 kg ha^{-1}) and other characters. In addition, some mutant lines (20 from M_4, 15 from M_6 and 7 from M_7) have been selected and these are in trial for further evaluation.

Tomato

Three AVRDC mutant lines TM-8, TM-14 and TM-17 and one Cherry type mutant line TM-19 have been selected for higher yield. In addition to that one summer mutant line (TM-219) was found to be promising in respect of fruit yield (38.5 t ha^{-1}), shape and size. Application will be made to NSB for registration these advanced lines as varieties.

Onion

Three mutants had significantly higher dry bulb yield than BARI Piaj-3 and 8 had lower weight loss on storing for one month at Rangpur and two at Mymensingh. The parent BARI Piaj-2 did not produce any seed. Ten mutants produced higher seed yield than BARI Piaj-3.

RICE

Preliminary yield trial with M_5 high yielding mutant lines of T. aman rice

Seedlings of 13 mutant lines derived from BRRI dhan29 by irradiating its seeds with carbon ion beams in T. aman season along with BRRI dhan49 were transplanted on 11 August 2011, 30 days after seed sowing. The experiment followed RCB design with 3 replications. Seedlings were transplanted at 15 cm distances within rows of 20 cm apart. A unit plot size was 1.5 m × 1.0 m. Recommended doses of fertilizers, cultural and intercultural operations were also followed as and when required. Data on plant height, days to maturity; number of effective tillers, panicle length, filled and unfilled grains per panicle and yield plot^{-1} were recorded. Maturity was recorded experiment basis while plant height, effective tiller number, panicle length, filled and unfilled grains/panicle was recorded from 5 hills in each plot at harvest. Grain yield was recorded from 1 m^2 which was latter converted to yield ha^{-1}. Finally, the recorded data were subjected to proper statistical analyses following the design used and presented in Table 1.

Table 1. Yield and some yield attributes of 13 mutant lines derived from BRRI dhan29 with carbon ion beams irradiation along with BRRI dhan49

Mutant/variety	Days to maturity	Plant height (cm)	Effective tiller (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield (t ha^{-1})
RM(2)-50 (C)-2-1-1	131	119.6	7.8	29.0	165.4	21.4	7.72
RM(2)-40 (C)-1-1-12	123	96.67	8.87	26.40	128.13	22.40	4.00
RM(2)-40 (C)-3-1-1	126	103.40	11.07	29.00	137.87	23.73	4.10
RM(2)-40 (C)-3-1-2	123	111.97	7.93	27.80	80.33	18.13	3.33
RM(2)-40 (C)-3-1-3	131	98.07	11.40	23.80	123.53	21.80	5.67
RM(2)-40 (C)-3-1-5	126	103.30	9.93	26.22	137.75	32.10	5.83
RM(2)-40 (C)-4-2-1	120	96.87	8.87	27.20	119.87	26.73	5.00
RM(2)-40 (C)-4-2-2	126	99.13	10.73	27.87	114.93	25.87	5.33
RM(2)-40 (C)-4-2-3	131	107.60	8.87	26.80	129.53	20.97	5.33
RM(2)-40 (C)-4-2-4	120	108.67	9.33	29.27	116.37	17.20	5.67
RM(2)-40 (C)-4-2-5	123	94.20	10.87	27.00	118.27	20.40	5.33
RM(2)-40 (C)-4-2-7	126	119.20	8.93	28.93	145.20	16.47	6.00
RM(2)-40 (C)-4-2-8	123	116.0	7.53	31.4	143.2	29.33	5.03
BRRI dhan49	136	103.8	8.53	24.73	129.67	18.40	5.67
LSD(0.05)	-	24.36	14.07	-	15.99	5.00	

Results showed that the mutants and the check variety differed significantly for yield and yield attributes. All the tested mutants took shorter period to mature, 120 to 131 days, while the check variety BRRI dhan49 took 136 days. The mutant RM (2)-4 (C)-4-2-4 took the shortest period, only 120 days, which was 16 days shorter than the check variety but with indifferent yield. Another mutant RM (2)-4(C)-4-2-1 also took 16 days shorter period to mature than the check variety but had lower grain yield. Moreover, two other mutants RM (2)-40(C)-3-1-5 and RM (2)-40(C)-4-2-7 produced a bit higher yield than the check variety but matured 10 days earlier. Filled grain was significantly the highest in the mutant RM (2)-50(C)-2-1-1 and it also had the highest grain yield, 7.72 t ha^{-1}, which was

36.16% higher than BRRI dhan49. This higher yield of this mutant was attributed to its significantly longer panicle length and higher number of filled grains panicle^{-1}. This mutant matured 5 days earlier than the check variety.

Evaluation and screening of F_4 populations of fine grain aromatic and higher iron containing rice in T. aman season

Seven F_4 populations of which 3 derived by crossing aromatic long fine grain Binadhan-9 with Binadhan-7 designated as RC(3), 3 by crossing high iron containing Red rice with Binasail designated as RC(2), and the other by crossing Red rice with Binadhan-7 designated as RC(1). All these populations were transplanted on 18 August 2011 at 37 days after sowing at BINA farm, Mymensingh in plant-progeny-rows. The three parents of the populations were also included in this experiment. Seedlings were transplanted at 15 cm distances within rows of 20 cm apart. The length of each row was 3.0 m and the number of rows per population was 7-17. Recommended doses of fertilizers, cultural and intercultural operations were also followed as and when necessitated. Data on plant height, days to maturity; number of effective tiller, panicle length, filled and unfilled grains panicle^{-1} and yield hill^{-1} were recorded. Maturity was recorded population basis while plant height, effective tiller number, panicle length, filled and unfilled grains panicle^{-1} and grain yield were recorded from only the selected hills of each population but from 5 hills of the parents at harvest. Finally, the recorded data were subjected to proper statistical analyses and presented in Table 2.

Table 2. Yield and some yield attributes of 13 F_4 selected hills with aromatic long fine grain and higher iron contents in T. aman season

Lines/variety	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield hill^{-1} (g)
RC(1)-3-1	129	116	8	26	110	11	21.4
RC(1)-3-2	129	127	12	31	155	25	25.2
RC(1)-3-3	129	123	8	30	166	22	20.6
RC(1)-3-4	129	120	11	30	180	18	28.6
RC(1)-3-5	129	134	10	31	204	19	31.6
RC(2)-2-1-1	131	140	9	28	212	5	32.9
RC(2)-2-1-2	131	146	10	30	207	22	36.2
RC(2)-2-1-3	131	144	14	30	207	22	47.2
RC(2)-2-2-1	131	129	9	33	166	17	28.4
RC(2)-2-4-1	123	121	7	30	137	55	19.0
RC(2)-2-4-2	123	115	11	28	169	15	35.4
RC(2)-2-4-3	123	121	10	28	147	55	32.7
RC(3)-4-1	123	127	15	34	166	55	34.6
Binadhan-7 (P)	123	100	12	27	120	11	25.0
Red rice (P)	134	109	15	29	110	39	26.0
Binadhan-9 (P)	128	121	11	30	149	35	24.5
SE	1	3	1	1	8	4	1.80

Based on maturity, panicle length, filled grains panicle^{-1} and grain yield/hill 13 hills were selected, 5 from RC(1) group, 7 from RC(2) group and 1 from RC(3) group. It showed that maturity period of all the selected hills ranged 123-131days, shorter than the parent Red rice. Three selected hills derived from crossing between Red rice and Binasail designated as RC (2)-2-4-1, RC (2)-2-4-2, RC (2)-2-4-3 and the parent Binadhan-7 took the shortest period to mature. Plant height of the selected hills ranged 115-146 cm with RC (2)-2-1-2 being the tallest while RC (2)-2-4-2 the shortest. In contrast, heights of the parents Binadhan-7 and Red rice were significantly shorter than any of the selected hills despite height of 4 hills did not differ from Binadhan-9. Effective tiller number of the hills ranged 8-15 with RC (3)-4-1 being the highest and RC (2)-2-4-1 the lowest.

Panicle length of the selected hills ranged 26-34 cm with RC (3)-4-1 being the longest while RC (1)-3-1 the shortest. In contrast, panicle length of the three parents ranged 27-30 cm with Binadhan-9 being the longest while Binadhan-7 the shortest. Filled grains panicle^{-1} ranged 110-212 g with RC (2)-2-1-1 being the highest while RC (1)-3-1 and Red rice the lowest. Nine hills had significantly higher grain yield hill^{-1} than any of the parent. All these hills will be screened again in the next boro season, 2012.

Evaluation and screening of M_2 populations of Mousar (local aus cv.) in T. aman season

Two M_2 bulk populations derived from irradiating the seeds of local aus cv. Mousar with carbon ion beams at 40 and 60 Gy doses, respectively, were transplanted on 14 August 2011 at 33 days after sowing at BINA farm, Mymensingh in two plots. The parent cv. Mousar was also included in this experiment in a separate plot. There were 20 rows in each of 40 and 60 Gy dose's plot but 5 rows parent. The length of each row was 3.0 m. Seedlings were transplanted at 15 cm distances within rows of 20 cm apart. Recommended doses of fertilizers, cultural and intercultural operations were also followed as and when required. Data on plant height, days to maturity; number of effective tiller, panicle length, filled and unfilled grains panicle^{-1} and yield hill^{-1} were recorded. Maturity was recorded population basis while plant height, effective tiller number, panicle length, filled and unfilled grains panicle^{-1} and grain yield were recorded from only the selected hills of each population but from 5 hills of the parents at harvest.

Finally, the recorded data were subjected to proper statistical analyses and presented in Table 3. Based on maturity, panicle length, filled grains panicle^{-1} and grain yield hill^{-1} 10 progenies have been selected. It appears that maturity of the selected progenies were significantly shorter than the parent Mousar despite having not significant difference within each other. In contrast, plant height of the M_2 progenies were significantly longer than the parent ranged, 108-134 cm. Five progenies had significantly higher number of effective tiller, 1 progeny had longer panicle length but none had higher filled and lower unfilled grains panicle^{-1}. The progeny with significantly higher number of effective tiller and longer panicle length had higher grain yield hill^{-1} also. All these progenies will be screened further in the next T. aman season.

Table 3. Yield and some yield attributes of 10 M_2 selected progenies of Mousar (local aus cv.) in T. aman season

Progeny/variety	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield hill^{-1} (g)
RM(3)-40(C)-1	105	116	11	23	67	4	12.2
RM(3)-40(C)-2	105	125	12	22	32	59	15.6
RM(3)-40(C)-3	105	124	14	28	65	67	20.9
RM(3)-40(C)-4	105	134	6	24	35	29	4.8
RM(3)-40(C)-5	105	121	12	22	65	12	17.8
RM(3)-60(C)-1	106	108	12	21	20	25	1.75
RM(3)-60(C)-2	106	115	10	20	33	5	5.9
RM(3)-60(C)-3	106	113	13	25	25	40	7.8
RM(3)-60(C)-4	106	113	9	21	78	4	4.9
RM(3)-60(C)-5	106	108	7	18	23	15	3.7
Mousar (P)	116	103	11	23.8	84	2.6	18.2
SE	1.0	2.71	0.74	0.81	7.21	6.88	2.05

Growing of M_1 generation of local deep water rice cv. Luxmi digha and aromatic rice cv. Kalozira in T. aman season

With a view to develop high yielding variety of deep water and aromatic rice, seeds of the local deep water rice cv. Luxmi digha and aromatic local cv. Kalozira were irradiated with 200, 250 and 300 Gy doses of gamma rays from ^{60}Co source of Institute of Food and Radiation Biology (IFRB), Savar. The irradiated seeds were sown separately dose-wise variety^{-1} on 30 July 2011. Seedling height was recorded from 10 randomly selected plants from each dose variety^{-1} at 24 days after sowing (DAS). The following day seedlings were transplanted at 15 cm distances within rows of 20 cm apart. Single seedling was transplanted in each hill of each dose variety^{-1}. Recommended doses of fertilizers, cultural and intercultural operations were also followed as and when required. Data on plant height, days to maturity; number of effective tiller, panicle length and filled and unfilled grains panicle^{-1} were recorded. Maturity was recorded dose basis while plant height, effective tiller number, panicle length and filled and unfilled grains panicle^{-1} were recorded from randomly selected 5 hills of each dose exposed to Luxmi digha only at harvest. The recorded data were subjected to proper statistical analyses and presented in Tables 4 and Table 5. It appears that seedling height of Luxmi digha was decreased at 200 and 300 Gy doses of gamma ray showing significant difference with non irradiated (control) but appeared indifferent between each other. Interestingly, seedling height at 250 Gy dose was increased significantly from 200 Gy dose. This means 250 Gy dose has stimulating effect on seedling height, could not be used for future plant breeding applications. But either 200 or 300 Gy dose could be used as the difference in height reduction between these two doses was not significant.

Interestingly, seedling height of Kalozira increased significantly with increasing doses of gamma rays. This means the doses used in this experiment had stimulating effect on seedling height and could not be used for further variant creation in Kalozira. Higher doses should be used in further plant breeding applications.

Table 4. Effect of different doses of gamma rays on seedling height of deep water rice local cv. Luxmi digha and aromatic local cv. Kalozira at 24 DAS in T. aman season

	Gamma ray dose (Gy)	Seedling height (cm) at 24 DAS
Luxmi digha		
	Control (0)	60.1
	200	51.3
	250	59.9
	300	50.6
	SE	2.62
Kalozira		
	Control (0)	41.3
	200	45.0
	250	46.7
	300	46.1
	SE	1.21

Effect of different doses of gamma rays on some yield attributes of deep water rice local cv. Luxmi digha in T. aman season is presented in Table 5. Like seedling height, all the yield attributes showed mostly similar response to exposed gamma ray doses. The harvested M_1 plants derived from irradiating the seeds of Luxmi digha with 200, 250 and 300 Gy have been kept dose wise to screen in M_2 generation in next T. aman season.

Table 5. Effect of different doses of gamma rays on some yield attributes of deep water rice local cv. Luxmi digha in T. aman season

Gamma ray dose (Gy)	Days to maturity	Plant height (cm)	Effective tiller (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)
Control (0)	106	149.8	10.4	24.2	100.2	11.6
200	106	136.2	9.6	23.8	130.0	37.4
250	106	146.6	12.2	25.2	99.0	28.0
300	106	141.2	8.6	23.6	116.0	29.4
SE	-	3.0	0.8	0.36	7.3	5.41

On-farm and on-station trials with 2 early maturing boro mutant lines

Seeds of 2 mutant lines of short duration boro rice along with BRRI dhan28 were sown during 5 to 18 January 2012 at 9 different locations of Bangladesh (Table 6). Seedlings were transplanted during 8 February to 1 March 2012. Age of seedlings varied between 35 to 44 days. In most of the locations, transplantation was made after harvest of long duration mustard/rapeseed following RCB designs with 3 replications. A unit plot size was 5.1 m × 4.0 m. Seedlings were transplanted at 15 cm distances within rows of 20 cm apart. Recommended doses fertilizers, cultural and intercultural operations were followed as and when required. Data on plant height, days to maturity; number of effective tillers hill^{-1}, panicle length, filled and unfilled grains panicle^{-1}and yield plot^{-1} were recorded. Maturity was recorded plot basis while plant height, effective tiller number, panicle length, filled and unfilled grains panicle^{-1} was recorded from hills plot^{-1} at harvest.

Table 6. Seed sowing, transplanting and seedling age of two short duration mutants along with BRRI dhan28

Location	Date of seed sowing	Date of transplanting	Age of seedlings (days)
BINA farm, Mymensingh	5 January 2012	8 February 2012	35
Ghunti, Mymensingh	5 January 2012	9 February 2012	36
Satkhira	8 January 2012	15 February 2012	39
Magura	8 January 2012	14 February 2012	40
Barisal	13 January 2012	28 February 2012	47
Natore	16 January 2012	23 February 2012	39
Rajshahi	16 January 2012	24 February 2012	40
Farmer's field, Rangpur	18 January 2012	1 March 2012	44
BINA sub-station farm, Rangpur	18 January 2012	1 March 2012	44

Grain yield was recorded from 1 m^2 which was latter converted to yield ha^{-1} at 14% moisture. Moisture data was recorded with a grain moisture meter. Grain characters like 1000-grain weight, length, breadth and length: breadth ratio were also recorded. Grain length and breadth was gathered from 25 grains of each mutant/variety. Finally, the recorded data were subjected to proper statistical analyses following the design used and are presented in Tables 7, 8, 9, 10 and 11.

Moreover, four farmers and extension agent gatherings were arranged at Magura, Barisal, Ghunti Mymensingh and Farmers field, Rangpur during harvest to collect their opinion on the comparative benefits of these two mutants over BRRI dhan28 in regards to transplantation after harvest of long duration mustard/rapeseeds.

Yield and some yield attributes of the mutant lines and the check variety BRRI dhan28 averaged over 9 locations of Bangladesh showed significant difference for plant height, panicle length, filled and unfilled grains $panicle^{-1}$, and grain yield ha^{-1} (Table 2). In contrast, effective tiller number did not show any significant difference. The two mutants had significantly shorter height than the check variety BRRI dhan28. Grain yield of the mutants were significantly higher than the check variety despite showed not significant difference between them.

Table 7. Yield and some yield attributes of two short duration mutant lines and the check variety BRRI dhan28 averaged over 9 locations of Bangladesh

Mutant/variety	Plant height (cm)	Effective tiller $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	Grain yield (tha^{-1})
RM(1)-200-(C)-1-10	87.46	10.68	21.70	91.96	15.77	5.35
RM(1)-200-(C)-1-17	87.79	10.34	22.49	96.56	14.32	5.42
BRRI dhan28	98.27	10.36	23.21	103.81	19.60	4.97
$LSD_{(0.05)}$	1.61	NS	0.43	4.91	2.33	0.22

NS = Not significant

The location showed also shown significant difference for yield and yield attributes (Table 8). Plant height, panicle length and filled grains $panicle^{-1}$ were the highest at farmer's field, Rangpur. In contrast, the shortest height and panicle length were recorded at Rajshahi. The highest unfilled and lowest filled grains $panicle^{-1}$ were recorded at Barisal. Grain yield was the highest at BINA farm, Mymensingh followed by farmer's field, Rangpur. The lowest grain yield was recorded at Satkhira. The performance of the mutants at Satkhira, Rajshahi, Barisal and even Natore were poor in terms of grain yield ha^{-1}. This might be due to late transplantation (Table 6). Earlier transplantation by 1 or two weeks with seedling age of ≤ 30 days may cause better performance which should be investigated latter.

Table 8. Yield and some yield attributes at 9 locations averaged over the mutants and variety

Mutant/variety	Plant height (cm)	Effective tiller $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	Grain yield ($t\ ha^{-1}$)
BINA farm, Mymensingh	95.09	9.53	23.33	104.18	16.27	6.84
Farmer's field, Rangpur	99.62	11.00	24.69	110.67	16.78	6.23
Ghunti, Mymensingh	96.11	10.36	21.40	105.98	10.09	6.10
BINA sub-station farm, Rangpur	93.58	8.98	24.31	97.62	15.49	6.00
Magura	89.20	10.86	21.91	99.38	11.91	5.67
Natore	83.36	15.29	22.36	104.98	9.40	5.08
Barisal	94.00	10.91	21.87	78.88	34.71	4.48
Rajshahi	81.82	9.29	20.51	79.07	20.29	3.48
Satkhira	88.22	7.29	22.16	96.76	15.16	3.21
$LSD_{(0.05)}$	2.80	1.00	0.74	8.50	4.03	0.38

Maturity period of the mutants and check variety differed with change in locations (Tables 6 and 9). Age of seedlings hardly affected maturity period as it was evident from Magura experiment where age of seedling was 40 days but maturity period was only 121-123 days (Tables 6 and 9). In contrast, at BINA sub-station farm, Rangpur maturity period was 128-129 days despite seedling age was 44 days. But with the same seedling age, maturity period was 134-137 days. The causes of such discrepancies are not clear, should be investigated latter.

Table 9. Maturity period of the mutants and the check variety at 9 locations

Location	RM(1)-200 (C)-1-1-10	RM(1)-200 (C)-1-1-17	BRRI dhan28
BINA farm, Mymensingh	129	128	131
Ghunti, Mymensingh	126	126	131
Satkhira	123	123	126
Magura	121	121	123
Barisal	131	131	133
Natore	130	130	133
Rajshahi	124	124	127
Farmer's field, Rangpur	134	134	137
BINA sub-station farm, Rangpur	128	128	129

The interaction between mutant/variety and location on yield and yield attributes presented in Table 10.The interaction of mutant/variety and location was significant for yield and all yield attributes except effective tiller number and panicle length (Table 11). The mutant RM(1)-200 (C)-1-17 produced the highest grain yield at BINA farm, Mymensingh, Satkhira, Magura, Barisal, and Rajshahi. In contrast, the other mutant produced highest yield at Ghunti, Mymensingh and farmer's field at Rangpur.

The grain characters of the mutants and the check variety presented in Table 11. The mutant RM (1)-200 (C)-1-17 had the highest 1000-grain weight, grain length and length: breadth ratio. In contrast, the other mutant RM (1)-200 (C)-1-10 had the second highest 1000-grain weight but the lowest grain length and length: breadth ratio.

Table 10. Interaction of mutant/variety and location on yield and some yield attributes

Mutant/variety	Plant height (cm)	Effective tiller $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	Grain yield ($t\ ha^{-1}$)
BINA farm, Mymensingh						
RM(1)-200-(C)-1-10	90.40	9.80	22.67	80.93	23.80	6.80
RM(1)-200-(C)-1-17	91.60	10.13	23.13	108.60	14.27	7.13
BRRI dhan 28	103.27	8.67	24.20	123.00	10.73	6.60
Ghunti, Mymensingh						
RM(1)-200-(C)-1-10	88.47	10.07	21.20	109.47	9.53	6.49
RM(1)-200-(C)-1-17	89.67	10.27	22.20	107.20	9.80	6.30
BRRI dhan28	110.20	10.73	20.80	101.27	10.93	5.50
Satkhira						
RM(1)-200-(C)-1-10	84.13	7.00	21.47	88.47	12.93	3.20
RM(1)-200-(C)-1-17	86.40	7.80	22.40	102.53	14.40	3.33
BRRI dhan28	94.13	7.07	22.60	99.27	18.13	3.10
Magura						
RM(1)-200-(C)-1-10	87.53	10.87	21.07	102.07	11.87	5.67
RM(1)-200-(C)-1-17	86.47	10.77	21.60	104.73	11.67	6.33
BRRI dhan28	93.60	10.93	23.07	91.33	12.20	5.00
Barisal						
RM(1)-200-(C)-1-10	88.47	11.13	21.13	79.27	28.40	4.78
RM(1)-200-(C)-1-17	90.60	11.87	21.67	81.40	23.07	4.87
BRRI dhan28	102.93	9.73	22.80	75.97	52.67	3.80
Natore						
RM(1)-200-(C)-1-10	78.93	15.40	21.87	93.27	11.40	4.98
RM(1)-200-(C)-1-17	78.87	14.87	22.20	112.40	8.47	4.88
BRRI dhan28	92.27	15.60	23.00	109.27	8.33	5.37
Rajshahi						
RM(1)-200-(C)-1-10	80.47	9.33	19.60	86.07	15.33	3.23
RM(1)-200-(C)-1-17	79.33	8.20	20.87	59.53	17.20	4.15
BRRI dhan 28	85.67	10.33	21.07	91.60	28.33	3.07
Farmer's field, Rangpur						
RM(1)-200-(C)-1-10	99.07	11.73	23.53	105.20	16.40	6.56
RM(1)-200-(C)-1-17	97.20	10.20	23.93	107.60	15.07	6.08
BRRI dhan28	102.60	11.07	26.60	119.20	18.87	6.04
BINA sub-station farm, Rangpur						
RM(1)-200-(C)-1-10	91.00	8.93	23.73	84.47	15.27	6.03
RM(1)-200-(C)-1-17	90.00	8.93	24.40	85.00	14.93	5.70
BRRI dhan28	99.73	9.07	24.80	123.40	16.27	6.27
$LSD_{(0.05)}$ for variety × location interaction	1.62	NS	NS	4.91	2.33	0.21

NS = Not significant

Table 11. Grain characters of the mutants and the check variety

Mutant/variety	1000-grain weight (g)	Grain length (mm)	Grain breadth (mm)	Length: breadth ratio
RM(1)-200-(C)-1-10	23.18	8.6	2.4	3.58
RM(1)-200-(C)-1-17	23.64	8.8	2.4	3.67
BRRI dhan28	22.90	8.7	2.4	3.63

Finally, it was revealed from the opinion of farmers and extension agents of Magura, Mymensingh, Barisal and Rangpur that both the mutants were better than the check variety because of their transplanting potential after harvest of mustard/rapeseed, potato and lentil, shorter plant height, do not lodge, erect plant and leaves, shorter duration, higher yield and similar grain quality as the check variety BRRI dhan28. They requested to release them as varieties soon as they can get the seed.

Preliminary yield trial with M_6 high yielding mutant lines of boro rice

Seedlings of 10 mutant lines derived from BRRI dhan29 by irradiating its seeds with carbon ion beams in boro season along with BRRI dhan29 were transplanted on 22 January 2012 at 41 days after seed sowing. The experiment followed RCB design with 3 replications. Seedlings were transplanted at 15 cm distances within rows of 20 cm apart. A unit plot size was 3.0 m × 2.0 m. Recommended doses of fertilizers, cultural and intercultural operations were also followed as and when necessitated. Data on plant height, days to maturity, number of effective tillers hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and yield plot^{-1} were recorded. Maturity was recorded plot basis while plant height, effective tiller number, panicle length, filled and unfilled grains panicle^{-1} were recorded from hills per plot at harvest. Grain yield was recorded from 1m^2 area which was latter converted to yield/ha at 14% moisture. Moisture data was recorded with a grain moisture meter. Finally, the recorded data were subjected to proper statistical analyses following the design used and presented in Table 12.

Table 12. Yield and some yield attributes of 10 mutant lines derived from BRRI dhan29 with carbon ion beam irradiation along with BRRI dhan29 at BINA farm, Mymensingh

Mutant/variety	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield (tha^{-1})
RM(2)-40 (C)-1-1-1	151	112.27	6.93	26.53	139.13	27.00	7.02
RM(2)-40 (C)-1-1-10	149	96.30	8.20	27.00	119.33	23.87	6.93
RM(2)-40 (C)-1-1-7	149	95.53	8.60	25.87	113.60	26.13	5.80
RM(2)-40 (C)-4-2-5	149	91.67	11.40	25.40	109.13	10.87	6.90
RM(2)-40 (C)-4-2-7	159	115.00	8.80	25.73	94.33	18.07	6.53
RM(2)-40 (C)-4-2-8	157	117.60	6.47	28.20	140.60	30.80	6.34
RM(2)-40 (C)-1-1-5	149	112.87	7.93	25.33	136.67	21.07	7.30
RM(2)-40 (C)-3-1-7	147	108.80	7.33	25.80	116.47	21.40	7.10
RM(2)-40 (C)-4-2-2	157	103.07	9.33	25.20	103.73	24.73	6.88
RM(2)-50 (C)-2-1-1	155	115.40	7.80	27.00	169.00	22.87	8.58
BRRI dhan29	159	97.50	10.40	24.57	127.75	22.65	7.23
$LSD_{(0.05)}$		9.47	1.53	NS	31.42	6.76	0.72

NS = Not significant

It appears that the mutants and the check variety differed significantly for yield and yield attributes except panicle length (Table 12). The mutants took 147 to 157 days to mature while their parent BRRI dhan29 took 159 days. The mutant RM (2)-40 (C)-3-1-7 took the shortest period only 147 days. Filled grains was significantly the highest in the mutant RM(2)-50 (C)-2-1-1 and it also had the highest grain yield at 14% moisture content, 8.58 t ha^{-1}, which was 1.35 t more than BRRI dhan29. This higher yield of this mutant was attributed to its considerable longer panicle length (Picture 5) and significantly higher number of filled grains panicle^{-1} (Table 12). This mutant together with those with higher filled grains panicle^{-1}, longer panicle length, statistically at par yield and shorter maturity period would be put into advance yield trial in the next boro season.

Evaluation and screening of F_5 populations of fine grain aromatic and higher iron containing rice in T. aman season

Twelve F_5 populations of which 7 derived by crossing high iron containing Red rice with Binadhan-7 designated as RC(1), 4 by crossing Red rice with Binasail designated as RC(2), and 1 by crossing aromatic long fine grain Binadhan-9 with Binadhan-7 designated as RC(3). All these populations were transplanted on 23 January 2012 at 37 days after sowing at BINA farm, Mymensingh in plant-progeny-rows. Three parents of the populations were also included in this experiment. Seedlings were transplanted at 15 cm distances within rows of 20 cm apart. The length of each row was 3.0 m and the number of rows per population was 10. Recommended doses of fertilizers, cultural and intercultural operations were also followed as and when necessitated. Data on plant height, number of effective tiller, panicle length, and filled and unfilled grains panicle^{-1} were recorded. Maturity was recorded population basis while plant height, effective tiller number, panicle length and filled and unfilled grains panicle^{-1} were recorded from only the selected hills of each population but from 5 hills of the parents at harvest.

Finally, the recorded data were subjected to proper statistical analyses and are presented in Table 13. Based on panicle length and filled grains panicle^{-1}, 34 plants have been selected, 14 from RC (1) group, 12 from RC (2) group and 8 from RC (3) group (Table 13). It appears that plant height of the selected plants ranged 80-138 cm with RC (2)-2-2-1-5 being the tallest while RC (2)-2-2-1-1 the shortest. Effective tiller number of the plants ranged 6-22 with RC (3)-4-1-4 being the highest and RC (1)-3-2-3 the lowest. Panicle length of the selected plants ranged 22-37 cm with RC (2)-2-2-1-5 being the longest while RC (2)-2-2-1-1 the shortest (Table 13). In contrast, panicle length of the three parents ranged 21-26 cm with Red rice being the longest while Binadhan-7 the shortest. Filled grains panicle^{-1} ranged 100-258 g with RC (3)-4-1-5 being the highest while RC (2)-2-4-1-2 the lowest. Unfilled grains panicle^{-1} ranged 4-45 g with RC (1)-3-2-2 being the lowest while RC (2)-2-2-1-4 and RC (2)-2-2-1-5 the highest. All these 34 plants will be further screened in the next T. aman season along with their parents.

Table 13. Yield and some yield attributes of 13 F_5 selected plants with aromatic long fine grain and higher iron contents in T. aman season

Lines/variety	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)
RC(1)-3-2-1	124	9	25	180	11
RC(1)-3-2-2	125	8	25	135	4
RC(1)-3-2-3	120	6	24	130	16
RC(1)-3-2-6	125	9	23	150	15
RC(1)-3-2-7	127	7	26	150	8
RC(1)-3-3-1	112	8	26	160	8
RC(1)-3-3-2	107	7	26	190	12
RC(1)-3-3-4	110	13	24	168	10
RC(1)-3-4-1	118	12	27	190	14
RC(1)-3-4-2	100	11	26	150	24
RC(1)-3-4-3	114	10	26	132	18
RC(1)-3-4-5	112	13	27	174	18
RC(1)-3-5-2	113	8	27	199	10
RC(1)-3-5-5	110	7	25	135	18
RC(2)-2-2-1-1	80	11	22	161	14
RC(2)-2-2-1-2	125	8	29	130	12
RC(2)-2-2-1-3	117	12	30	170	31
RC(2)-2-2-1-4	118	11	32	199	45
RC(2)-2-2-1-5	138	13	37	162	45
RC(2)-2-2-1-7	108	12	30	125	17
RC(2)-2-4-1-2	113	17	29	100	10
RC(2)-2-4-1-3	102	18	31	124	17
RC(2)-2-4-1-4	106	11	30	118	28
RC(2)-2-4-2-5	103	13	30	133	23
RC(2)-2-4-3-1	103	9	28	123	18
RC(2)-2-4-3-4	108	9	27	160	10
RC(3)-4-1-1	136	18	29	136	8
RC(3)-4-1-2	130	17	31	186	31
RC(3)-4-1-3	110	20	28	150	40
RC(3)-4-1-4	109	22	26	160	10
RC(3)-4-1-5	126	15	30	258	38
RC(3)-4-1-6	122	12	31	202	16
RC(3)-4-1-7	133	16	30	223	16
RC(3)-4-1-8	127	21	31	169	24
Binadhan-7 (P)	84	9	21	141	20
Red rice (P)	101	8	26	138	14
Binadhan-9 (P)	103	8	25	94	33
SE	2	1	1	6	2

Performance evaluation of NERICA-1 and NERICA-10 along with a local aus cv. Mousar under deficit irrigation condition

Seeds of NERICA-1 and NERICA-10 along with a local aus cv. Mousar were sown following dibbling method at BINA farm, Mymensingh on 12 February 2012. The experiment followed RCB design with three replications. Five sprouted seeds were sown on dry soil in holes at 15 cm distances within rows of 20 cm apart. The length of each row was 3.0 m and the number of rows plot^{-1} was 3. Recommended doses of fertilizers were applied. Three flood irrigations were applied at 8, 18 and 23 days after sowing (DAS). Data on plant height, number of effective tiller, panicle length, and filled and unfilled grains panicle^{-1} were recorded. Maturity was recorded variety basis while plant height, effective tiller number, panicle length and filled and unfilled grains panicle^{-1} were recorded from 5 randomly selected hills in each plot at harvest. Finally, the recorded data were subjected to proper statistical analyses and are presented in Table 14.

Table 14. Yield and some yield attributes of NERICA-1 and NERICA-10 along with a local aus cv. Mousar at BINA farm, Mymensingh under deficit irrigation condition

Mutant/variety	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield (t ha^{-1})
NERICA-1	106	84.53	7.27	23.47	83.93	32.47	1.47
NERICA-10	106	91.67	7.20	22.93	97.47	37.00	1.93
Mousar	104	110.20	15.13	24.60	85.10	9.53	4.00
$LSD_{(0.05)}$	-	9.72	3.93	NS	9.12	19.32	1.20

NS = Not significant

It appears that the local aus cv. Mousar had significantly higher yield, 142% and 107% more yield than NERICA-1 and NERICA-10, respectively, under dry seeding and deficit irrigation conditions and also matured 2 days earlier (Table 14). This higher yield of Mousar was attributed to its significantly higher effective tiller number and lower unfilled grains panicle^{-1}.

Growing of M_1 generation of NERICA-1 and NERICA-10 in boro season

With a view to develop higher yielding and salinity tolerant variety of rice, seeds of NERICA-1 and NERICA-10 were irradiated with 250, 350 and 450 Gy doses of gamma rays from ^{60}Co source of Institute of Food and Radiation Biology (IFRB), Savar. The irradiated seeds were sprouted and sown on dry soil in holes at 15 cm distances within rows of 20 cm apart separately dose wise variety^{-1} on 22 February 2012. This experiment followed non replicated design under rainfed condition. Recommended doses of fertilizers were used. Seedling height was recorded from 10 randomly selected plants from each dose variety^{-1} at 30 days after sowing (DAS). Data on plant height, number of effective tiller, panicle length, and filled and unfilled grains panicle^{-1} were recorded from 5 randomly selected in each plot at harvest. Finally, the recorded data were subjected to proper statistical analyses and are presented in Tables 15 and Table 16.

Table 15. Effect of different doses of gamma rays on seedling height of NERICA-1 and NERICA-10 in boro season

Gamma ray dose (Gy)	Seedling height (cm) at 24 DAS
NERICA-1	
Control (0)	37.5
250	41.8
350	34.6
450	31.7
SE	2.15
NERICA-10	
Control (0)	36.4
250	35.3
350	30.2
450	25.9
SE	2.43

Seedling height of NERICA-1 and NERICA-10 were decreased gradually with gradual increase in gamma ray doses except NERICA-1 at 250 Gy dose (Table 15). In contrast, plant height and yield plant^{-1} at maturity in NERICA-1 decreased gradually with gradual increase in gamma ray doses (Table 16) while only plant height at NERICA-10 showed such trend. These findings confirm the occurrence of chromosomal aberrations in these two varieties and thus new combinations are expected in M_2 generation which would be selected in the next T. aman seson. For this, M_1 seeds from each plant have been individually to grow plant-progeny-rows.

Table 16. Effect of different doses of gamma rays on some yield attributes of NERICA-1 and NERICA-10 in boro season

Gamma ray dose (Gy)	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Yield plant^{-1} (g)
NERICA-1						
Control (0)	88.2	8.4	25.4	133.4	27.1	15.86
250	83.8	6.2	24.6	101.4	39.4	10.29
350	76.2	7	24.8	83.2	42.6	6.10
450	3.75	4	24.4	86.8	49.6	3.50
SE	3.63	0.92	0.22	11.43	4.70	2.70
NERICA-10						
Control (0)	94	7.2	26.2	131.8	25.4	19.02
250	88.2	6.6	20.6	73	49.2	7.70
350	83.8	8.6	23.2	80.6	53.0	12.07
450	76.2	4.4	24	83.4	47.6	3.63
SE	3.8	0.9	1.2	13.4	6.2	3.29

JUTE

Zonal yield trial with M_9 mutant lines of tossa jute

The aim of this experiment is to develop tossa jute variety(s) with higher fiber and stick yields and lower lignin content with three mutant lines following RCB design with three replications. The parent O-9897 was also included in this experiment. Seeds were sown on 16-24 April 2011 at farmer's field at Mymensingh, Faridpur and Magura and BINA sub-station farms at Magura and Rangpur. Spacing between plants was 7-8 cm within rows of 30 cm apart. A unit plot size was 5.0 m × 4.0 m. Recommended doses of fertilizers, cultural and intercultural practices were followed as and when necessitated. Data on plant height, base diameter, green weight with and without leaves, dry fiber weight and stick weight were recorded after harvest. Green weight without leaves, fiber weight and stick weight were gathered from an area of 5 m^2 and later converted to t ha^{-1}. Finally, these data were subjected to proper statistical analyses and are presented in Table 17.

It appears that the mutant O_{97}/90/72-3 had significantly taller plant height at all locations than the check variety O-9897 except farmer's field at Magura. At farmer's field of Magura none of the characters had shown significant difference amongst the mutants and the check variety. In contrast, base diameter of O_{97}/90/72-3 had shown significant difference at Rangpur and Faridpur locations. Green weight with and without leaves of this mutant were also higher than the check variety at all locations despite having not significant difference at Rangpur and Mymensingh. Fiber weight of this mutant did not show significant difference with the check variety. Contrarily, stick weight was significantly higher than the check variety.

Finally, the mutant O_{97}/90/72-3 will be put into on-farm and on-station trials again at different jute growing areas of Bangladesh, next year to confirm its fiber and stick yield potentiality.

Growing of M_4 populations of tossa jute

The aim of this experiment is to select out tossa jute mutant lines with higher fiber and stick yields, and lower lignin and higher cellulose contents. For this, dry seeds of O-9897 were irradiated with 400, 500, 600, 700 and 800 Gy doses of gamma rays and selection based on the mentioned objectives during M_2 and M_3 generations. M_4 seeds were sown in April 2011 at BINA farm, Mymensingh in separate plots dose wise. Spacing between plants was 7-8 cm within rows of 30 cm apart. Recommended doses of fertilizers, cultural and intercultural practices were followed as and when necessitated. Based on plant height, base diameter and stem color 10 plants from 400 Gy, 4 from 500 Gy, 7 from 600 Gy, 4 from 700 Gy and 9 from 800 Gy doses were selected for preliminary yield trial during 2012.

Table 17. Means of fiber yield and yield attributes in 3 M_9 mutant lines of tossa jute at different locations of Bangladesh during 2011

Mutants	Plant height (cm)	Base diameter (cm)	Green weight with leaves (t ha^{-1})	Green weight without leaves (t ha^{-1})	Fiber weight (t ha^{-1})	Stick weight (t ha^{-1})
Magura (BINA Sub-station farm)						
O_{97}/80/200-3	3.13	1.77	51.58	46.75	2.50	-
O_{97}/90/72-3	3.35	2.00	65.08	60.08	2.33	-
O_{97}/40/25-3	2.83	1.87	51.17	45.75	2.50	-
O-9897(P)	2.87	1.83	50.67	44.50	2.33	-
LSD(0.05)	0.36	0.18	7.20	9.03	NS	-
Magura (Farmer's field)						
O_{97}/80/200-3	2.81	1.27	36.08	33.42	2.23	-
O_{97}/90/72-3	2.80	1.34	33.92	31.33	2.28	-
O_{97}/40/25-3	2.76	1.30	34.17	31.58	2.26	-
O-9897(P)	2.52	1.20	29.00	26.58	2.28	-
LSD(0.05)	NS	NS	NS	NS	NS	-
Faridpur						
O_{97}/80/200-3	2.69	1.87	56.25	51.83	4.93	4.93
O_{97}/90/72-3	2.78	2.03	67.75	62.67	4.07	6.47
O_{97}/40/25-3	2.65	1.80	48.50	45.08	4.27	6.13
O-9897(P)	2.63	1.80	52.58	48.33	3.76	6.27
LSD(0.05)	0.09	0.20	6.27	6.64	0.31	0.60
Rangpur						
O_{97}/80/200-3	3.02	2.53	51.75	46.92	4.87	5.33
O_{97}/90/72-3	3.31	3.10	64.25	59.58	5.20	6.58
O_{97}/40/25-3	2.95	2.60	51.50	45.50	4.00	5.84
O-9897(P)	2.91	2.27	59.25	54.33	4.73	6.00
LSD(0.05)	0.18	0.16	7.70	8.65	.0.48	0.64
Mymensingh						
O_{97}/80/200-3	2.98	1.83	45.00	38.25	3.73	7.87
O_{97}/90/72-3	3.40	2.20	59.58	58.33	4.00	7.67
O_{97}/40/25-3	3.20	2.07	59.17	50.42	3.97	6.40
O-9897(P)	3.19	2.03	58.50	50.42	4.07	5.13
LSD(0.05)	0.21	0.20	11.13	3.66	NS	1.35

NS = Not significant

WHEAT

Preliminary yield trial with some homozygous salt tolerant wheat lines

With a view to select out salt tolerant wheat lines with higher yield, this experiment was carried out with 37 homozygous wheat lines along with the popular wheat variety, Pradip. The experiment followed RCB design with 3 replications and set at two locations. Of the two locations one was at Satkhira in saline area and the other at Mymensingh in the non saline area. Three lines of 2.0 m length comprised a unit plot. Seeds were sown on 1st December at Satkhira and at Mymensingh in 2011. Recommended doses of fertilizers, cultural and intercultural operations were followed where necessary. Soil salinity records were gathered during sowing, vegetative and flowering stages. Data on plant number, plant height, effective tiller number, panicle length, grains panicle^{-1} and grain yield plot^{-1} were recorded at harvest. Grain yield plot^{-1} was converted to kg ha^{-1} latter. Finally, all the collected data were subjected to proper statistical analyses and are presented in Table 18.

Table 1. Comparison of plant population, yield and some yield attributes of 37 homozygous salt tolerant lines of wheat in the saline and non saline areas

Mutant/check	Plants plot^{-1} (no.)	Plant height (cm)	Effective tiller (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Grain yield ha^{-1} (kg)
Satkhira (saline area)						
L-885-10	20.33	82.30	9.07	10.60	59.00	2541.67
L-61-7	19.33	83.78	8.27	9.85	48.40	2500.00
L-61-12	32.00	84.80	9.07	9.23	55.80	3287.50
L-61-15	33.00	83.23	8.20	9.93	55.80	3020.83
L-61-18	31.00	83.23	9.27	10.43	55.23	3082.92
L-61-28	25.67	80.47	9.87	10.47	56.07	2456.67
L-61-33	33.33	82.77	7.83	9.47	49.20	3014.17
L-61-34	25.67	84.27	9.33	11.13	54.47	2453.33
L-61-35	33.67	87.87	8.87	9.50	40.87	2644.17
L-61-37	27.00	90.53	8.07	10.23	53.53	3162.50
L-879-1	37.00	82.72	11.27	10.23	46.47	3100.42
L-879-2	24.67	78.20	8.13	10.20	44.53	2458.04
L-879-4	34.33	78.63	9.73	10.13	58.40	2704.58
L-879-5	18.00	79.93	7.93	11.07	56.80	1914.17
L-879-11	25.67	81.62	9.07	10.33	67.93	2848.33
L-879-22	22.67	79.20	8.13	10.10	52.67	2330.42
L-879-32	24.67	80.20	8.60	9.87	46.93	2812.50
L-879-33	17.33	75.55	8.47	10.33	59.53	1977.92
L-879-34	24.33	82.47	8.07	10.47	47.27	2287.08
L-880-1	45.00	86.90	8.33	9.40	48.43	3937.50
L-880-5	38.67	86.77	7.60	10.31	37.53	4160.83
L-880-7	24.67	82.23	9.47	10.17	52.53	2789.58
L-880-10	34.33	77.73	9.50	10.27	55.33	3146.25
L-880-11	26.67	79.50	8.40	10.27	48.67	2583.13
L-880-13	35.67	73.00	8.23	10.60	48.67	2791.67
L-880-14	27.33	84.97	10.40	9.77	53.07	2662.08
L-880-15	22.00	79.00	9.00	10.37	52.13	1895.83
L-880-17	26.00	81.33	7.27	9.13	42.73	2187.50
L-880-18	8.67	83.77	9.73	10.10	56.63	892.08
L-880-19	19.33	86.53	9.03	10.70	51.67	1852.50
L-880-20	32.67	88.13	10.33	9.93	48.33	2288.33
L-880-26	29.33	82.43	8.93	9.77	41.20	2953.33
L-880-27	31.67	74.13	9.17	10.63	43.13	2854.17
L-880-34	30.67	87.67	10.50	9.90	45.93	3080.00
L-880-36	26.67	81.17	8.87	9.97	40.53	2750.00
L-880-37	32.00	82.77	9.37	9.60	50.60	3337.54
L-880-43	33.33	87.32	10.07	10.33	49.33	3517.04
Pradip	19.00	81.00	8.80	13.25	52.37	3168.21
$LSD_{(0.05)}$	3.32	5.25	1.08	2.48	9.89	270.58

Table 18 Contd.

Mutant/check	Plants plot^{-1} (no.)	Plant height (cm)	Effective tiller (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Grain yield ha^{-1} (kg)
Mymensingh (non saline area)						
L-885-10	24.67	92.73	8.40	12.13	57.47	2630.83
L-61-7	22.33	94.20	10.67	12.37	62.60	2647.58
L-61-12	28.67	95.73	9.73	11.83	55.73	3033.33
L-61-15	29.33	93.00	7.87	11.63	59.50	3010.54
L-61-18	20.33	94.10	8.47	11.80	50.87	2633.75
L-61-28	20.33	90.40	10.47	12.17	56.67	2461.46
L-61-33	32.67	88.60	6.73	10.77	36.13	3209.17
L-61-34	35.33	94.93	7.27	11.23	47.27	3343.75
L-61-35	23.67	95.40	7.80	10.80	54.60	2630.83
L-61-37	32.00	96.40	8.87	12.20	64.27	3175.42
L-879-1	27.33	88.87	9.87	11.07	49.60	2770.83
L-879-2	35.00	96.27	10.07	12.03	60.93	3529.17
L-879-4	26.67	95.93	8.87	11.40	60.73	2488.75
L-879-5	18.00	93.13	11.80	11.63	54.13	1883.75
L-879-11	17.67	93.27	9.67	11.77	58.47	1828.33
L-879-22	16.00	97.07	11.27	12.27	54.67	2499.17
L-879-32	29.67	97.33	12.93	11.80	56.17	2062.04
L-879-33	17.00	92.33	10.67	11.63	58.07	2163.75
L-879-34	32.33	95.80	10.27	11.90	63.13	2454.58
L-880-1	27.33	95.40	8.20	12.00	57.47	2959.58
L-880-5	22.00	110.40	11.80	13.07	54.97	3072.50
L-880-7	20.33	94.07	14.33	12.03	56.53	1268.42
L-880-10	26.33	97.40	11.00	12.37	58.53	3196.25
L-880-11	16.33	92.73	8.53	11.53	56.40	1910.21
L-880-13	28.67	95.87	11.40	12.10	56.37	3048.75
L-880-14	25.33	98.00	10.43	12.33	52.73	3139.58
L-880-15	20.00	91.53	12.27	11.90	52.97	2234.58
l-880-17	22.33	94.77	9.63	11.77	52.67	2215.83
L-880-18	19.00	89.87	11.60	12.10	52.93	2016.67
L-880-19	24.00	96.23	9.80	11.53	60.67	2435.00
L-880-20	22.33	90.17	11.27	12.10	50.47	3183.92
L-880-26	23.33	81.83	10.00	12.50	45.30	2842.08
L-880-27	26.00	96.63	12.53	13.00	50.17	1912.17
L-880-34	39.00	100.07	8.43	11.67	56.93	3961.67
L-880-37	29.67	95.87	11.87	11.40	48.40	3214.58
L-880-43	26.00	97.80	14.13	11.90	63.33	3427.50
Pradip	33.00	93.40	9.20	14.13	56.00	4503.33
$LSD_{(0.05)}$	3.32	6.40	2.55	0.64	8.22	403.86
$LSD_{(0.05)}$ for comparing between locations	7.50	5.68	1.89	NS	8.81	337.16

NS = Not significant

It appears that interaction of line and location for plant population, plant height, number of effective tiller number, grains panicle^{-1} and grain yield ha^{-1} were significant (Table 18). Only panicle length did not differ significantly. This means yield and yield attributes of wheat differ with change in location except panicle length. Yield and yield attributes of the lines had lower scores in saline area at Satkhira than the non saline area at Mymensingh. Plant population ranged 19-45 at Satkhira with the lowest in the check variety Pradip while the highest in L-880-1 followed by L-880-5. In contrast, it ranged 16-39 at Mymensingh with L-879-22 being the lowest while L-880-34 the highest. The line(s) that could maintain higher population in the saline soil mostly produced higher yields. Three lines L-880-5, L-880-1 and L-880-43 produced significantly higher yield than the check variety Pradip in the saline area. In contrast, none of the tested lines produced higher yield than Pradip in the non saline area at Mymensingh despite some of them appeared statistically at par. Finally, it could be concluded that L-880-5, L-880-1 and L-880-43 would be tested over other locations in the saline area to assess performance in terms of yield in Advance Yield Trial, next year.

Assessment of salt tolerance levels of different phenological stages of wheat

With a view to assess the tolerance levels of different phenological stages of wheat, this experiment was carried out with three lines/variety of wheat including the most popular variety Pradip. This lines/variety was subjected to five levels of salinity: control, 3, 6, 9 and 12 dS/m and three growth stages: pre sowing, vegetative, flowering and grain filling. A three factor experiment following CRD design with three replications was used. Plastic pots with 10 liter capacity were weighed and filled with 8 Kg soil mixture, prepared with sandy loam soil and rotten cow dung in a 1:1 ratio. The fertilizer needed for each pot was determined following the Fertilizer Recommendation Guide-2005. The total amount of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MP, Gypsum and Zinc sulphate. These were mixed thoroughly with the soil in each pot before sowing. For determination of plant available water analogus to field capacity, three earthen pots were weighed and filled with 8 kg of soil, as above. Then these were watered until leaked through the hole at the bottom. Thereafter, these were covered with black polyethylene sheet and weighed after cessation of water leaking through the perforated hole. Finally, plant available water was determined using the following formula-

$$\%\ \text{PAW} = \frac{\textit{Final weight}\,(\textit{pot} + \text{soil} + \textit{water}) - \textit{Initial weight}\,(\textit{pot} + \text{soil})}{\text{Soil } \textit{weight}} \times 100$$

For determination of initial moisture content and bulk density of the soil mixture three brass cores with 5 cm height and diameter were properly filled with the soil mixture and weighed. These were then oven dried at 105˚C for 24 hours. After cooling, these were again weighed and the dry soil removed. Weight of the blank cores was also recorded. Initial moisture content of the soil was calculated following the formula-

$$\%\ \text{Initial moisture content} = \frac{\text{Initial weight (brass core} + \text{soil)} - \text{oven dry weight (brass core} + \text{soil)}}{\text{Oven dry weight of soil}} \times 100$$

While bulk density was calculated using the formula-

$$\text{Bulk density (g/cc)} = \frac{\text{Oven dry weight of soil } \textit{mixture}\text{(g)}}{\text{Volume of soil mixture (cc)}}$$

Here, volume of soil mixture

$= \pi r^2 l$

Where, r = radius of brass core (cm)

l = height of brass core (cm)

In contrast, for determination of initial salinity three random samples of mixed soil were taken each with 50g, sun dried, pulverized and sieved. Twenty ml distilled water was added with 8g of such sieved mixed soil and was stirred for 30 minutes at 250 rpm. The following day, it was stirred again and electrical conductivity was recorded using an EC meter in dS/m.

Seeds were sown on 11 December 2011 and when the plants were established, only five healthy plants were kept in each pot. The pots were kept free from weeds. The plants were protected from insect pest by spraying appropriate insecticides as and when necessary.

The saline water was synthesized by using mixture of different salts: 50% NaCl, 15% Na_2SO_4, 10% $NaHCO_3$, $CaCl_2$, and $MgCl_2$ together with 5% $MgSO_4$ so that their compositions were almost alike their average compositions in the ground water of saline areas of Bangladesh. Fifty grams of such salt was dissolved liter^{-1} tap water to prepare the stock solution. The salinity of the stock solution was 80 dS/m.

The total amount of stock solution needed to raise the desired salinity of the soil mixture was estimated with the following equation-

$$V_1S_1 = V_2S_2$$

Where,

V_1 = volume of soil mixture in a pot

S_1 = desired salinity - initial salinity of the soil

V_2 = volume of water at 70-80% PAW

S_2 = salinity of stock solution

Again, volume of soil mixture (V_1) was determined using the following formula-

$$V_1 = \frac{\text{Weight of oven dried soil}}{\text{Bulk density of soil}}$$

Volume of water (V_2) was determined by dividing the weight of water with its density (0.98 g/cc).

The estimated amount of stock solution was then diluted to the desired salinity levels by adding tap water and then imposed during the assigned stage till harvest. The total amount of saline water for the respective doses at different phenological stages was applied during the initiation of the respective stage till maturity at installments except the pre sowing stage. At pre sowing stage, the whole amount of saline water needed for the respective doses was applied at a time before sowing. Contrary to pre sowing stage, 0.5 liter saline water was applied at each installment so that the moisture content of the pots remained 70-80% of plant available water (PAW). For the control, same amount of only fresh tap water was applied.

Relative performance was calculated following the formula-

$$\text{Relative performance (\% of control)} = \frac{\text{Performance of a trait under saline condition}}{\text{Performance under control condition}} \times 100$$

The relative performance of yield and some yield attributes of wheat at different phenological stages as affected by different levels of salinity are presented in Table 19 (a-f).

Germination of seeds of all lines/variety was quite normal at 3 dS/m when exposed to soil before sowing. In contrast, there was no germination of any seed of any lines/variety at 9 and 12 dS/m salinity levels upto 20-30 days after sowing. At 6 dS/m seed germination was affected to some extent and was delayed germination.

Plant height was affected more when salinity was imposed before sowing, particularly at 12 dS/m salinity with L-885 being the highest while Pradip the lowest (Table 19a). Moreover, height of Pradip was reduced markedly at 6 and 9 dS/m salinities with the highest reduction at 6 dS/m. In addition to 12 dS/m, height of L-885 was reduced to that of its control at 9 dS/m lesser extent. The check variety Pradip was more affected. At grain filling stage, effect of salinity on plant height was the highest in L-880 at 9 dS/m despite it had longer height at 12 dS/m salinity. This means, this reduction in height of L-880 at 9 dS/m was attributed to other factors, may be insect infestation.

Effective tiller number of any line/variety was not at all affected rather stimulated when exposed to 6 and 9 dS/m salinities before sowing except Pradip at 9 dS/m (Table 19b). In contrast, at 3 dS/m effective tiller number in L-880 was reduced by 14.29% and in L-885 by 2.04%. At 12 dS/m effective tiller number was reduced drastically in all line/variety with L-880 being the highest while pradip the least. Effective tiller number was mostly reduced in all lines/variety to that of their respective control treatments at the remainder three stages although with non linear trend.

When wheat plant was exposed to salinity at vegetative stage, no symptom of salinity appeared on plant height of any of the lines/variety rather it was stimulated. Salinity imposition at flowering stage showed some effect on plant height like pre sowing stage at 12 dS/m but with like plant height, panicle length was affected more in all lines/variety at 12 dS/m salinity when exposed before sowing followed by 9 dS/m (Table 19c). At 6 dS/m panicle length of L-880 and Pradip were reduced markedly. Highest reductions in panicle length to that of control were 4.50% in L-885 at 12 dS/m at vegetative stage, 9.49% in Pradip at 6 dS/m at flowering stage and 5.22% in L-885 at 12 dS/m at grain filling stage.

Table 19. Relative performance of different yield and yield attributes of wheat at different phenological stages as affected by different salinity levels

(a) Plant height (% of control)

Line/variety	Salinity level (dS/m)				
	Control	3	6	9	12
Pre-sowing					
L-880	100.00	110.90	105.57	100.93	29.89
L-885	100.00	99.34	104.91	73.68	24.04
Pradip	100.00	99.68	67.63	94.64	56.81
Vegetative					
L-880	100.00	104.92	107.05	108.85	102.24
L-885	100.00	106.44	109.82	107.63	106.18
Pradip	100.00	107.61	110.07	105.85	106.03
Flowering					
L-880	100.00	96.35	102.77	101.98	98.19
L-885	100.00	92.77	99.82	97.52	94.74
Pradip	100.00	99.84	100.16	100.05	91.80
Grain filling					
L-880	100.00	99.89	97.87	93.72	97.16
L-885	100.00	94.24	98.82	103.10	95.88
Pradip	100.00	109.93	100.77	96.00	101.51

(b) Effective tiller hill^{-1} (% of control)

Pre-sowing					
L-880	100.00	85.71	111.11	235.71	23.81
L-885	100.00	97.96	104.59	135.71	45.92
Pradip	100.00	100.00	73.41	162.50	51.14
Vegetative					
L-880	100.00	78.69	77.05	88.52	75.41
L-885	100.00	71.19	71.19	71.19	67.80
Pradip	100.00	69.64	62.50	73.21	73.21
Flowering					
L-880	100.00	106.78	93.22	76.27	86.44
L-885	100.00	78.33	75.00	84.17	71.67
Pradip	100.00	71.88	81.25	70.31	67.19
Grain filling					
L-880	100.00	94.64	105.36	108.93	82.14
L-885	100.00	92.19	95.31	82.81	95.31
Pradip	100.00	87.72	89.47	85.96	87.72

(c) Panicle length (% of control)

Pre-sowing					
L-880	100.00	103.05	95.43	85.18	25.91
L-885	100.00	101.67	102.77	63.38	28.30
Pradip	100.00	97.64	64.97	91.90	59.39
Vegetative					
L-880	100.00	99.60	107.43	98.41	96.33
L-885	100.00	98.41	99.81	98.31	95.50
Pradip	100.00	100.50	107.01	99.67	99.00
Flowering					
L-880	100.00	96.99	106.40	104.07	108.63
L-885	100.00	95.73	94.27	97.27	94.55
Pradip	100.00	97.93	90.51	94.11	97.17
Grain filling					
L-880	100.00	103.44	97.42	99.62	99.62
L-885	100.00	95.71	99.07	96.92	94.78
Pradip	100.00	100.00	104.75	97.50	99.75

(d) Grains panicle^{-1} (% of control)

Pre-sowing					
L-880	100.00	108.75	104.23	72.16	24.29
L-885	100.00	92.41	101.62	57.84	17.41
Pradip	100.00	90.27	90.12	70.21	49.40
Vegetative					
L-880	100.00	115.45	125.45	121.92	123.50
L-885	100.00	114.08	109.73	100.14	103.36
Pradip	100.00	111.84	101.80	112.64	120.11
Flowering					
L-880	100.00	122.45	103.88	139.85	92.91
L-885	100.00	110.34	93.62	113.85	101.91
Pradip	100.00	88.68	89.58	85.87	95.54
Grain filling					
L-880	100.00	92.33	93.86	90.39	110.72
L-885	100.00	91.00	92.27	82.27	89.48
Pradip	100.00	98.62	103.06	107.04	79.76

(e) Grain weight panicle^{-1} (% of control)

Line/variety	Salinity level (dS/m)				
	Control	3	6	9	12
Pre-sowing					
L-880	100.00	106.11	95.74	57.78	13.89
L-885	100.00	89.63	93.81	51.55	8.82
Pradip	100.00	89.31	59.21	56.74	40.13
Vegetative					
L-880	100.00	110.30	115.76	100.61	113.94
L-885	100.00	86.34	81.94	80.62	83.70
Pradip	100.00	125.99	118.64	116.38	120.90
Flowering					
L-880	100.00	106.29	89.14	110.29	84.57
L-885	100.00	122.82	106.71	130.87	125.50
Pradip	100.00	81.40	91.16	80.47	88.37
Grain filling					
L-880	100.00	108.54	92.96	90.45	106.53
L-885	100.00	105.61	93.37	97.96	97.96
Pradip	100.00	96.21	97.63	100.00	75.83

(f) Grain weight hill^{-1} (% of control)

L-880	100.00	92.68	100.42	144.42	15.69
L-885	100.00	109.01	104.70	137.80	15.39
Pradip	100.00	100.53	75.24	92.36	46.18
Vegetative					
L-880	100.00	110.30	115.76	100.61	121.82
L-885	100.00	86.34	81.94	80.62	91.63
Pradip	100.00	137.29	129.38	116.38	122.60
Flowering					
L-880	100.00	95.58	89.16	77.21	94.25
L-885	100.00	100.80	101.33	122.81	118.57
Pradip	100.00	79.17	73.02	76.79	75.20
Grain filling					
L-880	100.00	105.90	103.30	100.47	91.98
L-885	100.00	103.45	96.75	80.73	90.06
Pradip	100.00	95.79	99.77	94.16	71.96

Grains panicle^{-1} was also affected more in all lines/variety at 12 dS/m salinity when exposed before sowing followed by 9 dS/m (Table 19d). At 6 dS/m grains panicle^{-1} of Pradip reduced markedly. In contrast, at 3 dS/m it reduced markedly in L-885 and Pradip. It was stimulated in all lines/variety at all salinity levels when exposed to vegetative stage. When salinity was exposed to flowering stage, grain number in Pradip was reduced at all salinity levels with the highest being at 9 dS/m. But in L-880 it was reduced at 12 dS/m and in L-885 at 6 dS/m. At grain filling stage, it was reduced at all salinity levels in L-885 and at 3-9 dS/m in L-880 and at 3 and 12dS/m in Pradip.

Grain yield panicle^{-1} was affected more in all lines/variety at 12 dS/m salinity when exposed before sowing followed by 9 dS/m (Table 19e). At 6 dS/m grain yield panicle^{-1} was also reduced markedly with the highest being in Pradip at 3dS/m in L-880 and Pradip. At vegetative stage, grain yield panicle^{-1} was reduced at all salinity levels to that of control only in L-885. At flowering stage, it was reduced at all salinity levels to that of control only in Pradip and at 6 and 12 dS/m in L-880. At grain filling stage, grain yield panicle^{-1} was reduced at 6 to 12 dS/m in L-885, in Pradip at 3, 6 and 12 dS/m and in L-880 at 6 and 9 dS/m.

Grain yield hill^{-1} was affected more in all lines/variety at 12 dS/m salinity when exposed before sowing (Table 19f). At 6 and 9 dS/m grain yield panicle^{-1} was also reduced markedly in Pradip. When salinity was imposed at vegetative stage, yield hill^{-1} was reduced to that of control at all salinity levels only in L-885. In contrast, its yield was stimulated at all salinity levels to that of control when exposed at flowering stage. But that of L-880 and Pradip were reduced at this stage of development at all salinity levels. At grain filling stage, grain yield hill^{-1} in L-880 was mostly stimulated at all salinity levels except 12 dS/m while that of L-885 and Pradip were mostly reduced at all salinity levels except 3 dS/m in L-885.

Finally, it could be concluded that wheat is sensitive to soil salinity ≥6 dS/m when exposed before sowing. At the remainder stages, imposition of salinity up to 12 dS/m has little effect on yield and different yield attributes.

RAPESEED-MUSTARD

Zonal yield trial rapeseed mutants (*B. napus*)

Six M_7 mutant lines of rapeseed (*Brassica napus*) along with a check variety Binasarisha-4 and Binasarisha-5 were put into the trial. The trial was conducted in the BINA Head Quater farm, Mymensingh and in the farms of BINA sub-stations at Magura, Ishurdi and Rangpur. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 03 November in BINA Head Quaters 27 October at Magura, 28 October at Ishurdi and 3 November 2011 at Rangpur. Unit plot size was 12 m^2 (4 m × 3 m) with 25 cm row to row spacing and 6-8 cm from plant to plant within rows. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on plant height, branches plant^{-1}, siliquae plant^{-1} and seeds siliqua^{-1} were taken from 10 randomly selected plants from each plot. Maturity period was counted when 70% siliquae were matured. Seed yield of each plot was recoded after harvest and then converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

Results obtained from the trial of individual location and combined over four locations for all the characters are presented in Table 20. Significant variations were observed among the mutants and check variety for some of the characters in both the locations and combined over locations. On an average, days to maturity varied from 98-103 days, 90-99days, 94-103 days and 100-102 days at Mymensingh, Magura, Rangpur and Ishurdi, respectively. Most of the mutants had similar or longer duration for maturity with the check varieties. In case of plant height, the mutant MM-256 was the tallest in all locations.

Table 20. Mean of M_7 mutants and check of rapeseed for different characters

Locations	Mutants/check	Days to maturity (days)	Plant height (cm)	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	Seed yield (kg ha^{-1})
Mymensingh	MM-10	103	111.9cd	2.7ab	91.1a	30.7a	1355bc
	MM-35	102	110.6d	1.8b	76.3a	28.7a-c	1333bc
	MM-37	98	111.6cd	2.4ab	72.9a	30.0ab	1666a
	MM-256	103	140.4a	1.6b	97.9a	25.9c	1266c
	MM-210	100	124.5bc	2.0b	71.1a	28.5a-c	1511ab
	MM-211	100	126.2b	2.0b	75.1a	28.0a-c	1422bc
	Binasarisha-4	96	109.7d	2.3ab	88.5a	27.1bc	1689a
	Binasarisha-5	98	104.7d	3.3a	102.3a	29.3ab	1509ab
Magura	MM-10	90	123.7ab	2.6a	67.7b	30.0ab	1577a
	MM-35	92	116.1b	2.5a	66.2b	33.1a	1433a
	MM-37	93	124.5ab	2.7a	72.1ab	31.9ab	1511a
	MM-256	90	132.1a	2.9a	90.5a	30.8ab	1400a
	MM-210	99	116.9b	2.1a	77.1ab	27.9ab	1533a
	MM-211	96	117.7b	2.7a	73.8ab	27.3b	1355a
	Binasarisha-4	89	113.5b	2.2a	67.2b	32.1ab	1366a
	Binasarisha-5	92	114.0b	2.8a	73.1ab	29.5ab	1511a
Ishurdi	MM-10	94	93.9c	2.3ab	66.9a	24.3ab	978bc
	MM-35	95	97.5bc	2.1b	64.3a	25.7a	1222ab
	MM-37	99	106.5b	2.7ab	78.5a	23.1b	1288a
	MM-256	102	123.3a	2.9a	74.8a	24.2ab	1011bc
	MM-210	95	102.3bc	2.2b	61.5a	23.5ab	1055a-c
	MM-211	101	98.7bc	2.2b	62.9a	20.1c	955c
	Binasarisha-4	94	91.3c	2.3ab	70.8a	23.1b	1144a-c
	Binasarisha-5	97	95.2bc	2.1b	59.5a	22.3bc	1089a-c
Rangpur	MM-10	102	111.9cd	2.7ab	91.1a	30.7a	1391ab
	MM-35	102	110.6d	1.8b	72.9a	28.7a-c	1409ab
	MM-37	100	111.6cd	2.4ab	72.9a	30.0ab	1449a
	MM-256	102	140.4a	1.6b	97.9a	25.9c	1175b
	MM-210	100	124.5bc	2.0b	71.1a	28.5a-c	1306ab
	MM-211	102	126.2b	2.0b	75.1a	28.0a-c	1306ab
	Binasarisha-4	99	109.7d	2.3ab	88.5a	27.1bc	1400ab
	Binasarisha-5	99	104.7d	3.3a	102.3a	29.3ab	1426ab
Combined over four Locations	MM-10	97f	110.4cd	2.5ab	79.2a-c	28.9ab	1325b-d
	MM-35	98d	108.7cd	2.1b	69.9c	29.0a	1349bc
	MM-37	98d	113.6bc	2.5ab	74.1bc	28.7ab	1479a
	MM-256	99b	134.1a	2.3b	90.3a	26.7c	1213d
	MM-210	99b	117.0b	2.1b	70.2bc	27.1bc	1351bc
	MM-211	100a	117.2b	2.2b	71.7bc	25.9c	1260cd
	Binasarisha-4	95h	106.1d	2.3b	78.7a-c	27.3a-c	1400ab
	Binasarisha-5	97g	104.6d	2.9a	84.3ab	27.6a-c	1384ab
Location means	Mymensingh	100b	117.4a	2.3b	84.4a	28.5b	1469a
	Magura	93d	119.8a	2.6a	73.4b	30.3a	1461a
	Ishurdi	97c	101.1b	2.4ab	67.4b	23.3c	1093b
	Rangpur	101a	117.4a	2.3b	84.0a	28.5b	1358a

The common letters did not differ at 5% level of probability as per DMRT

Most of mutant lines had taller plant height than the check varieties Binasarisha-4 and Binasarisha-5 in all locations**.** The average number of branches ranged from 1.8-3.7, 2.1-2.9, 2.1-2.9 and 1.6-2.7 at Mymensingh, Magura, Rangpur and Ishurdi, respectively. At Mymensingh and Rangpur, MM-10 had highest number branches followed by MM-37, whereas, at Magura and Ishurdi MM-256 had the highest number of branches plant^{-1}. At Magura, MM-256 had the significantly highest number of siliqua/plant followed by MM-210, whereas no significant difference was found at Mymensingh, Ishurdi and Rangpur. Average number of seeds siliqua^{-1} ranged from 25.9-30.7, 27.3-33.1, 20.1-25.7 and 25.9-30.7 at Mymensingh, Magura, Rangpur and Ishurdi, respectively. The mutant lines MM-10, MM-35 and MM-37 had the higher number of seed siliqua^{-1} in most of the locatrions. Significant difference for grain yield was found at Mymensingh, Ishurdi and Rangpur. At Mymensingh, MM-37 gave the highest seed yield (1666 kg ha^{-1}) followed by MM-210 which was similar or higher than the two check varieties Binasarisha-4 and Binasarisha-5. At Magura, MM-10 gave highest seed yield (1577 kg ha^{-1}) followed by MM-210 and MM-37. The mutant lines MM-37 and MM-35 gave the higher seed yield at Ishurdi and Rangpur locations. In combined over locations, MM-37 produced highest seed yield (1479 kg ha^{-1}**)** followed by MM-210 (1351 kg ha^{-1}) and MM-35 (1349 kg ha^{-1}). Among four locations, the highest seed yield was obtained from Mymensingh (1469 kg ha^{-1}) followed by Magura (1461 kg ha^{-1}).

Preliminary yield trial with m6 rapeseed mutants (*B. juncea*)

Fourteen M_6 mutant lines of mustard (*B. juncea*) were put into the trial to assess their performance in respect of plant height, branches per plant, siliquae per plant, seeds per siliqua, maturity period and seed yield as compared to the check variety, BARI Sarisha-11. The trial was conducted at BINA Head Quarters, Mymensingh and in the farms of BINA sub-stations at Ishurdi and Magura. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Seeds were sown on 16 November 2011 in Mymensingh, 28 October 2011 at Ishurdi. Unit plot size was 12 m^2 (4 m × 3 m) keeping 30 cm row to row spacing and 6-8 cm from plant to plant within row. Recommended production packages i.e., application of recommended doses of fertilizers, weeding, thinning, irrigation, pesticide etc. were followed as and when necessary. Data were taken from 10 randomly selected plants from each plot. Maturity period was considered when 70% siliquae and plant turned into brownish color in each plot. Seed yield of each plot was recorded after harvest and then converted into kgha^{-1}. Appropriate statistical analysis was done for comparison of means of mutants and check for each character.

The results of individual location and combined over three locations for all the characters are presented in Table 21. On an average, maturity period varied from 92-108 days and MM-43 took 92 days to mature at Mymensingh which was 8-13 days earlier than BARI sarisha-11. The mutant line MM-31 produced the highest plant height (136 cm) having non-significant difference with BARI Sarisha-11 (130 cm) while MM-38, MM-39 and MM-43 produced the shortest plant height of 110 cm. The average number of branches per plant ranged from 2.4-3.2. The mutants lines MM-31 and MM-32 produced highest number of siliquae plant^{-1} (132). The number of seeds siliqua^{-1} ranged from 9.3-11.4. On an average, MM-37 (1465 kg ha^{-1}), MM-35 (1437 kg ha^{-1}) and MM-31 (1427 kg ha^{-1}) produced the highest seed yield which were statistically similar yield to the check BARI Sarisha-11. Between the two locations, Ishurdi showed slightly better performance in respect of seed yield (1380 kg ha^{-1}).

Table 21. Mean of M_6 mutants and check of rapeseed for different characters

Locations	Mutants/check	Days to maturity (days)	Plant height (cm)	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	Seed yield (kg ha^{-1})
Mymensingh	MM-30	100	113bc-e	3.1ab	130a-c	12.4a	1146d
	MM-31	98	127a	2.8b-d	141ab	10.8b-d	1354ab
	MM-32	96	116b	3.1ab	154a	11.3a-c	1250bc
	MM-33	97	107d-f	2.7bcd	97d	10.5c-e	1246bc
	MM-34	101	108c-e	2.3e	113b-d	10.3c-e	1237bc
	MM-35	100	112b-d	2.7b-d	112b-d	9.1f	1458ab
	MM-36	101	101gh	2.5de	92d	9.9d-f	1147d
	MM-37	95	105fg	2.4de	102cd	9.7d-f	1479ab
	MM-38	94	99i	2.8b-d	104cd	9.4ef	1354ab
	MM-39	94	100hi	3.3a	118b-d	10.3c-e	1375ab
	MM-40	101	113b-d	2.8b-d	108cd	10.0d-f	1187d
	MM-41	94	110b-e	2.5de	98d	11.9ab	1271bc
	MM-42	94	106efg	3.1a-c	117b-d	10.8b-d	1229bc
	MM-43	92	100hi	2.6de	100cd	11.3a-c	1212cd
	BARI Sarisha-11	100	115bc	2.5de	101cd	10.2c-e	1541a
Ishurdi	MM-30	104	116c	2.9a-c	125a	10.3bc	1450ab
	MM-31	104	145a	3.3a	122ab	10.1bc	1500a
	MM-32	100	125bc	2.8a-c	109a-c	11.3ab	1333ab
	MM-33	101	125bc	2.8a-c	121ab	11.3ab	1183cd
	MM-34	102	119bc	2.4c	79d	10.7bc	1400ab
	MM-35	102	127bc	3.1ab	111a-c	9.6c	1417ab
	MM-36	101	129b	2.9a-c	106a-c	10.4bc	1500a
	MM-37	100	125bc	2.9a-c	112a-c	10.4bc	1450ab
	MM-38	100	122bc	3.2a	124ab	12.7a	1000d
	MM-39	101	121bc	3.1ab	115a-c	11.3ab	1450ab
	MM-40	108	130b	3.0ab	93cd	10.3bc	1517a
	MM-41	107	120bc	3.2a	110a-c	11.5ab	1450ab
	MM-42	106	121bc	2.8abc	111a-c	10.4bc	1383ab
	MM-43	105	120bc	3.3a	112a-c	11.4ab	1250bc
	BARI Sarisha-11	109	144a	2.6bc	98b-d	10.3bc	1417ab
Combined over two locations	MM-30	102	115cd	3.0a	127ab	11.4ab	1298a-d
	MM-31	101	136a	3.0a	132a	10.5a-c	1427a-c
	MM-32	98	121bc	3.0a	132a	11.3ab	1292a-d
	MM-33	99	116cd	2.8a-c	109a-c	10.9a-c	1215cd
	MM-34	102	114cd	2.8a-c	96c	10.5a-c	1319a-d
	MM-35	101	119cd	2.4ab	111a-c	9.3d	1437a-c
	MM-36	101	115cd	2.6a-c	99bc	10.1bcd	1333a-d
	MM-37	98	115cd	2.7bc	107a-c	10.1cd	1465ab
	MM-38	97	110d	2.6ab	114a-c	11.1a-c	1479a
	MM-39	98	110d	3.0a	117a-c	10.8a-c	1412a-c
	MM-40	105	122bc	3.2ab	101bc	10.1cd	1352a-d
	MM-41	101	115cd	2.9ab	104a-c	11.17a	1360a-d
	MM-42	100	113cd	2.9ab	114a-c	10.6a-c	1306a-d
	MM-43	99	110d	3.0a	106a-c	11.4ab	1231b-d
	BARI Sarisha-11	105	130ab	2.9bc	100bc	10.3bc	1177d
Location means							
Mymensingh		97c	109d	2.8b	113a	10.5b	1300b
Ishurdi		103a	126a	3.0a	110b	10.8a	1380a

The common letters did not differ at 5% level of probability as per DMRT

Preliminary yield trial with early maturing F_6 (cross between Binasarisha-4 and Tori-7) rapeseed lines.

Eleven mutant lines of rapeseed cross between Binasarisha-4 and Tori-7 were put into the trial. The trial was conducted in the BINA HQ. farm, Mymensingh and in the farms of BINA sub-stations at Ishurdi. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 15 November in BINA Head Quarters 28 October at Ishurdi and 05 November at Rangpur. Unit plot size was 12 m^2 (4 m × 3 m) with 25 cm row to row spacing and 6-8 cm from plant to plant within rows. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on plant height, branches $plant^{-1}$, siliquae $plant^{-1}$ and seeds $siliqua^{-1}$ were taken from 10 randomly selected plants from each plot. Maturity period was counted when 70% siliquae were matured. Seed yield of each plot was recoded after harvest and then converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

Results obtained from the trial of individual location and combined over three locations for all the characters are presented in Table 22. Significant variations were observed among the mutants and check variety for some of the characters in both the locations and combined over locations.

The results of individual location and combined over three locations for all the characters are presented in Table 22. On an average, maturity period of the F_6 lines varied from 79-82 days which was 2-5 days earlier than Tori-7. The line RC-3 had the highest plant height (97.6 cm) having non-significant difference with Tori-7 (93.4 cm) while RC-6, RC-8 and RC-9 had the shortest plant height of 87 cm. The average number of branches per plant ranged from 3.4-4.0. The lines RC-5 and RC-9 produced highest number of siliqua $plant^{-1}$ (104.6). The number of seeds $siliqua^{-1}$ ranged from 14.4 -16.4. On an average, RC-4 (1189 kg ha^{-1}), RC-5 (1183 kg ha^{-1}) and RC-10 (1140 kg ha^{-1}) produced the highest seed yield which were statistically similar yield of the check Tori-7. Between the three locations, Rangpur showed slightly better performance in respect of seed yield (1215 kg ha^{-1}).

Table 22. Mean of F_6 rapeseed lines and check variety of mustard for different characters

Locations	Mutants/ varieties	Days to maturity (days)	Plant height (cm)	Branches $plant^{-1}$ (no.)	Siliquae $plant^{-1}$ (no.)	Seeds $siliqua^{-1}$ (no.)	Seed yield (kg ha^{-1})
	RC-1	78	89.5cd	3.9bc	100.9ab	14.9ab	889de
	RC-2	78	94.6bc	3.8cd	89.7ab	13.9bc	1083b
	RC-3	77	100.3a	4.5a	87.5bc	12.9cd	889de
	RC-4	78	92.5bc	4.3ab	114.1a	12.1e	1166a
	RC-5	78	93.2bc	4.1ab	104.0ab	12.8cd	1278a
Ishurdi	RC-6	78	87.0e	4.2ab	111.7ab	12.3de	1083b
	Tori-7	83	95.3ab	3.5d	102.3ab	13.8bc	750e
	RC-7	78	91.5bc	3.9bc	103.9ab	15.5a	993cd
	RC-8	81	91.2bc	4.3ab	108.5ab	13.9bc	1111a
	RC-9	79	88.7de	3.9bc	109.7ab	13.2cd	805de
	RC-10	78	88.9de	3.8cd	96.5abc	13.5cd	1167a

Table 22 Contd.

Locations	Mutants/ varieties	Days to maturity (days)	Plant height (cm)	Branches $plant^{-1}$ (no.)	Siliquae $plant^{-1}$ (no.)	Seeds $siliqua^{-1}$ (no.)	Seed yield (kg ha^{-1})
Rangpur	RC-1	86	93.7c	2.5d	96.3cd	15.7d	1183b-d
	RC-2	89	97.0bc	3.1bc	110.3a-c	15.6d	1067de
	RC-3	86	104.0a	2.9cd	93.3cd	15.7d	1161c-e
	RC-4	86	100.7ab	3.0b-d	112.7a-c	16.0d	1372a
	RC-5	86	100.0ab	3.5ab	130.7a	15.2d	1283a-c
	RC-6	86	93.0c	3.7a	117.3a-c	19.2c	1216bc
	Tori-7	89	92.3c	3.5ab	108.7a-b	20.4ab	1283a-c
	RC-7	87	100.0ab	2.9cd	100.0b-d	20.9ab	1305a-c
	RC-8	86	93.7c	3.0b-d	87.7d	21.9ab	1022ef
	RC-9	87	96.7bc	3.5a-c	122.0ab	19.9bc	1394a
	RC-10	87	97.0bc	3.1bc	106.7a-c	21.7a	1311ab
	RC-11	87	96.7bc	3.2a-c	102.7b-d	20.9ab	988f
Mymensingh	RC-1	74	89.7ab	3.9c	61.7bc	14.5a-c	930bc
	RC-2	74	88.7ab	5.0a	71.3ab	13.5bc	997bc
	RC-3	72	88.3ab	5.0a	72.3ab	14.7ab	725f
	RC-4	75	95.3a	4.2bc	73.0ab	15.6a	1028b
	RC-5	81	89.7ab	4.1bc	74.0ab	15.2ab	989bc
	RC-6	80	83.0cd	4.1bc	67.0ab	14.5ab	916b-d
	Tori-7	81	92.7ab	4.7ab	74.0ab	13.4bc	1222a
	RC-7	77	91.3ab	4.2bc	66.3a-c	15.2ab	866c-f
	RC-8	72	78.7de	4.2bc	50.0c	12.9cd	803df
	RC-9	72	76.0e	4.5ab	82.0a	14.8ab	994bc
	RC-10	72	84.0cd	4.3ab	59.obc	14.0ab	944b-d
	RC-11	74	86.0bc	4.1bc	71.3ab	12.7d	780ef
Combined over three locations	RC-1	79	90.9bc	3.4b	86.3ab	15.1bc	1001b-e
	RC-2	80	93.4ab	4.0ab	90.4ab	14.4d	1049a-d
	RC-3	78	97.6a	4.2a	84.4ab	14.4d	925de
	RC-4	80	96.2ab	3.8ab	99.9ab	14.6cd	1189a
	RC-5	82	94.3ab	3.9ab	104.6ab	14.4d	1183a
	RC-6	81	87.7c	4.0a	98.7ab	15.3bc	1072a-d
	Tori-7	84	93.4ab	3.9ab	95.0ab	15.9ab	1085a-c
	RC-7	81	94.3ab	3.7ab	90.1ab	17.2a	1048a-d
	RC-8	80	87.8c	3.8ab	82.0b	16.0ab	979c-e
	RC-9	79	87.1c	4.0ab	104.6a	16.0ab	1064a-d
	RC-10	79	90.0bc	3.8ab	87.4ab	16.4ab	1140ab
	RC-11	81	91.0bc	4.0ab	82.2b	15.5bc	852e
Location means	Ishurdi	79	91.9ab	4.1a	100.1a	13.5b	999b
	Rangpur	87	97.1a	3.2b	107.4a	18.5a	1215a
	Mymensingh	75	86.9b	4.4a	68.5b	14.3b	933b

The common letters in a column did not differ at 5% level of probability as per DMRT.

Preliminary yield trial with M_6 rapeseed mutants (*B. napus*)

Eight M_6 mutant lines of rapeseed (*Brassica napus*) along with a check variety Binasarisha-4 and Binasarisha-5 were put into the trial. The trial was conducted in the BINA HQ farm, Mymensingh and in the farms of BINA sub-stations at Ishurdi. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 02 November in BINA HQ 28 October 2011 at Ishurdi. Unit plot size was 12 m^2 (4 m × 3 m) with 25 cm row to row spacing and 6-8 cm from plant to plant within rows. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on plant height, branches plant^{-1}, siliqua plant^{-1} and seeds siliqua^{-1} were taken from 10 randomly selected plants from each plot. Maturity period was counted when 70% siliqua were matured. Seed yield of each plot was recorded after harvest and then converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

The results of individual location and combined over two locations for all the characters are presented in Table 23. On an average, maturity period of the M_6 Mutant lines varied from 83-91 days which was 5-8 days earlier than Binasarisha-4 and Binasarisha-5. The check variety Binasarisha-5 showed the longest plant height (97.3 cm), whereas, the mutant lines MM-81, MM-14 and MM-51 had the shortest plant height of 71.4 cm, 84.4 and 86.3, respectively. The average number of branches per plant ranged from 2.1-3.5. The mutants lines MM-26 and MM-82 produced highest number of siliqua plant^{-1} which were 84.2 and 78.7, respectively. The number of seeds/siliqua ranged from 22.4-26.5. On an average, all the mutants had lower seed yield than those of check varieties. Among the mutants, MM-15 produced higher seed yield (1117 kg ha^{-1}) followed by MM-63 and MM-82. Between the two locations, Mymensingh showed slightly better performance in respect of seed yield (1202 kg ha^{-1}).

Table 23. Mean of M_6 rapeseed mutants and check variety of mustard for different characters.

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	Seed yield (kg ha^{-1})
Mymensingh	MM-81	80	80.9bc	2.5ab	60.7ab	25.9cd	1050c-e
	MM-82	81	71.2d	2.5ab	48.8bc	24.1d	1067c-e
	Binasarisha-4	86	82.9a-c	1.8c	48.0bc	26.0b-d	1633a
	MM-14	82	71.1d	2.4ab	41.1c	26.2b-d	900e
	MM-15	81	83.1a-c	2.8ab	60.5ab	27.1bc	1150b-d
	MM-26	79	83.8a-c	2.9a	68.7a	24.7cd	1000de
	Binasarisha-5	89	89.8a	2.3bc	72.1a	24.7cd	1600a
	MM-63	81	76.3d	2.3bc	47.6bc	25.1cd	1217bc
	MM-64	79	80.1bc	2.6ab	54.1bc	28.5ab	1100cd
	MM-51	84	86.1ab	2.8ab	59.9ab	30.1a	1300b

Table 4 Contd.

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches $plant^{-1}$ (no.)	Siliquae $plant^{-1}$ (no.)	Seeds $siliqua^{-1}$ (no.)	Seed yield (kg ha^{-1})
Ishurdi	MM-81	88	71.4f	3.3ab	69.8bc	23.9bc	917c
	MM-82	85	87.9c-e	3.1bc	78.7ab	25.4ab	1000bc
	Binasarisha-4	91	94.0ab	2.1e	64.9b-d	25.3ab	1317a
	MM-14	83	84.4e	2.5de	52.2d	24.0bc	933bc
	MM-15	86	90.7b-d	2.9bc	70.3a-c	24.5b	1117b
	MM-26	88	86.9de	3.5a	84.2a	22.4c	950bc
	Binasarisha-5	91	97.3a	2.8cd	71.3a-c	23.9bc	1400a
	MM-63	87	87.7c-e	2.7cd	71.6a-c	26.5a	1000bc
	MM-64	83	91.7bc	2.5de	75.7ab	25.6ab	933bc
	MM-51	87	86.3de	2.8cd	60.9cd	25.3ab	958bc
Combined over two locations	MM-81	88	71.4f	3.3ab	69.8bc	23.9bc	917c
	MM-82	85	87.9cd	3.1ab	78.7ab	25.4ab	1000bc
	Binasarisha-4	91	94.0ab	2.1e	64.9b-d	25.3ab	1317a
	MM-14	83	84.4e	2.5de	52.2d	24.0bc	933bc
	MM-15	86	90.7bc	2.9bc	70.3a-c	24.5b	1117b
	MM-26	88	86.9de	3.5a	84.2a	22.4c	950bc
	Binasarisha-5	91	97.3a	2.8cd	61.3a-c	23.9bc	1300a
	MM-63	87	87.7cd	2.7cd	71.6a-c	26.5a	1000bc
	MM-64	83	91.7bc	2.5de	75.7ab	25.6ab	933bc
	MM-51	87	86.3de	2.8cd	60.9cd	25.3ab	958bc
Location mean	Mymensingh	82	80.5	2.5	56.2	26.2	1202
	Ishurdi	87	87.8	2.8	70.0	24.7	1053

The common letters did not differ at 5% level of probability as per DMRT.

Growing of M_4 population

A large number of M_3 variants developed from Binasarisha-4 and BARI Sarisha-11 were grown in plant progeny rows for selecting desirable mutants at BINA HQ farm, Mymensingh. From them a total of 25 lines have been selected primarily for further selection in M_5 generation.

Growing of F_5 population

F_4 population developed from the cross Binasarisha-4 and Tori-7 were grown at BINA HQ farm, Mymensingh. From them a total of 10 lines have been selected primarily for further selection in F_6 generation.

Maintenance of germplasm (mutants, local and exotic collection)

Forty germplasm were grown in the farms of BINA HQ farm, Mymensingh. After harvest, seeds of all these germplasm were collected and have been preserved as breeding materials.

GROUNDNUT

Advanced yield trial with two M_7 mutant lines of groundnut

This experiment was performed with 2 M_7 mutant lines of groundnut. Seeds were sown on 11 October 2011, at BINA sub-station farm, Ishurdi to assess performance of the mutant lines compare to their respective parents Dacca-1 and PK-1. The experiment followed RCB design with 3 replications and a unit plot size was 3.0 m × 2.70 m. Recommended doses of fertilizers were applied together with cultural and intercultural practices. Data on plant height, primary branches and mature pod plant^{-1} were recorded during harvest from randomly selected 10 competitive plants while pod weight plant^{-1}, 100-pod weight, 100-kernel weight and shelling percentage were recorded after proper sun drying. Pod yield was recorded from 1.0 m^2 area and converted latter to kg ha^{-1}. Finally, the recorded data were subjected to proper statistical analyses and are presented in Table 24.

Table 24. Pod yield and yield attributes of 2 M_7 mutant lines of groundnut at Ishurdi during early rabi season, 2011-12

Mutants/ varieties	Plant height (cm)	Branch plant^{-1} (no)	Mature pods plant^{-1} (no.)	Pod weight plant^{-1} (g)	100-pod wt. (g)	Pod yield (kg ha^{-1})	Shelling (%)
D_1/20/17-1	12.07	4.00	7.47	3.00	40.26	658.33	77.50
RS/25/3-1	11.43	4.00	8.43	2.97	35.17	652.67	83.90
Dacca-1	11.37	4.00	10.17	3.40	33.39	748.00	79.03
PK-1	11.73	4.00	7.50	2.67	35.54	586.67	78.90
$LSD_{(0.05)}$	NS	NS	0.92	NS	NS	55.58	NS

NS = Not significant

The overall performance of the mutant lines as well as the check varieties was very low, might be due to the sowing time. Presently, farmers mostly sow groundnut in the Rabi season from late December to mid February. However, the mutant lines and parents appeared indifferent in height, primary branch number, pod yield plant^{-1} and shelling while showed significant differences in mature pod number and pod yield ha^{-1}. Pod number is the most important yield attributes in groundnut was the highest of all in the check variety Dacca-1. The mutant RS/25/3-1 had significantly higher pod number than its parent PK-1. Like pod number, pod yield ha^{-1} was once again the highest in the check variety Dacca-1 while the other check variety the lowest. The mutant RS/25/3-1although had significantly lower yield than Dacca-1 but it produced significantly higher yield than its parent PK-1. The mutant D_1/20/17-1 although had indifferent pod number with the check variety PK-1 but had significantly higher pod yield ha^{-1} because of its higher pod size. This mutant also showed less infestation by jassid, leaf hopper and jute hairy caterpillar (data will be presented by Entomology Division). Finally, this experiment will be repeated in the coming Kharif-2 season for confirmation.

Advance yield trial with some late *Cercospora* leaf spot tolerant lines of groundnut

This experiment was performed with 11 lines derived from crossing between late *Cercospara* tolerant Zhingabadam with susceptible varieties of groundnut. Seeds were sown on 11 October 2011 at BINA sub-station farm, Ishurdi. Dacca-1 and Zhingabadam were included in this experiment as check varieties. The experiment followed RCB design with three replications and a unit plot size was 3.0 m × 2.1 m. Recommended doses of fertilizers were applied together with recommended cultural and intercultural practices. Data on plant height, primary branches, mature pod plant^{-1} and shelling percentage were recorded after harvest from randomly selected 10 competitive plants while pod weight plant^{-1} and 100-pod weight were recorded after proper sun drying. Pod yield was recorded from an area of 1.0 m^2 which was later converted to kg ha$^-$1. Finally, the recorded data were subjected to proper statistical analyses and are presented in Table 25.

Four lines had significantly shorter plant height than both the check varieties, Zingabadam and Dacca-1, despite heights of Zingabadam and Dacca-1 were indifferent. In contrast, only one line had significantly taller height. None of the lines had significantly higher number of mature pods than the parent Dacca-1while 4 had significantly higher than Zhingabadam. None of the lines had significantly higher pod yield plant^{-1} than any of check the varieties.

Table 25. Pod yield and yield attributes of some *Cercospora* leaf spot tolerant lines of groundnut at Ishurdi grown during early rabi season, 2011-12

Mutant/varieties	Plant height (cm)	Branch plant^{-1} (no.)	Pods plant^{-1} (no.)	Pod weight plant^{-1} (g)	100-pod weight (g)	Yield ha^{-1} (kg)	Shelling (%)
GC(1)-35-1-1	12.73	4.00	8.87	7.67	86.12	1686.67	72.15
GC(1)-24-1-1-1	9.43	4.00	12.57	5.43	43.30	1195.33	78.32
GC(1)-24-1-1-2	9.77	4.00	12.70	7.13	56.13	1569.33	75.47
GC(1)-4-1	11.27	4.00	10.60	9.87	93.86	2160.67	72.56
GC(1)-3-2-2-1	13.97	4.00	11.70	7.53	63.90	1657.33	81.24
GC(1)-32-3-2-1-1	13.20	4.00	14.10	8.17	57.93	1782.00	70.11
GC(1)-32-1-1-1-1	14.07	4.00	11.00	8.63	78.09	1899.33	73.00
GC(1)-39-1-2	11.10	4.00	12.73	8.20	63.52	1804.00	75.98
GC(1)-32-2-1-1	16.10	4.00	13.30	8.13	63.63	1789.33	73.96
GC(1)-32-3-1-1	13.30	4.00	14.60	12.10	83.22	2662.00	73.92
GC(1)-32-3-1-2	12.07	4.00	14.07	9.60	69.07	2097.00	78.69
Zhingabadam	13.47	3.97	9.27	9.57	103.74	2104.00	71.79
Dacca-1	13.53	4.00	18.27	8.43	45.98	1855.33	82.30
$LSD_{(0.05)}$	2.09	NS	3.88	3.16	20.76	182.23	4.11

Five lines had significantly bigger pod size, expressed here as 100-pod weight, than Dacca-1 including two which did not differ significantly to that of Zhingabadam. Finally, yield ha^{-1} was significantly higher in 3 lines than Dacca-1. Of these 3 lines, 1 produced significantly higher pod yield even than the other check variety Zhingabadam. These 3 lines GC(1)-4-1, GC(1)-32-3-1-1 and GC(1)-32-3-1-2 will be put into zonal yield trial, next year. Shelling percentage was significantly the highest in the check variety Dacca-1 and did not differ significantly with three others.

Screening F_2 population of groundnut for salinity tolerance

With a view to select salt tolerant groundnut lines, 42 F_2 populations and their 9 parents were subjected to 8 dS/m salinity during flowering till maturity. A same set of control i.e. watering with tap water was maintained. The experiment followed CRD design with three replications. Plastic pots with 10 litre capacity were weighed and filled with 8 kg soil mixture, prepared with sandy loam soil and rotten cow dung in a 1:1 ratio. The fertilizer needed for each pot was determined following the BARC Fertilizer Recommendation Guide-2005. The total amount of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MP, Gypsum and Zinc sulphate. These were mixed thoroughly with the soil in each pot before sowing. Plant available water, initial moisture content, initial soil salinity and salinity development in pot soil were done following the methods used, above, in assessing salt tolerance levels of different phenological stages in wheat experiment.

Seeds were sown on 18 August, 2011 and when the plants were established, only three healthy plants were kept in each pot. The pots were kept free from weeds. The plants were protected from insect pest by spraying appropriate insecticides as and when necessary.

The saline water was synthesized by using mixture of different salts: 50% NaCl, 15% Na_2SO_4, 10% $NaHCO_3$, $CaCl_2$, and $MgCl_2$ together with 5% $MgSO_4$ so that their compositions were almost alike their average compositions in the ground water of saline areas of Bangladesh. Fifty grams of such salt was dissolved liter^{-1} tap water to prepare the stock solution. The salinity of the stock solution was 80 dS/m. The total amount of stock solution needed to bring the salinity of the soil mixture to 8 dS/m was estimated following the same method used, above, in assessing salt tolerance levels of different phenological stages in wheat experiment.

The estimated amount of stock solution was then diluted to 8dS/m by adding tap water and then imposed during flowering till maturity at different installments so that the moisture content of the pots remained 70- 80% of plant available water (PAW). For the control, same amount of only fresh tap water was applied. Relative performance was calculated following the formula-

$$\text{Relative performance (\% of control)} = \frac{\text{Performance of a trait under saline condition}}{\text{Performance under control condition}} \times 100$$

The relative performance of yield and some yield attributes as affected by 8 dS/m salinity are presented in Table 26.

Relative plant height of the F_2s and parents ranged 57.14 to 113.32% (Table 26). In contrast, relative number of primary branch ranged 75.00 to 200%, 39 with either 100% or more and only 12 with less than 100%. This means upon salinity stress groundnut mostly produce more branches. Unlike plant height and branch number, relative mature pod number, pod and kernel yields had comparatively lower relative performances. Mature pod number ranged 0.00 to 80.86%, pod yield 0.00 to 74.77% and kernel yield 0.00 to 76.65%. Kernel yield is the ultimate product in groundnut. Therefore, it is proper to discriminate the F_2 and parents based on its relative kernel yields. The F_2 and parents with 50% and above relative kernel yields could be classified as salt tolerant. In this regard, 4 parents: Binchinabadam-2, Binchinabadam-3, Binchinabadam-4 and BARI Badam-7; and the F_2s: Binchinabadam-1 × Dacca-1, Binchinabadam-3 × Zhingabadam, Jx87015-SL-O1 × BARI Badam-7, Binchinabadam-4 × Binchinabadam-2 appeared tolerant. These 4 F_2 populations will be further screened in F_3 generation.

Table 26. Relative performance (% of control) of yield and yield attributes of 42 F_2 population and their 9 parents at 8 dS/m salinity imposed during flowering till maturity

F_2 population and parents	Plant height (%)	Primary branch number (%)	Pod plant^{-1} (%)	Pops plant^{-1} (%)	Pod yield plant^{-1} (%)	Kernel yield plant^{-1} (%)
Zhingabadam × Dacca-1	98.52	149.81	0.00	31.79	0.00	0.00
BARI Badam-7 × Dacca-1	65.45	100.00	0.00	0.00	0.00	0.00
ICGV-95063 × Dacca-1	84.54	100.00	2.02	200.00	11.64	10.10
BCB-1 × Dacca-1	69.15	100.00	36.01	424.34	74.65	71.52
BCB-2 × Dacca-1	71.41	120.12	27.27	43.62	17.32	17.50
BCB-3 × Dacca-1	71.24	110.21	8.11	69.99	24.16	22.10
BCB-4 × Dacca-1	70.76	120.12	4.55	65.19	14.19	14.65
Baribadam-7 × Zhingabadam	87.39	112.36	0.00	199.79	0.00	0.00
Jx87015-SL-O1 × Zhingabadam	74.61	150.00	10.72	59.07	23.50	23.44
ICGV-95063 × Zhingabadam	82.89	171.67	12.57	130.95	16.63	15.53
BCB-1 × Zhingabadam	57.14	110.21	0.00	86.96	0.00	0.00
BCB-2 × Zhingabadam	72.91	200.00	82.85	53.62	60.94	66.17
BCB-3 × Zhingabadam	72.62	120.12	55.41	96.46	33.09	33.36
BCB-4 × Zhingabadam	71.73	100.00	23.08	135.80	40.36	35.68
ICGV-90227 × Zhingabadam	95.63	120.12	56.45	122.17	0.00	0.00
Jx87015-SL-O1 × BARI badam-7	96.47	91.75	50.0	59.33	65.47	62.26
ICGV-95063× BARI badam-7	66.09	100.00	47.94	60.02	55.82	47.45
BCB-1 × BARI Badam-7	62.37	166.50	63.42	65.19	13.83	15.53
BCB-2 × BARI Badam-7	84.96	100.00	12.05	148.02	37.61	41.08
BCB-3 × BARI Badam-7	71.88	108.99	36.65	164.31	53.88	49.75
BCB-4 × BARI Badam-7	88.33	133.33	51.01	134.68	27.14	25.28
ICGV-90227 × BARI Badam-7	75.40	120.12	54.57	26.38	0.00	0.00
ICGV-90227 × jx87015-SL-O1	80.88	120.12	0.00	89.57	43.15	35.87
BCB-2 × Jx87015-SL-O1	82.81	85.65	22.47	172.03	55.79	50.17
BCB-3× Jx87015-SL-O1	80.22	91.75	37.11	46.70	21.19	21.77
BCB-4 × Jx87015-SL-O1	71.41	100.00	22.22	264.92	36.31	38.19
ICGV-90227 × Jx87015-SL-O1	77.49	100.00	69.20	50.09	19.44	17.55
BCB-1 × ICGV-95063	73.25	100.00	4.05	112.00	48.55	48.38
BCB-2 × ICGV-95063	76.98	100.00	80.86	185.71	64.34	49.96
BCB-3 × ICGV-95063	82.95	100.00	44.27	199.73	26.87	27.76
BCB-4 ×ICGV-95063	83.51	91.75	20.94	47.85	50.59	44.30
ICGV-90227 × ICGV-95063	88.48	91.75	76.70	87.62	50.36	49.15
BCB-42 × BCB-1	70.78	100.00	16.37	202.75	37.70	39.40
BCB-3×BCB-1	82.35	100.00	25.01	199.90	47.65	49.39
BCB-4 × BCB-1	72.54	75.00	28.41	76.32	12.28	12.33
ICGV-90227 × BCB-1	113.32	108.99	33.33	39.11	25.03	25.40
BCB-3 × BCB-2	90.11	100.00	5.36	62.21	37.84	40.62
BCB-4 × BCB-2	67.49	91.75	46.31	116.17	71.29	71.04
ICGV-90227 × BCB-2	82.35	91.75	69.49	233.00	19.78	20.58
BCB-4 × BCB-3	60.61	83.25	9.45	72.25	44.92	34.44
ICGV-90227 × BCB-3	82.95	75.00	35.12	53.86	17.84	16.71
ICGV-90227 × BCB-4	78.48	75.00	11.82	79.64	0.00	0.00
BCB-1	47.77	83.25	57.48	144.98	38.46	39.15
BCB-2	86.67	91.75	71.13	85.74	61.39	59.92
BCB-3	61.00	124.72	51.62	157.07	43.32	68.47
BCB-4	89.29	100.00	28.57	328.27	74.77	76.65
BARI Badam-7	72.62	100.00	51.20	137.52	57.40	55.65
Dacca-1	81.10	110.21	31.35	153.40	7.94	8.60
Zhingabadam	64.28	124.72	0.00	0.00	0.00	0.00
Jx87015-SL-O1	74.04	120.12	9.28	73.91	24.78	22.06
ICGV-95063	103.69	91.75	30.00	161.66	24.20	26.48

BCB = Binachinabadam

SESAME

On-station yield trial with advanced sesame mutants

The trial was conducted in the farms of BINA sub-station at Ishurdi and Magura during Kharif-I 2012. There were three advanced mutant lines and two check varieties (Binatil-2 and BARI Til-2). The mutants and check varieties were laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (4 m × 5 m) keeping 25 cm spacing between rows and 6-8 cm among the plants in a row. Seeds were sown within March 01-10, 2012. Recommended production packages like application of recommended doses of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data were taken for plant height, branches $plant^{-1}$, capsules $plant^{-1}$ and seeds $capsule^{-1}$ from 10 randomly selected plants from each plot. Maturity period was counted when 80% capsules were matured and most of the plants turned into straw or yellowish color in each plot. Seed yield of each plot was recorded after harvest and then converted into kilogram per hectare (kg ha^{-1}). Appropriate statistical analyses were performed for comparison of means of each character.

The results of each location are presented in Table 27. The results showed significant variations for all the characters among the mutant and check varieties in both locations except for days to maturity. The tallest plant height was found in mutant line SM-058 and SM-067 in at Ishurdi and Magura, respectively. The average number of branches ranged from 2.1-3.5, where the mutant line SM10-04 had the highest number of branches. The number of capsules $plant^{-1}$ was significantly higher in mutant line SM-10-04 followed by SM-067 in both locations. This line contained 3 capsules/axils, which is one of the important features of this mutant. SM-10-04 contained significantly higher number of seeds $capsules^{-1}$ in all locations. The higher of capsules as well as higher number of seeds $capsules^{-1}$ in SM10-04 resulted in significantly higher grain yield in both locations. The plants SM10-04 are hairy which acts as a natural barrier for aphid infestation. The mutant line SM-067 was also promising in respect of seed yield which gave higher or equal yield of two check varieties. Between the two locations, better performance in respect of seed yield was found at Magura. Application will be done to NSB for registration of these two lines as varieties.

Table 27. Mean performance of sesame mutants along with check varieties for different quantitative characters

Locations	Mutants/varieties	Days to maturity	Plant height (cm)	Branches $plant^{-1}$ (no.)	Capsules $plant^{-1}$ (no.)	Seeds $capsule^{-1}$ (no.)	Seed yield (kg ha^{-1})
Ishurdi	SM-10-04	90	92.8	3.5	87.5	67.3	1450
	SM-058	95	95.2	3.3	72.9	63.3	1360
	SM-067	92	90.2	2.9	70.2	65.2	1260
	Binatil-2 (check)	91	87.2	3.4	61.3	61.5	1270
	BARI Til-2 (check)	93	90.3	3.5	71.5	58.3	1280
	LSD	NS	4.955	0.704	12.75	4.127	122.8
Magura	SM-10-04	86	107.3	2.3	69.3	76.3	1560
	SM-058	92	108.3	2.5	63.6	68.6	1460
	SM-067	91	113.4	2.1	61.3	66.3	1420
	Binatil-2 (check)	90	104.2	3.0	55.6	68.6	1275
	BARI Til-2 (check)	89	111.3	3.1	54.3	63.3	1325
	LSD	NS	5.783	0.848	10.92	4.682	176.1

Advanced yield trial with promising sesame mutants

The trial was conducted in the farms of BINA sub-station at Ishurdi and Magura during Kharif-I 2012. There were three advanced mutant lines and two check varieties (Binatil-2 and BARI Til-2). The mutants and check varieties were laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (4 m × 5 m) keeping 25 cm spacing between rows and 6-8 cm among the plants in a row. Seeds were sown within March 01-10, 2012. Recommended production packages like application of recommended doses of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data were taken for plant height, branches $plant^{-1}$, capsules $plant^{-1}$ and seeds $capsule^{-1}$ from 10 randomly selected plants from each plot. Maturity period was counted when 80% capsules were matured and most of the plants turned into straw or yellowish color in each plot. Seed yield of each plot was recorded after harvest and then converted into kilogram per hectare (kg ha^{-1}). Appropriate statistical analyses were performed for comparison of means of each character.

The results are presented in Table 28. The results showed significant variations for all the characters among the mutant and check varieties in each location except for days to maturity. The average plant height ranged from 79-97 cm and 75-107 cm in at Ishurdi and Magura, respectively. Among the four mutants, SM-09 found to the tallest. The mutant line SM-09 had the highest number of branches $plant^{-1}$ as compared with unicum variety Binatil-1 and BARI Til-2 in both locations. The number of capsules $plant^{-1}$ ranged from 59-70 and 37-52 in at Ishurdi and Magura, respectively. Significantly higher number of seeds $capsules^{-1}$ was found in mutant line SM-white (white seed coat) followed by check Binatil-2. The mutant lines SM-09 and SM-08 were found to be promising in respect of seed yield in both locations. The mutant line SM-09 gave highest seed yield followed by SM-08. These lines will be further evaluated in different locations of the country.

Table 28. Mean performance of sesame mutants along with check varieties for different quantitative characters

Locations	Mutants/varieties	Days to maturity	Plant height (cm)	Branches $plant^{-1}$ (no.)	Capsules $plant^{-1}$ (no.)	Seeds $capsule^{-1}$ (no.)	Seed yield (kg ha^{-1})
Ishurdi	SM-white	90	79.3	1.2	59.3	73.1	1050
	SM-black	95	76.3	1.2	61.3	69.3	1090
	SM-8	89	88.4	3.3	70.2	59.2	1210
	SM-9	91	97.2	3.7	70.6	63.5	1290
	Binatil-1 (check)	93	95.2	0.0	36.3	72.2	1260
	BARI Til-2 (check)	95	96.4	2.9	77.2	59.3	1285
	LSD	NS	6.955	0.704	13.75	6.127	122.8
Magura	SM-white	87	82.6	1.2	48.3	85.3	1130
	SM-black	85	75.3	1.3	37.3	75.2	1160
	SM-8	90	106.3	2.3	52.2	77.3	1350
	SM-9	89	107.3	3.1	50.3	76.2	1380
	Binatil-1 (check)	90	98.2	0.0	32.6	83.2	1270
	BARI Til-2 (check)	93	105.6	2.6	54.6	69.2	1290
	LSD	NS	8.783	0.848	11.92	7.682	176.1

SOYBEAN

Zonal yield trial of promising soybean lines during rabi

Three promising soybean lines along with two check varieties were put into zonal yield trials during rabi 2012**.** The experiment was conducted in the BINA HQ farm, Mymensingh and BINA sub-stations at Magura and Rangpur. The experiment was laid out in randomized complete block design with three replications. Sowing was done within January 01-15, 2012. Spacing between rows was 30 cm and 5-7 cm between plants in a row. Unit plot size was 24 m^2 (5 m × 4.8 m). Research management i.e., packages of recommended managements were followed. Data on various characters, such as plant height, number of branches plant^{-1}, pods plant^{-1} and seeds pod^{-1} were taken from 10 randomly selected plants from each plot. Maturity period was counted when the plant and pods of each plot turned into yellowish brown color and almost all the leaves shed. Seed yield of each plot was recorded after sun drying of seeds and then converted into kg ha^{-1}. Data recorded from the experiment were analyzed following appropriate statistical design.

Location-wise mean values over two locations for different characters of the lines and the check varieties are presented in Table 29. Significant variations were observed among the lines and check varieties for all of the characters except for days to maturity in at Mymensingh and Magura. At Mymensingh and Magura all the lines matured within the range of 124-128 days, whereas, it took longer days to maturity (one week) in at Rangpur. The line BAU-S/70 had the longest average plant height and showed significant difference with AVRDC-78 and AVRDC-73. The line AVRDC-78 had

Table 29. Mean performance of soybean lines along with check varieties for different quantitative characters

Genotype	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Seed yield (kg ha^{-1})
Mymensingh						
BAU-S/70	124	102.6	3.2	63.4	2.1	3370
AVRDC-78	124	55.2	3.5	50.3	1.9	3220
AVRDC-73	126	79.3	3.8	45.3	2.1	3330
Binasoybean-1 (check)	124	82.2	3.1	53.3	1.9	3160
BARI Soybean-6 (check)	126	70.2	4.1	66.6	2.1	3050
$LSD_{0.05}$	NS	12.78	0.60	13.42	0.36	436.6
Magura						
BAU-S/70	127	77.3	1.2	56.3	2.1	2150
AVRDC-78	126	32.2	3.5	52.3	2.3	1820
AVRDC-73	128	56.6	3.6	43.3	2.1	1810
Binasoybean-1 (check)	129	87.3	2.4	54.2	1.9	2110
BARI Soybean-6 (check)	126	56.3	2.2	52.4	1.7	1850
$LSD_{0.05}$	NS	12.81	1.45	10.08	0.40	269.5
Rangpur						
BAU-S/70	132	90.3	1.9	89.3	2.2	2280
AVRDC-78	132	37.4	3.3	56.3	2.1	2175
AVRDC-73	126	47.9	2.4	51.6	2.2	1820
Binasoybean-1 (check)	130	53.6	2.1	74.2	1.8	2180
BARI Soybean-6 (check)	125	52.3	2.2	60.3	1.9	1920
$LSD_{0.05}$	1.68	11.31	0.91	18.37	0.41	190.2

the shortest plant height in all locations. The number pods plant^{-1} was higher in BAU-S/70 in all locations. In all locations, BAU-S/870 produced the average highest seed yield in all locations followed by AVRDC-73 in at Mymensingh and AVRDC-78 in at Magura and Rangpur. Application will be done to NSB for registration of the lines BAU-S/70 as variety.

Advanced yield trial of promising soybean mutants during rabi

Seven mutant lines with three check varieties (Binasoybean-1 and BARI Soybean-5 for Mymensingh and Magura; Binasoybean-1 and Binasoybean-2 for Noakhali) were put into advanced yield trial during rabi 2012. The experiment was conducted in the farms of BINA HQ farm, Mymensingh, BINA sub-station at Magura and in farmer's field at Noakhali. The experiment was laid out in randomized complete block design with three replications. Sowing was done within first week of January 2012. Spacing between rows was 30 cm and 5-7 cm between plants in a row. Unit plot size was 12 m^2 (4 m × 3 m). Research management i.e., packages of recommended managements were followed to ensure normal growth and development of plants. Data on various characters, such as plant height, number of branches plant^{-1}, pods plant^{-1} and seeds pod^{-1} were taken from 10 randomly selected plants from each plot. Maturity period was counted when the plant and pods of each plot turned into yellowish brown color and almost all the leaves shed. Seed yield of each plot was recorded after sun drying of seeds and then converted into kg ha^{-1}. Data recorded from the experiment were analyzed following appropriate statistical design.

Location-wise mean values over two locations for different characters of the lines and the check varieties are presented in Table 30. Significant variations were observed for all the characters in all locations. Among the mutants, average days to maturity ranged from 106-109 days, 116-123 days and 135-138 days in at Mymensingh, Magura and Noakhali, respectively. It indicated that, at Noakhali all the mutant lines as well as check varieties had prolonged days to maturity, which eventually reflected significantly higher grain yield in this location. Plant height ranged from 39-96 cm, 64-82 cm and 63-90 cm in at Mymensingh, Magura and Noakhali, respectively. Higher number of branches plant^{-1} in all mutant lines as well as check was found in at Noakhali. The average number of pods plant^{-1} in the mutant lines ranged from 1.82-2.32. The highest number of pods plant^{-1} was found in mutant lines SBM-17, SBM-20 and SBM-09 in at Mymensingh, Magura and Naokhali, respectively. At Mymensingh, the mutant line SBM-18 produced the highest seed yield (3080 kg ha^{-1}) followed by SBM-22 and SBM-09. Similarly, SBM-18 gave the highest grain yield followed by SBM-20 in at Magura, whereas, the mutant line SBM-22 produced highest seed yield followed by SBM-09 and SBM-18. Among the locations, all mutants as well as check varieties gave the highest seed yield at Noakhali area, which is considered one of the soybean growing belts in Bangladesh. Among mutant lines, some of the better mutants will be selected on the basis of yield and yield contributed characters for further trials.

Table 30. Mean performance of soybean mutants along with check varieties for different quantitative characters

Mutants and mothers	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Seed yield (kg ha^{-1})
Mymensingh						
SBM-09	106	84.3	2.2	58.2	1.97	2830
SBM-15	106	96.2	2.1	45.3	1.87	2790
SBM-17	106	88.3	2.1	59.6	1.94	2230
SBM-18	106	86.2	2.3	43.3	1.91	3080
SBM-20	108	94.3	2.5	48.1	1.82	2830
SBM-22	109	39.5	2.3	45.3	1.94	2840
SBM-23	108	86.2	2.8	46.3	1.91	2420
Binasoybean-1 (check)	113	81.6	1.9	42.6	2.18	2780
BARI Soybean-5 (check)	121	50.9	3.4	52.3	1.60	2580
$LSD_{0.05}$	4.27	12.27	0.95	7.95	0.54	417.1
Magura						
SBM-09	118	67.3	2.4	60.1	1.82	2380
SBM-15	116	74.2	2.3	52.2	1.99	2040
SBM-17	120	64.3	2.6	56.1	1.82	2030
SBM-18	120	67.3	2.1	59.3	2.10	2510
SBM-20	120	82.3	2.2	60.2	1.96	2450
SBM-22	123	77.8	2.1	56.3	1.95	2390
SBM-23	120	69.2	2.9	55.6	2.05	2230
Binasoybean-1 (check)	130	91.2	2.1	55.3	2.12	2210
BARI Soybean-5 (check)	122	66.3	3.4	85.3	1.89	2090
$LSD_{0.05}$	4.32	10.45	0.94	12.63	0.31	371.8
Noakhali						
SBM-09	135	63.1	4.5	61.8	1.85	3160
SBM-15	136	81.6	2.6	41.6	1.86	3010
SBM-17	138	63.6	3.6	51.6	1.85	2960
SBM-18	136	67.3	3.4	45.2	2.20	3160
SBM-20	136	90.3	3.8	54.2	2.10	2910
SBM-22	136	81.2	3.2	48.8	2.32	3250
SBM-23	138	69.2	3.3	52.3	1.89	3080
Binasoybean-1 (check)	141	96.3	2.9	40.6	2.10	2960
Binasoybean-2 (check)	138	35.8	4.1	35.8	2.10	2590
$LSD_{0.05}$	2.31	16.40	0.654	8.54	0.32	460.0

MUNGBEAN

On-farm trial of two promising mutants of mungbean

On-farm trials were carried out with two mutants along with two check varieties (Binamoog-8 and BARI Mung-6) at Magura, Ishurdi, Natore and Rajshahi during Kharif-1 season of 2012 to develop varieties with early maturity, higher seed yield and disease tolerance. Seeds were sown in RCB design with three replications. Unit plot size was 10 m × 8 m. Row to row and plant to plant distances were 40 cm and 10 cm, respectively. Data on days to maturity, plant height, pods plant^{-1}, pod length, seeds pod^{-1}, and seed yield per plot were recorded from five randomly selected plants from each plot. Plot seed yield was converted to kg ha^{-1}. Mean values were used for statistical analyses (Table 31).

Significant variation was observed among the mutant and check varieties for days to maturity and seed yield for all the locations. Results from mean over locations, the mutant MBM-07-3y-1 produced taller plant height than Binamoog-8 and BARI Mung-6. Both the mutants gave the almost similar number of pods plant^{-1} like check varieties. Both the check varieties produced the longest pod length. Mutant MBM-88 was found to be matured earlier than both check varieties. In respect of seed yield, Binamoog-8 produced the highest seed yield of 1794 kg ha^{-1} followed by MBM-07-3y-1 (1715 kg ha^{-1}). These MBM-88 and MBM-07-3y-1 mutant lines will be further evaluated in the next growing season at different locations.

Table 31. Performance of two elite lines along with the check varieties grown at four locations during 2012

Mutants/Varieties	Days to maturity	Plant height (cm)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Seed yield (kg ha^{-1})
Magura						
MBM-07-3y-1	70a	59.3a	21b	9.8b	12a	1625b
MBM-88	65b	45.2c	23a	8.2c	10b	1537d
Binamoog-8 (check)	65b	48.6c	21b	10.1a	13a	1691a
BARI Mung-6 (check)	69a	52.2b	20b	9.4b	13a	1575c
Ishurdi						
MBM-07-3y-1	71a	70.2a	22	9.7	13a	1838b
MBM-88	66b	44.5d	23	9.4	10b	1783c
Binamoog-8 (check)	66b	50.4c	23	9.8	13a	1904a
BARI Mung-6 (check)	69a	59.1b	20	9.9	12a	1783c
Natore						
MBM-07-3y-1	73a	51.4a	26a	8.1	12	1787b
MBM-88	63b	36.3c	25a	7.0	11	1779b
Binamoog-8 (check)	65b	45.5b	22b	8.3	11	1946a
BARI Mung-6 (check)	71a	51.8a	23b	8.9	11	1750b
Rajshahi						
MBM-07-3y-1	70a	65.6a	18	9.3	13	1608a
MBM-88	62b	46.3d	16	9.0	10	1479c
Binamoog-8 (check)	65ab	50.5c	18	10.3	13	1633a
BARI Mung-6 (check)	69a	60.7b	16	10.2	13	1546b
Average						
MBM-07-3y-1	71a	61.6a	22	9.2	13	1715b
MBM-88	64b	43.1c	22	8.4	10	1645c
Binamoog-8 (check)	65b	48.7c	21	9.6	13	1794a
BARI Mung-6 (check)	68ab	55.9b	20	9.6	12	1664c

*Same letters in a column do not differ significantly at 5% level.

Advanced yield trial of some promising mutants of mungbean

Advanced yield trials were carried out with 8 mutants along with two check varieties (Binamoog-5 and BARI Mung-6) at Mymensingh, Magura and Ishurdi during Kharif-1 season of 2012 to develop varieties with early maturity, higher seed yield and disease tolerance. Seeds were sown in RCB design with three replications. Unit plot size was 4 m × 5 m. Row to row and plant to plant distances were 40 cm and 10 cm, respectively. Recommended fertilizer doses were applied. Data on days to maturity, plant height, pods plant^{-1}, pod length, seeds/pod, and seed yield per plot were recorded from five randomly selected plants from each plot. Plot seed yield was converted to kg ha^{-1}. Mean values were subjected to statistical analyses.

The results of mean over locations for all the characters are presented in Table 32. It showed significant variation among all the mutants and check varieties. All the mutants produced shorter plant height than both check varieties. MBM-656-51(2) and MBM-657 produced the highest number of pods plant^{-1} as Binamoog-5 (check). Three mutants were found to be matured earlier (64-66 days) than other mutants and check varieties. In respect of seed yield, MBM-656-51(2) produced the highest seed yield (1692 kg ha^{-1}) followed by MBM-573-69 (1642 kg ha^{-1}) and MBM-477-60 (1601 kg ha^{-1}). Three mutants will be further evaluated for Zonal yield trial in next growing season at different locations.

Table 2. Mean performance of 8 mutant lines along with the check varieties grown at Mymensingh, Magura and Ishurdi during 2012

Varieties/mutants	Days to maturity	Plant height (cm)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Seed yield (kg ha^{-1})
Mymensingh						
MBM-508-67	73b	41.93	17	8.66	11.4	1280bc
MBM-477-60	68c	41.33	19	7.46	10.8	1313b
MBM-07 (yellow)	72b	40.66	18	7.90	10.8	1235c
MBM-656-51(2)	66c	38.6	21	7.20	10.6	1398a
MBM-573-69	66c	37.93	19	8.36	11.3	1355b
MBM-390-94 (yellow)	70bc	36.6	16	7.77	11.0	930f
MBM-346-13	70bc	35.1	16	8.87	10.8	1058e
MBM-657	68c	37.16	18	8.46	10.9	1183d
Binamoog-5 (check)	75a	44.16	20	8.93	11.0	1372a
BARI Mung-6 (check)	72b	41.73	18	8.87	10.8	1217c
Magura						
MBM-508-6	71a	39.50	18	8.73	11.9	1458d
MBM-477-60	69b	41.50	22	6.93	10.7	1648b
MBM-07 (yellow)	71a	40.53	17	7.97	10.8	1517c
MBM-656-51(2)	64c	35.20	22	6.90	9.9	1742a
MBM-573-69	65c	36.17	20	8.77	10.9	1683b
MBM-390-94 (yellow)	68b	35.00	22	7.47	11.0	1292f
MBM-346-13	69b	34.13	18	8.83	10.8	1313e
MBM-657	65c	36.00	21	8.83	11.2	1567c
Binamoog-5 (check)	72a	44.53	23	9.00	9.9	1482d
BARI Mung-6 (check)	71a	42.60	21	8.83	10.8	1483d

Table 32 Contd.

Varieties/mutants	Days to maturity	Plant height (cm)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Seed yield (kg ha^{-1})
Ishurdi						
MBM-508-67	72a	39.93	20	9.07	12.2	1602e
MBM-477-60	68b	44.27	25	6.77	11.1	1840b
MBM-07 (yellow)	74a	41.07	25	8.27	10.8	1620d
MBM-656-51(2)	63c	34.93	27	6.77	9.8	1935a
MBM-573-69	66bc	34.00	23	8.90	10.7	1888b
MBM-390-94 (yellow)	67bc	34.20	25	7.60	10.9	1738c
MBM-346-13	70b	34.60	22	9.23	10.7	1635d
MBM-657	65	34.53	29	9.23	11.0	1862b
Binamoog-5 (check)	75a	41.33	25	9.03	9.9	1790c
BARI Mung-6 (check)	73a	40.73	24	8.33	10.1	1620e
Average						
MBM-508-67	72a	40.46	18	8.82	11.8	1447d
MBM-477-60	68b	42.37	22	7.06	10.8	1601b
MBM-07 (yellow)	72a	40.76	20	8.04	10.8	1457d
MBM-656-51(2)	64c	36.24	23	6.96	10.1	1692a
MBM-573-69	66c	36.03	21	8.68	11.0	1642a
MBM-390-94 (yellow)	68b	35.27	21	7.61	11.0	1320e
MBM-346-13	70b	34.61	19	8.98	10.8	1336e
MBM-657	66c	35.90	23	8.84	11.0	1537c
Binamoog-5 (check)	74a	43.34	23	8.99	10.3	1548c
BARI Mung-6 (check)	72a	41.69	21	8.68	10.6	1440d

Growing of M_3 population of mungbean

M_3 variants developed from Binamoog-5 and BARI Mung-6 and all the variants were grown in plant-progeny-rows for selecting desirable mutants at Ishurdi sub-station farm during 2012. A total of 34 plants/lines have been selected for further selection in M_4 generation (Table 33).

Table 33. Mean performance of 34 mutant lines along with the check varieties grown at Ishurdi during 2012

Varieties/mutants	Days to maturity	Plant height (cm)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	100-seed wt. (g)	Seed yield plant^{-1} (g)
MBM-104-21	65	37.2	18	9.2	12	4.2	6.8
MBM-320-13(1)	72	39.4	16	7.8	11	3.9	7.0
MBM-94-3	71	56.1	15	8.0	11	3.2	5.4
MBM-110-12(5)	66	35.4	20	8.5	11	3.8	7.2
MBM-39-28	68	39.0	20	7.3	10	4.1	8.2
MBM-38-7(2)	67	36.7	18	7.8	11	3.4	5.8
MBM-90-3(1)	70	39.1	18	5.9	9	3.6	6.8
MBM-21-4(3)	71	35.5	23	7.3	11	4.1	7.8
MBM-74-14	70	40.1	20	7.0	10	3.3	5.8
MBM-527-114	73	40.3	18	8.0	11	4.5	5.8
MBM-427-37(3)	65	38.0	17	6.5	10	4.0	5.0
MBM-590-93	66	33.8	20	7.0	11	4.0	7.5
MBM-L-4(3)	68	38.6	15	6.7	11	4.8	7.0
MBM-28(1)	70	37.2	10	6.8	10	4.3	4.1
MBM-49-3(1)	70	57.1	20	7.1	10	4.0	8.0

Table 33 Contd.

Varieties/mutants	Days to maturity	Plant height (cm)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	100-seed wt. (g)	Seed yield plant^{-1} (g)
MBM-280-10	68	40.0	9	8.2	11	3.7	5.6
MBM-62-18	65	35.9	18	7.2	11	4.8	6.0
MBM-72-51(4)	68	40.5	11	7.3	10	4.1	7.5
MBM-201-3(1)	72	35.3	11	8.5	11	3.5	5.3
MBM-64-11(7)	70	38.5	23	7.8	11	4.0	6.9
MBM-84-9	68	41.2	18	9.0	12	4.0	8.0
MBM-79-11	65	35.9	22	7.5	10	4.3	4.8
MBM-87-7	71	38.5	22	8.1	11	4.5	8.0
MBM-108-12	66	35.6	12	8.0	11	4.7	4.7
MBM-234-1(3)	68	38.8	20	7.3	11	3.8	7.5
MBM-215-18(3)	67	39.2	13	9.0	12	3.5	5.0
MBM-234-18(7)	67	35.6	15	7.6	11	3.3	7.0
MBM-187-4(3)	67	39.5	15	6.5	11	4.8	5.5
MBM-201-6(5)	67	38.1	19	9.2	12	3.5	6.8
MBM-230-16	68	40.0	16	7.5	11	3.1	8.2
MBM-220-5(3)	68	41.6	20	8.5	11	3.5	7.5
MBM-175-13(1)	70	40.8	11	8.0	11	3.1	5.0
MBM-180-4(1)	70	38.9	18	9.5	12	3.6	7.1
MBM-39-4(1)	68	37.4	19	7.8	11	3.8	7.8
Binamoog-5 (check)	70	45.3	20	8.7	12	4.0	7.4
BARI Mung-6 (check)	69	41.2	18	8.8	12	4.2	7.3

Maintenance of germplasm lines of mungbean

Fifteen AVRDC germplasm were grown in the farm of BINA Head Quarters, Farm during 2012. Data on plant height, days to 50% flowering, days to maturity, pod length, number of pods plant^{-1}, number of seeds pod^{-1} and seed yield plant^{-1} were recorded from each genotypes (Table 34). At harvest, seeds of all these germplasm were collected and have been preserved as breeding materials for further evaluation.

Table 34. Agronomic performances of 15 mungbean germplasm of AVRDC

Germplasm	Plant height (cm)	Days to 50% flowering	Days to maturity	Pod length (cm)	pods plant^{-1} (no.)	seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield^{-1} plant (g)
AVRDC 01	45.0	43	72	9.20	22	10.0	3.5	5.30
AVRDC 02	37.2	45	72	8.20	17	10.8	5.1	4.47
AVRDC 03	32.0	46	79	7.60	19	7.4	4.4	2.26
AVRDC 04	37.0	45	75	9.60	17	11.6	6.2	3.03
AVRDC 05	39.6	44	74	6.20	19	10.2	4.3	5.84
AVRDC 06	48.4	42	66	10.60	17	9.4	4.3	5.60
AVRDC 07	36.8	43	71	6.20	22	10.4	5.5	4.04
AVRDC 08	32.2	47	78	6.00	16	8.8	3.5	4.03
AVRDC 09	37.2	42	67	8.80	18	9.2	3.5	5.60
AVRDC 10	32.4	45	78	6.80	14	6.1	3.6	2.23
AVRDC 11	36.8	40	65	6.60	18	8.8	5.1	5.52
AVRDC 12	35.6	45	70	6.40	19	7.0	4.4	5.30
AVRDC 13	30.2	43	70	5.40	21	6.2	2.8	5.85
AVRDC 14	34.4	40	68	5.60	12	6.8	4.8	3.90
AVRDC 15	39.4	42	70	6.60	11	7.2	3.3	4.82

CHICKPEA

On-farm trial of two promising mutant lines of chickpea

Two chickpea genotypes along with two check varieties (BARI sola-5 and Binasola-4) were grown in zonal yield trial at Nachole, Rajshahi, Ishurdi and Magura during 2011-2012. The main objective of this trial was to develop variety having large seed size and higher seed yield. The experiment was conducted in randomized complete block design with three replications. Unit plot size was 10 m × 8 m. Row to row and plant to plant distances were 40 and 15 cm, respectively. Data on plant height, days to maturity, plant height, primary branches, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight and seed yield were recorded. Data were analysed statistically (Table 35).

Table 35. Performance of two mutants along with 2 check varieties of chickpea for different characters during 2011-2012

Variety	Days to maturity	Plant height (cm)	Primary branches plant^{-1}	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield (kg ha^{-1})
Nachole							
P-70	119	60.5	3.4	49.9	1.1	24.2	1943
CPM-860	120	54.1	3.4	45.6	1.2	23.8	2073
BARI Sola-5 (check)	121	51.6	3.4	59.9	1.4	12.0	1562
Binasola-4 (check)	121	54.6	3.4	53.6	1.3	12.7	1570
$LSD_{(0.05)}$	0.98	2.52	2.11	12.20	0.78	0.97	158
Rajshahi							
P-70	120	72.6	3.8	83.0	1.0	25.9	2067
CPM-860	123	68.7	3.2	59.6	1.4	25.1	2185
BARI Sola-5 (check)	122	61.4	3.3	90.3	1.6	12.8	1685
Binasola-4 (check)	120	60.1	3.0	68.8	1.8	13.3	1615
$LSD_{(0.05)}$	0.34	3.56	1.21	10.79	0.96	0.89	136
Ishurdi							
P-70	117	41.8	4.7	37.4	1.4	25.2	1791
CPM-860	115	43.3	3.8	31.8	1.1	24.0	1655
BARI Sola-5 (check)	121	37.2	4.6	56.0	1.5	12.7	1562
Binasola-4 (check)	118	37.4	4.1	39.9	1.6	12.4	1545
$LSD_{(0.05)}$	0.25	3.66	0.88	4.22	0.53	0.81	123
Magura							
P-70	122	59.4	4.4	75.5	1.2	25.4	1955
CPM-860	120	55.8	4.0	68.1	1.1	25.0	1985
BARI Sola-5 (check)	120	49.0	4.2	84.0	1.4	12.9	1625
Binasola-4 (check)	121	51.8	4.2	59.8	1.1	13.3	1690
$LSD_{(0.05)}$	2.62	7.17	1.73	11.21	0.31	0.57	129
Average							
P-70	119	58.5	4.0	61.4	1.1	25.2	1939
CPM-860	119	55.5	3.6	51.3	1.5	24.5	1974
BARI Sola-5 (check)	121	49.8	3.9	72.5	1.5	12.6	1608
Binasola-4 (check)	120	51	3.6	55.5	1.5	12.9	1605
$LSD_{(0.05)}$	0.82	4.62	1.27	10.76	0.94	0.79	118

From combined analysis, both the genotypes matured earlier than the check varieties. The mutants P-70 and CPM-860 mutants/lines produced taller plant height than both check varieties. Both the genotypes had higher seed size (25.40 g and 25.03 g, respectively) than the check varieties BARI Sola-5 and Binasola-4. Large seeded chickpea gets higher consumer preferences in the market. CPM-860 produced the highest seed yield (1974 kg ha^{-1}) followed by P-70 (1939 kg ha^{-1}). Application will be made for these two genotypes to the National Seed Board for registration as varieties.

Growing of M_3 population of chickpea

Dry seeds of CPM-860, BARI Sola-4, Binasola-4, BARI Sola-5 and BARI Sola-7 were irradiated with different doses of gamma rays (200, 300 and 400 Gy). A total of 125 lines of CPM-860, BARI sola-7, BARI Sola-5, Binasola-4 and BARI Sola-4 were grown in plant progeny rows in M_3 generation for selecting true breeding lines of desirable mutants like high yield, early maturing, bolder seed size genotypes of chickpea at Godagari, Rajshahi. Plant height, days to maturity, no. of pods plant^{-1}, no. of seeds pod^{-1}, 100 seed wt. and seed yield plant^{-1} were recorded (Table 36). Among them 44 desirable mutants/lines were selected based on early maturity, bolder seed size and higher seed yield. All these mutants/lines need further evaluation in M_4 generation.

Table 36. Performance of M_3 mutants along with 5 parents of chickpea for different characters during 2011-2012

Variety/mutants	Days to maturity	Plant height (cm)	Primary branches plant^{-1}	Pods plant^{-1} (no.)	seeds pods^{-1} (no.)	100-seed weight (g)	Seed yield^{-1} plant (g)
CPM-860-2-1	117	40.9	6.4	55.2	1.4	23.18	9.8
CPM-860-3-2	115	42.5	5.4	45.2	2.4	22.25	10.2
CPM-860-3-4	109	44.9	4.4	25.4	1.2	26.67	9.7
CPM-860-4-1	112	43.4	6.0	62.4	1.4	23.25	9.0
CPM-860-4-2	116	45.3	6.2	5.4	1.4	23.86	10.3
CPM-860 (parent)	118	38.0	5.8	51.2	1.8	24.68	9.6
BARI Sola-7-2-1	114	33.7	5.6	67.0	1.6	11.31	7.1
BARI Sola-7 -2-2	114	34.2	5.2	44.0	1.8	11.25	7.5
BARI Sola-7-2-L-1	114	39.8	4.8	66.0	1.2	11.68	7.0
BARI Sola-7-3-1	117	31.6	4.2	53.8	2.0	11.85	6.0
BARI Sola-7-3-2	117	32.6	4.6	64.2	1.8	10.50	6.6
BARI Sola-7-3-3	117	29.6	4.4	49.8	1.4	10.85	4.8
BARI Sola-7-3-L-1	117	34.8	4.6	79.2	1.8	11.32	5.3
BARI Sola-7-4-1	117	31.0	4.4	63.6	1.0	10.80	7.5
BARI Sola-7-4-2	117	32.1	5.0	63.0	1.6	10.91	7.1
BARI Sola-7-4-2	117	32.0	4.6	37.8	1.4	12.31	7.0
BARI Sola-7-4-L-1	117	33.8	3.6	52.8	1.0	10.90	6.8
BARI Sola-7 (parent)	117	40.1	4.6	56.2	1.6	11.54	6.5
BARI Sola-5-2-1	120	35.6	4.4	42.2	1.6	11.68	8.0
BARI Sola-5- 2-2	120	32.9	5.4	68.8	1.4	10.97	7.8
BARI Sola-5- 2-3	120	33.4	4.8	55.4	1.2	10.98	8.5
BARI Sola-5-2-L-2	120	36.3	5.8	62.0	1.8	12.05	8.6
BARI Sola-5-2-L-3-1	116	37.0	4.0	50.8	1.2	11.16	5.8
BARI Sola-5-2-L-3-2	116	31.0	3.8	29.8	1.2	11.21	7.9

Table 36 Contd.

Variety/mutants	Days to maturity	Plant height (cm)	Primary branches plant^{-1}	Pods plant^{-1} (no.)	seeds pods^{-1} (no.)	100-seed weight (g)	Seed yield^{-1} plant (g)
BARI Sola-5-2-L-3-3	116	36.2	4.6	47.0	1.2	10.56	8.5
BARI Sola-5-4-1	116	31.2	3.4	16.6	1.2	12.16	7.0
BARI Sola-5-4-2	116	38.4	3.0	28.6	1.4	12.67	8.5
BARI Sola-5 (parent)	120	36.0	3.8	59.8	1.0	12.25	7.6
Binasola-4-2-1	117	49.2	3.2	83.0	1.8	1304	9.0
Binasola-4-2-2	117	37.0	5.5	77.8	1.6	12.34	9.2
Binasola-4-2-3	117	44.6	6.0	78.2	1.4	11.55	8.8
Binasola-4-2-L-1	117	41.0	5.4	72.4	1.8	12.36	8.5
Binasola-4-3-1	117	112.8	5.4	75.0	1.8	12.26	9.2
Binasola-4-3-2	117	42.2	6.4	78.8	1.8	12.08	9.1
Binasola-4-3-L-1	117	37.4	6.2	69.8	1.8	12.26	7.8
Binasola-4 (parent)	117	28.6	3.8	61.0	1.6	12.01	8.7
Binasola-4-3-3	117	32.8	2.8	71.8	1.4	12.36	8.5
Binasola-4-3-L-2	117	33.0	3.4	75.6	1.6	12.36	8.6
BARI Sola4 (parent)	117	38.6	5.6	68.2	1.4	11.90	6.7
BARI Sola-4-2-1	117	37.5	4.0	43.8	1.7	11.90	7.2
BARI Sola-4-2-L-1	117	33.2	5.0	45.0	1.8	11.92	5.0
BARI Sola-4-2-2	120	35.8	3.0	37.5	1.5	11.91	6.3
BARI Sola-4-2-3	115	31.6	2.6	29.8	1.6	12.90	7.8
BARI Sola-4-3-L-1	115	35.9	4.0	50.0	1.4	12.90	5.9
BARI Sola-4-4-1	116	37.7	3.6	50.8	2.6	12.90	7.0
BARI Sola-4-4-2	118	35.4	4.6	44.6	1.4	12.90	5.8
BARI Sola-4-4-L-1	120	38.8	4.2	41.8	1.4	12.90	8.2

Screening of Kabuli mutants of chickpea

Kabuli mutants were derived from Binasola-2 (parent) with gamma rays of 300 Gy. These mutants were grown for selecting desirable types. Selected plants/lines will be tested for Preliminary yield trial in the next growing season.

LENTIL

On station yield trial of four selected mutants of lentil

Four mutants along with a check variety, BARI Masur-4 were put into on station yield trial at Maugra and Ishurdi. The experiment was carried out in a randomized complete block design with three replications. Unit plot was 5 m × 4 m. Distances between rows and plants were 30 cm and 5-6 cm, respectively. Plant height, number of primary branches plant^{-1}, days to maturity, number of pods plant^{-1} and yield per plot were recorded from randomly selected 10 plants of each plot. Plot yield was converted to kg ha^{-1}. Statistical analysis of different characters of the mutants and check are presented in Table 36.

Results showed that significant variations were present in all the characters except number of primary branches plant^{-1}. It was observed from results that plant height ranged from 35.2 to 39.5 cm. The days to maturity ranged from 103 to 112 days for mutants while it was 112 days for mother variety of BARI Masur-4. The mutant LM-156-1 matured earlier among the mutants and the check. The mutant LM-123-7 produced the highest number of pods plant^{-1}. In Magura, mutant LM-123-7 produced significantly the highest seed yield (2061 kg ha^{-1}) followed by LM-28-2 and LM-156-1. At Ishurdi, mutants LM-123-7 produced the highest seed yield among the mutants and the check variety. But, the mutant LM-123-7 produced higher in average seed yield and number of pods plant^{-1} among the mutants and the check variety. The selected mutant lines LM-123-7 and LM-28-2 will be grown in the next year to assess their yield potential at different locations of Bangladesh.

Table 37. Mean of yield and yield contributing characters of the selected promising mutants grown at Magura and Ishurdi during 2011-12

Mutant/variety	Plant height (cm)	Branches plant^{-1} (no.)	Days to maturity	Pods plant^{-1} (no.)	Seed yield (kg ha^{-1})		Mean
					Magura	Ishurdi	
LM-156-1	35.7b	2.6NS	103c	158.0bc	1862b	1810b	1836b
LM-28-2	38.4a	2.6	108b	163.7b	1890b	1821b	1856b
LM-67-7	35.2b	3.0	110a	159.9bc	1823b	1815b	1819b
LM-123-7	39.5a	2.7	107b	184.5a	2061a	2005a	2033a
BARI Masur-4 (check)	38.0a	2.9	112a	150.9c	1565c	1500c	1533c

Same letters in a column do not differ significantly at 5% level.

Zonal yield trial for the selected mutants of lentil

Five mutants along with check variety, BARI Masur-4 were put into on station yield trial at Maugra and Ishurdi. The experiment was carried out in a randomized complete block design with three replications. Unit plot was 5 m × 4 m. Distances between rows and plants were 30 cm and 5-6 cm, respectively. Plant height, number of primary branches plant^{-1}, days to maturity, number of pods plant^{-1} and seed yield (kg ha^{-1}) were recorded from randomly selected 10 plants of each plot. Plot yield was converted to kg ha^{-1}. Statistical analysis of different characters of the mutants and check are presented in Table 38.

Results showed that significant variations were present in all the characters except number of primary branches plant^{-1}. It was observed from the results that plant height ranged from 35.4 to 42.6 cm. The days to maturity ranged from 105 to 113 days for mutants while it was 113 days for mother variety of BARI Masur-4. The mutant LM-24-3 matured earlier than both the mutants and the check variety. The mutant, LM-21-1, LM-24-3 and LM-14-2 produced higher number of pods plant^{-1}. In Magura, mutant LM-21-1 produced significantly the highest seed yield of 2100 kgha^{-1} followed by LM-24-3 and LM-14-2. At Ishurdi, mutants LM-21-1 produced the highest seed yield among the mutants and the check variety. But, the mutant LM-21-1 produced higher in average seed yield and number of pods plant^{-1} among the mutants and the check variety. The selected mutant lines of LM-121-1, LM-24-3 and LM-14-2 will be grown in the next year to assess their yield potential at different locations of Bangladesh.

Table 38. Mean of yield and yield contributing characters of the selected promising mutants grown at Magura and Ishurdi during 2011-12

Mutant/variety	Plant height (cm)	Branches plant^{-1} (no.)	Days to maturity	Pods plant^{-1} (no.)	Seed yield (kg ha^{-1})		Mean
					Magura	Ishurdi	
LM-21-1	42.6a	2.6NS	106c	196.2a	2100a	2010a	2055a
LM-101-8	36.4b	2.5	110ab	162.2bc	1790cd	1801b	1796c
LM-48-1	42.0a	2.5	109ab	168.8b	1911bc	1890ab	1901bc
LM-24-3	36.8b	2.3	105c	195.6a	2090a	1990a	2040a
LM-14-2	35.4b	2.5	108bc	193.0a	2070ab	1925ab	1998ab
BARI Masur-4 (check)	37.0b	2.7	113a	154.0c	1545d	1510c	1528d

Same letters in a column do not differ significantly at 5% level.

Advanced yield trial for the selected mutants of lentil

Six mutants along with the check variety, BARI Masur-4 were put into an advanced yield trial at Magura and Ishurdi. The experiment was carried out in a randomized complete block design with three replications. Unit plot was 4 m × 3 m. Distances between rows and plants were 30 cm and 5-6 cm, respectively. Plant height, number of primary branches plant^{-1}, days to maturity, number of pods plant^{-1} and seed yield (kg ha^{-1}) were recorded from randomly selected 10 plants of each plot. Plot yield was converted to kg ha^{-1}. Statistical analysis of different characters of the mutants and check are presented in Table 39.

Table 39. Mean of yield and yield contributing characters of the selected promising mutants grown at Magura and Ishurdi during 2011-12

Mutant/variety	Plant height (cm)	Branches plant^{-1} (no.)	Days to maturity	Pods plant^{-1} (no.)	Seed yield (kg ha^{-1})		Mean
					Magura	Ishurdi	
LM-93-3	37.8b	2.9NS	109b	171.1b	1894a	1825ab	1860ab
LM-37-8	43.8a	2.7	107c	138.9de	1690bc	1640c	1665bc
LM-20-3	41.5ab	2.7	105c	128.4e	1564bc	1535c	1550c
LM-13-1	39.8ab	2.8	110b	194.3a	1990a	1910a	1950a
LM-15-9	41.8ab	2.6	112ab	190.0ab	1904a	1894a	1899ab
LM-99-4	41.9ab	2.7	113ab	156.0bc	1800ab	1808b	1804ab
BARI Masur-4 (check)	41.5ab	2.8	116a	148.4cd	1485c	1464c	1475c

Same letters in a column do not differ significantly at 5% level.

Results showed that significant variations were present in all the characters except number of primary branches plant^{-1}. It was observed from results that plant height ranged from 37.8 to 43.8 cm. The days to maturity ranged from 105 to 116 days for mutants while it was 116 days for mother variety BARI Masur-4. The mutant LM-20-3 matured earlier than the check variety BARI Masur-4. The mutants LM-13-1 and LM-15-9 produced higher number of pods plant^{-1} than the mutants and check. At Magura, mutant LM-13-1 produced significantly the highest seed yield of 1990 kg ha^{-1} followed by LM-15-9 among the mutants and the check variety. At Ishurdi, the mutant LM-13-1 produced the highest seed yield at all the locations. But, in average the mutants LM-13-1 produced significantly the highest seed yield of 1950 kg ha^{-1}. Out of 6 mutants, two showed promising in respect of number of pods plant^{-1} and seed yield. The selected mutant lines of LM-13-1 and LM-15-9 will be grown in the next year to assess their yield potential at different locations of Bangladesh.

On-farm yield trial of three mutants and a check variety of lentil

Trials on three promising lentil mutants along with a check variety were conducted at Natore, Ishurdi, Magura and Jessore during 2011-12 in order to assess the performance of those mutants at farmer's field. The mutants were LM-185-2, LM-75-4, LM-132-7 and BARI Masur-4 (check). Each trial was conducted in non-replicated field of 10 m × 10 m. Seeds were sown @ 35 kg ha^{-1} in lines with 30 cm distance between rows. Data on days to maturity and yield $kgha^{-1}$ were recorded from each trial and are summarized in Tables 40a and 40b.

The duration and yield of lentil mutants/variety ranged from 98-110 days and 2499-1959 $kgha^{-1}$, respectively at Magura of which the mutant LM-75-4 produced highest yield (2499 kg ha^{-1}) than the remaining mutant and check variety. The mutant LM-75-4 matured earlier by 9-12 days than the check variety, while at Jessore the mutant LM-75-4 produced highest yield (2390 kg ha^{-1}) followed by the mutant LM-132-7. At Natore and Ishurdi, mutants LM-75-4 and LM-132-7 produced higher seed yield than the check variety. The duration of LM-185-2 ranged from 104-110 days and that of LM-75-4, LM-132-7 and BARI Masur-4, 98-104 days, 102-105 days and 111-116 days over the locations with mean 107 days, 101 days, 103 day and 114 days, respectively. Yield ranged from 1998-2185 kg ha^{-1}, 2175-2499 kg ha^{-1}, 2130-2312 $kgha^{-1}$, and 1612-2124 kg ha^{-1}, in the mutants LM-185-2, LM-75-4, LM-132-7 and BARI Masur-4, yield over all locations 2058, 2315, 2221 and 1881 $kgha^{-1}$, respectively.

Table 40a. Mean of days to maturity of three mutants and a check variety of lentil at four locations during 2011-2012 (average of four locations)

Mutant/lines	Natore	Ishurdi	Magura	Jessore	Average
LM-185-2	110b	109b	105b	104b	107b
LM-75-4	104c	102c	98c	99c	101c
LM-132-7	105c	104c	99c	102c	103c
BARI Masur-4 (check)	116a	115a	111a	113a	114a

Same letters in a column do not differ significantly at 5% level.

Table 40b. Mean of yield of three mutants and a check variety of lentil at four locations during 2011-2012 (average of four locations)

Mutant/lines	Natore	Ishurdi	Magura	Jessore	Average
LM-185-2	2089b	1998ab	2185b	1959b	2058b
LM-75-4	2198a	2175a	2499a	2390a	2315a
LM-132-7	2145a	2130b	2312a	2296a	2221ab
BARI Masur-4 (check)	1890c	1612c	2124b	1899b	1881c

Same letters in a column do not differ significantly at 5% level.

Evaluation of ICARDA lines of lentil

Seeds of 7 genotypes along with one check variety, BARI masur-4 were put into yield trial at Magura and Ishurdi. The experiment was carried out in a randomized complete block design with three replications. Unit plot was 3 m × 1.2 m. Distances between rows and plants were 30 cm and 5-6 cm, respectively. Plant height, number of primary branches/plant, days to maturity, number of pods $plant^{-1}$ and seed yield (kg ha^{-1}) were recorded from randomly selected 10 plants of each plot. Plot yield was converted to kg ha^{-1}. Statistical analysis of different characters of the mutants and check are presented in Table 41.

Results showed that significant variations were present in all the characters except plant height and number of primary branches plant^{-1} (Table 41). It was observed from results that plant height ranged from 36.3 to 42.3 cm. The days to maturity ranged from 107 to 113 days for genotypes while it was 113 days for check variety BARI Masur-4. The genotype ICA-23105 produced significantly the highest pods plant^{-1}. Yield of the genotype ICA-23105 was the highest at Magura with significant difference from the reminder genotypes including BARI Masur-4. At Ishurdi, ICA-23105 had significantly in different yield despite having significant difference with the others. In average over two locations, the genotype ICA-38105 had the highest seed yield followed by ICA-23128. Out of seven genotypes, two genotypes showed promising in respect of number of pods plant^{-1} and seed yield. The selected lines of ICA-38105 and ICA-23128 will be grown in the next year to assess their yield potential at different locations of Bangladesh.

Table 41. Mean of yield and yield contributing characters of ICARDA lines of lentil grown at Magura and Ishurdi during 2011-12

Lines/variety	Plant height^{-1} (cm)	Branch plant^{-1} (no.)	Days to maturity	Pods plant^{-1} (no.)	Seed yield (kg ha^{-1})		Mean
					Magura	Ishurdi	
ICA-23118	42.0a	2.7NS	108b	173.6ab	1863a	1797ab	1830ab
ICA-23126	42.1a	2.4	107b	171.7ab	1773ab	1698b	1736b
ICA-23136	38.1ab	2.7	110ab	172.3ab	1805ab	1788ab	1797b
ICA-23121	41.0a	2.5	110ab	173.8ab	1816ab	1770b	1793b
ICA-23129	36.3b	2.5	112a	154.8bc	1387c	1446c	1417c
ICA-23105	39.0ab	2.5	110ab	183.6a	1897a	1839a	1868a
ICA-23128	42.3a	2.0	111a	165.3b	1853a	1799ab	1826ab
BARI Masur-4 (check)	37.2b	2.5	113a	140.7dc	1498c	1485c	1492c

Same letters in a column do not differ significantly at 5% level.

Zonal yield trial of some promising lines of lentil

The zonal yield trials were conducted with three entries along with a check variety, BARI Masur-5 at Jessore, Magura and Ishurdi during 2011-12. Seeds were sown in randomized complete block design with three replications. Unit plot size was 5 m × 4 m with 30 cm row to row distance. Recommended cultural practices were done. Data on days to maturity, plant height, number of primary branches, pods plant^{-1}, and seed yield plot^{-1} were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kg ha^{-1}. Statistical analysis of different characters of the accessions and the check are presented in the Table 42.

Table 42. Mean of yield and yield contributing characters of three promising accessions and a check variety BARI Masur-5 during 2011-12 at two locations Ishurdi and Magura

Accession/variety	Plant height (cm)	Primary branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Maturity (days)	Seed yield (kg ha^{-1})			
					Ishurdi	Magura	Jessore	combined
217	41.7a	3.3a	165.4a	118a	1975a	1962a	1769a	1902a
209	37.1c	2.1c	112.1c	117a	1233c	1777ab	1462b	1490b
208	39.3b	3.0b	132.2b	113b	1890a	1837ab	1750a	1825a
BARI Masur-5 (Check)	40.0b	2.8b	103.7c	119a	1483b	1592b	1293b	1456b

Same letter(s) in a column did not differ significantly at 5% level.

Results revealed that all the characters showed significant variation among the accessions and the check (Table 42). The accession 217 attained the tallest plant height, produced the highest number of primary branches as well as the highest number of pods plant^{-1}. This accession 217 also produced the highest seed yield (1975, 1962, 1769 kg ha^{-1}) at all three locations, Ishurdi, Magura and Jessore followed by the accession 208 (1890, 1837 and 1750 kg ha^{-1}) which were statistically identical. Accession 208 was the earliest for maturity period (113 days) among the check (119 days) and other accessions (118 and 117 days, respectively).

Advanced yield trials of some promising lines of lentil

An advanced yield trial was carried out with seven lines and a check variety BARI Masur-5 at two locations, BINA sub-station farm, Ishurdi and Magura during 2011-12. Seeds were sown in randomized complete block design with three replications. Unit plot size was 4 m × 3 m with 30 cm row to row distance. Recommended cultural practices were done. Data on days to maturity, plant height, number of primary branches, pods plant^{-1} and seed yield plot^{-1} were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kg ha^{-1}. Statistical analysis of different characters of the lines and the check are presented in the Table 43.

Table 43. Mean of yield and yield contributing characters of seven promising lines and a check variety BARI masur-5 during 2011-12 at two locations Ishurdi and Magura

Strains	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Maturity (days)	Yield (kg ha^{-1})			
					Ishurdi	Magura	Combined	Yield increased (%)
207	34.6c	2.7bc	104cd	116bc	1417c	1466cd	1441cd	10
202	35.6c	2.5bc	134ab	118a	1300c	1444cd	1372d	10
203	35.0c	2.4c	89d	115c	1383c	1666bc	1524c	20
204	41.2a	2.6bc	102cd	117ab	1300c	1190d	1245d	-
205	38.8ab	2.9ab	126ab	115c	1717b	1844ab	1780b	28
206	41.1a	3.3a	142a	116abc	2050a	2089a	2069a	36
9	38.5b	2.3c	94cd	113d	1300c	1244d	1272d	-
BARI Masur-5	39.8ab	2.6bc	114bc	117ab	1383c	1253d	1318d	

Means followed by same letter in a column did not differ significantly at 5% level.

Results revealed that there were significant differences among the tested lines and check for all the characters. Lines 203, 205 and 9 matured earlier than the check and the other lines. Regarding plant height, 204 and 206 were the tallest. The highest number of branches and pods plant^{-1} were observed in lines 205 and 206. The seed yield of two locations showed that the lines 206 and 205 produced the highest seed yield of 2050 and 1717 kg ha^{-1} at Ishurdi and 2089 and 1844 kg ha^{-1} at Magura. The average seed yield over two locations was also highest for two lines 206 and 205 and the seed yield was increased by 36% and 28%, respectively.

Growing of M_3 generation

To create variability three selected germplasm 118, 138 and 135 along with a popular variety BARI Masur-5 were irradiated with 100, 150, 200 and 250 Gy of gamma rays. A total of 50 M_1 plants were harvested from two doses, 150 and 100 Gy. Pod and seed were not formed in two doses, 200 and 250 Gy. Seeds of selected 38 M_2 plants were grown in plant-progeny-rows at Magura sub-station along with the mother lines/variety. Each row was 2 m long with 30 cm row to row distance. Recommended cultural practices were done. Seeds of the selected 13 M_3 plants were harvested separately to grow M_4 population.

Table 44. Mean values of different characters of the selected M_3 mutants of lentil during 2011-12

Strains and radiation dose	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Maturity (days)	Yield plant^{-1} (g)
150 Gy					
137-1-10	32.1	2.0	65	105	0.89
137-2-10	37.5	3.6	70	102	0.9
137-5-10	37.1	4.0	85	101	1.2
138-1-10	40.5	1.9	50	102	0.8
118-1-10	42.0	2.6	65	107	0.89
118-5-10	44.1	2.8	60	106	0.85
118-8-10	47.2	2.5	66	108	0.9
118-9-10	48.1	3.0	51	106	0.8
BARI Masur-5-1-10	38.5	2.2	40	108	0.7
100 Gy					
137-4-10	36.1	2.5	50	102	0.8
138-1-10	30.1	1.7	35	106	0.6
138-2	32.1	1.9	45	105	0.7
137 (mother)	40.1	2.0	33	108	0.7
138 (mother)	36.3	3.0	31	110	0.6
118 (mother)	42.1	3.0	28	112	0.5
BARI Masur-5 (mother)	40.0	3.0	40	112	0.6
Range	32.1-48.1	2-4	28-85	101-112	0.5-1.2

TOMATO

Zonal yield trial of a promising winter mutant (M_8) line

Only one promising winter mutant line (TM-110) along with two checks varieties (Binatomato-5 and BARI Tomato-7) at BINA sub-station- Ishurdi, Magura, Rangpur and BINA HQ. during the winter 2011-12. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Unit plot size was 5 m × 4 m and as a result the area of each plot was 20 m^2 having 50 cm spacing for both row to row and plant to plant as well. Recommended production packages such as-application of manures and fertilizers, weeding, mulching, irrigation, application of fungicide and insecticide and sticking etc. were followed as and when necessary to ensure normal plant growth and development.

Data were taken for plant height, days to 90% fruit ripening, number of fruits plant^{-1}, average fruit weight from 10 randomly selected plants from each harvest in an unit plot. Fruit yield of each plot was recorded for each harvest in kg and finally converted into t ha^{-1}. There in no data gathered from Magura due to extremely less fruit setting after vegetative growth.

The collected row data for all the parameters were compiled for analysis so as to get concluding remarks. The mean values for different characters of mutant and as well as checks are presented in Table 45. The results showed significant variation among the mutant and check varieties for all the concerned characters.

On an average, check variety BARI Tomato-7 produced the tallest plant (85.1 cm) having the longest maturity period of 113 days, lowest number of fruits per plant (19) and inversely the larger fruit size (93.0 g fruit^{-1}) and as well as gave the highest fruit yield (69.21 t ha^{-1}) for combined over three locations.

On the other hand, TM-110 had the shortest plant height of 71.53 cm along with lowest maturity period (103 days) having the highest number of fruits (32.67 plant^{-1}) with smallest fruit size (53.33 g fruit^{-1}) and finally produced the average fruit yield of 64.2 t ha^{-1}. Considering yield and yield attributing characters the winter mutant TM-110 was not significantly higher than two of the check varieties.

Table 45. Mean of important characters and fruit yield of the mutant along with check varieties over two locations during winter in 2011-12

Mutant lines/ check	Plant height (cm)	Days to 90% fruit ripening	No. of fruits plant^{-1}	Av. fruit weight (g)	Fruit yield (t ha^{-1})			Av. fruit yield (t ha^{-1})
					BINA Hq.	Ishurdi	Rangpur	
TM-110	71.5c	103b	32.7a	53.3c	65.6ab	64.1b	64.2ab	64.2ab
Binatomato-5	78.9b	107b	23.3b	81.3b	66.3a	69.1a	53.9b	61.1b
BARI Tomato-7	85.1a	113a	19.0b	93.0a	64.7b	66.6ab	71.8a	69.2a

Preliminary yield trial of promising mutants of winter tomato in BINA headquarter, Mymensingh

The experiment was conducted with two promising mutant lines along with three check varieties in BINA farm, Mymensingh during late winter in 2011-12. Twenty eight days old seedlings were transplanted into the main field. The experiment was laid out in a randomized complete block design with three replications. The area of unit plot size was 20 m^2 (5 m × 4 m). Spacing for both row to row and plant to plant within the rows was 50 cm. Recommended doses of manures and fertilizers, cultural and intercultural operations were followed as and when necessitated. Before flowering stages, sticking were put down in each plant individually.

Data on different parameters within the mutants were recorded at vegetative, reproductive and ripening stages as well from 10 randomly selected plants. Apart from this, data on average fruit weight, number of fruits plant^{-1} and fruit yield per plot were collected from each harvest. And finally, fruit yield of each plot (up to last harvest) was converted into t ha^{-1}. The mean performances of five lines/varieties regarding the parameters are presented in Table 46.

Table 46. Mean of important characters and fruit yield of promising lines along with check varieties

Mutants/varieties	Plant height (cm)	Days to 90% fruit ripening	Fruits plant^{-1} (no.)	Average fruit weight (g)	Fruit yield plant^{-1} (kg)	Yield (t ha^{-1})
TM-110	70.7e	101c	25.0a	53.3e	1.3c	50.6b
TM-219	80.3d	114a	23.0ab	81.0c	1.8ab	66.6ab
BARI Tomato-3	114.3a	114a	18.7b	94.7b	1.8ab	66.6ab
Binatomato-5	92.8c	109b	21.7ab	70.0d	1.4bc	51.8b
BARI Tomato-14	103.7b	116a	19.3b	114.3a	2.1a	77.7a

From the mean results it showed that TM-110 had the shortest plant having early maturing behaviour among all the entries followed by TM-219 while BARI Tomato-3 had the tallest plant with the longest maturity period of 114 days (Table 46. TM-110 also produced the highest number of fruits per plant (25 plant^{-1}) as compared to others though it had a smallest fruit size of 53.3 g fruit^{-1}. As considered the fruit yield and also total yield per hectare, there was non-significant difference in between two mutants. Check varieties, BARI Tomato-14 and Binatomato-5 produced fruit yield of 77.7 t ha^{-1} and 66.6 t ha^{-1} respectively.

It will be noticed that during the last three years the mutant TM-219 also performed better in respect of fruit yield in the growing season of late winter and also in summer season with the help polythene cover. Application will be made soon to NSB for registration of this mutant.

On-farm and on-station trial of two promising summer M_7 mutant lines

Two promising mutant lines along with two check varieties were put into trial in BINA HQ farm, sub-stations at Magura and Rangpur, BINA annex farm, Jamalpur and farmers' field at Magura and Rangpur in late summer (Nov 2011-July 2012). The experiment was laid out in a RCBD with three replications. Unit plot size was 6 m^2 (3 m × 2 m). Spacing in row to row was 40 cm and plant to plant was 40 cm. Seeds were sown in the last week of October. Recommended production packages like application of recommended doses of fertilizers, weeding, mulching, regular irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data were taken for plant height, 90% fruit maturity, number of fruits plant^{-1} and average fruit weight from 5 randomly selected plants from each plot. Maturity period was considered when 90% fruits were matured and most of the plants turned into straw or yellowish color in whole plot. Experiment conducted at BINA farm and in the farmers' field at Magura had uneven and incomplete due to extreme temperature at beginning stage and excessive rainfall in later stage and thus no outcome from these locations. Therefore, results of these locations are not included in this report. Appropriate statistical analysis was performed for comparison of means of each parameter for the locations of Magura, Rangpur and Jamalpur which is shown in Tableb 47.

The mean values for different characters of the mutants and check varieties are presented in Table 47. The results showed significant variation among the mutants and the check varieties for most of the characters.

Table 47. Mean performance of important characters and fruit yield of promising lines along with check varieties

Mutant lines/ check	Plant height (cm)	Fruits plant^{-1} (no.)	Days to 90% fruit ripening	Av. fruit weight (g)	Fruit yield (t ha^{-1})			Av.fruit yield (t ha^{-1})
					Rangpur	Magura	Jamalpur	
TM-134	83.6b	11c	80b	55b	28.3c	19.8b	19.7b	22.6c
TM-219	90.8a	15b	80b	60a	27.4c	25.2ab	45.4a	32.3a
Binatomato-3	84.5b	15b	68d	40d	37.9a	9.2c	22.2b	2.1c
BARI Tomato-5	88.2a	20a	83a	38e	33.3b	27.8a	21.4b	27.5b

On an average, TM-219 produced the tallest plant (90.8 cm) followed by the check variety BARItomato-5 of 88.2 cm. In addition to that BARItomato-5 produced higher number of fruits per plant (20 $plant^{-1}$) having the longest maturity period (83 days) having the lowest average fruit weight of 38 g. As TM-219 had the larger fruit size and thus it produced highest fruit yield in context of 3 locations among all the entries.

On the other hand, the results revealed that considering of three locations among the mutant lines and check; TM-134 had the shortest plant height of 83.6 cm while TM-219 and Baritomato-5 had the tallest plants with longest maturity period (90% fruit maturity). Between two (TM-134 and TM-219) lines there was a significant yield difference considering all locations (TM-134 22.6 t ha^{-1} while TM-219 32.3 tha^{-1}).

Growing of M_2 generation with AVRDC mutants

Some lines of AVRDC and Taiwan has been grown at BINA HQ. farm and Rangpur substation. Among all these entries TM-1, TM-2, TM-3, TM-4 and TM-5 were heat tolerant and thus grown better in summer and late winter. Their detailed study summarized hereafter. Currently some of these lines are exclusive in field condition which needs to take care in intensive manner for the next years.

Table 48. A detailed study of AVRDC tomato lines

Sl. No.	Full Accession Name	BINA Code	General description
1.	CL5915-93D4-1-0-3	TM-1	Dwarf plant, broader leaf with deep green color, fruit shape-round, less infected in Tomato mosaic virus (TMV), globe fruit shape
2.	CLN2413R	TM-2	Long plant height with broader leaf, fruit surface ridged
3.	CLN2418A	TM-3	Dwarf plant, green leaf, smaller fruit with round shaped, light insect infestation was found.
4.	CLN2001A	TM-4	Deep green leaf with round shape, fruit size also round, medium plant height
5.	CLN1621L	TM-5	Light green leaf, elongated fruit, huge nos. and cluster flowering
6.	CLN3125O (AVTOV 1004)	TM-6	Completely round fruit shape, comparatively less no. of fruit in each plant, infected in Tomato mosaic virus (TMV)
7.	CLN3125P (AVTOV 1005)	TM-7	Long plant and elongated fruit shape
8.	CLN3078A (AVTOV 1007)	TM-8	Dwarf plant, pale green leaf color, round and smaller fruit size
9.	CLN3078C (AVTOV 1008)	TM-9	Dwarf plant, pale green leaf color, round and smaller fruit size
10.	CLN3078G (AVTOV 1009)	TM-10	Long plant height with deep green color of leaf, Larger fruit size with round shaped
11.	CLN3070J (AVTOV 1010)	TM-11	Dwarf plant, elongated fruit shape
12.	CLN3125A (AVTOV 1001)	TM-12	Dwarf plant, Leaf infected and curled, wavy fruit shape
13.	CLN3125L (AVTOV 1003)	TM-13	Dwarf plant, light green leaf, heavy branching elongated fruit, huge nos. and cluster bearing habit
14.	CLN3024A	TM-14	Dwarf plant, light green leaf, elongated smaller fruit, huge nos. and cluster bearing habit, Less infected up to harvest
15.	CLN3070A	TM-15	Comparatively more dwarf plant, Round fruit shape, comparatively less no. of fruit in each plant
16.	4 TOM 031	TM-17	Long plant height with deep green color of leaf, Larger fruit size with round shaped
17.	4 TOM 021 (Cherry)	TM-19	Cherry type tomato, long plant, huge flowering with alternate bearing habit, deep green leaves, consecutive fruit setting
18.	Juliet 1437 (Cherry)	TM-20	Cherry type tomato, long plant, huge flowering with alternate bearing habit, deep green leaves, consecutive fruit setting

Note: Within bracket i.e. AVTOV. From Sl. No. 6-13 indicates new code by AVRDC.

ONION

Preliminary yield trial with M_5 mutant lines of summer onion for bulb yield potential in Kharif, 2011 season

Seeds of seven M_5 mutant lines that produced enough seeds and had comparatively better bulb yield potentials in last winter season were sown on 15 June for Ishurdi and that of Magura on 15 July 2011 in steel tray at BINA glass house and office yard, respectively. The parent variety, BARI Piaj-2 was also included in this experiment. Seedlings were transplanted on 23 August 2011 at Ishurdi and 15 September at Magura following RCBD with 3 replications. A unit plot size was 1.2 m × 0.8 m and 2.4 m × 0.8 m at Ishurdi and Magura locations, respectively. Plants were spaced at 15 cm within rows of 20 cm apart. Recommended doses of cowdung and fertilizers were applied during final land preparation and after 20 days of transplanting. Data on plant height and bulb diameter were recorded from randomly selected five competitive plants and yield from the whole $plot^{-1}$ were recorded at harvest. Yield $plot^{-1}$ was then converted to yield ha^{-1}. We know onion is a biennial crop completes vegetative growth in first year and reproductive growth in the following year. As the onion in the experiment at Magura received favorable conditions for flowering just at the time of bulb maturity, they switched over to reproductive phase. When onion starts to flower the previously formed bulbs split and become inconsumable. Considering all these, no bulb was harvested rather left for seed production. During seed harvest, non replicated data on total number of plants, seed yield $plant^{-1}$ and seed yield $plot^{-1}$ were recorded. Finally, the collected data were subjected to proper statistical analyses and are presented in Tables 49 and 50.

It appears that plant height of the mutant lines did not differ significantly with the parent BARI Piaj-2 and even amongst themselves (Table 49). In contrast, bulb diameter, the most important yield attributes in onion showed significant differences. The mutant line BP2/75/13 had the widest diameter followed by the parent BARI Piaj-2 showing no significant difference with each other. Like bulb diameter, bulb yield was the highest in BP2/75/13 followed by the parent BARI Piaj-2. This means the more the bulb diameter the more will be the bulb yield.

Table 49. Bulb yield and yield attributes of some mutant lines of summer onion in Kharif season, 2011

Mutant lines/varieties	Plant height (cm)	Bulb diameter (cm)	Bulb yield (kg ha^{-1})
BP2/75/2	13.78	4.70	2913.19
BP2/75/5	12.97	4.27	899.31
BP2/75/6	14.50	4.20	2288.19
BP2/75/13	13.38	5.30	3881.94
BP2/100/1	13.33	4.77	3079.86
BP2/100/12	15.50	4.32	913.19
BP2/75/3	12.30	4.80	2017.36
BARI Piaj-2	13.87	5.03	3854.17
$LSD_{(0.05)}$	NS	0.58	603.78

NS = not significant

The parent, BARI Piaj-2 and the mutant BP2/75/2 could not produce any seed despite the seed yield of the remainder mutant lines ranged 0.63 to 4.0 g plant^{-1} with BP2/100/12 being the highest and BP2/100/2 the least (Table 50). The highest seed yield ha^{-1} was produced by the mutant BP2/75/5 followed by BP2/75/13. The mutant BP2/75/13 also produced the highest bulb yield ha^{-1} and had the widest bulb diameter (Table 49).

Table 50. Seed yield of some mutant lines of summer onion at Magura in 2011-12

Mutant lines/varieties	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})
BP2/75/2	0.00	0.00
BP2/75/5	2.05	67.71
BP2/75/6	1.00	12.15
BP2/75/13	1.57	38.19
BP2/100/1	2.25	15.63
BP2/100/12	4.00	34.72
BP2/100/2	0.63	32.99
BARI Piaj-2	0.00	0.00
SE±	0.47	8.08

Preliminary yield trial with M_5 mutant lines of summer onion for bulb yield potential in winter and M_6 seed production

This experiment performed with 13 M_5 mutant lines of onion derived by irradiating the seeds of summer type BARI Piaj-2 to assess bulb yield potential in winter. Seeds were sown on 26 October 2011 at BINA farm, Mymensingh. Seedlings were transplanted on 14 December 2011 at BINA farm, Mymensingh and 18 December 2011 at BINA sub-station farm, Rangpur following RCBD with 3 replications. The summer variety BARI Piaj-3 was also included in this experiment. For seed production, seedlings of 26 M_5 mutant lines together with the parent BARI Piaj-2 were transplanted on 19 December 2011 at BINA sub-station farm, Ishurdi following non-replicated design. A unit plot size of 2.0 m × 0.6 m was used at Mymensingh while 1.8 m × 0.4 m at Rangpur. For seed production, unit plot sizes ranged 2 to 34 rows of 1.5 m length. Plants were spaced at 15 cm within rows of 20 cm apart. Recommended doses of cow dung and fertilizers were applied together with recommended cultural and intercultural practices for seed and bulb productions for the respective experiments. Data on plant height and bulb diameter were recorded from 5 plants while fresh bulb weight from whole plot at harvest. Dry weight was recorded after sun drying for one month. Fresh and dry weight of bulb was finally converted to kg ha^{-1}. Moreover, data on total and flowering plants, seed yield plant^{-1} from randomly selected 10 competitive plants seed yield and plot^{-1} were recorded during harvest from the experiment set for M_6 seed production. Finally, number of flowering plants were converted to percentage and that of seed yield plot^{-1} to yield ha^{-1} and subjected to proper statistical analyses and are presented in Tables 51, 52 and 53.

Table 51. Bulb yield and related traits of 13 mutant lines of summer onion during winter season of 2011-12 at Rangpur including weight loss on storage

Mutant lines/varieties	Plant height (cm)	Bulb diameter (cm)	Fresh weight of bulb (kg ha^{-1})	Dry weight of bulb (kg ha^{-1})	Rate of weight loss (%)
BP2/75/5	28.80	12.40	6388.89	5115.74	18.02
BP2/125/5	20.67	10.27	3148.15	2500.00	20.77
BP2/100/1	26.40	12.00	7638.89	5717.59	25.32
BP2/75/12	21.47	11.40	3287.04	2152.78	13.80
BP2/75/3	26.00	11.40	5092.59	3009.26	39.88
BP2/100/5	27.27	11.07	6851.85	5694.44	19.21
BP2/75/2	27.27	12.40	7638.89	5601.85	23.50
BP2/75/13	26.07	11.67	5694.44	3703.70	39.03
BP2/100/2	28.73	12.33	6157.41	5416.67	14.16
BP2/75/11	28.60	12.67	3425.93	3055.56	11.17
BP2/125/1	28.67	12.93	7222.22	6157.41	14.74
BP2/75/6	25.73	11.87	5138.89	4606.48	10.23
BARI Piaj-3	28.73	13.20	5324.07	4629.63	24.06
$LSD_{(0.05)}$	NS	NS	677.02	661.97	3.51

NS= Not significant

It appears that the plant height and bulb diameter of the mutant lines grown at Rangpur had not shown significant difference with the check variety, BARI Piaj-3, and also amongst themselves (Table 51). In contrast, fresh and dry weights of bulb had shown such significant differences. Six mutant lines had significantly higher fresh weight of bulb than the check variety with BP2/75/2 and BP2/100/1 being the highest followed by BP2/125/1 and BP2/100/5. In contrast, 5 mutant lines had significantly higher dry weight of bulb with BP2/125/1 being the highest followed by BP2/100/1. The mutant line BP2/125/1 also had significantly lower rate of weight loss on storing compared to the check variety together with five others.

At Mymensingh, plant height, bulb diameter, fresh and dry weight of bulb ha^{-1} was higher than that of Rangpur (Table 52). The mutant line BP2/75/5 had the tallest while BP2/75/11 the shortest plant height at Mymensingh. Bulb diameter of the mutant lines did not differ significantly with each other or even with the check variety. Five mutant lines produced significantly higher bulb yield than the check variety with BP2/125/1 being the highest followed by BP2/125/5. The mutant BP2/75/5 produced significantly higher dry weight of bulb ha^{-1} than the check variety together with the fact that it had the lowest rate of weight loss on storage.

It is evident that the mutants with the highest population had the lowest percentage of flowering plants and vice versa (Table 53). This rule deviated in case of the parent BARI Piaj-2, although it had lower plant population yet it had the lowest percentage of flowering plants and the flowering plants did not produce any seed, finally. In contrast, almost all the mutants that flowered could produce seed. Seed yield $plant^{-1}$ and $ha^{-1}$of the mutants ranged 0.04 to 1.07g and 11.76 to 357.14 kg with BP2/75/11 being the highest while BP2/125/1 the lowest.

Table 52. Bulb yield and related traits of 13 mutant lines of summer onion during winter season, 2011-12 at Mymensingh including weight loss on storage

Mutant lines/varieties	Plant height (cm)	Bulb diameter (cm)	Fresh weight of bulb (kg ha^{-1})	Dry weight of bulb (kg ha^{-1})	Rate of weight loss (%)
BP2/75/5	50.77	15.48	10555.56	8777.78	16.04
BP2/125/5	43.57	15.67	11319.44	8444.44	26.47
BP2/75/12	44.33	13.70	5138.89	3861.11	25.39
BP2/75/3	42.40	15.53	9375.00	5750.00	40.37
BP2/100/5	41.40	14.80	9027.78	6388.89	30.43
BP2/75/2	41.60	14.67	9444.44	7500.00	20.08
BP2/75/13	43.67	14.80	7847.22	5694.44	28.47
BP2/100/2	45.93	14.93	7569.44	5833.33	23.32
BP2/75/11	39.67	13.93	5972.22	5416.67	12.61
BP2/125/1	42.60	15.27	11944.44	8166.67	32.41
BP2/75/6	42.20	15.40	6805.56	5277.78	22.91
BP2/100/12	41.80	14.33	1058.33	6527.78	26.30
BARI Piaj-3	48.33	16.43	9727.78	7458.33	23.31
$LSD_{(0.05)}$	4.12	NS	111.24	1007.23	4.16

NS = Not significant

Table 53. Seed yield and yield attributes of 22 mutant lines of summer onion along with the parent BARI Piaj-2 during winter season, 2011-12 at Ishurdi

Mutant lines	Total plant (no.)	Flowering plant (%)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})
BP2/75/2	252	60.32	0.24	79.37
BP2/75/3	401	79.05	0.24	78.97
BP2/75/5	224	87.50	0.22	74.40
BP2/75/6	283	68.55	0.08	25.91
BP2/75/7	239	77.41	0.06	20.92
BP2/100/7	44	90.91	0.20	68.18
BP2/100/12	192	81.25	0.08	26.04
BP2/100/1	162	83.95	0.43	144.03
BP2/100/2	443	73.59	0.16	52.67
BP2/100/5	291	56.70	0.12	38.95
BP2/75/13	230	71.30	0.07	23.19
BP2/125/1	340	77.94	0.04	11.76
BP2/75/8	26	96.15	0.69	230.77
BP2/75/11	84	76.19	1.07	357.14
BP2/75/12	51	76.47	0.69	228.76
BP2/100/8	20	100.00	0.90	300.00
BP2/100/11	25	88.00	0.80	266.67
BP2/125/2	101	83.17	0.30	99.01
BP2/125/3	39	87.18	0.26	85.47
BP2/125/5	101	84.16	0.35	115.51
BP2/125/9	82	78.05	0.34	113.82
BP2/100/6	90	71.11	0.20	66.67
BARI Piaj-2	21	9.52	0	0.0
SE	26.60	3.69	0.06	20.42

Finally, based on higher seed production, fresh and dry bulb yields and lowest/lower weight loss on storage, 6 mutants have been selected to evaluate further in advance yield yrial, next winter. The mutants are: BP2/75/2, BP2/75/5, BP2/75/13, BP2/100/1, BP2/100/2 and BP2/125/1.

CROP PHYSIOLOGY DIVISION

RESEARCH HIGHLIGHTS

Three aromatic rice mutants/cultivars were evaluated at six on-stations and four farmers' fields. Average yield of KD5-18-150, BRRI dhan34 and Kalizira was 3.37, 2.60 and 2.14 tha^{-1}, respectively. Crop duration of the varieties ranged from 138-143 days.

Five mungbean mutants along with two check varieties Binamoog-7 and Binamoog-8 were evaluated at two locations and out of these, two mutants N_3J-305 and E_4I-915 had consistent seed yield over locations and matured six days earlier than Binamoog-7 and Binamoog-8.

Thirty five genotypes of lentil were screened at BINA sub-stations Magura and Ishurdi. Among these, fifteen were selected for further screening.

Four rice genotypes *viz.*, Binadhan-8, PBRC-37, NERICA-1 and NERICA-10 were evaluated with four levels of salinity *viz.*, control, 6, 9 and 12 dSm^{-1}. NERICA-1 and PBRC-37 showed better performance with respect to yield and yield attributes.

Growth, morpho-physiological characters, yield attributes and seed yield were investigated in four soybean mutants *viz.*, SBM-13, SBM-17, SBM-20 and SBM-22 along with a newly released variety, Binasoybean-1. High yielding genotypes have taller plant, higher number of branches, LA, TDM and AGR which resulted in higher number of pods $plant^{-1}$ than the low yielding soybean genotypes; and among the genotypes, SBM-20 produced the highest seed yield due to superiority of yield attributes than the others.

Precise N-application on the basis of nitrate reductase activity in Binatomato-6 demonstrated that 150 kg N ha^{-1} was sufficient for normal plant growth and development when urea was applied during 20-80 days after transplanting at 20 days intervals.

Foliar application of chitosan growth regulator on maize (QPM-I) revealed that three spray with 100 ppm at different growth stages increased the yield in maize.

On-station trial of fine grain aromatic rice

One advanced mutants, KD_5-18-150 and two check cultivars BRRI dhan34 and Kalizira were evaluated at different sub-stations of BINA viz., Magura, Comilla, Ishurdi, Rangpur, Mymensingh and Jamalpur for their yield performance during T. aman season of 2011. The experiments were conducted following RCBD design with four replications. The unit plot size of each experiment was 8 m × 5 m. Fertilizers such as Urea, TSP and MP were applied at the rate of 86, 90 and 30 $kgha^{-1}$, respectively. Transplanting was done with 30-day-old seedlings having the hill spacing of 20 cm × 15 cm. Normal weeding and other cultural practices were done as and when necessary. At harvest, 10 hill $plot^{-1}$ were randomly selected for collecting data of yield contributing characters. Grain yield $plot^{-1}$ was finally converted into t ha^{-1}.

The height and panicle length of the rice genotypes were statistically insignificant (Table 1). The higher no. of effective tiller $hill^{-1}$, higher number of filled grains $panicle^{-1}$, higher grain size, harvest index as well as higher yield (t ha^{-1}) were produced by the mutant KD_5-18-150. Kalizira showed the lowest 1000-grain weight, grain yield and harvest index. BRRI dhan34 showed medium status. Among the genotypes, KD_5-18-150 recorded the highest seed yield all over the locations compared to other genotypes (Table 2). Mutants KD_5-18-150 produced the highest grain yield (4.0 t ha^{-1}) at Mymensingh and the lowest in Rangpur (2.85 t ha^{-1}) sub-station.

Table 1. Means of yield contributing characters of three fine grain rice mutants/cultivars at six location of BINA sub-stations and Mymensingh HQ during T. aman season of 2011

Mutant/varieties	Plant height (cm)	Effective tiller $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	HI (%)
KD_5-18-150	146.4 a	7.167 a	26.3 a	116.0 a	13.20 a	3.624 a	38.30 a
BRRI dhan34	147.2 a	6.633 b	26.7 a	116.7 a	10.87 b	2.798 b	34.43 b
Kalizira	146.9 a	6.167 b	24.3 a	97.0 b	11.33 c	2.174 c	32.23 c
CV(%)	0.81	3.11	4.38	2.87	2.77	2.70	2.00

In a column, means followed by the same letter (s) do not differ significantly at 5% level.

Table 2. Interaction of genotypes and locations on grain yield of three fine grain rice mutants/cultivars at six locations of BINA sub-stations and Mymensingh HQ during T. aman season of 2011

Mutants/cultivars	Grain yield (t ha^{-1})					
	Ishurdi	Rangpur	Magura	Comilla	Mymensingh	Jamalpur
KD_5-18-150	3.01 d	2.85 e	3.8 b	3.55 c	4.00 a	3.77 b
BRRI dhan34	2.4 ij	2.65 fg	2.66 f	2.52 hi	2.87 e	2.65 fg
Kalizira	2.12 k	2.00 k	2.10 k	2.10 k	2.31 j	2.53 gh

In a column, means followed by the same letter(s) do not differ significantly at 5% level.

Yield trial of fine grain aromatic rice genotypes in farmers' field

One advanced mutants, KD_5-18-150 and two check cultivars BRRI dhan34 and Kalizira were evaluated at different locations viz., Magura, Comilla, Ishurdi and Rangpur, for their yield performance during T. aman season of 2011. The experiments were conducted following RCB design with four replications. The unit plot size of each experiment was 8 m × 5 m. Fertilizers such as Urea, TSP and MP were applied at the rate of 86, 90 and 30 kgha^{-1}, respectively. Transplanting was done with 30-day-old seedlings having the hill spacing of 20 cm × 15 cm. Normal weeding and other cultural practices were done as and when necessary. At harvest, 10 hill plot^{-1} were randomly selected for collecting data of yield contributing characters. Grain yield plot^{-1} was finally converted into tha^{-1}.

KD_5-18-150 recorded the highest seed yield all over the locations compared to other genotypes (Table 3). Mutants KD_5-18-150 produced the highest grain yield (3.50 t ha^{-1}) at Magura and Comilla and the lowest in Rangpur (2.83 t ha^{-1}) due to the scarcity of irrigation facilities.

Table 3. Interaction of genotypes and locations on grain yield of three fine grain rice mutants/cultivars at four locations of farmers field during T. aman season of 2011

Mutants/cultivars	Grain yield (t ha^{-1})			
	Ishurdi	Rangpur	Magura	Comilla
KD_5-18-150	3.16 b	2.83 c	3.50 a	3.45 a
BRRI dhan34	2.72 cd	2.64 de	2.50 ef	2.43 f
Kalizira	2.22 g	2.24 g	1.82 gh	2.05 g

In a column, means followed by the same letter(s) do not differ significantly at 5% level.

Morpho-physiological evaluation of summer mungbean mutants

The experiments were conducted during Kharif-I season of 2012 at two locations *viz.,* BINA sub-stations, Magura and Ishurdi with five mungbean mutants along with two check varieties Binamoog-7 and Binamoog-8 to evaluate the performance of genotypes through yield and yield attributes. The experiments were laid out following a RCB design with three replications having a unit plot size of 3 m × 2.0 m. Row to row and plant to plant distances were 30 cm and 10 cm, respectively. Urea, triple superphosphate and muriate of potash were applied at the rate of 40, 120 and 80 kgha^{-1}, respectively at the time of final land preparation. Proper cultural practices were followed as and when necessary. Data on morphological and yield attributes were recorded at harvest from 10 randomly selected plants in each plot and seed yield was taken from the whole plot and converted into kgha^{-1}.

Data of different parameters showed significant differences among the genotypes in both the locations at $P \leq 0.01$ (Table 4). The highest number of pods plant^{-1} found in genotype N3J-305 (28.77) which was followed by genotypes E_4I-915, Binamoog-8 and Binamoog-7 (Average 21.03) and the lowest was found in MB 1 (13.73). Out of seven, three genotypes N3J-305, E_4I-915 and Binamoog-7 produced higher pod wt. plant^{-1} consequently higher seed pod^{-1}, seed weight plant^{-1} and finally seed yield kg ha^{-1} in Magura. Though genotypes MB 1 and MB 13 produced larger seed but yield was lower due to lower number of pods plant^{-1}, seeds pod^{-1} and seed weight plant^{-1}.

In Ishurdi, three genotypes N_3J-305, E_4I-915 and Binamoog-7 found higher number of pods plant^{-1} (25.05) while MB 1 recorded lower. In respect of seed yield, N3J-305 produced higher yield due to higher number of pods plant^{-1} and seed weight plant^{-1} which was followed by E_4I-915 and Binamoog-7 and the lowest seed yield was produced by MB 1 due to lower number of pods plant^{-1}, seed weight plant^{-1}. In case of mean seed yield (kg ha^{-1}) over locations, showed that N_3J -305 produced the highest seed yield (Average 1750 kg ha^{-1}) followed by Binamoog-7 (Average 1654 kg ha^{-1}) and E_4I-915 (Average 1605 kg ha^{-1}). Two genotypes, N_3J-305 and E_4I-915 matured six days (Average 65 days) earlier than rest of the genotypes (Average 71.2 days). So two genotypes, N_3J-305 and E_4I-915 had consistent higher seed yield over locations matured six days earlier than Binamoog-7 and Binamoog-8. (Table 4 and 5).

Table 4. Mean Performance of seven mungbean genotypes over locations on morphological, yield attributes and yield during Kharif-I in Magura 2012

Genotypes	Pods plant^{-1} (no.)	Pod wt. plant^{-1}	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed weight plant^{-1} (g)	Seed yield (kg ha^{-1})	Crop duration (Days)
MB 1	13.73 d	6.85 b	10.45 ab	4.60 a	4.11 b	1233 b	72 a
MB 13	17.10 c	6.92 b	9.53 b	4.18 ab	4.16 b	1246 b	71 a
MB 35	15.25 cd	7.04 b	10.50 ab	3.14 c	4.23 b	1267 b	71 a
Binamoog-7	21.33 b	8.49 a	11.15 a	2.38 d	5.10 a	1529 a	72 a
Binamoog-8	19.67 b	7.20 b	10.95 a	3.82 b	4.32 b	1296 b	69 b
N_3J-305	28.77 a	8.46 a	10.30 ab	2.99 c	5.08 a	1523 a	64 c
E_4I-915	22.10 b	8.02 a	10.95 a	2.43 d	4.81 a	1444 a	64 c
CV (%)	8.12	5.40	6.53	10.60	5.40	5.48	1.21

In a column, same letter(s) do not differ significantly at P ≤ 0.05 by DMRT.

Table 5. Performance of seven mungbean genotypes over locations on morphological, yield attributes and yield during Kharif-I in Ishurdi 2012

Genotypes	Pods plant^{-1} (no.)	Pod weight plant^{-1}	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed weight plant^{-1} (g)	Seed yield (kg ha^{-1})	Crop duration (Days)
MB 1	15.35 d	7.20 c	10.45	5.09 a	5.53 c	1381 c	72 a
MB-2	19.85 b	6.49 c	10.90	4.33 b	6.49 bc	1623 bc	72 a
Binamoog-7	25.05 a	10.06 a	10.35	2.63 cd	7.11 ab	1778 ab	72 a
Binamoog-8	16.15 cd	7.16 c	10.90	4.24 b	6.11 bc	1528 bc	72 a
MB 35	18.20 bc	8.25 b	10.35	3.75 b	6.05 bc	1512 bc	69 b
N_3J-305	25.05 a	8.71 b	10.15	3.09 c	7.91 a	1977 a	66 c
E_4I-915	25.05 a	8.65 b	10.25	2.41 d	7.06 ab	1766 ab	66 c
CV (%)	7.79	8.27	6.61	11.02	10.63	10.63	1.68

In a column, same letter(s) do not differ significantly at P ≤ 0.05 by DMRT.

Screening of lentil mutants with respect to yield and yield attributes

Thirty five genotypes of lentil including 30 mutants, three exotic lines and two check varieties BARI Masur-4 and Binamasur-3 were screened in two locations of BINA sub-station Magura and Ishurdi in 2012. The experiment was set in line sowing with three replications. Each row was 3 m long with 30 cm row to row distance and plant to plant distance was 5-6 cm. Recommended doses of fertilizers were applied during land preparation. Recommended cultural practices were done as and when necessary. Data on plant height, branches plant^{-1}, pods plant^{-1}, pod wt. plant^{-1}, seeds pod^{-1}, 100-seed weight seed weight plant^{-1} and crop duration were recorded from randomly selected 10 plants of each line.

The results revealed that out of 35 genotypes, 9 genotypes *viz.*, E_5M-1020, N_5M- 568, N_5M- 330, E_2M-728, N_4I- 404, N_5I-504, N_4I-411, E_4I-925 and E_1I-130 showed better performances in terms of number of pods plant^{-1} (82.15)**,** number of **s**eeds pod^{-1} (2.01) and seed weight plant^{-1} (3.34 g) in Magura (Table 6). In Ishurdi, the genotypes N_5M-1027, N_5M- 555, E_2M-727, E_1M-604, E_5M- 1026, E_1I-130, N_5M-330, E_2M-720, E_4I-925 and N_4I-411 showed better performance in respect of number of pods plant^{-1}, pod wt. plant^{-1}, seed weight plant^{-1}, 100-seed weight and number of seeds pod^{-1} (Table 7). It was observed that the genotypes E_1I-130, N_5M- 330, E_4I-925 and N_4I-411 showed better performance in both the locations. However, genotypes selected from each location should be tested further.

Table 6. Performance of some lentil genotypes on morphological, yield attributes and yield during Rabi season in Ishurdi 2012

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Pod weight plant^{-1}	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed wt. plant^{-1} (g)	Crop duration (Days)
E_5M-1020	39.5	4.60	60.00	2.51	1.57	1.61	1.48	115
E_2M-752	33.7	4.30	48.87	2.71	1.50	1.49	1.59	115
N5M-560	32.0	3.83	60.33	2.74	1.67	1.52	1.61	114
N_5M-1027	39.2	4.50	62.40	3.27	1.53	1.75	1.85	114
N_5M- 555	30.7	3.97	74.80	3.79	1.43	1.82	2.10	113
E_3M-819	30.6	4.47	64.33	3.02	1.70	1.68	1.78	114
E_5M- 1042	33.3	4.30	51.00	1.82	1.63	1.49	1.07	115
N_5M- 546	30.6	4.13	52.73	2.40	1.57	1.41	1.41	109
N_5M- 568	40.1	4.60	60.20	2.60	1.50	1.64	1.53	113
N_3M-320	34.6	4.47	58.73	2.84	1.70	1.79	1.67	114
N_5M- 564	36.6	3.87	59.60	2.27	1.57	1.40	1.33	114
E_2M-727	39.9	5.10	64.00	3.83	1.50	1.77	2.16	114
E_4I-1016	33.9	4.33	62.33	2.90	1.60	1.80	1.71	114
E_1M-604	38.1	4.47	70.00	3.17	1.50	1.86	1.87	114
N_5M- 505	37.0	4.73	54.67	2.29	1.43	1.65	1.34	113
E_5M- 1026	38.9	5.13	68.00	3.08	1.57	1.56	1.81	115
E_1I-130	33.9	4.60	85.33	3.10	1.53	2.03	1.83	114
N_5M- 330	40.2	5.20	70.20	3.15	1.70	1.78	1.85	113
BARI Masur-4	50.2	5.60	78.83	3.06	1.67	2.05	1.80	114
E_4I-704	32.3	4.47	45.80	2.42	1.37	1.80	1.42	113
E_3I-316	34.3	4.67	53.53	2.46	1.70	1.75	1.45	108
N_4I-415	30.9	4.33	63.80	2.54	1.73	1.62	1.50	114
N_4M-412	33.6	5.00	61.33	2.83	1.57	1.86	1.66	110
E_2M-728	33.9	4.93	51.00	2.25	1.80	1.72	1.32	111
N_4I- 404	39.7	5.20	67.33	2.58	1.50	1.57	1.52	109
E_2M-720	37.8	5.93	76.13	3.50	1.60	1.59	1.95	113
Binamasur-3	38.0	5.53	61.67	2.44	1.70	1.58	1.43	112
E_5M- 501	36.3	5.53	60.20	3.17	1.50	1.63	1.78	107
N_5I-504	34.7	5.40	64.67	3.20	1.70	1.70	1.88	113
N_4M-540	32.6	4.73	72.00	2.75	1.50	1.78	1.62	109
N_4I-411	36.9	5.07	63.67	3.54	1.57	2.15	1.97	112
E_4I-925	36.5	5.07	71.47	3.40	1.73	2.01	1.92	116
RTP-635	37.1	4.20	48.20	2.46	1.40	2.16	1.44	113
IC-4414	34.7	4.47	61.00	2.81	1.70	1.74	1.65	117
IC-44251	32.5	4.33	81.33	3.14	1.70	1.69	1.75	114
$LSD_{0.05}$	2.432	0.4608	9.437	0.3958	0.1858	0.0728	0.2304	2.263
CV (%)	4.16	5.98	9.17	8.52	7.28	2.27	8.50	1.23

Table 7. Performance of some lentil genotypes on morphological, yield attributes and yield during Rabi season in Magura 2012

Genotypes	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Pod weight $plant^{-1}$	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed weight $plant^{-1}$ (g)	Crop duration (Days)
E_5M-1020	44.97	8.40	96.80	1.60	2.01	1.62	3.29	117
E_2M-752	39.20	7.33	67.67	1.53	1.44	1.64	2.35	117
N5M-560	43.40	6.80	72.00	1.63	1.62	1.61	2.75	116
N_5M-1027	43.07	5.13	55.40	1.60	1.47	1.79	2.41	116
N_5M- 555	42.30	5.67	69.67	1.57	1.79	1.82	2.93	115
E_3M-819	44.60	5.73	61.90	1.73	1.62	1.69	2.65	116
E_5M- 1042	42.93	6.53	67.20	1.70	1.53	1.76	2.51	116
N_5M- 546	42.07	6.00	55.87	1.57	1.25	1.73	2.05	111
N_5M- 568	45.00	6.13	88.80	1.50	1.87	1.49	3.06	115
N_3M-320	44.67	6.33	61.67	1.67	1.51	1.62	2.47	116
N_5M- 564	45.80	6.80	66.67	1.60	1.00	1.61	1.63	115
E_2M-727	43.93	6.93	67.40	1.57	1.24	1.57	2.03	116
E_4I-1016	41.73	6.07	65.00	1.57	1.53	1.72	2.50	115
E_1M-604	47.00	7.00	63.33	1.53	1.48	1.57	2.42	116
N_5M- 505	40.07	6.87	67.20	1.40	1.54	1.63	2.52	115
E_5M- 1026	42.60	7.17	71.00	1.67	1.64	1.56	2.68	116
E_1I-130	44.27	5.67	50.20	1.57	2.06	1.75	3.37	115
N_5M- 330	41.87	7.00	77.33	1.63	1.93	1.75	3.16	114
BARI Masur-4	39.80	7.93	79.67	1.60	1.85	1.91	3.02	116
E_4I-704	45.73	6.00	57.90	1.43	1.40	1.46	2.30	115
E_3I-316	45.20	5.87	67.83	1.63	1.28	1.81	2.09	109
N_4I-415	41.60	6.40	78.33	1.63	1.83	1.62	2.99	114
N_4M-412	45.73	5.87	77.00	1.53	1.73	1.74	2.82	108
E_2M-728	43.67	7.10	77.33	1.73	1.92	1.58	3.14	113
N_4I- 404	42.47	6.20	87.67	1.53	2.16	1.60	3.53	111
E_2M-720	43.07	5.07	68.40	1.67	1.51	1.73	2.46	113
Binamasur-3	44.60	7.33	66.00	1.63	1.57	1.67	2.56	114
E_5M- 501	42.33	5.57	52.00	1.57	1.04	1.63	1.71	109
N_5I-504	44.93	5.93	79.47	1.63	2.01	1.65	3.49	115
N_4M-540	41.27	6.07	51.53	1.43	1.55	1.71	2.70	112
N_4I-411	42.67	6.00	86.00	1.63	1.96	2.11	3.40	114
E_4I-925	45.40	5.40	95.77	1.67	2.16	1.66	3.63	117
RTP-635	41.93	4.80	53.93	1.47	1.26	1.77	2.05	115
IC-4414	42.53	5.67	64.33	1.63	1.87	1.67	3.06	117
IC-44251	45.57	6.20	71.40	1.60	1.80	1.57	3.02	116
$LSD_{0.05}$	5.912	1.765	9.856	0.1262	0.2186	0.2822	0.3607	1.989
CV (%)	8.37	17.16	8.68	4.81	8.16	10.36	8.18	1.07

Effect of salinity on four rice genotypes with respect to yield and yield attributes

A pot experiment was carried out at BINA pot experiment yard with four rice genotypes *viz.*, Binadhan-8, PBRC-37, NERICA-1 and NERICA-10 in boro season 2012 to evaluate the effect of salinity on ion absorption and yield attributes. The experiment was set following CRD with four replications. To establish the experiment perforated pots were filled up with 8 kg well mixed soil with cow dung and fertilizer @ 50N, 25 P and 25 K mg kg^{-1} of soil. A polythene shade was established above the experiment area to avoid the rain water. Eight filled pots were set in each glass fibre tray and filled the tray with water up to the neck of the pot. Sprouted three seeds were sown in each pot. Recommended cultural practices were done as and when necessary. Four levels of salinity viz. 0, 6, 9 and 12dSm^{-1} were imposed at maximum tillering stage and remained up to the harvest. To collect data different samples have been collected at final harvest.

Results showed that NERICA-1 produced the highest grain weight hill^{-1} due to higher panicle hill^{-1}, panicle length and 1000-grain wt. which was followed by PBRC-37 and the lowest grain yield was obtained in Binadhan-8 due to lower panicle hill^{-1}, panicle length and 1000-grain wt. (Table 8). Plant height, total tiller hill^{-1}, panicle hill^{-1}, filled grain and grain wt. hill^{-1} decreased significantly with increasing salinity level except panicle length and unfilled grain panicle^{-1} due to the effect of different levels of salinity. Panicle length showed highest at 9 dSm^{-1}. So, results revealed that NERICA-1 and PBRC-37 found better under salinity up to 12 dSm^{-1} with respect to yield and yield attributes.

Table 8. Effect of salinity on morphological and yield attributes at reproductive stage in four rice genotypes in 2012

Treatments	Plant height (cm)	Total tiller hill^{-1} (no.)	Panicle hill^{-1} (no.)	Panicle length (cm)	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	1000-grain weight (g)	Grain weight hill^{-1} (g)
Genotypes								
Binadhan-8	76.44 d	23.88 c	11.69 c	20.79 d	73.73 a	20.65 b	20.53 c	7.46 c
PBRC-37	87.13 b	27.81 a	13.13 b	21.18 b	74.3 a	19.65 c	22.06 b	8.89 b
NERICA-1	90.44 a	26.5 b	13.56 a	21.61 a	70.86 b	22.38 a	22.31 a	10.38 a
NERICA-10	77.66 c	24.13 c	11.69 c	20.91 c	60.9 c	22.08 a	22.13 ab	8.39 b
Salinity (dSm^{-1})								
Control	92.22 a	28.38 a	15 a	21.5 b	89.74 a	13.09 d	25.88 a	15.15 a
6	84.94 b	26.63 b	13.13 b	20.76 c	75.07 b	13.88 c	22.01 b	9.36 b
9	82.35 c	25.19 c	12.44 c	21.57 a	65.79 c	20.73 b	20.19 c	7.14 c
12	72.16 d	22.13 d	9.5 d	20.66 d	49.19 d	37.06 a	18.96 d	3.46 d
CV%	1.70	2.09	3.77	0.26	2.71	2.87	1.28	7.12

In a column, same letter(s) do not differ significantly at $P \leq 0.05$ by DMRT.

Evaluation of soybean genotypes based on morpho-physiolocal criteria

The experiment was conducted with 4 soybean mutants *viz*. SBM-13, SBM-17, SBM-20 and SBM-22 along with a check variety Binasoybean-1 at BINA farm, Mymensingh during the period from 11 January to 30 May 2012. The experiment was laid out in a RCB design with 3 replications. The size of the unit plot was 3 m × 4 m. Distances between block to block and plot to plot were 1.0 and 0.5 meter, respectively. Urea, triple super phosphate (TSP), muriate of potash (MOP) and gypsum were used as source of nitrogen, phosphorus, potassium and sulphur @ 40, 120, 80 and 40 kg ha^{-1}, respectively. Total amount of Urea, TSP, MOP and gypsum were applied at basal doses during final land preparation. The seeds of five soybean genotypes were hand sown in rows on 11 January 2012. Plant protection measures were taken at 45 and 60 DAS against fruit and shoot borer by spraying Diapam 60 EC @ 0.25%. To study ontogenetic growth characteristics, a total of six harvests were made and at final harvest, data were collected from randomly selected 10 plants from each plot on some morpho-physiological parameters, yield attributes and yield. The first crop sampling was done for collecting data on growth parameter at 35 DAS and continued at an interval of 10 days up to 110 DAS i.e. till attaining physiological maturity. From each sampling, five plants were randomly selected from each plot and uprooted for collecting necessary parameters. The plants were separated into leaves, stems and roots and the corresponding dry weight were recorded after oven drying at 80 ± 2°C for 72 hours. The leaf area of each sample was measured by LICOR automatic leaf area meter (Model: LICOR 3000). The growth analyzing attribute like AGR, RGR and NAR were calculated using the formulae of Radford (1967). The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjusted with Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C.

The ontogenetic plant height, leaf area and total dry mass production of soybean genotypes differed significantly at all growth stages (Table 9-11). Of the mutants/variety, SBM-20 was the tallest (63.3 cm) whilst Binasoybean-1 was the shortest (40.3 cm) of all. The maximum number of branches, leaf area and TDM plant^{-1} as well as biological yield was observed in SBM-20 whilst the lowest was recorded in BINAsoybean-1. However, total dry mass and leaf area increased till 80 DAS. Results also indicated that high yielding genotypes showed higher in TDM and LA than the low yielding ones. In present study, the high yield genotypes showed higher of branches plant^{-1}. The variation in growth parameters like AGR and RGR of soybean genotypes were significant at all growth stages (Table 12-13). AGR increased till 70-80 DAS followed by a decline with age. On the other hand, the RGR and NAR showed higher values at early growth stages and declined latter on (Table 13-14). The mutant SBM-20 showed the advance in AGR and RGR at most of the growth stages compared to others. In contrast, Binasoybean-1 showed lesser in case of AGR but reverse trend was observed in RGR over its growth period. The lower value of AGR at initial stages of growth was the result of lower LAI. At 80 DAS, the AGR value was found to be maximum which mean that plants expanded it's assimilate for the growth of leaf area for feeding of pods. The declining of AGR after reaching the maximum in all genotypes might be the result of abscission of leaves. Pod number, the most important yield attribute, was found significant difference among the genotypes. Results revealed that high yielding genotypes produced higher numbers of pods plant^{-1} (Table 15). SBM-20 produced the highest number of pods plant^{-1} (23.1) whilst SBM-17 produced the lowest (19.2 plant^{-1}). The mutant SBM-20 produced highest seed yield plant^{-1} (8.51g plant^{-1}) as well as seed yield hectare^{-1} (2.84 t ha^{-1}) followed by SBM-13 (7.62g plant^{-1} and 2.54 t ha^{-1}). In contrast, Binasoybean-1 produced the lowest seed yield (6.65g plant^{-1} and 2.22 t ha^{-1}) due to fewer pods plant^{-1}. However, in case of unit area basis, result revealed that seed yield ha^{-1} was rationale to seed yield plant^{-1}. Further, the low yielder genotypes, Binasoybean-1 showed the highest harvest index (36.9%). High HI always does not contribute to high yield, high yield is determined by physiological process leading to a high net accumulation of photosynthates and it's partitioning into plant and seed. This opinion has been reflected in the present study. Here, SBM-20 was high yielder mutant and also showed lower HI.

Table 9. Plant height at different age in five soybean mutants/variety

Variety/mutants	Plant height (cm) at different days after sowing					
	40	50	60	70	80	90
Binasoybean-1	17.2 b	27.4b	30.0b	33.2b	40.3c	45.3c
SBM-13	21.1 a	35.9a	38.6a	42.6a	47.1b	53.2b
SBM-17	20.0ab	32.9a	38.4a	44.6a	63.0b	50.1bc
SBM-20	21.3 a	34.9a	40.6a	50.9a	63.3a	65.1a
SBM-22	18.6ab	35.0a	42.7a	45.4a	48.5 b	51.6bc
F-test	**	**	**	**	**	**
CV (%)	6.96	9.29	8.87	10.45	3.94	6.42

Same letter(s) in a column do not differ significantly at $P \leq 0.05$ by DMRT.
** indicate significance at 1% level of probability.

Table 10. Leaf area production at different days after sowing in five mutants/ variety soybean

Variety/mutants	Leaf area (cm^2) $plant^{-1}$ at different days after sowing					
	40	50	60	70	80	90
Binasoybean-1	83.9d	333.3c	633.9c	1230.1d	1431.8c	1118.7c
SBM-13	106.6bc	361.6bc	893.5c	1230.1d	1435.1d	1245.9b
SBM-17	149.3a	400.0a	1603.1a	1171.1d	2653.1a	1220.0bc
SBM-20	152.2b	495.4b	1632.0b	1478.9a	2683.0a	1320.0a
SBM-22	92.5cd	335.7c	760.8d	1681.9b	2090.7b	1122.0c
F-test	**	**	**	**	*	*
CV (%)	9.18	10.54	5.97	3.21	3.39	4.59

Same letter(s) in a column do not differ significantly at $P \leq 0.05$ by DMRT.
** indicate significance at 1% level of probability.

Table 11. Total dry mass production as influenced by genotypes of soybean at different days after sowing

Variety/Mutants	Total dry mass $plant^{-1}$ (g) at different days after sowing					
	40	50	60	70	80	90
Binasoybean-1	5.7b	7.0b	10.0b	13.6c	21.1b	31.8b
SBM-13	7.0a	9.6a	12.8a	15.7b	22.8b	33.3b
SBM-17	6.6a	9.3a	12.8a	14.7b	21.7b	33.4b
SBM-20	7.0a	10.0a	13.4a	21.1a	26.9a	41.7a
SBM-22	6.2ab	9.7a	12.2a	16.1b	22.2b	33,8b
F-test	**	*	**	**	**	**
CV (%)	6.96	6.8	8.86	3.95	4.58	1.26

Same letter(s) in a column do not differ significantly at $P \leq 0.05$ by DMRT.
*, ** indicate significance at 5% and 1% level of probability, respectively.

Table 12. Effect of genotypes on absolute growth rate at different growth stages in soybean

Variety/mutants	Absolute growth rate (mg $plant^{-1}$ day^{-1}) at different days after sowing				
	40-50	50-60	60-70	70-80	80-90
Binasoybean-1	57 c	73 d	136 d	297 b	168 b
SBM-13	75 b	122 b	278 b	327 c	250 a
SBM-17	85 a	99 c	195 c	390 b	155 b
SBM-20	79 ab	147 a	344 a	400 b	211 a
SBM-22	75 b	126 b	255 b	461 a	164 b
F-test	**	**	**	**	**
CV (%)	5.25	10.86	11.30	6.95	12.48

Same letter(s) in a column do not differ significantly at $P \leq 0.05$ by DMRT.
** indicate significance at 1% level of probability.

Table 13. Relative growth rate at different growth stages in five soybean mutants/variety

Variety/mutants	Relative growth rate (mg g^{-1} day^{-1}) at different days after sowing				
	40-50	50-60	60-70	70-80	80-90
Binasoybean-1	138.6 a	52.9 c	75.2 b	72.0 a	26.1 a
SBM-13	130.2 b	78.1 a	80.4 ab	50.1 c	26.3 a
SBM-17	132.0 ab	61.7 b	64.5 c	66.8 b	17.7 b
SBM-20	134.0 ab	76.5 a	84.4 a	51.1 c	19.1 b
SBM-22	127.7 b	79.4 a	74.6 b	67.5 ab	16.0 b
F-test	**	**	**	**	**
CV (%)	6.22	4.13	5.24	3.94	11.35

Same letter(s) in a column do not differ significantly at P ≤ 0.05 by DMRT.
** indicate significance at 1% level of probability.

Table 14. Net assimilation rate at different growth stages in five soybean mutants/variety

Variety	Net assimilation rate (mg dm^2 day^1) at different days after sowing				
	40-50	50-60	60-70	70-80	80-90
Binasoybean-1	70.19c	74.07b	40.46b	49.20a	53.03ab
SBM-13	131.14b	54.03bc	27.77c	55.19a	60.96a
SBM-17	76.97c	35.31d	18.21d	23.36c	40.18c
SBM-20	117.92d	42.84cd	53.7a	27.45bc	48.65bc
SBM-22	178.70a	83.67a	20.63d	35.00b	53.58ab
F-test	**	**	**	**	**
CV%	15.39	12.58	1082	13.43	10.19

Same latter(s) in a column do not differ significantly at P ≤ 0.05 by DMRT.
** Indicate significance at 1% level of probability.

Table 15. Some morpho-physiological characters and yield components and seed yield in five soybean mutants /variety

Variety/mutants	Branches plant^{-1} (no)	Biological yield plant^{-1} (g)	Pods plant^{-1} (no)	Seeds pod^{-1} (no)	100-seed weight (g)	Seed weight plant^{-1} (g)	Seed yield (tha^{-1})	Harvest index (%)
Binasoybean-1	2.33 ab	12.86 b	19.4 b	2.81	12.2 d	6.65 c	2.22 c	36.9 a
SBM-13	2.33 b	113.67 b	21.3 ab	2.84	12.6 c	7.62 b	2.54 ab	35.3 a
SBM-17	2.20 ab	13.66 b	19.2 b	2.57	14.0 a	6.90 bc	2.30 bc	30.2 b
SBM-20	3.00 a	16.70 a	23.1 a	2.75	13.4 b	8.51 a	2.84 a	31.2 b
SBM-22	2.53 ab	13.00 b	21.9 ab	2.63	12.8 c	7.37 bc	2.46 b	31.3 b
F-test	**	**	*	NS	*	**	**	**
CV (%)	13.04	2.89	7.78	4.98	5.69	5.00	6.26	4.98

Same letter(s) in a column do not differ significantly at P ≤ 0.05 by DMRT.
*, ** indicate significance at 5% and 1% level of probability, respectively; NS = Not significant.

Determination of nitrogen requirement for Binatomato-6 based on nitrate reductase activity

The experiment was conducted at BINA farm, Mymensingh during Rabi season of 2011-2012 to determine the accurate metabolic requirement of nitrogen by tomato variety for its optimal productivity on the basis of a key enzyme for nitrate assimilation, the nitrate reductase (NR). Binatomato-6 was selected as test crop. Three five doses *viz.,* 0, 50, 100 150 and 200 kg N ha^{-1} were used. Nitrogen was applied as urea. Urea was applied in four equal splits at 20, 40, 60 and 80 days after transplanting (DAT). Nitrate reductase activity was determined from 30 DAT to every 10 days interval up to final harvest. Data on fruit yield were also recorded.

Results showed that NRA varied significantly due to different N-doses at all growth stages. NRA increased with plant age till flowering and fruiting stages (70 DAT) followed by a decline (Table 16). NRA with the higher doses of N indicating higher biological activity at those doses of 150 and 200 kg N ha^{-1}. Results indicated that N requirement was the maximum during flowering and fruit development stages. Therefore, final application of urea should be before flowering finishing and fruit development stages. The highest fruit yield as well as straw yield was recorded in 200 kg N ha^{-1} due to production of increased number of fruits $plant^{-1}$ that was statistically similar to 150 kg N ha^{-1}. Therefore, 150 kg ha^{-1} was sufficient for normal plant growth and development if urea was applied frequently with 20 days interval.

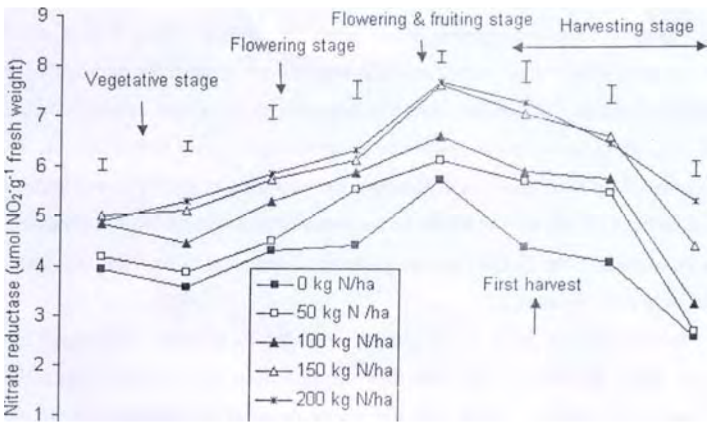


Fig. 1. Ontogenetic nitrate reductase activity as influenced by N-doses

Table 16. Effect of different levels of nitrogen on yield attributes and yield in tomato

N-doses (kg ha^{-1})	Fruits $plant^{-1}$ (no.)	Single fruit wt. (g)	Fruit wt. $plant^{-1}$ (kg)	Fruit yield (t ha^{-1})	Straw wt. $plant^{-1}$ (g)
0	30.0b	770c	1.00c	35.0c	37.67d
50	13.5b	815c	1.10c	39.6c	40.06cd
100	16.0a	955b	1.53b	55.1b	49.30b
150	17.6a	1080a	1.90a	68.4a	60.65a
200	17.5a	1115a	1.95a	70.2a	62.24a

In a column, same letter(s) do not differ significantly at $P \leq 0.05$ by DMRT.

Effect of different levels of Chitosan application on yield of maize

The experiment was conducted at the farmers field, Mymensingh, Bangladesh during the period from December 2011 to April 2012 to investigate the response of grain yield to different concentrations of Chitosan growth promotor. Quality protein maize-1 (QPM-1) was used as planting material. Five different concentrations of Chitosan *viz.,* 0. 50, 75, 100 and 125 ppm were sprayed three times at 40, 55 and 70 days after sowing (DAS). In control, water was sprayed as per treatment. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4 m × 5 m. Plant spacing was 70 cm × 30 cm. Fertilizers such as urea, TSP, MOP and gypsum were applied @ 285, 250, 180 and 40 kg ha^{-1}, respectively. Urea was applied in three splits at 30, 50 and 70 DAS and other fertilizers were applied as basal dose during final land preparation. Other cultural practices such as weeding and pest control were done as and when necessary for normal plant growth and development.

Chitosan concentration had significant effect on plant height, biological yield, harvest index, yield components and seed yield in maize except number of cobs $plant^{-1}$ (Table 17). Results revealed that all the plant parameters were greater in Chitosan applied plants than control plants except 50 ppm Chitosan. The highest plant height (218 cm), biological yield (278.0 g $plant^{-1}$), yield attributes (except 100-seed weight) and seed yield (6.32 t ha^{-1}) was recorded in 100 ppm followed by 125 ppm amd 75 ppm. The seed yield was higher in 100 ppm Chitosan might be due to increase number of seeds cob^{-1}. In contrast, the lowest above mentioned parameters was recorded in control plants where no Chitosan was sprayed. Further, the highest 100-grain weight and harvest index wererecorded in 125 ppm Chitosan indicating dry matter partitioning to economic yield was better in 125 ppm concentration than the other concentrations. However, the grain and biological yield was lower in 125 ppm than 100 ppm Chitosan indicating application of Chitosan @ 125 ppm may be toxic for maize production. So, Chitosan may be applied thrice @ 100 ppm for increased grain yield of maize after few more field trials.

Table 17. Effect of different levels of Chitosan on some morphological characters, yield attributes and seed yield in maize cv. QPM-1

Concentration	Plant height (cm)	Biological yield $plant^{-1}$ (g)	Seeds cob^{-1} (no.)	100-seed weight (g)	Seed yield (t ha^{-1})
0	190.0c	235.5c	456.2b	22.94d	5.10c
50	188.0c	299.3c	436.2c	23.31cd	4.64d
75	211.0b	258.8b	450.0b	24.08bc	5.59bc
100	218.0a	278.0a	511.7a	23.95b	6.32a
125	212.0ab	255.6b	460.7b	25.08a	5.95ab

In a column, same letter(s) do not differ significantly at $P \leq 0.05$ by DMRT.

SOIL SCIENCE DIVISION

RESEARCH HIGHLIGHTS

Due to site-specific variations in land management practices, differences were found in soil texture, organic carbon, total nitrogen, available phosphorus, available sulfur and exchangeable cations (Ca, K and Na) within the soils of Pabna district of Ganges River Floodplain area.

Arsenic contamination was found in the soils of the Ganges River Floodplain area. Results recommend a careful consideration for irrigation waters during irrigation.

An augmentation of crop yields was observed due to 25% increase of N, P, K and S fertilizers with a few exceptions.

Incorporation of press mud and/or tobacco dust @ 2 t ha^{-1} along with recommended fertilizer dose for MYG recorded identical grain yield of boro and T. aman compared to fertilizers applied for HYG. In case of HYG, IPNS based recommended fertilizers with press mud or tobacco dust @ 2 t ha^{-1} performed better compared to those with full dose of chemical fertilizer.

25% potassium fertilizers may be reduced due to addition of rice straw from the previous crop along with recommended doses of NPKS fertilizers were found the best for T. Aman rice production as well as K mining from the soil.

Balu river water contains acceptable amount of pH and NO_3 whereas, the EC, Ca, Mg, PO_4, and Fe exceeded the recommended limit for drinking water, irrigation water and for aquaculture.

The overall concentration of heavy metals in Balu river water showed the trend: Zn > Ni > Cd > Pb > Cr. The highest values of different heavy metals found at Termuni area whereas the lowest values were found at Demra Ghat.

Within 4 weeks of incubation, a rapid decrease in dry matter was observed with losses of about 59% in soybean, 57% in lentil and 47% in mungbean. On average 51.67% N remained in soybean residue, whereas in lentil and mungbean the value of %N remaining was 54.60 and 61.33 respectively.

PGPR biofertilizer along with cow dung and poultry manure can substitute 40% nitrogen application in rice cultivation.

$P_{20}B_3Mo_2$ along with rhizobial inoculant can be applied for sustainable mungbean cultivatioin.

External use of 50% P fertilizer can be saved either from TSP or cow dung (CD) with the application of phosphatic biofertilizer with 50% P from TSP or CD for the cultivation of lentil, chickpea and boro rice, respectively.

SOIL MANAGEMENT AND BIOFERTILIZER

Evaluation of Soil Characters for Assessment of Land Degradation Situation in Bangladesh

Evaluation of Soil Characters for Assessment of Land Degradation Situation in Pabna district

A study was initiated to evaluate the changes in soil characters over time for the assessment of land degradation situation in Bangladesh. The study was based on the selected sampling sites of Reconnaissance Soil Survey Reports of SRDI staffs, (1963-75) and Kawaguchi and Kyuma (1977). Based on those previous sites, soil samples from the same sites/series were collected from Pabna district during January, 2010. The sampled soil series covered part of the Ganges River Floodplain Soils and a brief description of the soil series is presented in Table 1.

Table 1. Description of the soil series in terms of morphology and land uses at different locations of Ganges River Floodplain area

Soil series	Sampling Location	Physiographic unit	Land type	Present land use
Sara	Baserpata, Sahapur, Ishurdi, Pabna	Ganges River Floodplains	Highland	Fruits garden/ vegetables
Gopalpur	Radhanagar, Sadar, Pabna	,,	Medium highland	Boro-F-T. aman
Ishurdi	Saraikadi, Muladuli, Ishurdi Pabna	,,	Medium lowland	Boro-F-T. aman
Ghior	Jotkan, Hemayetpur, Sadar, Pabna	,,	Lowland	Boro-F-T. aman

The soil samples were collected on a profile basis from each location and taken to the laboratory for physical and chemical analysis. The soils were then dried at room temperature, processed and passed through 10 mm sieve and stored for analysis. The soil samples were analyzed following standard methods, viz.: particle size distribution by a hydrometer and soil pH by glass electrode pH meter, organic carbon by wet Oxidation and total nitrogen by micro-Kjeldahl method, available phosphorus and available sulfur were extracted from the soil by dilute acid solutions and exchangeable cations e.g. Ca, K and Na were determined by ammonium acetate extraction method. The results of the soil characters were calculated on a profile basis. The mean and ranges of surface soil characters are presented in Table 2.

Table 2. Mean and ranges of characters of some selected soil series of Ganges River Floodplains during the period 2010

Soil characters	Mean	Range
Sand (%)	36.9	23.4-55.4
Silt (%)	39.0	33.0-48.0
Clay (%)	24.1	11.6-38.6
Texture	Silt loam to Clay loam soil	
pH	7.30	7.20-7.49
Organic C (%)	1.35	0.56-2.02
Total N (%)	0.13	0.02-0.21
Avail-P (ppm)	17.96	8.54-29.96
Avail-S (ppm)	23.63	14.30-32.10
Exch. Ca (me %)	17.5	15.0-22.50
Exch. K (me %)	0.58	0.52-0.65
Exch. Na (me %)	0.96	0.73-1.24

From the particle size distribution (Table 2), the texture of the soils was found silt loam to silty clay loam. The variations in soil texture within these soils might be due to the local variation in soil morpho-physical characteristics, micro-geographical and differences in farm management practices. The soils were alkaline in reaction. Variations in organic carbon, total nitrogen, available phosphorus, available sulfur and exchangeable cations were also observed (Table 2). These variations in organic carbon, total nitrogen, available phosphorus, available sulfur and exchangeable cations within the soils might be due to the local differences in soil characteristics, changes in cropping systems (e.g. crop types, fertilization, irrigation, etc.) and other management practices in the farming communities.

Changes in particle size distribution

The changes in particle size distribution (sand, silt and clay contents) of the soils under study during the period between 1960s and 2010 are shown in Table 3. Changes in the particle size distribution showed a decline in the sand contents in favour of the clay and silt contents in the Sara series soil. The opposite trend of Sara series was observed for the Ghior soil. Changes in the particle size distribution showed no definite trend of decrease or increase in the sand, silt and clay contents for the surface and sub-soils. The process that can contribute to the loss of silt and clay from the surface or sub-soils might be run off from the higher to the lower fields or the removal with the seepage.

Table 3. Changes in sand, silt and clay content in different soil series of Pabna during the period between 1960s and 2010

Soil sries	Depth (cm)	pH			Organic C (%)			Total N (%)		
		1960s	2010	% change	1960s	2010	% change	1960s	2010	% change
Sara	0-15	77.0	55.4	-28.1	14.0	33.0	+136	9.0	11.6	+28.9
	15-32	73.0	52.4	-28.2	17.0	34.0	+100	10.0	13.6	+36.0
	32-50	88.0	57.4	-34.8	9.0	30.0	+233	3.0	12.6	+320
	50-60	55.0	45.4	-17.5	33.0	37.0	+12.1	12.0	17.6	+46.7
Gopalpur	0-15	9.20	26.4	+187	59.7	48.0	-19.6	31.1	25.6	-17.7
	15-32	12.3	20.4	+65.9	58.6	42.0	-28.3	29.1	37.6	+29.2
	32-50	37.1	12.4	-66.6	35.7	45.0	+26.1	27.2	42.6	+56.6
	50-60	75.5	16.4	-78.3	14.6	53.0	+263	9.9	30.6	+209
Ishurdi	0-15	40.0	42.4	+6.00	30.0	37.0	+23.3	30.0	20.6	-31.3
	15-32	28.0	30.4	+8.57	31.0	40.0	+29.0	41.0	29.6	-27.8
	32-50	38.0	20.4	-46.3	34.0	41.0	+20.6	28.0	38.6	+37.9
	50-60	35.0	26.4	-24.6	51.0	45.0	-11.8	14.0	28.6	+104
Ghior	0-15	8.0	23.4	+193	16.0	38.0	+138	76.0	38.6	-49.2
	15-32	7.0	14.4	+106	7.0	20.0	+186	86.0	65.6	-23.7
	32-50	5.0	14.4	+188	45.0	40.0	-11.1	50.0	45.6	-8.8
	50-60	10.0	16.4	+64.0	44.0	40.0	-9.1	46.0	43.6	-5.2

Changes in soil pH, organic carbon and total N contents

Table 4 shows the changes in pH values of the soils under study during the period between 1960s and 2010. The changes in pH values showed a decrease in both surface and sub-soils except an increase in the surface soil pH value in the Ghior series soil. The decline in pH values is mainly due to the local differences of the farm management practices (fertilization, irrigation, etc.) in the study areas. The changes in pH values of different soils partially supported by the changes in the exchangeable cations contents.

Changes in organic carbon and total N contents showed either an increase or decrease in the surface and sub-soils, respectively (Table 4). The increase or decrease in organic carbon and total N contents was mainly due to the local differences in soil characteristics and farm management activities.

Table 4. Changes in pH, total C and total N content in different soil series of Pabna during the period between 1960s and 2010

Soil sries	Depth	pH			Organic C (%)			Total N (%)		
	(cm)	1960s	2010	% change	1960s	2010	% change	1960s	2010	% change
Sara	0-15	8.1	7.20	-11.1	0.40	0.56	+41.0	0.04	0.02	-42.5
	15-32	8.0	7.31	-8.63	0.40	0.40	+0.75	0.03	0.02	-41.7
	32-50	7.7	7.28	-5.45	0.20	0.24	+21.0	0.03	0.02	-50.0
	50-60	8.2	7.33	-10.6	-	0.73	-	-	0.14	-
Gopalpur	0-15	8.1	7.26	-10.6	1.10	1.25	+13.6	0.11	0.14	+28.4
	15-32	8.2	7.50	-7.98	0.80	0.68	-14.3	0.08	0.09	+20.0
	32-50	8.2	7.62	-7.19	0.54	0.44	-18.0	0.05	0.06	+21.2
	50-60	8.3	7.65	-8.05	0.46	0.34	-25.5	0.01	0.03	+130.8
Ishurdi	0-15	8.1	7.49	-7.53	1.44	1.58	+9.72	0.11	0.16	+45.5
	15-32	8.0	7.50	-6.25	0.40	0.73	+81.3	0.04	0.07	+75.0
	32-50	8.1	7.61	-6.05	0.38	0.32	-15.3	0.04	0.06	+50.0
	50-60	8.1	7.65	-5.56	-	0.24	-	-	0.63	-
Ghior	0-15	6.4	7.44	+16.3	3.06	2.02	-34.2	0.28	0.21	-25.0
	15-32	7.5	7.48	-0.27	0.77	0.56	-26.8	0.07	0.09	+28.6
	32-50	7.9	7.40	-6.33	0.41	0.73	+76.8	0.03	0.05	+66.7
	50-60	8.0	7.62	-4.75	-	0.16	-	-	0.49	-

Changes in exchangeable cation (Ca, K and Na) contents

Table 5 shows the changes in exchangeable Ca, K and Na contents of the Gopalpur and Ghior series soils during the period between 1960s and 2010. Changes in the exchangeable Ca contents showed a decrease in all the layers of soils except an increase in the lower 32-60 cm layers at Ghior series soils. Changes in the exchangeable K contents showed a general increase in all the layers of soils except a decrease in the 15-32 cm layers at Ghior series soils. Changes in exchangeable Na content showed a general increase in all the sampled layers of both the soils except a decrease in the top soil layer of the Gopalpur series (Table 5). The decrease or increase in the exchangeable cation contents in different soils might be due to the local differences in the natural environment and the farming activities (e.g. fertilizations, irrigation, etc.).

Table 5. Changes in exchangeable Ca, K and Na content in different soil series of Pabna during the period between 1960s and 2010

Soil series	Depth	Exch. Ca (me %)			Exch. K (me %)			Exch. Na (me %)		
	(cm)	1960s	2010	% change	1960s	2010	% change	1960s	2010	% change
Gopalpur	0-15	41.48	22.50	-45.8	0.41	0.65	+58.5	2.07	1.24	-40.1
	15-32	42.71	16.25	-62.0	0.57	0.52	-8.77	0.47	1.04	+121
	32-50	24.02	17.50	-27.1	0.28	0.47	+67.7	0.34	0.72	+112
	50-60	26.70	15.00	-43.8	0.10	0.30	+200	0.32	1.05	+228
Ghior	0-15	29.10	17.50	-39.9	0.09	0.52	+478	0.11	0.98	+791
	15-32	30.30	18.75	-38.1	0.07	0.43	+514	0.11	0. 84	+664
	32-50	17.70	18.75	+5.9	0.03	0.32	+967	0.10	0.92	+820
	50-60	17.00	18.75	+10.3	0.03	0.28	+833	0.11	0.68	+518

Conclusion

The study shows positive and/or negative variations in soil texture, organic carbon, total nitrogen, available phosphorus, available sulfur and exchangeable cations (Ca, K and Na) within the Ganges River Floodplain area. These variations in the soil characteristics are the indications of site-specific soil fertility improvement and/or depletion might be due to local land management practices within the period between 1960s and 2010.

Assessment of Arsenic contamination in soils and crops of different AEZs

Assessment of Arsenic contamination in soils of Ganges River Floodplains from Kustia and Panba districts

Arsenic (As) is a toxic heavy metal. Groundwater As contamination is a severe problem in Bangladesh. The southeast and southwest parts of the country are severely arsenic affected. Besides domestic use (drinking, cooking, etc.), a significant quantity of groundwater is utilized in agricultural sector, especially for irrigation. This toxic element may enter into the food chain and thus posing a significant threat to human health.

Presently environmental pollution has become a major problem along with increase of the world population. Many reports indicated the large variability of groundwater arsenic problem on both local and regional scale. It has been estimated that water poisoning is affecting as many as 85 million people, nearly 13 million of which is contaminated with As. It is not unlikely that irrigation with As contaminated groundwater may increase its level in soil and this toxic element may consequently be the health hazard after entering into the food chain through crop uptake. However, no detailed information is available regarding the status of As content in soils, and on how As content variations are associated with different soil types and are influenced by the soil properties. Therefore, it is necessary to assesses the changes in As status of different soils and identify the factors regulating the As contamination in the soils of Bangladesh. In our present study, we tried to assess the extent of arsenic contamination in some selected soils of the Ganges River Floodplain area in Bangladesh.

Materials and Method

Soil sampling and laboratory analysis

The study was based on selected sampling sites of Reconnaissance Soil Survey Reports of SRDI staffs, (1963-75) and Kawaguchi and Kyuma (1977). Only the surface soil samples have been used for arsenic analysis. Air-dried soil samples were grinded and passed through a 10 mm sieve and stored in a plastic bottle for laboratory analysis. Approximately 0.5 g of air-dried soil samples were taken in a 100 ml digestion tube. Several concentrated acids are commonly utilized in acid digestion procedure. After several steps of extraction, the total arsenic content was measured by hydride generation Atomic Absorption Spectrophotometer according to Loeppert (2002).

Results and Discussion

Arsenic contamination in agricultural soils

Although many reports [(Ali and Wakatsuki (2002), Karim *et al.* (1997), Ishiga *et al.* (2000), Nickson *et al.* (2000) and Asia Arsenic Network (AAN, 1999 and 2000)] indicated the large variability of groundwater arsenic contamination, there are little indication of increasing soil arsenic concentration on both local and regional scale over time because of irrigation. However, Ali et al. (2003) reported the arsenic concentrations in some selected soils in the Ganges River Floodplain area of Bangladesh. Comparison among the soils of different physiographic units showed no increase rather showed a mean decrease in the total arsenic contents during the period between 1967 and 1995 in Bangladesh. The present study showed the higher total arsenic contents in the different soil series of during the period between 1960s and 2010. (Table 6). The increase or decrease of the total arsenic contents in the different soil series (Table 7) might be associated with the local differences in parent materials (e.g. arsenic-bearing minerals), farm management practices (e.g. use of arsenical pesticides), continental inputs (e.g. dry and wet deposition) and other biogeochemical activities.

According to Vinogradov (1959) and Backer and Chesnin (1975), the natural content of arsenic in soils is about 5 mg kg^{-1}, the same to Bowen (1979) is 6 mg kg^{-1}. Smith *et al.* (1998) reported a background arsenic level of 8 mg kg^{-1} for non-contaminated agricultural soils. The safe levels of arsenic for irrigation water is 0.2 ppm (upper limit) in Bangladesh (GOB, 1997), but the As levels for different soils and food materials are yet to be established in Bangladesh.

However, Ali *et al.* (2003) proposed the background level of arsenic for the selected soil series, physiographic units and land types in Bangladesh. The present arsenic levels (e.g. Tables 6 and 7) show clear indication of arsenic contamination in soils of Ganges River Floodplain area during the period 2010.

Table 6. Surface soil characters of different soil series of Ganges River Floodplains from Pabna-Kustia during the period 2010

Soils	Sand	Silt	Clay	pH	OC	TN	Exch. Ca	Exch. K	Exch. Na	Total As
		%				%		(me %)		(mg kg^{-1})
Sara	35.4	43.0	21.6	7.20	0.56	0.203	15.00	0.58	0.73	16.78
Gopalpur	58.4	26.0	15.6	7.26	1.25	0.182	22.50	0.65	0.98	14.06
Ishurdi	42.4	37.0	20.6	7.49	1.58	0.160	15.00	0.57	1.17	10.64
Ghior	43.4	28.0	28.6	7.44	2.02	0.210	17.50	0.82	1.68	14.06
Garuri	35.4	19.0	45.6	6.69	1.25	0.140	17.50	0.53	1.33	16.50
Gopalpur	51.9	30.0	18.1	7.51	1.04	0.091	15.00	0.44	1.49	12.03
Garuri	31.3	38.0	20.7	7.28	1.20	0.105	16.25	0.44	1.43	13.27
Sara	38.4	39.0	22.6	7.38	0.58	0.084	18.75	0.50	1.52	16.31
Gopalpur	41.4	35.0	23.6	7.40	0.81	0.119	18.75	0.38	1.36	18.28
Ishurdi	33.3	37.0	29.7	7.49	1.21	0.088	17.50	0.51	1.08	20.06
Ghior	33.3	32.0	34.7	7.47	1.76	0.125	20.00	0.41	1.49	16.25

Table 7. Changes in total arsenic (As) contents in different soils of Ganges River Floodplains from Pabna-Kustia districts during the period between 1967 and 2010

Soil series	1967	1995	2010
Gopalpur	13.5	10.3	14.06
Garuri	14.0	8.4	16.50
Gopalpur	10.4	9.0	12.03
Garuri	11.5	11.6	13.27

Conclusion

The present results show clear arsenic contamination in different soils of Ganges River Floodplain area (based on the reported reference level). However, the results indicate a careful consideration of As level for irrigation water.

Soil Fertility and Fertilizer Management for Crops and Cropping Patterns (SPGR funded)

Fertilizer is a key component in the agricultural production systems of Bangladesh. Its use efficiency is also becoming much more important in the market economy of agriculture products. Present level of fertilizer use in farmer's field shows under or over use of recommended fertilizer dose. It requires farm level investigation to find out reasons for such gap between the recommended dose and farmer's actual practices. It is therefore, also necessary to upgrade the fertilizer recommendation guide in different agro-ecological regions not only for increasing crop productivity but also for improving soil fertility.

Assessment of physico-chemical characters of the soils under study

Initial soil samples from different experimental fields were collected and analyzed. Initial soil status of different experimental sites is given in Table 8.

Table 8. Initial soil characteristics under study

Location	pH	OM (%)	N (%)	P (ppm)	K (meq %)	S (ppm)
Birgonj, Dinajpur	5.4	1.74	0.087	25.5	0.09	12.0
Debigonj, Panchagarh	5.4	1.20	0.060	16.6	0.09	21.9
Kaligonj, Lalmonirhat	5.3	1.74	0.087	31.6	0.11	19.1
Pirgonj, Rangpur	5.6	1.35	0.068	20.1	0.13	11.2
Madhupur, Tangail	6.7	1.10	0.055	08.6	0.10	14.8
Trisal, Mymensingh	6.9	1.57	0.079	05.7	0.13	19.8
Atgharia, Pabna	7.0	1.76	0.088	11.8	0.15	18.4
Baraigram, Natore	6.6	1.36	0.068	09.5	0.15	15.5
Shamnagar, Satkhira	7.8	2.60	0.142	13.6	0.29	20.2
Range	5.3-7.8	1.10-2.60	0.055-0.142	5.6-31.6	0.09-0.29	11.2-21.9

A total of 365 composite soil samples out of 500 have already been collected using GPS on different depths (0-15, 15-30 and 30-45 cm) from selected AEZs (5 samples spot^{-1}). A total of 265 composite soil samples out of 365 have been analyzed for pH, OM, texture, N, P, K and S analysis and analysis of the rest 100 samples are going on. Under the baseline study, selected characteristics of the soils in different experimental sites are given in Table 9. It was observed that chemical properties decrease with the increase in soil depth.

Table 9. Selected characteristics of top soil (0-15 cm and 15-30 cm) at different locations under baseline study

Location	Depth (cm)	pH	OM (%)	N (%)	P (ppm)	K (meq %)	S (ppm)
Birgonj, Dinajpur	0-15	5.4-5.6	0.98-1.45	0.06-0.14	13.5-28.8	0.06-0.08	12.6-19.7
	15-30	5.6-5.8	0.90-1.00	0.06-0.08	07.1-22.5	0.05-0.07	09.1-14.7
Debigonj, Panchagarh	0-15	5.3-5.6	0.93-1.13	0.09-0.17	14.9-20.5	0.05-0.07	16.9-24.6
	15-30	5.2-5.5	0.80-1.10	0.06-0.09	09.2-23.8	0.04-0.06	12.6-19.8
Kaligonj, Lalmonirhat	0-15	5.2-5.5	0.95-1.53	0.10-0.17	11.8-23.6	0.04-0.10	13.3-25.8
	15-30	5.4-5.9	1.00-1.40	0.08-0.09	09.0-22.3	0.04-0.09	10.5-13.3
Pirgonj, Rangpur	0-15	5.4-5.6	0.85-1.59	0.06-0.17	12.8-24.2	0.08-0.13	16.2-24.7
	15-30	5.2-5.5	0.60-1.50	0.06-0.11	08.1-20.4	0.08-0.13	10.5-14.1
Madhupur, Tangail	0-15	6.3-6.5	0.85-1.20	0.08-0.17	08.0-15.6	0.08-0.10	08.5-16.2
	15-30	6.0-6.5	0.60-1.20	0.06-0.17	05.0-10.8	0.09-0.12	08.3-14.2
Trisal, Mymensingh	0-15	6.8-7.0	1.21-1.75	0.09-0.11	08.0-15.0	0.07-0.09	11.2-16.1
	15-30	6.2-6.5	1.10-1.60	0.08-0.11	10.7-21.1	0.06-0.09	07.3-12.2
Atgharia, Pabna	0-15	6.6-6.9	1.18-1.78	0.12-0.17	11.0-21.0	0.09-0.13	12.6-24.7
	15-30	6.4-6.9	1.00-1.00	0.10-0.15	13.1-20.7	0.10-0.14	08.8-13.7
Baraigram, Natore	0-15	6.4-7.0	1.11-1.71	0.14-0.22	12.0-28.0	0.10-0.18	09.8-24.6
	15-30	6.8-7.1	1.00-1.60	0.11-0.15	15.9-26.8	0.12-0.17	07.8-11.7
Shamnagar, Satkhira	0-15	6.4-7.0	1.11-1.71	0.14-0.22	12.0-28.0	0.10-0.18	09.8-24.6
	15-30	6.8-7.1	1.00-1.60	0.11-0.15	15.9-26.8	0.12-0.17	07.8-11.7

Response of fertilizers to different crops and cropping patterns

Yield of T. aman rice

(Kharif II-2011)

T. Aman rice experiment during kharif-II, 2011 was conducted at 7 different locations (Birgonj, Dinajpur; Pirgonj, Rangpur; Debigonj, Panchagarh; Kaligonj, Lalmonirhat; Trisal, Mymensingh, Madhupur, Tangail and Ghatail, Tangail). According to cropping pattern, four experiments with potato as first crop were set up during Rabi season, 2012 at Birgonj, Dinajpur; Pirgonj, Rangpur; Debigonj, Panchagarh and Kaligonj, Lalmonirhat; wheat at Atgharia, Pabna, and mustard at Madhupur, Tangail. After harvesting Rabi crops, 2012 five field experiments during kharif I-2012 (Boro rice) were set up at Birgonj, Dinajpur; Pirgonj, Rangpur; Debigonj, Panchagarh; Trisal, Mymensingh and Madhupur, Tangail. RCB design was used in these experiments with three replications. Intercultural operation i.e. irrigation, weeding, thinning, insecticide/fungicide spray were done whenever necessary. Data were collected on soil properties (pH, OM, N, P, K and S), yield and yield component and nutrient concentration of the plant sample.

Table 10. Effects of fertilizers on yield of T. aman rice (Binadhan-7) during Kharif-II season, 2011

Treatments	Trisal, Mymensingh		Madhupr, Tangail		Ghatail, Tangail		Birgonj, Dinajpur	
	Yield (t ha^{-1})							
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1= 100% NPK (STB)	3.87bc	5.13b	3.97b	4.47e	3.57d	4.97c	3.93c	4.53c
$T_2 = T_1$ + 25% N	4.03ab	4.73b	4.53ab	4.87de	4.00cd	5.67bc	4.37bc	5.87b
$T_3 = T_1$ + 25% NP	4.60ab	4.80b	5.00a	6.20a	4.70b	6.03b	5.03ab	6.10ab
$T_4 = T_1$ + 25% NK	4.80ab	5.13b	4.77a	5.90ab	4.93b	6.20ab	5.13ab	6.47ab
$T_5 = T_1$ + 25% PK	4.70ab	5.63ab	4.53ab	5.87ab	4.47bc	5.53bc	4.93ab	5.47bc
$T_6 = T_1$ + 25% NPK	5.20a	6.40a	5.10a	5.60bc	5.50a	6.80a	5.72a	7.07a
T_7 = 75% of T_1	3.53bc	5.23b	3.93b	5.83cd	3.73d	5.23c	3.73c	4.43c
T_8 = Control	2.67c	3.60c	2.87c	3.73f	2.17e	3.77d	2.87d	3.27d

In a column, means followed by the same letter(s) are not significantly different at 5% level.
Trisal, Mymensingh: T_1 (STB) = $N_{64}P_{14}K_{28}S_6Zn_1$
Madhupur, Tangail: T_1 (STB) = $N_{68}P_{12}K_{32}S_8Zn_1$
Ghatail, Tangail: T_1 (STB) = $N_{60}P_{12}K_{36}S_8Zn_1$
Birgonj, Dinajpur: T_1 (STB) = $N_{64}P_6K_{32}S_8Zn_1$

Results indicate that application of N, P, K fertilizers at different proportion significantly affected both the grain and straw yields of T. aman rice (Table 10 and Table 11). Incrase of rice grain yield at 7 different locations, the highest yield was found in treatment T_6 (T_1 + 25% NPK). Statistically identical yield was observed in treatment T_2, T_3, T_4 and T_5 at Trisal, Mymensingh and Madhupur, Tangail; T_3, T_4 and T_5 at Birgonj, Dinajpur; T_3 at Debigonj, Panchagar; T_2, T_3 and T_4 at Kaligonj, Lalmonirhat and T_2 at Pirgonj, Rangpur. Incrase of straw, the highest yield was found in treatment T_6 (T_1 + 25% NPK) except Madhupur, Tangail where the highest yield was observed in treatment T_3 (T_1 + 25% NP). Statistically identical yield was found in T_5 at Trisal, Mymensingh; T_4 at Ghatail, Tangail; T_3 and T_4 at Birgonj, Dinajpur; T_1, T_4 and T_5 at Debigonj, Panchagar; T_2, T_4, T_5 and T_7 at Kaligonj, Lalmonirhaqt and all treatments except T_7 and T_8 at Pirgonj, Rangpur.

Table 11. Effects of fertilizers on the growth and yield of T. aman rice (Binadhan-7) Kharif-II season, 2011

Treatments	Debigonj, Panchagarh		Kaligonj, Lalmonirhat		Pirgonj, Rangpur	
	Yield (t ha^{-1})					
	Grain	Straw	Grain	Straw	Grain	Straw
T_1= 100% NPK (STB)	4.07cd	6.30ab	3.24bcd	3.56bc	4.14c	4.85ab
$T_2 = T_1$ + 25% N	4.30bcd	6.03b	3.58abc	4.40ab	4.63ab	5.12a
$T_3 = T_1$ + 25% NP	4.80ab	6.03b	3.81ab	3.77bc	4.37bc	4.69ab
$T_4 = T_1$ + 25% NK	4.23bcd	6.73ab	3.65abc	4.27ab	4.55b	5.19a
$T_5 = T_1$ + 25% PK	4.37bc	6.37ab	3.31bcd	3.95ab	4.34bc	4.69ab
$T_6 = T_1$ + 25% NPK	5.27a	6.90a	4.51a	3.94a	4.97a	5.06a
T_7 = 75% of T_1	3.67de	4.83c	3.01cd	3.88ab	3.45d	4.35bc
T_8 = Control	3.17e	3.60d	2.64d	2.98c	2.77e	3.80c

In a column, means followed by the same letter(s) are not significantly different at 5% level
Debigonj, Panchagarh: T_1 (STB) = $N_{67}P_6K_{32}S_6Zn_1$
Kaligonj, Lalmonirhat: T_1 (STB) = $N_{64}P_6K_{32}S_6Zn_1$
Pirgonj, Rangpur: T_1 (STB) = $N_{65}P_6K_{28}S_8Zn_1$

Nutrient Uptake (T. aman rice, 2011)

Nutrient uptake by T. Aman rice at different locations was influenced due to different treatments (Table 12 to Table 15). The highest N uptake was observed in treatment T_6 at four locations namely Trisal, Mymensingh; Kaligonj, Lalmonirhat; Pirgonj, Rangpur and Debigonj, Panchagarh. But at Madhupur, Tangail; Birgonj, Dinajpur and Ghatail, Tangail the highest uptake of N was recorded in treatment T_4. In case of P highest uptake was observed at Trisal, Mymensingh; Kaligonj, Lalmonirhat; Pirgonj, Rangpur; Debigonj, Panchagarh and Ghatail, Tangail in treatment T_6; at Madhupur, Tangail in treatment T_3 and at Birgonj, Dinajpur in treatment T_4. Treatment T_6 showed the highest uptake of K at all locations except at Madhupur, Tangail (treatment T_4). The highest uptake of S was observed in treatment T_6 at Trisal, Mymensingh; in treatment T_4 at Madhupur, Tangail; Birgonj, Dinajpur and Ghatail, Tangail and in treatment T_1 at Debigonj, Panchagarh. The lowest uptake of N, P, K and S was observed in control treatment at all locations.

Table 12. Effects of fertilizers on nutrient uptake (kg ha^{-1}) by T. aman rice (Binadhan-7) during Kharif-II season, 2011

Treatments	Trisal, Mymensingh				Madhupur, Tangail			
	N	P	K	S	N	P	K	S
T_1= 100% NPK (STB)	079	10.5	088	6.6	67	08.4	078	6.7
$T_2 = T_1$ + 25% N	071	09.5	075	6.5	82	10.8	087	9.4
$T_3 = T_1$ + 25% NP	084	11.4	082	7.7	90	13.1	096	8.9
$T_4 = T_1$ + 25% NK	100	11.4	098	6.9	90	11.6	115	9.2
$T_5 = T_1$ + 25% PK	088	12.2	112	7.5	78	10.9	096	9.0
$T_6 = T_1$ + 25% NPK	102	14.5	128	8.3	87	11.9	100	8.2
T_7 = 75% of T_1	064	09.5	083	6.5	70	10.0	086	7.4
T_8 = Control	043	06.5	051	3.6	43	06.7	054	5.2

Table 13. Effects of fertilizers on nutrient uptake (kg ha^{-1}) by T. aman rice (Binadhan-7) during Kharif-II season, 2011

Treatments	Kaligonj, Lalmonirhat				Pirgonj, Rangpur			
	N	P	K	S	N	P	K	S
T_1= 100% NPK (STB)	61	08.3	75	5.0	79	11.5	75.4	6.6
$T_2 = T_1$ + 25% N	64	11.2	74	5.9	89	12.5	89.5	7.2
$T_3 = T_1$ + 25% NP	67	10.9	60	6.2	76	10.7	78.5	7.4
$T_4 = T_1$ + 25% NK	73	11.0	92	5.5	86	12.1	93.8	6.8
$T_5 = T_1$ + 25% PK	61	09.6	77	5.3	76	12.4	74.8	6.6
$T_6 = T_1$ + 25% NPK	77	11.7	101	6.3	92	14.0	98.3	7.2
T_7 = 75% of T_1	53	07.8	68	5.1	61	10.9	73.3	5.8
T_8 = Control	38	06.8	43	3.3	47	06.6	53.5	3.8

Table 14. Effects of fertilizers on nutrient uptake (kg ha^{-1}) by T. aman rice (Binadhan-7 during Kharif-II season, 2011

Treatments	Debigonj, Panchagarh				Birgonj, Dinajpur			
	N	P	K	S	N	P	K	S
T_1= 100% NPK (STB)	083	14.6	088	08.3	073	11.7	068	08.0
$T_2 = T_1$ + 25% N	082	14.8	108	08.6	084	13.1	090	09.0
$T_3 = T_1$ + 25% NP	093	14.3	094	09.6	100	14.1	089	09.6
$T_4 = T_1$ + 25% NK	091	15.6	116	08.5	104	16.6	097	10.4
$T_5 = T_1$ + 25% PK	086	14.3	096	09.2	098	14.0	090	09.6
$T_6 = T_1$ + 25% NPK	103	17.4	133	10.6	111	19.8	109	10.0
T_7 = 75% of T_1	074	12.2	089	06.4	068	10.3	068	07.9
T_8 = Control	050	07.4	047	04.7	045	07.7	044	04.6

Table 15. Effects of fertilizers on nutrient uptake (kg ha^{-1}) by T. aman rice (Binadhan-7) during Kharif-II season, 2011

Treatments	Ghatail, Tangail			
	N	P	K	S
T_1= 100% NPK (STB)	070	14.5	76	7.8
$T_2 = T_1$ + 25% N	079	15.4	90	8.4
$T_3 = T_1$ + 25% NP	093	17.0	91	10.6
$T_4 = T_1$ + 25% NK	099	19.5	98	20.5
$T_5 = T_1$ + 25% PK	091	16.6	94	9.2
$T_6 = T_1$ + 25% NPK	106	23.4	95	9.6
T_7 = 75% of T_1	072	13.4	83	8.5
T_8 = Control	041	09.1	58	4.3

Rabi crops (2011-12)

The tuber yield of potato at four different locations during Rabi 2011-12 are shown in Table 16. The highest tuber yield of potato was obtained in treatment T_6 (T_1 + 25% NPK) at Debigonj, Panchagar which was statistically higher than other treatments. But at Birgonj, Dinajpur and Kaligonj, Lalmonirhat the highest potato yield was recorded in treatment T_4 which was statistically identical with treatment T_3 and T_6. Besides at Pirgonj, Rangpur treatment T_6 showed the highest yield which was statistically similar to treatment T_2, T_3, T_4 and T_5.

Increase of mustard and wheat significantly different yields were obtained among the treatments (Table 17). The highest yield of mustard (1.40 t ha^{-1}) was recorded in treatment T_6. It was noted that highest grain yield of wheat was observed in treatment T_6 which differed statistically with other treatments.

Table 16. Effects of fertilizers on the tuber yield (t ha^{-1}) of potato at different locations during Rabi, 2011-2012

Treatment	Potato Tuber (t ha^{-1})			
	Debigonj, Panchagar (Cardinal)	Birgonj, Dinajpur (Granula)	Kaligonj, Lalmonirhat (Granula)	Pirgonj, Rangpur (Local)
T_1= 100% NPK (STB)	14.70d	27.71c	20.47c	2.84d
$T_2 = T_1$ + 25% N	18.68c	29.65ab	21.80bc	3.38bcd
$T_3 = T_1$ + 25% NP	18.68c	30.00ab	22.68ab	3.94ab
$T_4 = T_1$ + 25% NK	17.76c	30.20a	24.36a	3.50bc
$T_5 = T_1$ + 25% PK	20.17b	28.68bc	21.54bc	3.42bcd
$T_6 = T_1$ + 25% NPK	21.91a	29.24ab	24.11a	4.18a
T_7 = 75% of T_1	12.45e	24.46d	16.99d	2.92cd
T_8 = Control	09.46f	14.29e	10.42e	1.67e

In a column, means followed by the same letter (s) are not significantly different at 5% level.
Debigonj, Panchagar (potato): T_1 (STB) = $N_{150}P_{18}K_{135}S_8Zn_2B_1$
Birgonj, Dinajpur (Potato): T_1 (STB) = $N_{135}P_{25}K_{135}S_{12}Zn_2B_1$
Kaligonj, Lalmonirhat(Potato) :T_1(STB) = $N_{135}P_8K_{130}S_{10}Zn_2B_1$
Pirgonj, Rangpur (Potato): T_1 (STB) = $N_{145}P_8K_{118}S_{12}Zn_2B_1$

Table 17. Effects of fertilizers on the yield (t ha^{-1}) of mustard at Madhupur, Tangail and wheat at Atgharia, Pabna during Rabi, 2011-2012

Treatment	Mustard (Madhupur, Tangail)		Wheat (Atgharia, Pabna)	
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1= 100% NPK (STB)	5.04e	1.53c	1.12c	1.53c
$T_2 = T_1$ + 25% N	6.50bc	1.81abc	1.17bc	1.81abc
$T_3 = T_1$ + 25% NP	7.88a	2.11a	1.30ab	2.11a
$T_4 = T_1$ + 25% NK	6.89b	1.83abc	1.32ab	1.83abc
$T_5 = T_1$ + 25% PK	5.83cd	1.72abc	1.35a	1.72abc
$T_6 = T_1$ + 25% NPK	6.75b	2.05ab	1.40a	2.05ab
T_7 = 75% of T_1	5.71de	1.60bc	0.87d	1.60bc
T_8 = Control	3.33f	0.46d	0.32e	0.46d

Madhupur, Tangail (Mustard): T_1 (STB) = $N_{85}P_{24}K_{60}S_{12}Zn_2B_1$
Atgharia, Pabna (Wheat): T_1 (STB) = $N_{120}P_{18}K_{75}S_{10}Zn_2B_1$

Kharif-1 crops (2012)

Application of fertilizers using different combinations significantly affected the grain and straw yield of boro rice at different locations (Table 18 and Table 19). The highest grain yield was observed in different treatments at different locations that are in T_6 at Trisal, Mymensingh; T_3 at Madhupur, Tangail and Debigonj, Panchagarh; T_6 at Birgonj, Dinajpur and T_5 at Pirgonj, Rangpur. Straw yield was found highest in T_5 at Trisal, Mymensingh and Madhupur, Tangail; T_4 at Birgonj, Dinajpur; T_6 at Debigonj, Panchagarh and T_3 at Pirgonj, Rangpur.

Table 18. Effects of fertilizers on the growth and yield of Boro rice (BRRI dhan29) during Kharif-I season, 2011

Treatments	Trishal, Mymensingh		Madhupur, Tangail		Birgonj, Dinajpur	
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1= 100% NPK (STB)	5.87c	6.47ab	4.08c	6.24a	5.59de	6.87d
T_2 = T_1 + 25% N	6.13bc	6.38ab	4.29bc	6.46a	5.77cd	8.77ab
T_3 = T_1 + 25% NP	6.13bc	7.06a	4.64a	7.10a	5.95c	7.50cd
T_4 = T_1 + 25% NK	5.80c	5.82b	4.48ab	6.32a	5.39e	9.15a
T_5 = T_1 + 25% PK	6.33ab	7.22a	4.17c	7.18a	6.57b	7.50cd
T_6 = T_1 + 25% NPK	6.53a	6.97a	4.52a	6.60a	6.95a	7.75bcd
T_7 = 75% of T_1	5.03d	5.60b	3.10d	4.45b	5.03f	8.39abc
T_8 = Control	2.40e	3.60c	2.28e	3.80b	2.65g	3.77e

In a column, means followed by the same letter(s) are not significantly different at 5% level.
Trisal, mymensingh: T_1 (STB) = $N_{140}P_{25}K_{90}S_8Zn_1B_{0.5}$
Madhupur, Tangail: $N_{150}P_{20}K_{70}S_{10}Zn_1B_{0.5}$. Note: Yield was lower due to disorder of irrigation source in the pick growing period.
Birgonj, Dinajpur: $N_{140}P_{08}K_{75}S_{10}Zn_1B_{0.5}$

Table 19. Effects of fertilizers on the growth and yield of Boro rice (BRRI dhan28) during Kharif-I season, 2011

Treatments	Debigonj, Panchagarh		Pirgonj, Rangpur	
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1= 100% NPK (STB)	5.90b	7.27b	5.43ab	6.91a
T_2 = T_1 + 25% N	6.37ab	8.32ab	5.70ab	7.13a
T_3 = T_1 + 25% NP	7.00a	8.77ab	5.54ab	7.33a
T_4 = T_1 + 25% NK	6.37ab	8.55ab	5.11b	7.30a
T_5 = T_1 + 25% PK	6.37ab	7.50b	5.77a	7.22a
T_6 = T_1 + 25% NPK	6.87a	9.37a	5.34ab	6.36a
T_7 = 75% of T_1	4.25c	4.80c	4.08c	6.60a
T_8 = Control	2.00d	3.72c	2.79d	3.96b

In a column, means followed by the same letter (s) are not significantly different at 5% level.
Debigonj, Panchagarh: T_1 (STB) = $N_{150}P_{08}K_{75}S_8Zn_1B_{0.5}$
Pirgonj, Rangpur: T_1 (STB) = $N_{146}P_{08}K_{65}S_{10}Zn_1B_{0.5}$

Nutrient uptake

Nutrient uptakes by crops are shown in Table 20-22.

Table 20. Effects of fertilizers on nutrient uptake (kg ha^{-1}) by Boro rice (BRRI dhan29) during Kharif-I season, 2011

Treatments	Debigonj, Panchagarh				Birgonj, Dinajpur			
	N	P	K	S	N	P	K	S
T_1= 100% NPK (STB)	102b	16.5c	134ab	13.5c	86d	13.7bc	105a	12.4c
T_2 = T_1 + 25% N	98b	16.9bc	137ab	13.8c	123a	16.4a	142a	12.3c
T_3 = T_1 + 25% NP	130a	27.2a	126ab	16.8b	118a	15.4ab	128a	15.7b
T_4 = T_1 + 25% NK	107b	13.1d	132ab	15.1bc	106bc	16.9a	138a	15.3b
T_5 = T_1 + 25% PK	103b	17.0bc	110b	13. 9c	116ab	17.0a	137a	18.3a
T_6 = T_1 + 25% NPK	135a	19.8b	146a	18. 6a	120a	16.6a	140a	12.5c
T_7 = 75% of T_1	76c	11.8d	76c	9.9d	99c	12.6c	126a	12.0c
T_8 = Control	35d	6.2e	60c	5.3e	43e	7.1d	62b	4.9d

In a column, means followed by the same letter (s) are not significantly different at 5% level.

Table 21. Effects of fertilizers on nutrient uptake (kg ha^{-1}) by Boro rice (BRRI dhan29 during Kharif-I season, 2011

Treatments	Madhupur, Tangail				Trisal, Mymensingh			
	N	P	K	S	N	P	K	S
T_1= 100% NPK (STB)	84a	12.18ab	94ab	8.9b	101ab	14.6bc	108ab	10.7cde
$T_2 = T_1$ + 25% N	81a	12.68a	85ab	10.5ab	109ab	14.2bc	110ab	10.3de
$T_3 = T_1$ + 25% NP	93a	13.69a	105a	11.4a	113a	15.7b	113a	12.9ab
$T_4 = T_1$ + 25% NK	86a	11.02b	97ab	9.3ab	93bc	13.7c	90bc	11.5bcd
$T_5 = T_1$ + 25% PK	82a	13.62a	113a	9.4ab	112a	15.1bc	111a	13.1a
$T_6 = T_1$ + 25% NPK	84a	12.48a	108a	9.6ab	102ab	18.2a	105ab	12.1abc
T_7 = 75% of T_1	54b	8.09c	74bc	6.5c	80c	13.6c	85c	9.5e
T_8 = Control	39c	5.51d	49c	5.2c	43d	6.0d	61d	5.7f

In a column, means followed by the same letter(s) are not significantly different at 5% level.

Table 22. Effects of fertilizers on nutrient uptake (kg ha^{-1}) by Boro rice (BRRI dhan29) at Pirgonj, Rangpur during Kharif-I season, 2011

Treatments	Pirgonj, Rangpur			
	N	P	K	S
T_1= 100% NPK (STB)	99bc	15.3a	50c	11ab
$T_2 = T_1$ + 25% N	110ab	15.1a	51c	12a
$T_3 = T_1$ + 25% NP	118a	15.8a	69a	11ab
$T_4 = T_1$ + 25% NK	94cd	14.8a	67ab	12a
$T_5 = T_1$ + 25% PK	119a	15.3a	71a	11ab
$T_6 = T_1$ + 25% NPK	111a	15.1a	60b	12a
T_7 = 75% of T_1	84d	11.9b	31d	10b
T_8 = Control	49e	6.1c	14e	5c

In a column, means followed by the same letter(s) are not significantly different at 5% level

Fertilizer requirement for crops/cropping pattern at Chalanbil area, Natore (AEZ-5)

Cropping pattern: Garlic-B. aman

There was remarkable variation of yield parameters among the treatments. Significantly different yield of garlic was obtained due to the treatments (Table 23). The highest yield of garlic (9.03 t ha^{-1}) was recorded in treatment T_2 which was statistically identical with all other treatments except T_7 and T_8.

Table 23. Effects of fertilizers on the yield (tha^{-1}) of garlic at Chalanbil area, Natore during Rabi, 2011-2012

Treatment	Plant height (cm)	Leaves (no.)	Single bulb weight (g)	Bulb diameter (cm)	Cloves bulb^{-1} (no.)	Garlic yield (bulb)
T_1= 100% NPK (STB)	51.6	4.1	9.1	9.2	15.3	8.22ab
$T_2 = T_1$ + 25% N	51.8	4.1	10.5	9.6	17.1	9.03a
$T_3 = T_1$ + 25% NP	52.5	4.1	9.9	9.4	16.7	8.53ab
$T_4 = T_1$ + 25% NK	50.8	4.2	9.0	9.4	17.3	8.71ab
$T_5 = T_1$ + 25% PK	54.1	4.4	9.2	8.8	16.8	8.64ab
$T_6 = T_1$ + 25% NPK	52.0	4.1	10.7	9.8	17.9	8.45ab
T_7 = 75% of T_1	49.7	4.2	7.6	8.7	15.0	7.69b
T_8 = Control	46.1	3.7	6.3	8.1	9.7	6.22c

T_1 (STB) = $N_{100}P_{35}K_{100}S_{25}Zn_2B_1$

Fertilizer requirement for crops adapted in saline area at Shamnagar, Satkhira (AEZ-13)

Cropping pattern: Boro-Fallow-T. aman

Application of different levels of fertilizers significantly influenced the yield and nutrient uptake by Boro rice (Tables 24 & 25). Statistically higher grain yield was obtained in treatment T_3 which was statistically similar to all other treatments except treatment T_4, T_6 and T_7. Straw yield was also found higher in treatment T_3 which was statistically identical with T_4 and T_6.

Table 24. Effects of fertilizers on the grain yield (t ha^{-1}) of Boro rice (Binadhan-8) at Shamnagar, Satkhira during Kharif-1, 2011

Treatments	Plant height (cm)	Panicle length (cm)	Tillers hill^{-1} (no)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1= 100% NPK (STB)	90.07bc	22.73a	09.40c	4.66abc	5.71b
T_2 = T_1 + 25% N	90.47b	22.67a	11.00ab	4.74abc	5.57b
T_3 = T_1 + 25% NP	90.53b	23.87a	11.93a	5.50a	6.71a
T_4 = T_1 + 25% NK	93.00a	23.73a	10.67abc	4.53bc	5.97ab
T_5 = T_1 + 25% PK	89.00c	23.00a	11.60ab	5.13ab	5.83b
T_6 = T_1 + 25% NPK	90.07bc	23.27a	10.53bc	5.04ab	6.35ab
T_7 = 75% of T_1	87.33d	23.40a	09.33c	4.05c	4.74c
T_8 = Control	72.07e	19.97b	06.73d	2.07d	2.57d
CV (%)	0.88	4.65	7.05	9.90	7.66

In a column, means followed by the same letter(s) are not significantly different at 5% level.
T_1 (STB) = $N_{120}P_{20}K_{12}S_4Zn_1B_{0.5}$

Table 25. Effects of fertilizers on nutrient uptake (kg ha^{-1}) by Boro rice (BRRI dhan29) at Shamnagar, Satkhira during Kharif-I season, 2011

Treatments	Pirgonj, Rangpur			
	N	P	K	S
T_1= 100% NPK (STB)	86ab	13.5bc	77bc	10.3b
T_2 = T_1 + 25% N	88ab	12.7cd	79b	10.7b
T_3 = T_1 + 25% NP	98a	15.1ab	108a	12.4a
T_4 = T_1 + 25% NK	90ab	12.2cd	79b	10.6b
T_5 = T_1 + 25% PK	78bc	11.2d	86b	10.8b
T_6 = T_1 + 25% NPK	101a	15.9a	80b	12.1a
T_7 = 75% of T_1	69c	9.3e	66c	9.0c
T_8 = Control	33d	6.6f	32d	4.5d
CV (%)	10.04	9.12	8.14	7.26

Integrated soil fertility and nutrient management for sustained crop production

Utilization of different organic materials for increased crop production and maintained soil fertility in Rice-Fallow-Rice cropping pattern

The experiment was initiated during 2010-11 at BINA farm, Mymensingh using Rice-Fallow-Rice cropping pattern to determine the suitability of different sources of organic materials for integrated use with chemical fertilizers for increasing crop productivity and maintain soil fertility. The initial nutrient content of different organic materials and soil properties used at different experiments are presented in

Tables 26 and 27. There were nine treatment combinations (Table 28) and the experiment was laid out in a randomized complete block design with three replications. Organic materials were applied to each crop before rice transplanting.

Table 26. Nutrient content (%) of the organic materials used in the experimental field

Name of the manure	N	P	K	S
Tobacco dust	1.00	0.13	0.85	0.20
Press mud	1.50	0.20	0.80	0.28
Cow dung	1.11	0.26	1.16	0.13
Rice straw	0.50	0.11	1.55	0.08
Poultry manure	2.15	0.53	0.75	0.95
Range	0.50-2.15	0.11-0.53	0.75-1.55	0.08-0.95

Table 27. Soil characteristics of the experimental sites

Location	pH	OM (%)	Total N (%)	Available nutrients (ppm)				Excha. cation
				P	S	Zn	B	K (meq %)
BINA farm, Mymensingh	6.5 (SA)	0.98 (VL)	0.09 (VL)	13 (M)	08 (VL)	1.3 (M)	0.48 (Opt)	0.10 (L)
BINA substation, Rangpur	5.8 (SA)	1.06 (L)	0.08 (VL)	12 (L)	14 (L)	0.70 (L)	0.29 (L)	0.19 (M)
Range	5.8-8.1	0.98-1.25	0.08-0.09	11-13	07-14	0.70-1.60	0.16-0.48	0.09-0.19

Note: SA = Slightly Acidic, SAL = Slightly Alkaline, L = Low, VL = Very Low
M = Medium, H = High, VH = Very High, Opt. = Optimum

Table 28. Treatment detail of the experiment

Treatments	Boro rice	T. aman rice
T_1	Control	Control
T_2	Fert. based on AEZ	Recommended Fert. based on AEZ
T_3	STB based Fert. for HYG	Recommended Fert. based on HYG (50% P & S)
T_4	T_2 + 1 ton press mud ha^{-1}	75% Recommended Fert. based on AEZ + 1 ton press mud ha^{-1}
T_5	T_2 + 1 ton tobacco dust ha^{-1}	75% Recommended Fert. based on AEZ + 1 ton tobacco dust ha^{-1}
T_6	T_2 + 2 ton press mud ha^{-1}	75% Recommended Fert. based on AEZ + 2 ton press mud ha^{-1}
T_7	T_2 + 2 ton tobacco dust ha^{-1}	75% Recommended Fert. based on AEZ + 2 ton tobacco dust ha^{-1}
T_8	T_3 + 2 ton press mud ha^{-1} based on IPNS	Recommended Fert. based on HYG + 2 ton press mud ha^{-1} based on IPNS
T_9	T_3 + 2 ton tobacco dust ha^{-1} based on IPNS	Recommended Fert. based on HYG + 2 ton tobacco dust ha^{-1} based on IPNS

Results

Results indicated that application of different packages of fertilizers increased grain and straw yields of rice differed significantly over absolute control treatment (Table 29). The grain and straw yields of T. aman rice (cv. Binadhan-7) during 2011 ranged from 1.90-5.20 and 3.00-6.83 t ha^{-1}, respectively. The highest grain yield of 5.20 t ha^{-1} was recorded in treatment T_8 ($N_{90}P_{12}K_{36}S_{10}$ kg ha^{-1}) which was statistically identical with T_9, T_7, T_6, and T_3. On the other hand, treatment T_1 which received no fertilizer produced lowest yields of 1.90 t ha^{-1}. The grain and straw yields of Boro rice (cv. Binadhan-5) during 2012 ranged from 2.10–5.95 and 3.35–7.09 t ha^{-1}, respectively. The highest grain yield of 5.95 t ha^{-1} was recorded in treatment T_8 (N_{140}, P_{20}, K_{80}, S_{20}, Zn_3 and B_2 kg ha^{-1} with 2 t ha^{-1} press mud based on IPNS) which was statistically identical with T_9, T_7, T_6, and T_3, respectively. On the other hand, treatment T_1 which received no fertilizer produced lowest yields of 2.10 t ha^{-1}. Like grain yields, the straw yields also differed significantly due to treatments. Azad and Leharia (2002) reported that grain and straw yields of rice significantly increased with the combination of organic and inorganic fertilizers.

Table 29. Effect of fertilization on the yield of boro and T. aman rice at BINA farm, Mymensingh

Treatments	T. aman-2011 (Binadhan-7)		Mean of 2 yrs. (T. aman)		Boro-2012 (Binadhan-5)		Mean of 3 yrs. (Boro)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	1.90d	3.00d	2.03	3.06	2.10c	3.35e	2.03	2.97
T_2	3.13c	3.95cd	3.33	4.30	4.18b	4.55d	3.96	4.54
T_3	4.50ab	5.90ab	4.52	5.57	5.80a	5.90c	5.26	5.90
T_4	3.93bc	4.60c	4.06	5.64	4.50b	5.35cd	4.24	6.01
T_5	3.89bc	4.83bc	4.13	5.88	4.68b	5.50cd	4.15	5.72
T_6	4.58ab	5.80ab	4.62	6.44	5.80a	7.00a	5.30	6.70
T_7	4.78ab	6.33a	4.85	6.58	5.68a	6.35bc	5.07	6.62
T_8	5.20a	6.80a	5.10	6.90	5.95a	7.55a	5.76	7.09
T_9	5.18a	6.83a	5.00	7.20	5.88a	6.10bc	5.66	6.52

Fertilizer dose (MYG): Boro-$N_{98}P_{14}K_{56}S_{14}Zn_2 B_1$, T.Aman-$N_{65}P_8K_{25}S_8$ (kg ha^{-1})
Fertilizer dose (HYG): Boro-$N_{140}P_{20}K_{80}S_{20}Zn_3B_2$, T.Aman-$N_{90}P_{12}K_{36}S_{10}$ (kg ha^{-1})

Data in Table 30 shows the cost and benefit of different treatments used in the experiment. The highest gross margin of Tk.1,63,663 ha^{-1} was obtained with the treatment T_8 followed by Tk. 1,60,593 ha^{-1} and 1,56,430 ha^{-1} in the treatment T_9 and T_7, respectively. Among the treatments, T_7 treatment gave the highest marginal benefit cost ratio (6.85). The second highest marginal benefit-cost ratio was found in treatment T_6 (6.77).

Table 30. Economic analysis of Boro-Fallow-T. aman rice cropping pattern

Treatments	Economic yield (kg ha^{-1})		Gross return (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Marginal gross margin (Tk ha^{-1})	MBCR
	Grain	Straw					
T_1	4000	6300	66300	-	66300	-	-
T_2	7300	8500	118000	12217	105783	39483	3.23
T_3	10300	11800	166300	16937	149363	43580	4.90
T_4	8430	9950	136400	12150	124250	57950	4.77
T_5	8570	10330	138880	12150	126730	60430	4.97
T_6	10380	12800	156980	13150	143830	89050	6.77
T_7	10460	12680	169580	13150	156430	90130	6.85
T_8	11150	14350	181600	17937	163663	97363	5.43
T_9	11060	12930	178830	18237	160593	94293	5.17

Grain = 15 Tk kg^{-1}, Straw = 1.00 Tk kg^{-1}, Urea = 12 Tk kg^{-1}, TSP = 22 Tk kg^{-1}, MP = 25 Tk kg^{-1}
Gypsum = 10 Tk kg^{-1}, Zn = 100 Tk kg^{-1}, Boron = 80 Tk kg^{-1}, MBCR = Marginal benefit cost ratio

The amounts of N, P, K and S uptake by Boro-Fallow-T.aman rice as affected by different treatments combination are presented in Table 31. Nutrient uptake increased with increase of yield. The highest uptake was found in T_8 treatment in case of N, P and S but for K it was in treatment T_7. The nutrient uptake ranged among the nutrients are N (42-159), P (08-29), K (62-222) and S (04-17) kg ha^{-1}.

Table 31. Nutrient uptake (kg ha^{-1}) as affected by different treatment combinations of organic and inorganic fertilization in Rice-Fallow-Rice cropping pattern

Treatments	Nutrient uptake (kg ha^{-1})			
	N	P	K	S
T_1	42	8	62	04
T_2	103	20	142	11
T_3	133	25	183	15
T_4	136	21	192	15
T_5	119	21	178	13
T_6	147	28	189	15
T_7	150	29	222	15
T_8	159	29	216	17
T_9	156	27	213	16
Range	42-159	8-29	62-222	04-17

Conclusion

Integrated nutrient management by involving chemical fertilizers with organic manures and incorporation of press mud and/or tobacco dust @ 2 t ha^{-1} along with recommended fertilizer dose for MYG recorded identical grain yield of boro and T. aman rice compared to fertilizers applied for HYG. In case of HYG, IPNS based recommended fertilizers with press mud or tobacco dust @ 2 t ha^{-1} performed better compared to those with full dose of chemical fertilizers. Thus it can be concluded that for efficient production rice and maintenance of soil productivity integrated use of organic manure or crop residues with chemical fertilizers is needed.

Monitoring and management of saline soil for increased crop production

The experiment was conducted at Kaligonj, Satkhira district of saline area. The experiment was laid out in RCB design and there were six treatments Viz. T_1 = control, T_2 = Fertilizer for MYG, T_3 = Fertilizer for MYG + CD (5 t ha^{-1}), T_4 = Fertilizer for HYG, T_5 = Fertilizer for HYG + CD (5 t ha^{-1}) based on IPNS, T_6 = Farmers practices, for the crops (Mungbean and mustard), each replicated three times. Each replication represented a block. There were 18 (6 × 3) unit plots. The recommended doses of fertilizer treatments used in the experiment. Full dose of P, K, S, Zn, B fertilizers and 1/3rd of N fertilizer were applied at the time of final land preparation. The rest of N fertilizer was applied in two equal split, i.e. 30 days of transplanting and 60 days after sowing. The soil sample was collected for soil texture, pH, organic matter, total N, exchangeable K available P, and S. Plant samples (Grain and straw) were collected from the field experiment for analysis for NPKS content.

Table 32. Nutrient status of initial soil of farmer's field at Kaligonj, Satkhira

pH	OM (%)	Total N (%)	Available nutrients (ppm)				Exch. Cation (meq %)	EC (ds/m)
			P	S	Zn	B	K	
7.8	2.60	0.14	13.6	20.2	-	-	0.29	4.6
Critical level	-	0.12	10	10	0.6	0.2	0.12	

Results

The yield of Munabean and Mustard are presented in table 2. Results indicated that application of different packages of fertilizers increased grain significantly over absolute control treatment. The grain yield of mungbean (cv. Binamoog-7) ranged from 0.69 to 1.21 t ha^{-1}. The highest yield of 1.21 t ha^{-1} was recorded in treatment T_5 = Fertilizer for HYG + CD (5 t ha^{-1}) based on IPNS. The lowest yield was recorded in absolute control treatment. The mustard (cv. Binasharisha-5) yield ranged from 0.39 to 1.10 t ha^{-1}. The highest yield of 1.12 t ha^{-1} was recorded in treatment T_5 = Fertilizer for HYG + CD (5 t ha^{-1}) based on IPNS. The lowest yield was recorded in absolute control treatment.

Table 33. Grain yield of mungbean and mustard at Kaligonj and Shamnagar under Satkhira district

Treatments	Yield (t ha^{-1})	
	Mungbean (Binamoog-7)	Mustard (Binasharisha-5)
T_1	0.69b	0.39c
T_2	1.06a	0.80b
T_3	1.08a	1.00ab
T_4	1.00a	1.06a
T_5	1.21a	1.10a
T_6	1.10a	0.96ab
Fertilizer dose (MYG)	$N_{15}P_{18}K_{10}S_4B_1$ (kg ha^{-1})	$N_{36}P_{13}K_{30}S_8$ (kg ha^{-1})
Fertilizer dose (HYG)	$N_{20}P_{25}K_{18}S_8B_1$ (kg ha^{-1})	$N_{50}P_{17}K_{40}S_{10}$ (kg ha^{-1})

Conclusion

The mungbean and mustard could be very much useful and suitable in saline area to increased crop production. The treatment T_5 = Fertilizer for HYG + CD (5 t ha^{-1}) based on IPNS was found the best and produced highest yield of mungbean and mustard which were 1.21 and 1.10 t ha^{-1}, respectively. Suitable management practices of saline soil would be very crucial for crop production and combination of organic materials and chemical fertilizer found suitable for higher crop production.

Response of NERICA rice to different management packages nutrient under drought environment

The experiment was conducted in drought prone area of Godagari, Rajshahi district. The experiment was laid out in RCB design with three replications and had six treatments. Viz. T_1 = control, T_2 = Recommended fertilizer for moderate yield goal (MYG) + cowdung (5 t ha^{-1}), T_3 = Recommended fertilizer for high yield goal (HYG), T_4 = Recommended fertilizer for high yield goal (HYG) + cowdung (5 t ha^{-1}), T_5 = Recommended fertilizer for high yield goal (HYG) + cowdung (5 t ha^{-1}) based on IPNS, T_6 = Recommended fertilizer for high yield goal (HYG) + 10% excess fertilizer of HYG. Each replication represented a block. There were 18 (6 × 3) unit plots. The fertilizer treatments used in the experiment were recommended dose. Full dose of P, K, S, Zn, B fertilizers and $1/3^{rd}$ of N fertilizer were applied at the time of final land preparation. The rest of N fertilizer was applied in two equal split, i.e. 15 and 35 days of transplanting. The soil sample was analysis for soil texture, pH, organic matter, total N, exchangeable K available P, and S. Plant samples (grain and straw) were collected from the field experiment. Composite soil samples (0-15 cm depth) were collected from the experimental plot before setting and after completion of the experiment.

Results

The grain and straw yields of Boro rice of 2012 are presented in Table 2. Results indicated that application of different packages of fertilizers increased grain and straw yield significantly over absolute control treatment. The grain and straw yields of Boro rice (cv. NERICA-10) during 2012 ranged from 1.68-5.29 and 2.04–5.69 t ha^{-1}, respectively. The highest grain yield of 5.29 t ha^{-1} was recorded in treatment T_5 (Recommended fertilizer for high yield goal + Cowdung @ 5 t ha^{-1} based on IPNS) which was statistically different with other treatments. Treatment T_1 which received no fertilizer produced lowest yields of 2.17 t ha^{-1}. Like grain yields, the straw yields also differed significantly due to treatments. The highest straw yield of 5.69 t ha^{-1} was recorded in treatment T_5 (Recommended fertilizer for high yield goal + cowdung @ 5 t ha^{-1} based on IPNS) which was statistically different with other treatments. On the other hand, the lowest straw yields (2.04 t ha^{-1}) was recorded in absolute control treatment.

Table 34. Nutrient status of initial soil of farmer's field at Godagari, Rajshahi

pH	OM (%)	Total N (%)	Available nutrients (ppm)				Exch. cation K (meq %)
			P	S	Zn	B	
5.2	1.55	0.11	10	13	1.6	0.45	0.12
Critical level		0.12	8.0	10.0	0.6	0.2	0.12

Table 35. Effect of different levels of fertilizer on yield and yield contributing characters

Treatments	Plant height (cm)	Tiller $hill^{-1}$ (no.)	Panicle length (cm)	Seed $panicle^{-1}$ (no.)	1000 seed weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	78.00c	4.03c	17.33b	58.77b	24.98	1.68d	2.04e
T_2	85.87b	5.57b	22.77a	120.93a	26.91	4.29c	4.27d
T_3	91.30ab	6.67a	22.60a	123.07a	26.84	4.42b	4.91c
T_4	89.97ab	6.87a	23.10a	132.40a	26.04	4.53b	5.07c
T_5	92.00a	7.27a	23.20a	135.20a	25.77	5.29a	5.69a
T_6	91.57a	6.77a	22.83a	132.67a	26.02	4.75b	5.37b

Fertilizer dose (Boro): MGY-$N_{98}P_{20}K_{50}S_{15}Zn_2B_1$ and HYG-$N_{120}P_{25}K_{65}S_{20}Zn_3B_1$,

Conclusion

Recommended fertilizer dose and along with cowdung (5 t ha^{-1}) was found best treatment combination and produced highest biological yield (Grain and straw). But depending on the local environment, further research is underway to observe the suitability of agricultural production which would be very much economically viable and sustainable production.

Potassium management in soils and crop growth

Effects of different levels of rice residue to potassium supply and its impact on soil fertility using Rice-Fallow-Rice cropping pattern

The experiment was conducted at BINA farm using the cropping pattern, Boro-Fallow-T. aman. The experiment was laid out in RCB design. There were four treatments for the first crop (Boro rice) and ten treatments for the second crop (T. aman rice), each replicated three times. The fertilizer treatments used in the experiment were recommended dose. For Boro rice full dose of P, K, S, Zn, B fertilizers and 1/3 of N fertilizer were applied at the time of final land preparation. The rest of N fertilizer was applied in two equal split, i.e. 30 days of transplanting and 60 days after transplanting. And for T. aman rice P, K S and 1/3rd of urea were applied as basal and rest N fertilizer were applied as like first crop. The soil sample was analysis for soil texture, pH, organic matter, total N, exchangeable K available P, and S. Plant samples (Grain and straw) were collected from the field experiment and were analyzed for NPKS content.

Table 36. Treatments combination of different fertilizer management packages

Boro rice (var. Binadhan-5)		T. aman rice (var. Binadhan-7)	
T_1	Control (No fert. or rice straw.)	T_1	Control (No fert. or rice straw.)
T_2	50% NPKSZnB	T_2	50% NPKS + 100% rice straw removed
T_3	75% NPKSZnB	T_3	75% NPKS + 100% rice straw removed
T_4	100% NPKSZnB	T_4	100% NPKS +100% rice straw removed
		T_5	100% NPS +50% K fert.+ 25% Boro rice straw removed.
		T_6	100% NPS +50% K fert.+ 50% Boro rice straw removed.
		T_7	100% NPS +50% K fert.+ 75% Boro rice straw removed.
		T_8	100% NPS +75% K fert.+ 25% Boro rice straw removed.
		T_9	100% NPS +75% K fert.+ 50% Boro rice straw removed.
		T_{10}	100% NPS +75% K fert.+ 75% Boro rice straw removed.

Results

The grain and straw yields of Boro rice of 2012 are presented in Table 37. Results indicated that application of different packages of fertilizers increased grain and straw yield significantly over absolute control treatment. The grain and straw yields of Boro rice (cv. Binadhan-5) during 2012 ranged from 2.25-6.24 and 3.05–7.75 t ha^{-1}, respectively. The highest grain yield of 6.24 t ha^{-1} was recorded in treatment T_4 (N_{140}, P_{25}, K_{45}, S_{20}, Zn_4 and B_2 kg ha^{-1}) which was statistically different with other treatments. Like grain yields, the straw yields also differed significantly due to treatments. The lowest grain and straw yields were recorded in absolute control treatment. The grain and straw yields of T. aman rice (cv. Binadhan-7) during 2011 ranged from 2.17-5.20 and 3.18-7.13 t ha^{-1}, respectively. The highest grain yield of 5.20 t ha^{-1} was found in two treatments (T_8 and T_9). On the other hand, treatment T_1 which received no fertilizer produced lowest yields of 2.17 t ha^{-1}. Like grain yields, the straw yields also differed significantly due to treatments.

Table 37. Effect of different fertilizer management packages and rice straw on the yield of Boro and T. aman rice at BINA farm, Mymensingh

Treatments	Boro-2012 (Var. Binadhan-5)				T. Aman-2011 (Var. Binadhan-7)			
	Yield (t ha^{-1})		Mean of 3 yrs.		Yield (t ha^{-1})		Mean of 3 yrs.	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	2.25c	3.05d	2..63	3.50	2.17e	3.18e	2.44	3.87
T_2	4.13b	4.85c	3.72	4.40	3.10d	4.27d	3.12	4.72
T_3	4.95b	5.85b	4.92.	6.12	3.83c	4.73d	3.57	5.04
T_4	6.24a	7.75a	5.98	7.20	4.40bc	5.33cd	4.60	5.54
T_5					4.17bc	5.00d	4.50	5.53
T_6					4.40bc	5.50cd	4.55	5.23
T_7					4.60ab	6.20bc	4.64	5.48
T_8					5.20a	7.03ab	4.94	6.75
T_9					5.20a	7.13a	5.02	6.40
T_{10}					4.57ab	6.10c	4.60	6.02

Fertilizer dose (HYG): Boro-$N_{140}P_{20}K_{80}S_{20}Zn_3B_2$, T. aman-$N_{90}P_{12}K_{36}S_{10}$ (kg ha^{-1})

Data in Table 38 shows the cost and benefit of different treatments used in the experiment. The highest gross margin of Tk. 1,86,480 ha^{-1} was obtained with the treatment T_9 followed by Tk. 1,86,380 ha^{-1} and 1,76,550 ha^{-1} in the treatment T_8 and T_7, respectively. Among the treatments, T_9 treatment gave the highest marginal benefit cost ratio (5.55). The second highest marginal benefit-cost ratio was found in treatment T_8 (5.54).

The amounts of N, P, K and S uptake by Boro-Fallow-T. aman rice as affected by different treatments combination are presented in Table 39 Nutrient uptake increased with increase of yield. The highest uptake of N and P was found in T_8 and T_9 treatment but in case of K and S it was in treatment T_{10}. The nutrient uptake ranged among the nutrients are N (95-247), P (8-18), K (75-214) and S (08-22) kg ha^{-1}.

Change in soil fertility status is very little due to the addition of fertilizer and rice straw in the cropping pattern (Table 40). The nutrient status of initial and post harvest soil were not remarkably change due to the different treatment except control.

Table 38. Economic analysis of Boro-Fallow-T. aman rice cropping pattern

Treatments	Economic yield (kg ha^{-1})		Gross return (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Marginal gross margin (Tk ha^{-1})	MBCR
	Grain	Straw					
T_1	4420	6230	72530	-	72530	-	-
T_2	7230	9120	117570	8887	108683	36153	4.07
T_3	8780	10580	142280	13331	128949	56419	4.23
T_4	10640	13080	172680	17775	154905	82375	4.63
T_5	10410	12750	168900	17025	151875	79345	4.66
T_6	10640	13250	172850	17025	155825	83295	4.89
T_7	10840	13950	176550	17025	159525	86995	5.11
T_8	11440	14780	186380	17400	168980	96450	5.54
T_9	11440	14880	186480	17400	169080	96550	5.55
T_{10}	10810	13850	176000	17400	158600	49917	2.87

Grain = 15 Tk kg^{-1}, Straw = 1.00 Tk kg^{-1}, Urea = 12 Tk kg^{-1}, TSP = 22 Tk kg^{-1}, MP = 25 Tk kg^{-1}, Gypsum = 10 Tk kg^{-1}, Zn = 100 Tk kg^{-1}, Boron = 80 Tk kg^{-1}, MBCR = Marginal benefit cost ratio.

Table 39. Nutrient uptake (kg ha^{-1}) as affected by different treatment combinations of organic and inorganic fertilization in Rice-Fallow-Rice cropping pattern

Treatments	Nutrient uptake (kg ha^{-1})			
	N	P	K	S
T_1	95	8	75	8
T_2	183	15	156	19
T_3	215	17	181	19
T_4	237	17	201	22
T_5	244	16	202	22
T_6	242	16	207	22
T_7	237	18	210	21
T_8	247	17	204	21
T_9	234	17	214	21
T_{10}	241	16	204	22

Table 40. Nutrient status of initial and post harvest soil in Rice-Fallow-Rice cropping pattern

Treatments	pH	OM (%)	Total N (%)	Available nutrients (ppm)				Exch. cation K (meq %)
				P	S	Zn	B	
				Initial soil				
	6.5	0.98	0.09	13	08	1.3	0.48	0.10
				Post harvest soil				
T_1	6.5	0.97	0.09	12	6	-	-	0.09
T_2	6.6	0.98	0.10	12	9	-	-	0.10
T3	6.5	0.97	0.12	13	9	-	-	0.11
T4	6.5	0.97	0.12	13	10	-	-	0.11
T5	6.5	0.98	0.13	12	9	-	-	0.11
T_6	6.6	0.98	0.10	12	10	-	-	0.10
T_7	6.5	0.97	0.11	12	9	-	-	0.10
T_8	6.6	0.98	0.12	13	10	-	-	0.11
T_9	6.6	0.99	0.12	13	9	-	-	0.11
T_{10}	6.5	0.98	0.11	13	10	-	-	0.11

Conclusion

Potassium replenishment through application of fertilizer or organic sources is important for sustainable crop production. Application of K fertilizer increase rice production along with other nutrients and incorporation of rice straw as a source of K fertilizer may produce substantial grain yield of T. aman rice. Thus use of 140 kg N, 25 kg of P, 45 kg K, 20 kg S, 4 kg Zn and 2 kg B ha^{-1} for Boro rice and 80 kg N, 8 kg of P, 22.5 kg of K, 8 kg of S ha^{-1} and 75% rice straw addition from previous crop for T. Aman were found to be the best treatment combination for the rice-rice cropping pattern as well as K mining from the soil.

Evaluation of different organic fertilizer for field trail using vegetable

Evaluation of "Biogen Jaibo sar (BJS)" on Lady's finger and "Krishibid Jaibo sar (KJS)" on Indian spinach production

Field experiments were conducted at BINA farm, Mymensingh, BINA sub-station farm, Ishurdi and BINA substation farm Rangpur during second week of May to third week of August, 2012 to observe the effect of organic fertilizers on Lady`s finger and Indian spinach production. The experiments comprised of seven treatments: T_1 = Recommended chemical fertilizer (RCF), T_2 = 85% RCF, T_3 = 70% RFC, T_4 = 85% RCF + 3 t ha^{-1} JS, T_5 = 85% RCF + 1 t ha^{-1} JS, T_6 = 70% RCF + 3 t ha^{-1} JS, T_7 = 70% RCF + 1 t ha^{-1} JS. The experiments were laid out in a RCB design with three replications. Organic fertilizers were applied before one week of final land preparation. After seven days of organic fertilizer application, one-third urea and all TSP, MP and Gypsum were applied. Urea was applied in two equal splits. Both of these installments were applied as broadcast and incorporated with soil followed by weeding. The fresh lady's finger and Indian spinach were harvested at different growing period.

Table 41. Initial soil status of the experimental sites.

Soil properties	BINA farm, Mymensingh	BINA substation, Ishurdi	BINA substation, Rangpur
pH	6.6	7.8	5.8
OM (%)	1.04	1.27	1.06
Nitrogen (%)	0.1	0.11	0.08
Phosphorus (ppm)	15.3	11.0	12
Potassium (meq%)	0.16	0.22	0.19
Sulphur (ppm)	15.8	18.6	14.2

Results

Lady's finger

Fresh fruit yield of lady's finger on different treatments of different locations shown in Table 42. In different locations, fresh fruit yield of lady's finger changed significantly due to the treatments. The fresh fruit yield of lady's finger ranged from 7.2 to 17.0 t ha^{-1} at both the locations (Table 42). The fresh fruit of lady's finger ranges from 7.2 to 10.0 at Mymensingh and 12.3 to 17.0 t ha^{-1} at Ishurdi, respectively. The highest yield was recorded in T_4 (85% RCF + 3 t ha^{-1} BJS) treatment at Mymensingh and Ishurdi. The lowest yield was obtained from treatment T_3 (70% RCF) at both the locations. From the different treatments of the organic and inorganic fertilizer packages, the results demonstrated that 3 t ha^{-1} BJS along with 85% RCF performed highest fruit yield in Mymensingh and Ishurdi.

At Mymensingh, the application of BJS increased the gross and net return in all the treatments (Table 43). The gross return and net return ranged from Tk. 1,44,000/- to 2,00,000/- and Tk. 1,37,294/- to 1,76,857/- per hectare, respectively. At Ishurdi the application of BJS increased the gross and net return in all the treatments. The gross return and net return ranged from Tk. 2,46,000/- to 3,40,000/- and Tk. 2,39,294/- to 3,16,857/- ,respectively per hectare. The highest net return and marginal return were obtained from T_4 (85% RCF + 3 t ha^{-1} BJS) treatment. However the highest gross return, net returns and marginal return were obtained from T_4 treatment. In both the locations (Mymensingh and Ishurdi) the highest MBCR (1.40 and 1.92, respectively) were obtained from T_4 treatment.

Indian Spinach

Fresh weight of Indian Spinach for different treatments at two locations is shown in Table 42. In both the locations, the yields were increased significantly due to the treatments. The yields ranged from 27.8 to 48.5 t ha^{-1} depending on the KJS used and locations (Table 42). However, the highest yield of 48.5 t ha^{-1} was recorded in treatment T_4 (85% RCF + 3 t ha^{-1} KJS) at Rangpur. The fresh weight of Indian Spinach ranged from 33.6 to 47.9 t ha^{-1} at Mymensingh. On the other hand, the yield ranged from 27.8 to 48.5 t ha^{-1} at Rangpur. The highest yield was recorded in treatment T_4 (85% RCF + 3 t ha^{-1} KJS) at both the locations while the lowest yield was obtained by the treatment T_3 (70% RCF) at both the locations. From the different treatments of organic and inorganic fertilizer packages, it may be concluded that 3 t ha^{-1} KJS along with 85% RCF performed the highest fresh vegetable yield at Mymensing and Rangpur.

Table 42. Effect of "Biogen Jaibo Sar" on Lady`s finger and "Krishibid Jaibo Sar" on Indian spinach production in different locations

Treatments	Fresh wt. (t ha^{-1})			
	Lady's finger		Indian spinach	
	Mymensingh	Ishurdi	Mymensingh	Rangpur
T_1: $N_{120}P_{24}K_{60}S_2$ (RCF)	7.7bc	14.1bc	41.6bc	36.4bc
T_2: 85% RCF	7.3c	13.9c	38.3cd	35.7c
T_3: 70% RCF	7.2c	12.3d	33.6e	27.8d
T_4: 85% RCF + 3 t ha^{-1} JS	10.0a	17.0a	47.9a	48.5a
T_5: 85% RCF + 1 t ha^{-1} JS	8.1b	14.8bc	42.4bc	43.9ab
T_6: 70% RCF + 3 t ha^{-1} JS	8.4b	15.4b	43.6ab	47.6a
T_7: 70% RCF + 1 t ha^{-1} JS	7.4c	13.7c	34.8de	34.8cd

Recommended Chemical fertilizer, @ N_{120} P_{24} K_{60} S_{20} kg ha^{-1} at Mymensingh & Ishurdiur
Recommended Chemical fertilizer @ N_{120} P_{24} K_{60} S_{20} kg ha^{-1} at Mymensingh & N_{120} P_{24} K_{80} S_{20} at Rangpur

Table 43. Cost benefit ratio of "Biogen Jaibo Sar" on Lady's finger production at two locations

Treatments	Yield (t ha^{-1})	Gross return	Variable cost	Net return	Marginal return	MBCR
		Tk ha^{-1}				
Mymensingh						
T_1	7.7	1,54,000	9,580	1,44,420	-	-
T_2	7.2	1,46,000	8,143	1,37,857	-6,563	-0.81
T_3	7.3	1,44,000	6,706	1,37,294	-7,126	-1.06
T_4	10.0	2,00000	23,143	1,76,857	32,437	1.40
T_5	8.1	1,62,000	13,143	1,48,857	4,437	0.34
T_6	8.4	1,68,000	21,706	1,46,294	1,874	0.09
T_7	7.4	1,48,000	11,706	1,36,294	-8,126	-0.69
Ishurdi						
T_1	14.1	2,82,000	9,580	2,72,420	-	-
T_2	13.9	2,78,000	8,143	2,69,857	-2,563	-0.31
T_3	12.3	2,46,000	6,706	2,39,294	-33,126	-4.94
T_4	17.0	3,40,000	23,143	3,16,857	44,437	1.92
T_5	14.8	2,96,000	13,143	2,82,857	10,437	0.79
T_6	15.4	3,08,000	21,706	2,86,294	13,874	0.64
T_7	13.7	2,74,000	11,706	2,62,294	-10,126	-0.87

Lady's finger = Tk 20 kg^{-1}, Urea = Tk 12 kg^{-1}, TSP = Tk 22 kg^{-1}, MP = Tk 25 kg^{-1},
Gypsum = Tk 9 kg^{-1}, Organic fertilizers = Tk 5 kg^{-1}.

The estimated gross return, variable cost, net return and marginal benefit cost ratio (MBCR) presented in Table 44. The application of fertilizer increased the gross and net return in all the treatments. The gross and net return ranged from Tk 3,36,000/- to 4,79,000/- and Tk 3,29,294/- to 4,55,857/- hectare^{-1}, at Mymensingh respectively .On the other hand, the gross and net return ranged from Tk 2,78,000/- to 4,85,000/- and Tk 2,71,294/- to 4,61,857/- at Rangpur respectively. However, the highest gross and net return 4,85,000/- and 4,61,857/- hectare^{-1} was obtained from T_4 at Rangpur. The highest MBCR was obtained 5.44 from T_5 (85% RCF + 1 t ha^{-1} KJS) treatment at Rangpur.

Table 44. Cost benefit ratio of "Krishibid Jaibo Sar (KJS)" production on Indian spinach at two locations

Treatments	Yield (t ha^{-1})	Gross return	Variable cost	Net return	Marginal return	MBCR
		Tk ha^{-1}				
Mymensingh						
T_1	41.6	4,16,000	9,580	4,06,420	-	-
T_2	38.3	3,83,000	8,143	3,74,857	-31563	-3.88
T_3	33.6	3,36,000	6,706	3,29,294	-77126	-11.5
T_4	47.9	4,79,000	23,143	4,55,857	49437	2.14
T_5	42.4	4,24,000	13,143	4,10,857	4437	0.34
T_6	43.6	4,36,000	21,706	4,14,294	7874	0.36
T_7	34.8	3,48,000	11,706	3,36,294	-70126	-5.99
Rangpur						
T_1	36.4	3,64,000	9,580	3,54,420	-	-
T_2	35.7	3,57,000	8,143	3,48,875	-5563	-0.68
T_3	27.8	2,78,000	6,706	2,71,294	-83126	-12.40
T_4	48.5	4,85,000	23,143	4,61,857	107437	4.64
T_5	43.9	4,39,000	13,143	4,25,857	71437	5.44
T_6	47.6	4,76,000	21,706	4,54,294	99874	4.60
T_7	34.8	3,48,000	11,706	3,36,394	-18126	-1.55

Indian spinach = Tk 10 kg^{-1}, Urea = Tk 12 kg^{-1}, TSP = Tk 22 kg^{-1}, MP = Tk 25 kg^{-1},
Gypsum = Tk 9 kg^{-1}, Organic fertilizers = Tk 5 kg^{-1}.

Conclusion

From the results it is revealed that there was ample scope of increasing the yield of lady's finger and Indian spinach through the use of organic fertilizers along with recommended inorganic fertilizers based on integrated nutrient management approaches. The uses of organic fertilizers are capable to reduce 15-30% of the recommended chemical fertilizers and can increase the yield upto 25% depending on the location.

Characterization and Management of river polluted soils for increasing crop production

Comparative Assessment of Heavy Metal Pollution in Balu River during 2011-12

A comparative study was carried out to assess the heavy metal concentration of the polluted Balu River during the year of 2011-12. River water was collected (upto 150 cm depth) from different four locations, such as- Termoni, Itakhola, Nagarpara and Demra, Ghat at one month interval, from 3 different depths (up to 150 cm). Different heavy metal parameters- Cr, Pb, Cd, Ni and Zn were analyzed from the collected water samples and results are described below:

Chromium (Cr) concentration in Balu river water:

The Cr concentration are presented in Table 45-48 and Figure 1-2. From the table 45, it is observed that Cr concentration at Termuni area in Balu river water under different water depths ranged from 0.07 to 0.15 mgL^{-1} during the year 2011-12. The maximum Cr concentration in surface water (0-50 cm) was recorded as 0.12 mgL^{-1} during the month of January-February 2012, whereas, the minimum value was found as 0.07 mgL^{-1} during the month of July – August, 2011. Among the different water depths more or less similar Cr concentration were recorded, which ranged from 0.07 to 0.12 mgL^{-1}. From the research results of Itakhola area, it was noted that the maximum Cr concentration was recorded as 0.11 mgL^{-1} during the month of February' 2012 and the minimum value was recorded as 0.05 mgL^{-1} during the month of July' 2011 (Table 46). More or less similar results were found from the water samples collected at different depths which ranged from 0.05-0.11 mgL^{-1}. In case of Nagarpara area, comparatively, a lower value was noted, where the Cr concentration ranged from 0.04 to 0.11 mgL^{-1} (Table 47). Considering the different water depths, there was no distinct differences of the Cr concentrations and the maximum and minimum value were recorded as 0.11 mgL^{-1} and 0.04 mgL^{-1} respectively. The Cr concentration in Balu river water at Demra location are presented in Table 48. From the results, it is noted that under surface water (0-50 cm) depth the maximum Cr concentration was observed as 0.07 mgL^{-1} during the month of February, 2012 and the minimum Cr value was recorded as 0.04 mgL^{-1} during July, 2011. Among the different water depths, the Cr concentrations was more or less closer, though comparatively higher Cr concentration was noted under 101-150 cm depth, which ranged from 0.06 to 0.08 mgL^{-1} and the highest Cr concentration was found during the month of February, 2012.

The mean Cr concentration (as maximum and minimum value) in Balu river water at different locations (such as Termuni, Itakhola, Nagarpara and Demra) is presented in the Fig. 1. From the figure, it was observed that the maximum Cr concentration was recorded as 0.118 mgL^{-1} from the Termuni area, which was also identical with the value from Itakhola and Nagarpara. Comparatively the lower Cr concentration was found from the water samples collected from Demra area (0.07mgL^{-1}). Considering both locations and sampling times (months), the highest Cr concentration in Balu river water was found as 0.12 mgL^{-1} at Termuni area during the month of January-March, 2012 and the lowest Cr value (0.05 mgL^{-1}) was noted at Demra area during the month of June and July (Fig. 2). Similar concentration (0.05 mgL^{-1}) was also observed from the water sample collected at Nagarpara during the month of July and August, 2011.

Table 45. Cr (mgL^{-1}) concentration in Balu River water at three different depths of Termuni location during the year 2011-2012

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.07	0.09	0.09	0.08
Aug'11	0.07	0.09	0.09	0.08
Sep'11	0.10	0.10	0.10	0.10
Oct'11	0.40	0.11	0.11	0.20
Nov'11	0.10	0.11	0.12	0.11
Dec'11	0.11	0.11	0.12	0.11
Jan'12	0.12	0.12	0.12	0.12
Feb'12	0.12	0.12	0.12	0.12
March'12	0.11	0.12	0.12	0.12
April'12	0.11	0.12	0.11	0.11
May'12	0.11	0.11	0.11	0.11
June'12	0.10	0.10	0.10	0.10
Average	0.13	0.11	0.11	0.11
Maximum	0.115	0.12	0.12	0.20
Minimum	0.07	0.09	0.09	0.08
Std. Dev.	0.09	0.01	0.01	0.03

Table 46. Cr (mgL^{-1}) concentration in Balu River water at three different depths of Itakhola location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.05	0.06	0.07	0.06
Aug'11	0.06	0.06	0.07	0.06
Sep'11	0.08	0.08	0.08	0.08
Oct'11	0.08	0.08	0.08	0.08
Nov'11	0.08	0.08	0.08	0.08
Dec'11	0.10	0.11	0.10	0.10
Jan'12	0.10	0.11	0.11	0.11
Feb'12	0.11	0.11	0.11	0.11
March'12	0.10	0.11	0.11	0.11
April'12	0.10	0.11	0.11	0.11
May'12	0.09	0.10	0.11	0.10
June'12	0.07	0.09	0.09	0.08
Average	0.09	0.09	0.09	0.09
Maximum	0.11	0.11	0.11	0.11
Minimum	0.05	0.06	0.07	0.06
Std. Dev.	0.02	0.02	0.02	0.02

Table 47. Cr (mgL^{-1}) concentration in Balu River water at three different depths of Nagarpara location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.04	0.05	0.05	0.05
Aug'11	0.05	0.06	0.06	0.05
Sep'11	0.06	0.06	0.06	0.06
Oct'11	0.06	0.07	0.07	0.07
Nov'11	0.08	0.08	0.08	0.08
Dec'11	0.10	0.11	0.10	0.10
Jan'12	0.11	0.11	0.10	0.11
Feb'12	0.11	0.11	0.10	0.11
March'12	0.10	0.11	0.11	0.10
April'12	0.09	0.10	0.10	0.10
May'12	0.07	0.08	0.10	0.08
June'12	0.06	0.07	0.07	0.07
Average	0.08	0.08	0.08	0.08
Maximum	0.11	0.11	0.11	0.11
Minimum	0.04	0.05	0.05	0.05
Std. Dev.	0.02	0.02	0.02	0.02

Table 48. Cr (mgL^{-1}) concentration in Balu River water at three different depths of Demra location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.04	0.05	0.06	0.05
Aug'11	0.05	0.06	0.06	0.06
Sep'11	0.05	0.06	0.06	0.06
Oct'11	0.05	0.06	0.06	0.06
Nov'11	0.06	0.06	0.07	0.06
Dec'11	0.05	0.06	0.06	0.06
Jan'12	0.06	0.07	0.07	0.07
Feb'12	0.07	0.07	0.08	0.07
March'12	0.07	0.07	0.07	0.07
April'12	0.06	0.07	0.07	0.07
May'12	0.06	0.06	0.06	0.06
June'12	0.05	0.05	0.06	0.05
Average	0.05	0.06	0.07	0.06
Maximum	0.07	0.07	0.08	0.07
Minimum	0.04	0.05	0.06	0.05
Std. Dev.	0.01	0.01	0.01	0.01

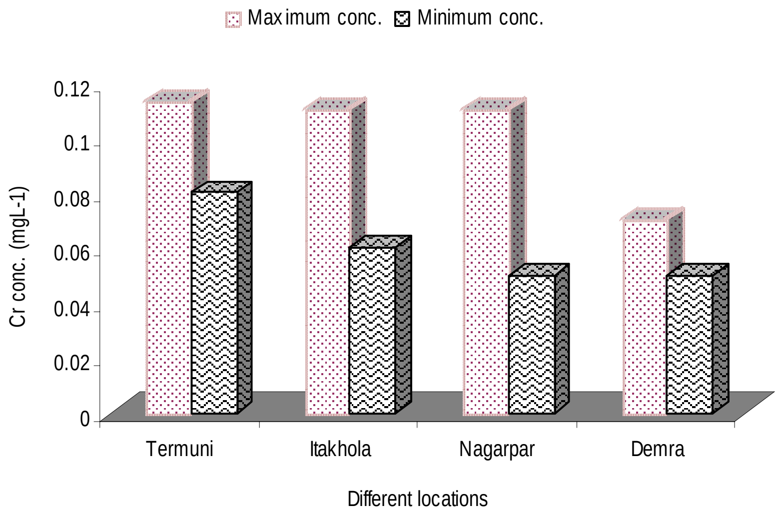


Fig. 1. Mean Cr concentration (as maximum and minimum value) varied in Balu river water under different locations during 2011-2012.

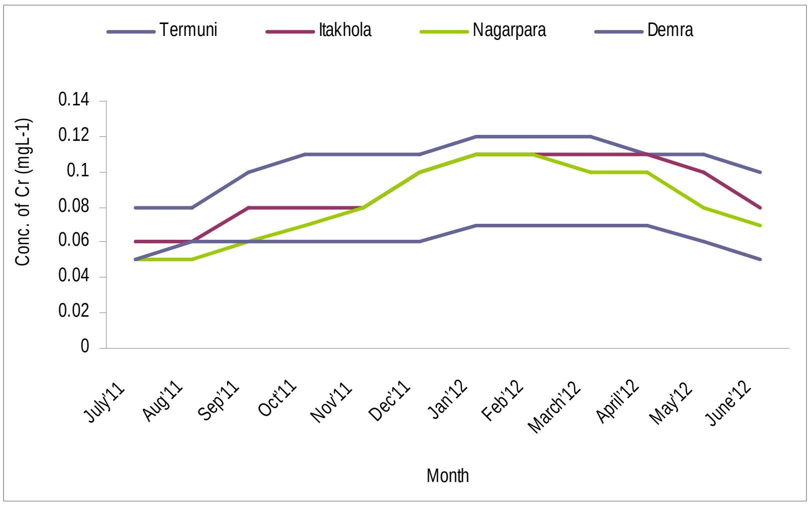


Fig. 2. Cr concentration in Balu river water varied at different locations and months during the year 2011-2012.

Cadmium (Cd) concentration in Balu river water:

The Cd concentration are presented in Table 49-52 and Fig. 3.

From the table 49, it was observed that Cd concentration ranged from 0.03 to 0.16 mgL^{-1} during the year July'11-March'12. The maximum Cd concentration in surface water (0-50cm) was recorded as 0.16 mgL^{-1} during the month of March' 2012, whereas, the minimum value was found as 0.03 mgL^{-1} during month of July'2011. Among the different water depths there was no distinct variation or changes of Cd concentration were shown, where the average Cd concentration was found as 0.10, 0.12 and 0.12 mgL^{-1} under the water depths of 0-50, 51-100 and 101- 150cm, respectively (Table 49).

From the results of Itakhola area, within the surface water depth (0-50 cm) the maximum Cd concentration was observed as 0.13 mgL^{-1} during the month of February and March' 2012 and the minimum Cd value was recorded as 0.04 mgL^{-1} during the month of July and August'2011 (Table 50). More or less similar results were found from the water samples collected from different depths which ranged from 0.02 to 0.15 mgL^{-1}, the highest Cd concentration was as 0.05 mgL^{-1} was noted during the month of March, 2012 the water samples collected within 101-150 cm depth.

In case of Nagarpara area, within 0-50 cm water depth, the Cd concentration ranged from 0.04 to 0.20 mgL^{-1} among the different water depths (Table 51) and comparatively lower concentration were observed within 51-100 cm which ranged from 0.05 mgL^{-1} during July' 2011 to 0.18 mgL^{-1} during the month of February to April 2012. Considering the different water depths, there was differences of Cd concentrations were observed, though the highest Cd concentration was recorded as 0.20 mgL^{-1}, during the month of December 2011 to March 2012 (Table 51).

The concentration in Balu river water at Demra location are presented in Table 52, Fig. 3. From the results, it was noted that under surface water (0-50 cm) depth the maximum Cd concentration was observed as 0.11 mgL^{-1} during the month of February and March 2012 and the minimum Cd was recorded as 0.04 mgL^{-1} during July 2011. Among the different water depths, the Cr concentrations was more or less closer, though comparatively higher Cd concentration was noted under 101-150 cm depth, which ranged from 0.06 to 0.08 mgL^{-1} and the highest Cd concentration was found during the month of February 2012.

At the location of Demra the Cd concentration in Balu river water ranged from 0.04-0.14 mgL^{-1} during the month of July 2011 to March 2012 (Table 52).

Considering the mean Cd concentration in Balu river water at different locations, the maximum value was recorded from the Nagarpara area (0.18 mgL^{-1}) which was followed by value found from Termuni and Itakhola area. The Minimum Cd value (0.03 mgL^{-1}) was observed in the water sample collected from Itakhola area (Fig. 3). On average, during the sampling time, the highest mean Cd concentration in Balu river water was found as 0.18 mgL^{-1} duing the month of February'2012and March, 2012. The lowest mean Cd value (0.03 mgL^{-1}) was noted from the water sample collected during the month of July 2011 (Fig. 3).

Table 49. Cd (mgL^{-1}) concentration in Balu River water at three different depths of Termuni location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.03	0.06	0.06	0.05
Aug'11	0.06	0.07	0.08	0.07
Sep'11	0.07	0.09	0.09	0.08
Oct'11	0.08	0.09	0.11	0.09
Nov'11	0.10	0.10	0.11	0.10
Dec'11	0.11	0.11	0.12	0.12
Jan'12	0.14	0.16	0.13	0.14
Feb'12	0.15	0.16	0.15	0.15
March'12	0.16	0.16	0.16	0.16
April'12	0.14	0.15	0.16	0.15
May'12	0.12	0.14	0.15	0.14
June'12	0.09	0.12	0.14	0.12
Average	0.10	0.12	0.12	0.11
Maximum	0.16	0.16	0.16	0.16
Minimum	0.03	0.06	0.06	0.05
Std. Dev.	0.04	0.04	0.03	0.04

Table 50. Cd (mgL^{-1}) concentration in Balu River water at three different depths of Itakhola location during the year 2011-2012.

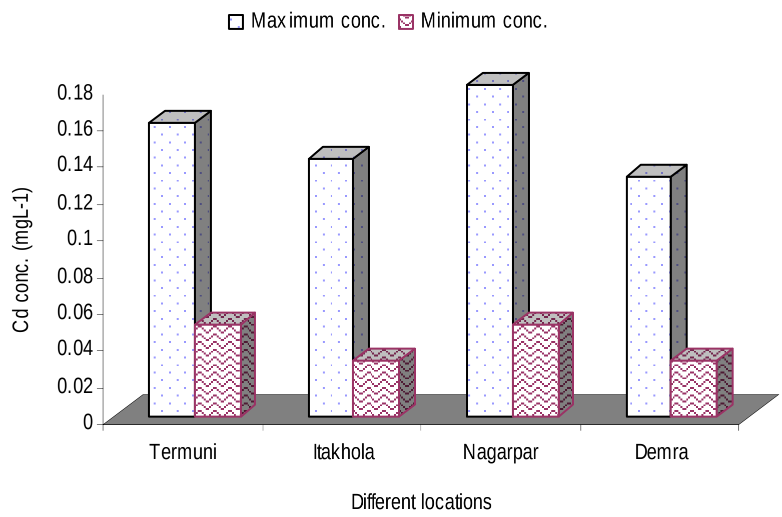
Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.04	0.02	0.02	0.03
Aug'11	0.04	0.04	0.04	0.04
Sep'11	0.06	0.05	0.06	0.06
Oct'11	0.08	0.08	0.08	0.08
Nov'11	0.12	0.11	0.06	0.10
Dec'11	0.11	0.11	0.10	0.11
Jan'12	0.12	0.13	0.12	0.12
Feb'12	0.13	0.14	0.14	0.14
March'12	0.13	0.14	0.15	0.14
April'12	0.12	0.12	0.13	0.12
May'12	0.11	0.11	0.12	0.11
June'12	0.08	0.11	0.09	0.09
Average	0.10	0.10	0.09	0.09
Maximum	0.13	0.14	0.15	0.14
Minimum	0.04	0.02	0.02	0.03
Std. Dev.	0.03	0.04	0.04	0.04

Table 51. Cd (mgL^{-1}) concentration in Balu River water at three different depths of Nagarpara location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.04	0.05	0.07	0.05
Aug'11	0.08	0.08	0.08	0.08
Sep'11	0.11	0.11	0.11	0.11
Oct'11	0.11	0.12	0.12	0.12
Nov'11	0.12	0.11	0.12	0.12
Dec'11	0.20	0.14	0.12	0.15
Jan'12	0.17	0.16	0.16	0.16
Feb'12	0.17	0.18	0.17	0.18
March'12	0.18	0.18	0.17	0.18
April'12	0.17	0.18	0.17	0.17
May'12	0.11	0.14	0.11	0.12
June'12	0.09	0.10	0.08	0.09
Average	0.13	0.13	0.12	0.13
Maximum	0.20	0.18	0.17	0.18
Minimum	0.04	0.05	0.07	0.05
Std. Dev.	0.05	0.04	0.04	0.04

Table 52. Cd (mgL^{-1}) concentration in Balu River water at three different depths of Demra location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.04	0.05	0.05	0.05
Aug'11	0.05	0.05	0.06	0.06
Sep'11	0.07	0.07	0.07	0.07
Oct'11	0.07	0.08	0.09	0.08
Nov'11	0.08	0.09	0.10	0.09
Dec'11	0.09	0.11	0.10	0.10
Jan'12	0.10	0.12	0.12	0.11
Feb'12	0.11	0.12	0.13	0.12
March'12	0.11	0.13	0.14	0.13
April'12	0.09	0.11	0.13	0.11
May'12	0.08	0.10	0.12	0.10
June'12	0.06	0.08	0.11	0.08
Average	0.08	0.09	0.10	0.09
Maximum	0.11	0.13	0.14	0.13
Minimum	0.04	0.05	0.05	0.05
Std. Dev.	0.02	0.03	0.03	0.03



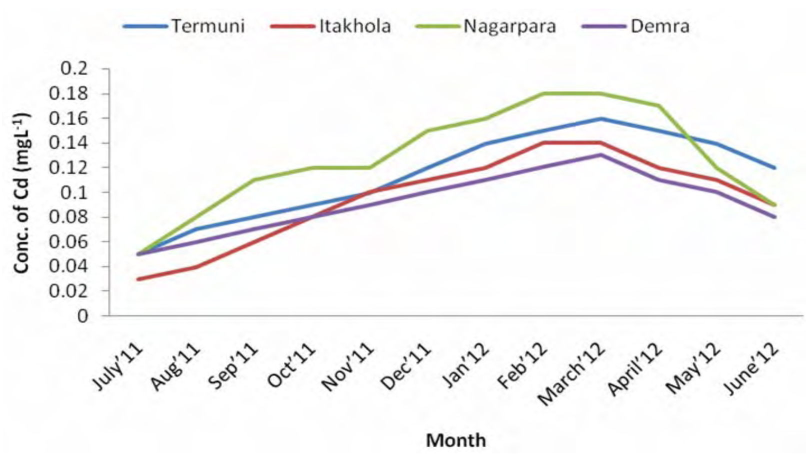


Fig. 3. Cd (mgL^{-1}) concentration in Balu river water at different locations and months during the year 2011-2012.

Nickel (Ni) concentration in Balu river water

The Ni concentration are presented in Table 53-56 and Fig. 4.

From the table 53 it was noted that Ni concentration at Termuni area under different water depths ranged from 0.21 to 0.49 mgL^{-1}. Within surface water (0-50 cm), the highest Ni concentration was observed as 0.39 mgL^{-1} during the month of February’ 2011 and the lowest concentration was recorded as 0.21 mgL^{-1} during July’ 2011. The amount of Ni concentration slightly increases with increasing the river water depth which ranged from 0.25 mgL^{-1} during the month of June and July’ 2011 to 0.49 mgL^{-1} during the month of February and March’ 2012 within 51-150 cm depth.

The maximum Ni concentration at river water depths (51-100 cm) and (101-150 cm) was recorded as 0.49 mgL^{-1} during the month of February, 2012 and March, 2012, whereas, the minimum value was found as 0.21 mgL^{-1} during month of July, 2011. Among the different water depths a significant changes are found in Ni concentration, where the average Ni value was found as 0.28, 0.34 and 0.37 mgL^{-1} under the water depths of 0-50, 51-100 and 101- 150 cm, respectively (Table 53). From the Itakhola area, the maximum Ni concentration was observed as 0.39 mgL^{-1} during the month of February, 2012 and the minimum value was recorded as 0.19 mgL^{-1} during the month of July’ 2011 (Table 54). Here comparatively a higher value was noted and More or less similar results were found form the water samples collected from different depths. In case of Nagarpara area, where the Ni concentration in Balu river water ranged from 0.11 to 0.32 mgL^{-1} (Table 55). Considering the different water depths, there was little differences of Ni concentrations were observed, though the highest Ni concentration was recorded as 0.32 mgL^{-1}, during the month of March, 2012 (Table 55). At the location of Demra the Ni concentration in Balu river water ranged from 0.09-0.24 mgL^{-1} during the month of July, 2011 to February, 2012 (Table 56).

Considering the mean Ni concentration in Balu river water at different locations, the maximum value was recorded from the Termuni area (0.44 mgL^{-1}) which was followed by value found from Nagarpara and Itakhola area. The Minimum Ni value (0.13 mgL^{-1}) was observed in the water sample collected from Nagarpara area (Fig. 4). On average, during the sampling time, the highest mean Ni concentration in Balu river water was found as 0.44 mgL^{-1} during the month of February’2012. The lowest mean Ni value (0.13 mgL^{-1}) was noted from the water sample collected during the month of July’2011 (Fig. 4).

Table 53. Ni (mgL^{-1}) concentration in Balu River water at three different depths of Termuni location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July’11	0.21	0.25	0.28	0.25
Aug’11	0.23	0.28	0.30	0.27
Sep’11	0.24	0.29	0.35	0.29
Oct’11	0.27	0.33	0.39	0.33
Nov’11	0.28	0.35	0.42	0.35
Dec’11	0.29	0.35	0.44	0.36
Jan’12	0.33	0.40	0.46	0.40
Feb’12	0.39	0.44	0.49	0.44
March’12	0.34	0.49	0.41	0.41
April’12	0.28	0.33	0.37	0.33
May’12	0.25	0.27	0.30	0.27
June’12	0.23	0.27	0.25	0.25
Average	0.28	0.34	0.37	0.33
Maximum	0.39	0.49	0.49	0.44
Minimum	0.21	0.25	0.25	0.25
Std. Dev.	0.05	0.08	0.08	0.06

Table 54. Ni (mgL^{-1}) concentration in Balu River water at three different depths of Itakhola location during the year 2011-2012.

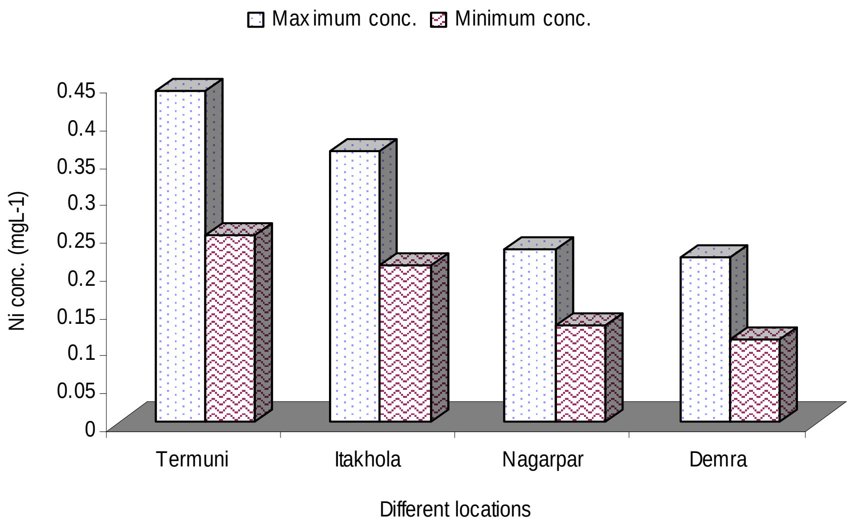
Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July’11	0.19	0.22	0.22	0.21
Aug’11	0.20	0.2	0.23	0.21
Sep’11	0.20	0.22	0.23	0.22
Oct’11	0.23	0.27	0.25	0.25
Nov’11	0.25	0.27	0.34	0.29
Dec’11	0.27	0.32	0.33	0.31
Jan’12	0.30	0.37	0.36	0.34
Feb’12	0.33	0.35	0.39	0.36
March’12	0.29	0.29	0.37	0.32
April’12	0.26	0.24	0.33	0.28
May’12	0.22	0.22	0.26	0.23
June’12	0.21	0.2	0.23	0.21
Average	0.25	0.26	0.29	0.27
Maximum	0.33	0.37	0.39	0.36
Minimum	0.19	0.20	0.22	0.21
Std. Dev.	0.04	0.06	0.06	0.05

Table 55. Ni (mgL^{-1}) concentration in Balu River water at three different depths of Nagarpara location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.13	0.16	0.11	0.13
Aug'11	0.13	0.19	0.13	0.15
Sep'11	0.14	0.19	0.18	0.17
Oct'11	0.17	0.23	0.19	0.20
Nov'11	0.18	0.2	0.21	0.20
Dec'11	0.18	0.19	0.23	0.20
Jan'12	0.21	0.2	0.27	0.23
Feb'12	0.22	0.17	0.29	0.23
March'12	0.18	0.15	0.32	0.22
April'12	0.16	0.15	0.28	0.20
May'12	0.13	0.18	0.22	0.18
June'12	0.13	0.19	0.17	0.16
Average	0.16	0.18	0.22	0.19
Maximum	0.22	0.23	0.32	0.23
Minimum	0.13	0.15	0.11	0.13
Std. Dev.	0.03	0.02	0.07	0.03

Table 56. Ni (mgL^{-1}) concentration in Balu River water at three different depths of Demra location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.13	0.11	0.09	0.11
Aug'11	0.15	0.14	0.12	0.14
Sep'11	0.15	0.16	0.13	0.15
Oct'11	0.16	0.18	0.15	0.16
Nov'11	0.19	0.22	0.18	0.20
Dec'11	0.19	0.22	0.17	0.19
Jan'12	0.23	0.19	0.2	0.21
Feb'12	0.24	0.19	0.22	0.22
March'12	0.21	0.17	0.19	0.19
April'12	0.17	0.15	0.17	0.16
May'12	0.16	0.15	0.15	0.15
June'12	0.15	0.14	0.14	0.14
Average	0.18	0.17	0.16	0.17
Maximum	0.24	0.22	0.22	0.22
Minimum	0.13	0.11	0.09	0.11
Std. Dev.	0.04	0.03	0.04	0.03



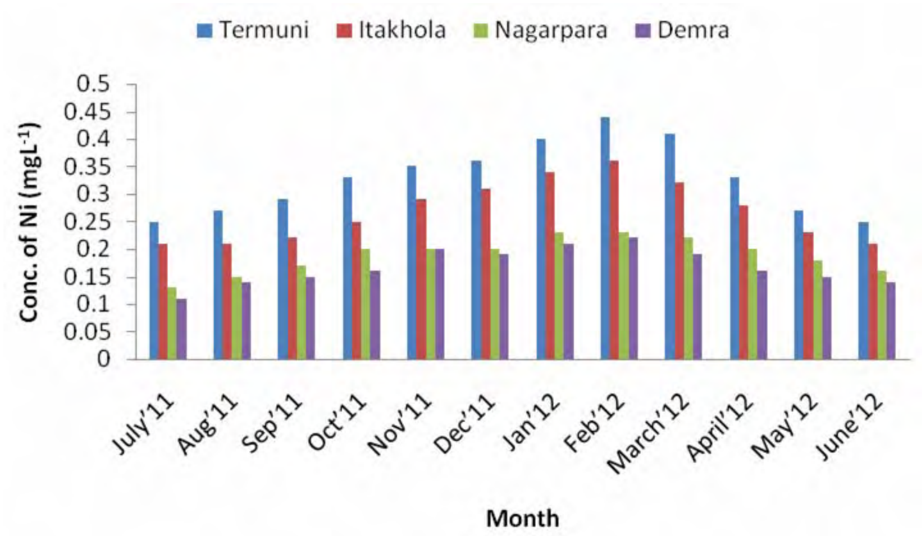


Fig. 4. Ni (mgL^{-1}) concentration in Balu river water at different locations and months during the year 2011-2012.

e. Lead (Pb) concentration in Balu river water:

The Pb concentration are presented in Table 57-60 and Fig. 5.

The table 57 described that Pb concentration at Termuni area under different water depths ranged from 0.06 to 0.22 mgL^{-1}. The maximum Pb concentration at river water depths (101-150 cm) was recorded as 0.22 mgL^{-1} during the month of January, 2012, whereas, the minimum value was found as 0.06 mgL^{-1} during month of August, 2011. Among the different water depths no significant changes are found in Pb concentration, where the average Pb value was found as 0.10, 0.13 and 0.15 mgL^{-1} under the water depths of 0-50, 51-100 and 101- 150 cm, respectively (Table 57).

From the Itakhola area, the maximum Pb concentration was observed as 0.15 mgL^{-1} during the month of January, 2012 and February, 2012 and the minimum value was recorded as 0.04 mgL^{-1} during the month of July, 2011 and August, 2011 (Table 58). Here comparatively a lower value was noted and More or less similar results were found form the water samples collected from different depths.

In case of Nagarpara area, where the Pb concentration in Balu river water ranged from 0.04 to 0.12 mgL^{-1} (Table 59). Considering the different water depths, there was no significant differences of Pb concentrations were observed, though the highest Pb concentration was recorded as 0.12 mgL^{-1}, during the month of December, 2011 and January, 2012 (Table 59).

At the location of Demra the Pb concentration in Balu river water ranged from 0.03-0.19 mgL^{-1} during the month of July, 2011 to January, 2012 (Table 60).

Considering the mean Pb concentration in Balu river water at different locations, the maximum value was recorded from the Termuni area (0.18 mgL^{-1}) which was followed by value found from Nagarpara and Itakhola area. The Minimum Pb value (0.05 mgL^{-1}) was observed in the water sample collected from Itakhola and Nagarpara area (Fig. 5). On average, during the sampling time, the highest mean Pb concentration in Balu river water was found as 0.18 mgL^{-1} duing the month of January, 2012. The lowest mean Pb value (0.05 mgL^{-1}) was noted from the water sample collected during the month of July, 2011 (Fig. 5).

Table 57. Pb (mgL^{-1}) concentration in Balu River water at three different depths of Termuni location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.07	0.09	0.11	0.09
Aug'11	0.06	0.08	0.09	0.08
Sep'11	0.09	0.10	0.11	0.10
Oct'11	0.10	0.11	0.13	0.11
Nov'11	0.11	0.14	0.15	0.13
Dec'11	0.12	0.16	0.18	0.15
Jan'12	0.15	0.18	0.22	0.18
Feb'12	0.13	0.17	0.19	0.16
March'12	0.11	0.16	0.17	0.15
April'12	0.10	0.15	0.16	0.13
May'12	0.08	0.13	0.14	0.12
June'12	0.07	0.12	0.12	0.10
Average	0.10	0.13	0.15	0.13
Maximum	0.15	0.18	0.22	0.18
Minimum	0.06	0.08	0.09	0.08
Std. Dev.	0.03	0.03	0.04	0.03

Table 58. Pb (mgL^{-1}) concentration in Balu River water at three different depths of Itakhola location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.04	0.05	0.07	0.05
Aug'11	0.04	0.06	0.08	0.06
Sep'11	0.07	0.08	0.09	0.08
Oct'11	0.09	0.09	0.11	0.10
Nov'11	0.11	0.10	0.12	0.11
Dec'11	0.11	0.11	0.14	0.12
Jan'12	0.12	0.14	0.15	0.14
Feb'12	0.10	0.13	0.15	0.13
March'12	0.08	0.11	0.13	0.11
April'12	0.07	0.09	0.11	0.09
May'12	0.06	0.07	0.10	0.08
June'12	0.05	0.06	0.08	0.06
Average	0.08	0.09	0.11	0.09
Maximum	0.12	0.14	0.15	0.14
Minimum	0.04	0.05	0.07	0.05
Std. Dev.	0.03	0.03	0.03	0.03

Table 59: Pb (mgL^{-1}) concentration in Balu River water at three different depths of Nagarpara location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July’11	0.04	0.05	0.07	0.05
Aug’11	0.04	0.05	0.07	0.05
Sep’11	0.07	0.06	0.08	0.07
Oct’11	0.08	0.07	0.09	0.08
Nov’11	0.10	0.09	0.11	0.10
Dec’11	0.10	0.11	0.12	0.11
Jan’12	0.11	0.12	0.12	0.12
Feb’12	0.11	0.11	0.11	0.11
March’12	0.09	0.10	0.11	0.10
April’12	0.08	0.09	0.10	0.09
May’12	0.07	0.08	0.09	0.08
June’12	0.05	0.07	0.08	0.07
Average	0.08	0.08	0.09	0.09
Maximum	0.11	0.12	0.12	0.12
Minimum	0.04	0.05	0.07	0.05
Std. Dev.	0.03	0.02	0.02	0.02

Table 60: Pb (mgL^{-1}) concentration in Balu River water at three different depths of Demra location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July’11	0.03	0.05	0.07	0.05
Aug’11	0.03	0.04	0.05	0.04
Sep’11	0.05	0.07	0.07	0.06
Oct’11	0.07	0.06	0.08	0.07
Nov’11	0.08	0.08	0.09	0.08
Dec’11	0.13	0.14	0.14	0.14
Jan’12	0.16	0.19	0.17	0.17
Feb’12	0.16	0.17	0.09	0.14
March’12	0.13	0.12	0.10	0.12
April’12	0.08	0.09	0.09	0.09
May’12	0.05	0.06	0.06	0.06
June’12	0.04	0.05	0.06	0.05
Average	0.08	0.09	0.09	0.09
Maximum	0.16	0.19	0.17	0.17
Minimum	0.03	0.04	0.05	0.04
Std. Dev.	0.05	0.05	0.03	0.04

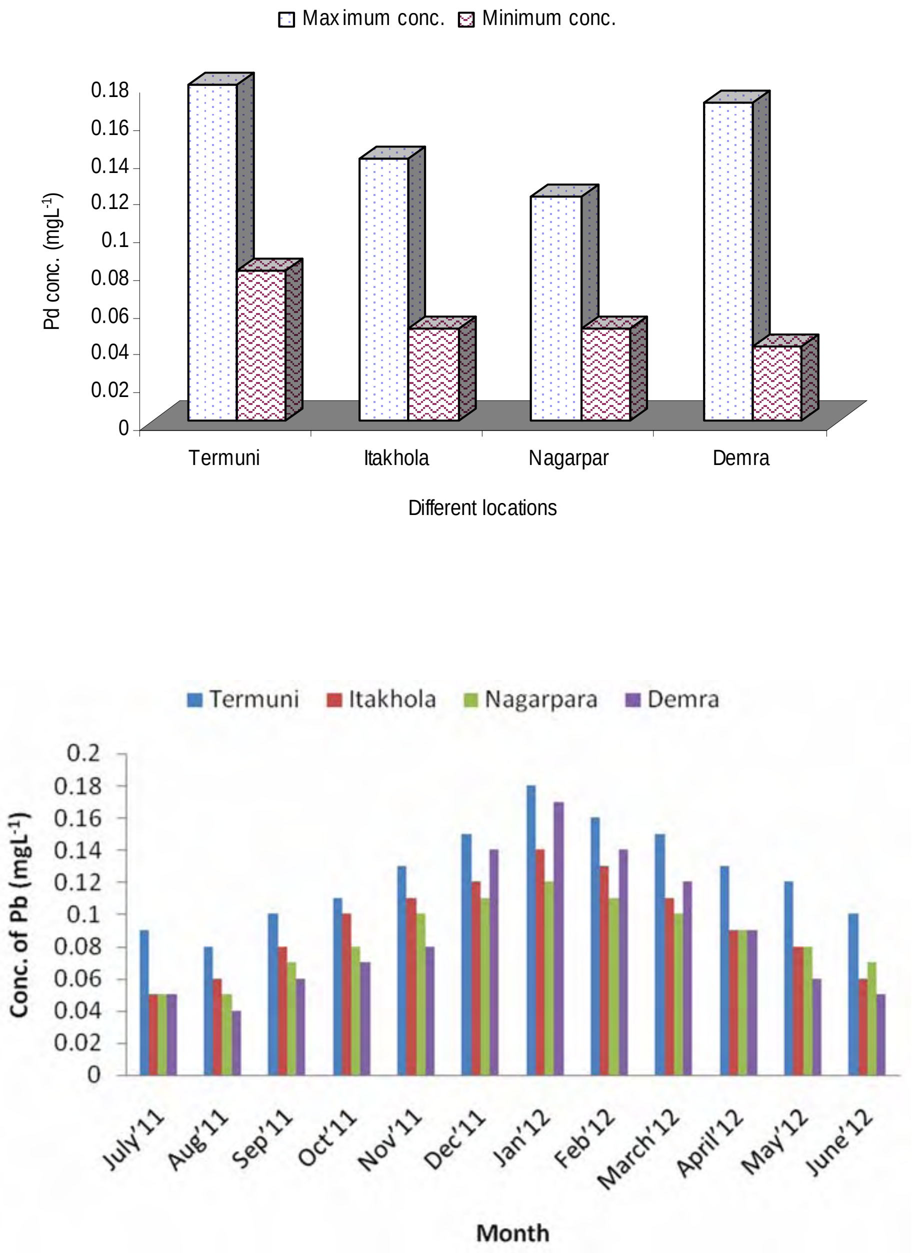


Fig. 5. Pb (mgL^{-1}) concentration in Balu river water at different locations and months during the year 2011-2012.

f. Zinc (Zn) concentration in Balu river water:

The Zn concentration are presented in Table 61-64 and Fig. 6.

The table 61 described that Zn concentration at Termuni area under different water depths ranged from 0.83 to 2.88 mgL^{-1}. The maximum Zn concentration at Balu river water at depths (51-100 cm) was recorded as 2.88 mgL^{-1} during the month of February, 2012, whereas, the minimum value was found as 0.83 mgL^{-1} during month of August'2011 and September, 2011. Among the different water depths no significant changes are found in Zn concentration, where the average Zn value was found as 1.47, 2.10 and 2.15 mgL^{-1} under the water depths of 0-50, 51-100 and 101- 150 cm, respectively (Table 61).

From the Itakhola location, the maximum Zn concentration was observed as 2.46 mgL^{-1} during the month of May, 2012 and the minimum value was found as 0.70 mgL^{-1} during the month of July, 2011 (Table 62). More or less similar results were found form the water samples collected from different depths.

In case of Nagarpara area, where the Zn concentration in Balu river water ranged from 0.71 to 1.89 mgL^{-1} (Table 63). Considering the different water depths, there was no significant differences of Zn concentrations were observed, though the highest Zn concentration was recorded as 1.89 mgL^{-1}, during the month of January, 2012 (Table 63).

At the Demra area the Zn concentration in Balu river water ranged from 0.68-1.87 mgL^{-1} during the month of August, 2011 to January, 2012 (Table 64).

Considering the mean Zn concentration in Balu river water at different locations, the maximum value was recorded from the Termuni area (2.75 mgL^{-1}) which was followed by value found from Nagarpara and Itakhola area. The Minimum Zn value (0.82 mgL^{-1}) was observed in the water sample collected from Nagarpara area (Fig. 6). On average, during the sampling time, the highest mean Zn concentration in Balu river water was found as 2.75 mgL^{-1} during the month of February, 2012. The lowest mean Zn value (0.82 mgL^{-1}) was noted from the water sample collected during the month of July, 2011 (Figure 6).

Table 61. Zn (mgL^{-1}) concentration in Balu River water at three different depths of Termuni location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.89	1.18	1.59	1.22
Aug'11	0.83	1.73	1.44	1.33
Sep'11	0.83	1.58	1.63	1.34
Oct'11	1.06	1.83	1.90	1.60
Nov'11	1.35	2.29	2.31	1.98
Dec'11	1.48	2.55	2.53	2.19
Jan'12	2.48	2.80	2.75	2.68
Feb'12	2.56	2.88	2.82	2.75
March'12	2.19	2.73	2.53	2.48
April'12	1.63	2.02	2.34	2.00
May'12	1.27	1.93	2.04	1.75
June'12	1.09	1.70	1.89	1.56
Average	1.47	2.10	2.15	1.91
Maximum	2.56	2.88	2.82	2.75
Minimum	0.83	1.18	1.44	1.22
Std. Dev.	0.62	0.54	0.47	0.53

Table 62. Zn (mgL^{-1}) concentration in Balu River water at three different depths of Itakhola location during the year 2011-2012.

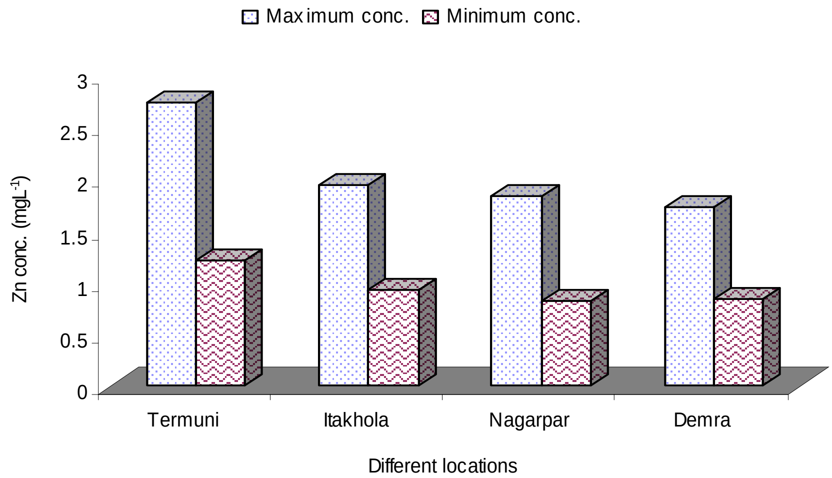
Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.70	1.43	1.51	1.21
Aug'11	0.76	1.07	1.21	1.01
Sep'11	0.80	0.91	1.10	0.94
Oct'11	0.87	1.33	1.19	1.13
Nov'11	1.39	1.53	1.34	1.42
Dec'11	1.47	2.00	1.38	1.62
Jan'12	2.10	2.18	1.53	1.94
Feb'12	2.03	1.97	1.66	1.89
March'12	1.85	2.18	1.38	1.80
April'12	1.72	2.13	1.63	1.83
May'12	1.57	2.46	1.58	1.87
June'12	1.21	2.23	1.51	1.65
Average	1.37	1.79	1.42	1.52
Maximum	2.10	2.46	1.66	1.94
Minimum	0.70	0.91	1.10	0.94
Std. Dev.	0.50	0.51	0.18	0.37

Table 63. Zn (mgL^{-1}) concentration in Balu River water at three different depths of Nagarpara location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.71	0.83	0.91	0.82
Aug'11	0.75	0.93	0.96	0.88
Sep'11	0.80	0.98	1.07	0.95
Oct'11	0.86	1.12	1.31	1.10
Nov'11	1.25	1.52	1.76	1.51
Dec'11	1.44	1.65	1.67	1.59
Jan'12	1.76	1.88	1.89	1.84
Feb'12	1.78	1.62	1.78	1.73
March'12	1.29	1.36	1.45	1.37
April'12	1.24	1.26	1.30	1.27
May'12	1.18	1.16	1.28	1.21
June'12	1.15	1.15	1.46	1.25
Average	1.18	1.29	1.40	1.29
Maximum	1.78	1.88	1.89	1.84
Minimum	0.71	0.83	0.91	0.82
Std. Dev.	0.36	0.32	0.33	0.33

Table 64. Zn (mgL^{-1}) concentration in Balu River water at three different depths of Demra location during the year 2011-2012.

Month	Water depth			
	0-50 cm	51-100 cm	101-150 cm	Mean
July'11	0.70	0.90	1.15	0.91
Aug'11	0.68	0.78	1.06	0.84
Sep'11	0.71	0.85	1.20	0.92
Oct'11	1.17	1.33	1.36	1.29
Nov'11	1.29	1.40	1.51	1.40
Dec'11	1.47	1.71	1.80	1.66
Jan'12	1.51	1.82	1.87	1.73
Feb'12	1.36	1.50	1.75	1.54
March'12	1.20	1.29	1.57	1.36
April'12	1.13	1.16	1.45	1.25
May'12	1.03	1.13	1.32	1.16
June'12	0.87	1.00	1.24	1.04
Average	1.09	1.24	1.44	1.26
Maximum	1.51	1.82	1.87	1.73
Minimum	0.68	0.78	1.06	0.84
Std. Dev.	0.30	0.33	0.27	0.30



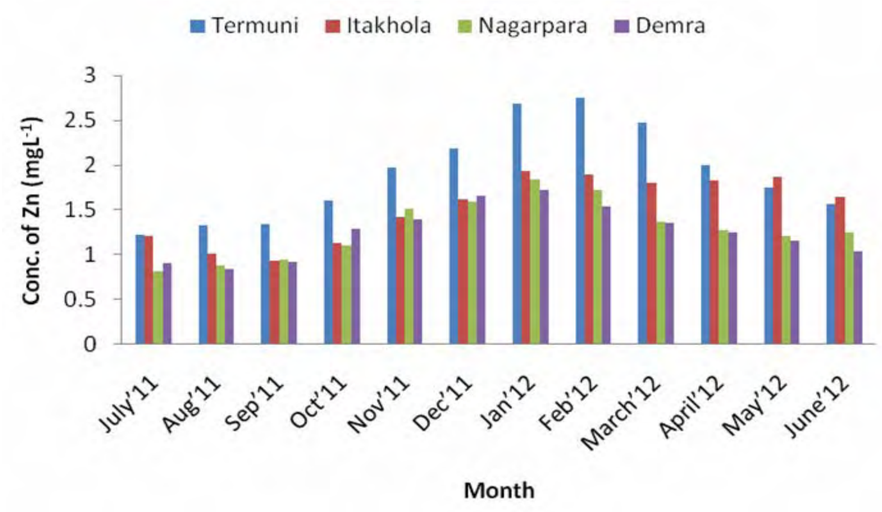


Fig. 6. Zn (mgL^{-1}) concentration in Balu river water at different locations and months during the year 2011-2012.

Comparative assessment of different chemical properties of polluted Balu river water during wet and dry season

The present study was carried out to find the status and the contamination level of different chemical properties such as pH, EC, NO_3 - N, NH_4 - N, PO_4, Ca, Mg, Fe, Cd, Pb, Cr, Ni and Zn from the water samples from 8 different locations such as-Termuni, Babur Zaiga, Ithakhola, Nagarpara, Nalchata, Thulthulia, Paschim Gao and Demra of Narayanganj District along the Balu river side area. The experimental findings are discussed under the following headings:

Chemical Properties of Balu River Water

1.1. pH (H^+ Concentration)

The pH (H^+ concentration) value are presented (Table 65.1 and Fig. 7.1) From the results it was observed that, the pH value of the Balu river water significantly varied due to different locations and seasons. During the wet season (i.e.; July-Sept' 2011) on average, the pH value of the Balu river water ranged from 7.24 to 7.55, whereas, it varied from 7.47 to 8.04 during dry season (Nov'11 to Jan' 12). Among the different locations, the maximum pH value was found at Nalchata area (7.76), which was also statically identical with the value of Nagarpara (7.74) and Itakhola (7.72). The minimum pH value was noted from the water sample at Thultuhulia as 7.42. Considering both location and season the maximum pH value was found at Itakhola (8.04) during dry season and the minimum value was noted at Demra (7.24) during wet season.

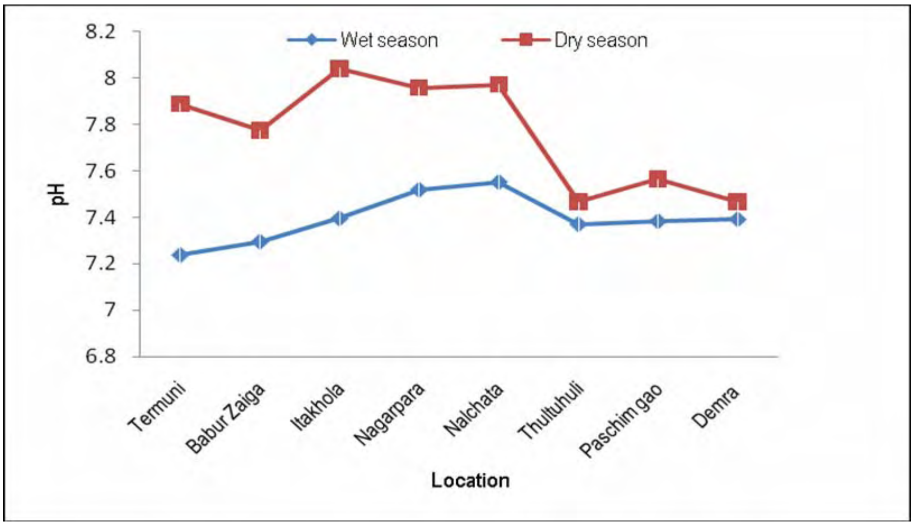


Fig. 7.1. Average pH in Balu river water varied at different locations and seasons during 2011-12.

Table 65.1. H^+ concentration (pH) of Balu river water (0-50 cm) varied at different locations and seasons during 2011-2012.

Location/ Season	Teruni	Babur Zaiga	Itakhola	Nagarpara	Nalchata	Thulthulia	Paschim gao	Demra	Mean (season)
Wet season	7.24f	7.30ef	7.36c-f	7.51cd	7.55cd	7.37def	7.38c-f	7.39c-f	7.39B
Dry season	7.88ab	7.77b	8.04a	7.96a	7.97a	7.46c-e	7.56c	7.46c-e	7.76A
Mean (Location)	7.56A	7.54BC	7.72A	7.74A	7.76A	7.42C	7.47BC	7.43C	

Note:

i) Mean followed by same latter(s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of both i.e. Season × Location.

ii) Wet Season indicates the average value of three months: July to September 2011 and Dry season indicates the average value of three months: November to January, 2011-12.

Electrical Conductivity (EC)

The EC (electrical conductivity) values are presented (Table 65.2 and Fig. 7.2) From the results it was observed that, the EC value of the Balu river water significantly varied due to different locations and seasons. During the wet season (i.e; July – September, 2011) on average, the EC value of the Balu river water ranged from 1.05 to 1.33 $mScm^{-1}$, whereas, it varied from 1.10 to 1.54 $mScm^{-1}$ during dry season (November 2011 to January 2012). Among the different locations, the maximum EC value was found 1.44 $mScm^{-1}$ at Termuni area, which was statically, differ from the value of Babur zaiga (1.37 $mScm^{-1}$). The minimum EC value was noted as 1.08 $mScm^{-1}$ from the water sample at Demra location. The high salinity content caused high EC in this contaminated sample, so it should be controlled or minimized immediately. Considering both locations and season the maximum Ec value was found at Termuni area (1.54 $mScm^{-1}$) during dry season and the minimum value was noted at Demra ghat (1.05 $mScm^{-1}$) during wet season.

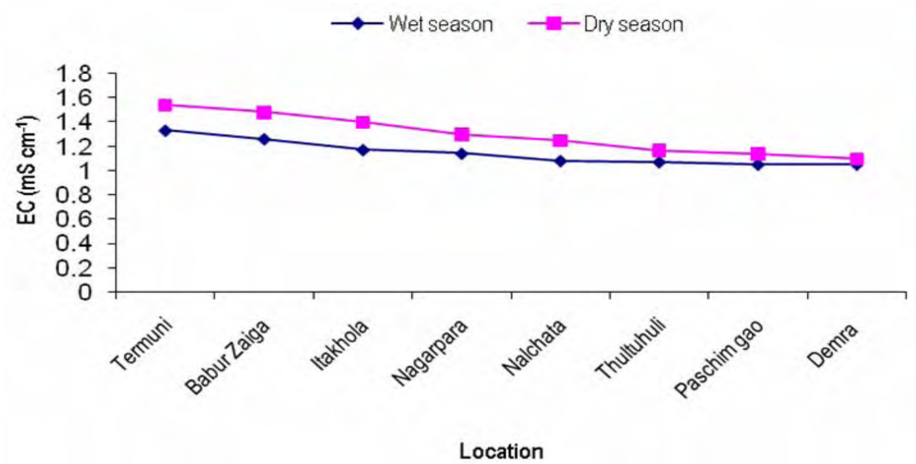


Fig. 7.2. Average EC in Balu river water varied at different locations and seasons during' 2011-12.

Table 65.2. Electrical Conductivity (EC mS/cm) concentration in Balu river water (0-50 cm) varied at different locations and seasons during 2011-2012.

Location/season	Termuni	Babur Zaiga	Itakhola	Nagarpara	Nalchata	Thulthulia	Paschim gao	Demra	Mean (season)
Wet season	1.33d	1.26f	1.17g	1.14h	1.08j	1.07k	1.05l	1.05l	1.14B
Dry season	1.54a	1.48b	1.40c	1.30e	1.25f	1.17g	1.14h	1.10i	1.30A
Mean (Location)	1.44A	1.37B	1.28C	1.22D	1.17E	1.12F	1.09G	1.08H	

Note:

i) Mean followed by same latter(s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of both i.e. Season × Location.

ii) Wet Season indicates the average value of three months: July to September 2011 and Dry season indicates the average value of three months: November to January, 2011-12.

Nitrate Nitrogen (NO_3 – N)

The NO_3 – N (Nitrate nitrogen) concentration of the water sample are given (Table 65.3 and Fig. 7.3). From the results it was observed that, the NO_3 – N concentration of the Balu river water significantly varied due to different locations and seasons. During the wet season (i.e; July-September, 2011) on average, the NO_3 – N value of the Balu river water ranged from 1.02 to 1.63mgL^{-1}, whereas, it varied from 1.26 to 3.95 mgL^{-1} during dry season (Nov'11 to Jan' 12). On average the maximum NO_3 – N was recorded as 2.12 mgL^{-1} in dry season. Among the different locations, the highest NO_3 – N value was found at Termuni area (2.79 mgL^{-1}), which was also statically identical with the value of Babur zaiga (2.33 mgL^{-1}). The minimum NO_3 – N value was noticed from the water sample at Demra (1.14 mgL^{-1}), which also statically identical with the result from Paschum gao (1.22 mgL^{-1}) and Thultuhulia (1.25 mgL^{-1}) area.

Considering both location and season the highest NO_3 – N value was noted at Termuni area during dry season (3.95 mgL^{-1}) and the minimum value was found at Demra ghat during wet season (1.02 mgL^{-1}).

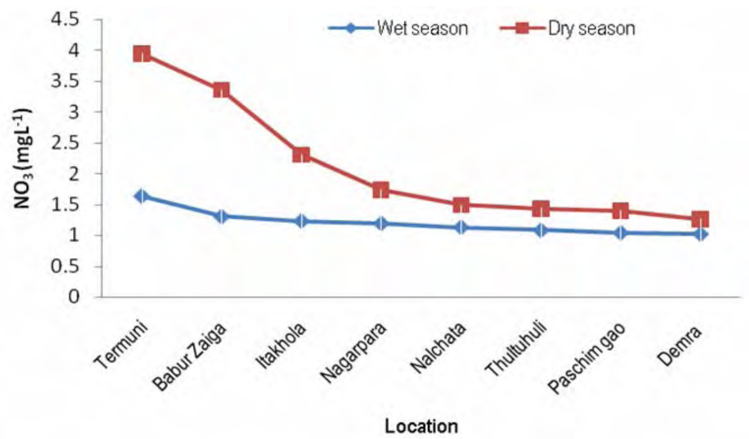


Fig. 7.3. Average NO_3 in Balu river water varied at different locations and seasons during 2011-12.

Table 65.3. NO_3 – N (mgL^{-1}) concentration in Balu river water (0-50 cm) varied at different location and season during 2011-2012.

Location/season	Termuni	Babur Zaiga	Itakhola	Nagarpara	Nalchata	Thulthulia	Paschim gao	Demra	Mean (season)
Wet season	1.63de	1.30f-h	1.23f-i	1.19g-i	1.13hi	1.08hi	1.04hi	1.02i	1.20B
Dry season	3.95a	3.36b	2.31c	1.74d	1.49ef	1.43e-g	1.40e-g	1.26f-i	2.12A
Mean (Location)	2.79A	2.33B	1.78C	1.47D	1.31DE	1.25EF	1.22EF	1.14F	

Note:

i) Mean followed by same latter(s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of both i.e. Season × Location.

ii) Wet Season indicates the average value of three months: July to September 2011 and Dry season indicates the average value of three months: November to January, 2011-12.

Ammonium Nitrogen NH_4 - N (mgL^{-1})

The NH_4 – N (Ammonium nitrogen) concentration of the water sample are presented (Table 65.4 and Fig. 7.4). From the results it was observed that, the NH_4 – N concentration of the Balu river water significantly varied due to different locations and seasons. During the wet season (i.e; July-September, 2011) on average, the concentration of NH_4 – N of the Balu river water ranged from 1.77 to 2.97mgL^{-1}, whereas, it varied from 2.19 to 5.29 mgL^{-1} during dry season (Nov'11 to Jan' 12). Among the different locations, the highest NH_4^+- N concentration was noted as 4.13 mgL^{-1} in Termuni area, which was also statically identical with the value of Babur zaiga (3.51 mgL^{-1}) and Itakhola (3.84 mgL^{-1}). The minimum NH_4 – N concentration was noticed as 1.99 mgL^{-1} from the water sample at Nagarpara location.

Considering both location and season, the maximum NH_4 – N concentration was recorded as 5.29 mgL^{-1} at Termuni area during dry season whereas, the minimum value was noted as 1.78 mgL^{-1} at Nagarpara during wet season.

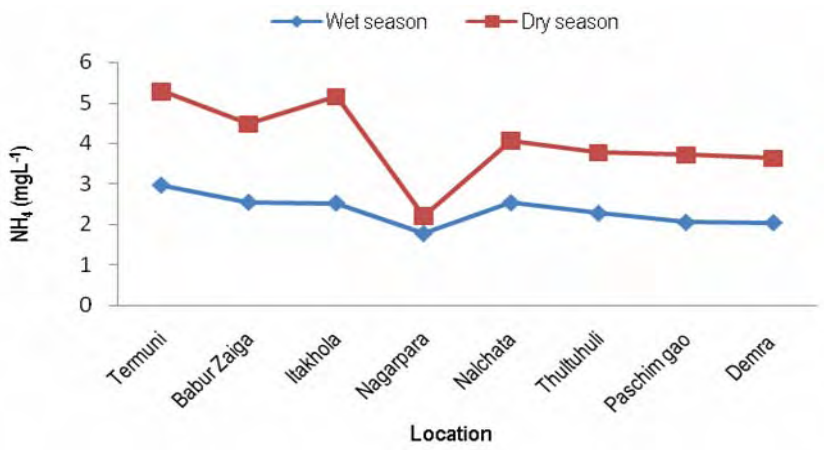


Fig. 7.4. Average NH_4 in Balu river water varied at different locations and seasons during 2011-12.

Table 65.4. NH_4 – N (mgL^{-1}) concentration in Balu river water (0-50 cm) varied at different location and season during 2011-2012.

Location/Season	Termuni	Babur Zaiga	Itakhola	Nagarpara	Nalchata	Thulthulia	Paschim gao	Demra	Mean (season)
Wet season	2.973cd	2.547de	2.528de	1.777e	2.533de	2.273de	2.047de	2.040de	2.340B
Dry season	5.290a	4.480ab	5.153a	2.193de	4.060b	3.773bc	3.713bc	3.633bc	3.037A
Mean (Location)	4.132A	3.513ABC	3.841AB	1.985D	3.297BC	3.023C	2.880C	2.837C	

Note:

i) Mean followed by same latter(s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of both i.e. Season × Location.

ii) Wet Season indicates the average value of three months: July to September, 2011 and Dry season indicates the average value of three months: November to January, 2011-12.

Calcium concentration (mgL^{-1})

The Calcium (Ca) concentration of the water sample are presented in Table 65.5 and Figure 7.5. From the results we observed that, the Calcium value of the Balu river water significantly varied due to different locations and seasons. During the wet season (i.e; July-September, 2011) on average the concentration of the Balu river water ranged from 23.200 to 45.497 mgL^{-1}, whereas, it varied from 39.220 to 61.077 mgL^{-1} during dry season (November 2011 to January, 2012).

Among the different locations, the maximum calcium concentration was found as 53.287 mgL^{-1} at Termuni area, which was also statically identical with the value recorded from Babur zaiga (50.502 mgL^{-1}). The minimum calcium concentration was noted as 31.210 mgL^{-1} from the water sample at Nagarpara area.

Considering both locations and seasons the maximum Calcium concentration was found at Termuni area during dry season (61.077 mgL^{-1}) and the minimum value was noted at Nagarpara during wet season (23.200 mgL^{-1}).

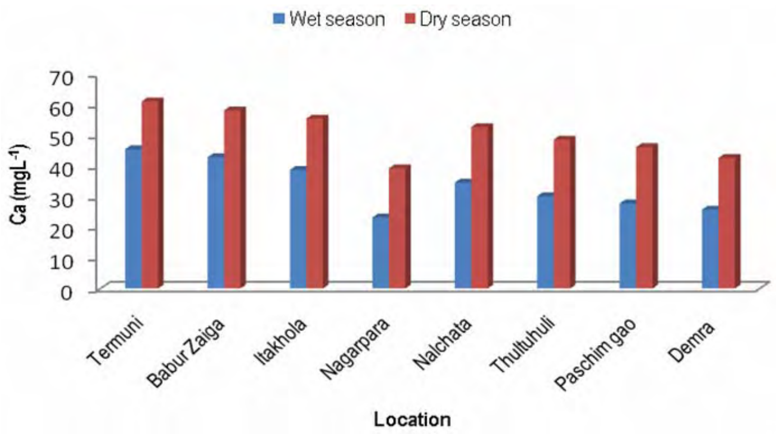


Fig. 7.5. Average Ca concentration in Balu river water varied at different locations and seasons during 2011-12.

Table 65.5. Ca (mgL^{-1}) concentration in Balu river water (0-50 cm) varied at different location and season during 2011-2012.

Location/Season	Termuni	Babur Zaiga	Itakhola	Nagarpara	Nalchata	Thulthulia	Paschim gao	Demra	Mean (season)
Wet season	45.50de	42.86e	38.73f	23.20j	34.59g	30.15h	27.77hi	25.75ij	33.57B
Dry season	61.08a	58.14ab	55.50bc	39.22f	52.73c	48.65d	46.16d	42.63e	50.54A
Mean (Location)	53.29A	50.50B	47.11C	31.21H	43.66D	39.40E	36.97F	34.19G	

Note:

i) Mean followed by same latter(s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of both i.e. Season × Location.

ii) Wet Season indicates the average value of three months: July to September, 2011 and Dry season indicates the average value of three months: November to January, 2011-12.

Magnesium concentration (mgL^{-1})

The Magnesium (Mg) concentration of the water sample are presented (Table 65.6, and Fig. 7.6). From the results it was observed that, the Magnesium concentration of the Balu river water significantly varied due to different locations and seasons. During the wet season (i.e., July-September 2011) on average, the Mg concentration of the Balu river water ranged from 14.247 to 29.723 mgL^{-1}, whereas, it varied from 35.687 to 72.567 mgL^{-1} during dry season (November 2011 to January 2012). Among the different locations, the maximum magnesium concentration was as 51.145 mgL^{-1} found at Termuni area, which was also statically identical with the value 47.352 mgL^{-1} of Babur Zaiga. The minimum magnesium concentration was noticed from the water sample at Nagarpara area (26.047 mgL^{-1}). Considering both locations and seasons the maximum magnesium concentration was found as 72.567 mgL^{-1} at Termuni area during dry season and the minimum value was noted at Demra ghat area (14.260 mgL^{-1}) during wet season.

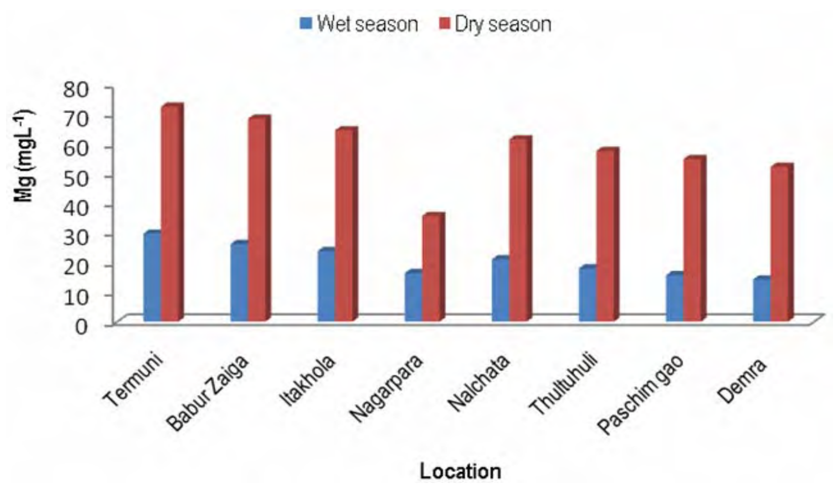


Fig. 7.6. Average Mg in Balu river water varied at different locations and seasons during 2011-12

Table 65.6. Mg (mgL^{-1}) concentration in Balu river water (0-50 cm) varied at different location and season during 2011-2012.

Location/Season	Termuni	Babur Zaiga	Itakhola	Nagarpara	Nalchata	Thulthulia	Paschim gao	Demra	Mean (season)
Wet season	29.72h	26.20hi	23.85ij	16.41kl	21.04jk	17.99kl	15.69l	14.26l	20.64B
Dry season	72.57a	68.51ab	64.61bc	35.69g	61.54cd	57.64de	54.88ef	52.25f	58.46A
Mean (Location)	51.15A	47.35B	44.23BC	26.05F	41.29C	37.82D	35.28DE	33.25E	

Note:

i) Mean followed by same latter(s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of both i.e. Season × Location.

ii) Wet Season indicates the average value of three months: July to September, 2011 and Dry season indicates the average value of three months: November to January' 2011-12.

Phosphate concentration (mgL^{-1})

The Phosphate (PO_4) concentration of the water sample are presented (Table 65.7 and Fig. 7.7). From the results it was observed that, the Phosphate concentration of the Balu river water significantly varied due to different locations and seasons. During the wet season (i.e; July-September, 2011) the mean phosphate value of the Balu river water ranged from 3.193 to 12.827 mgL^{-1}, whereas, it varied from 9.41 to 25.447 mgL^{-1} during dry season (Nov'11 to Jan' 12). Among the different locations, the maximum Phosphate concentration was found at Termuni area (19.137 mgL^{-1}), which was also statically identical with the value of Babur Zaiga (16.980 mgL^{-1}). The minimum Phosphate value was noted from the water sample at Nagarpara (6.302 mgL^{-1}).

Considering the variation both locations and seasons the highest Phosphate concentration was found as 25.447 mgL^{-1} at Termuni during dry season and the minimum value was noted at Nagarpara (3.193 mgL^{-1}) during wet season.

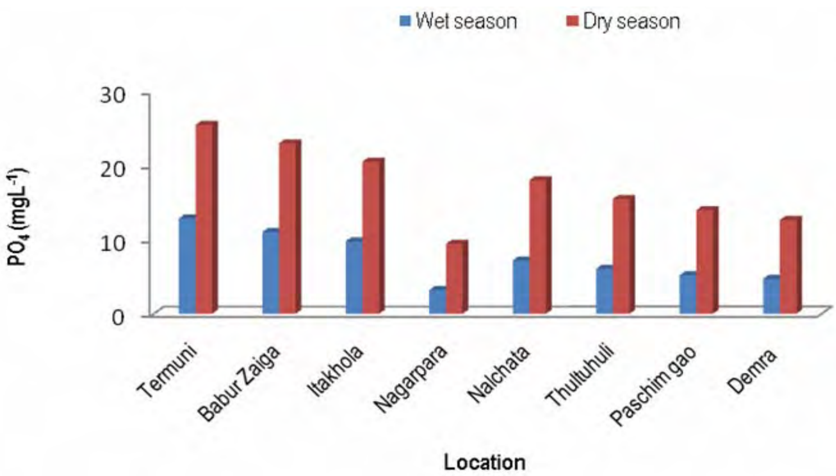


Fig. 7.7. Average PO_4 in Balu river water varied at different locations and seasons during 2011-12.

Table 65.7. PO_4 (mgL^{-1}) concentration in Balu river water (0-50 cm) varied at different location and season during 2011-2012.

Location/Season	Termuni	Babur Zaiga	Itakhola	Nagarpara	Nalchata	Thulthulia	Paschim gao	Demra	Mean (season)
Wet season	12.827ef	11.010fg	9.757h	3.193j	7.177hi	6.047ij	5.177ij	4.693ij	7.485B
Dry season	25.447a	22.950ab	20.493bc	9.410gh	18.00cd	15.453de	13.957e	12.633ef	17.293A
Mean (Location)	19.137A	16.980B	15.125B	6.302F	12.590C	10.750CD	9.567DE	8.663E	

Note:

i) Mean followed by same latter(s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of both i.e. Season × Location.

ii) Wet Season indicates the average value of three months: July to September 2011 and Dry season indicates the average value of three months: November to January, 2011-12.

Concentration of Iron (Fe)

The Iron (Fe) concentration of the water sample are presented (Table 65.8 and Fig. 7.8). From the results it was observed that, the Fe concentration of the Balu river water significantly varied due to different locations and seasons. During the wet season (i.e.; July-September, 2011) on average, the value of the Balu river water ranged from 0.337 to 0.873 mgL^{-1}, whereas, it varied from 1.828 to 2.522 mgL^{-1} during dry season (Nov'11 to Jan' 12). Among the different locations, the maximum Fe concentration was found as 1.697 mgL^{-1} at Termuni area, which was also statically identical with the value of Babur Zaiga (1.575 mgL^{-1}). The minimum Fe value was noticed from the water sample at Nagarpara (0.848 mgL^{-1}). Concentration of Fe in the Karasu Greek region was 180-920 $microgL^{-1}$ as reported by Yalcin et al. (2008). Considering both location and season the maximum Fe concentration was found at Termuni area (2.522 mgL^{-1}) during dry season and the minimum value was noted at Nagarpara (0.337 mgL^{-1}) during wet season.

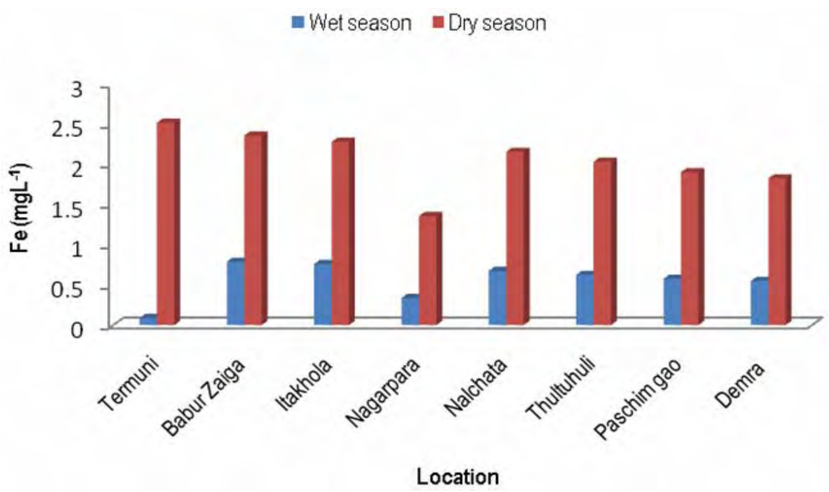


Fig. 7.8. Average Fe in Balu river water varied at different locations and seasons during 2011-12.

Table 65.8. Fe (mgL^{-1}) concentration in Balu river water (0-50 cm) varied at different location and season during 2011-2012.

Location/Season	Termuni	Babur Zaiga	Itakhola	Nagarpara	Nalchata	Thulthulia	Paschim gao	Demra	Mean (season)
Wet season	0.873h	0.789hi	0.761hi	0.337k	0.676ij	0.625ij	0.576j	0.550j	0.648B
Dry season	2.522a	2.362b	2.284bc	1.359g	2.159cd	2.036de	1.905ef	1.828f	2.057A
Mean (Location)	1.697A	1.575B	1.522BC	0.848G	1.417CD	1.331DE	1.241EF	1.189F	

Note:

i) Mean followed by same latter(s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of both i.e. Season × Location.

ii) Wet Season indicates the average value of three months: July to September 2011 and Dry season indicates the average value of three months: November to January, 2011-12.

Soil water and nitrogen management for sustainable crop production in drought prone areas of Bangladesh using nuclear techniques

Effect of soil water and Nitrogen levels on the growth and yield of wheat

The present study was conducted to develop improved management approaches to improve N and water use efficiency in wheat in drought prone areas of Bangladesh with a view to minimize the soil water and N loss. The experiment was assigned in a RCBD 2-factor split-plot design with 3 replications. The main plot treatment consists of 3 levels of irrigations, such as- W_1 = Irrigation as Farmers' practices, W_2 = Two irrigations (at CRI and before flowering/anthesis stage of wheat), W_3 = Three irrigations (at CRI, flag leaf ligule emergence and before flowering/anthesis stage of wheat). Four levels of N fertilizer were assigned in a spilt-plot as follows: N_0 = No Nitrogen (control), N_1 = 50 kg N ha^{-1}, N_2 = 100 kg N ha^{-1} and N_3 = 150 kg N ha^{-1}. The 1st year results are given as follows:

Wheat seeds were sown on 4th December, 2011 and the harvest was completed on 29th March, 2012. During harvest, the data for yield and yield contributing characters were recorded and analyzed statistically. Plant and soil samples from the non-isotopic plots were collected and analyzed in the laboratory of Soil Science Division of BINA. The soil and plant samples were also collected from the ^{15}N isotope plot and the laboratory analysis are in progress. The initial soil characteristics of the experimental field are given in Table 66. The data for yield and yield parameters, the amount of total N uptake by wheat and the soil analytical results are given in Table 67-73.

Mean effect of different irrigations on the yield and yield attributes of wheat:

From the table 67, it is observed that different irrigation approaches significantly increases the plant height of wheat and the tallest (93.37 cm) plants were observed in the treatment W_3. The dwarf plant (87.23 cm) was noticed in W_1 (Farmer practice), which was also statistically identical with the treatment W_2. The other parameters such as- spike length, grain and straw yield did not show any significant variation due to different irrigation treatments, though the highest yield of grain and straw were recorded in the treatment W_3 as 3.86 and 5.13 t ha^{-1}, respectively.

Mean effect of different N levels on the yield and yield attributes of wheat

Different levels of N fertilizer significantly affected the yield and yield parameters of wheat grown at Rajshahi during the year of 2011-2012 (Table 68). The tallest wheat plant (93.62 cm) was observed in N_3 treatment which was also identical with the value of N_1 (91.83 cm) and N_2 (93.54 cm). The dwarf plant of 82.41cm was noticed in the treatment N_0 where no N was applied. Similarly the highest (11.64 cm) and the lowest (10.27 cm) spike length of wheat plants were recorded in the treatment N_2 and N_0, respectively. The maximum grain yield (4.21 t ha^{-1}) of wheat was observed in the plot N_2 where the N application rate was 100 kg ha^{-1}. The minimum grain yield (2.06 t ha^{-1}) of wheat was noticed under N_0 treatment. Similar trends were observed in case of straw yield of wheat and the highest and lowest yield were as 5.40 and 2.88 t ha^{-1} in the treatment N_2 and N_0, respectively.

Interaction effect of irrigation and N on the yield and yield attributes of wheat:

Different irrigation approaches combined with the different N levels significantly influenced on the grain and straw yield of wheat at Barind area during 2011-12 (Table 69-71). Considering the grain yield of wheat the highest yield was observed in the treatment combination W_3N_2 (4.97 t ha^{-1}), which was also showed an identical results with the value from the treatment combination W_2N_2 (4.09 t ha^{-1}), W_3N_3 (4.36 t ha^{-1}) and W_1N_3 (4.02 t ha^{-1}). Similar results were noticed in case of straw yield of wheat and the maximum and minimum values were recorded in the treatment combination W_3N_2 (6.64 t ha^{-1}) and W_1N_0 (2.74 t ha^{-1}), respectively. Different irrigation and N levels affected on the amount of N uptake in grain and straw of wheat (Table 72). The maximum N uptake of 75.54 kg ha^{-1} was noticed in the treatment combination of W_3N_2, whereas, the minimum value (27.05 kg ha^{-1}) was found in W_3N_0 treatment. Regarding the N uptake in wheat straw, the highest (21.54 kg ha^{-1}) and lowest (5.75 kg ha^{-1}) values were noticed in the treatment combination of W_3N_3 and W_2N_0, respectively. During the harvest of wheat, the soil samples were also analyzed for determining the content of total N, SOC and available P (Table 73). From the table, it was observed that due to different irrigation and N levels the amount of total N, SOC and available P showed a variations, which ranged from 0.09 to 0.11% for N, 0.53-0.79% for SOC and 12.35-23.01 ppm for available P in the soil during the time of wheat harvest.

Table 66. Initial physico-chemical properties of soil collected from wheat experimental field at Barind area (Godagari), Rajshahi during 2011-12.

Soil properties	0-15 cm depth	15-30 cm depth	30-50 cm depth
Soil Texture	clay loam	clay	clay
% Sand	34.44	28.44	34.44
% Silt	36.00	28.00	18.00
% Clay	29.56	43.56	47.56
Soil O.C (%)	1.59	0.88	0.56
Soil pH	6.30	6.66	6.45
EC (dSm^{-1})	2.15	1.47	1.80
Total N (%)	0.10	0.06	0.05
Available P (ppm)	16	14	13
Exchangeable K meq/100	0.28	0.31	0.28
WHC (%)	30.64	25.37	-

Table 67. Mean Effect of different Irrigation practices on the yield and yield parameters of wheat grown at Barind area (Godagari) during 2011-12.

Treatment	Plant height (cm)	Spike length (cm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
W_1	87.23b	10.99	3.21	4.28
W_2	90.45ab	11.08	3.32	4.55
W_3	93.37a	11.19	3.86	5.13
Level of significance	**	NS	NS	NS
%CV	2.79	4.27	18.18	23.66

Legend: W_1 = Irrigation as Farmer's practices
W_2 = Two irrigations (at CRI and before flowering/anthesis stage of wheat).
W_3 = Three irrigations (at CRI, flag leaf ligule emergence and before flowering/anthesis stage of wheat).

Table 68. Mean Effect of different N levels on the yield and yield parameters of wheat grown at Barind area (Godagari) during 2011-12.

Treatment	Plant height (cm)	Spike length (cm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
N_0	82.41b	10.27c	2.06b	2.88b
N_1	91.83a	11.02b	3.56a	5.05a
N_2	93.54a	11.64a	4.21a	5.40a
N_3	93.62a	11.42ab	4.02a	5.28a
Level of significance	**	**	**	**
CV(%)	2.79	4.27	18.18	23.66

Legend: N_0 = No Nitrogen (control) N_2 = 100 kg N ha^{-1}
N_1 = 50 kg N ha^{-1} N_3 = 150 kg N ha^{-1}

Table 69. Interaction Effect of different Irrigation and N levels on plant height of wheat grown at Barind area (Godagari) during 2011-12.

Treatment	W_1	W_2	W_3	Mean
N_0	82.30fg	81.67g	83.27fg	82.41
N_1	86.37ef	92.73b-d	96.40ab	91.83
N_2	89.33de	92.40b-d	98.90a	93.54
N_3	90.93cd	95.02a-c	94.90a	93.61
Mean	87.23	90.45	93.36	90.34

Legend: W_1 = Irrigation as Farmers' practices
W_2 = Two irrigations (at CRI and before flowering/anthesis stage of wheat).
W_3 = Three irrigations (at CRI, flag leaf ligule emergence and before flowering/anthesis stage of wheat).

N_0 = No Nitrogen (control) N_1 = 50 kg N ha^{-1}
N_2 = 100 kg N ha^{-1} N_3 = 150 kg N ha^{-1}

Table 70. Interaction Effect of different Irrigation and N levels on the grain yield of wheat grown at Barind area (Godagari) during 2011-12.

Treatment	W_1	W_2	W_3	Mean
N_0	2.12cd	1.91d	2.17cd	2.06
N_1	3.13bc	3.59b	3.96ab	3.56
N_2	3.57b	4.09ab	4.97a	4.21
N_3	4.02ab	3.70b	4.36ab	4.02
Mean	3.21	3.32	3.86	3.46

Legend: W_1 = Irrigation as Farmer's practices
W_2 = Two irrigations (at CRI and before flowering/anthesis stage of wheat).
W_3 = Three irrigations (at CRI, flag leaf ligule emergence and before flowering/anthesis stage of wheat).

N_0 = No Nitrogen (control) N_1 = 50 kg N ha^{-1}
N_2 = 100 kg N ha^{-1} N_3 = 150 kg N ha^{-1}

Table 71. Interaction Effect of different Irrigation and N levels on the straw yield of wheat grown at Barind area (Godagari) during 2011-12.

Treatment	W_1	W_2	W_3	Mean
N_0	2.74	2.78	3.13b	2.88
N_1	4.45	5.57	5.13a	5.05
N_2	4.35	5.21	6.64a	5.40
N_3	5.57	4.64	5.62a	5.27
Mean	4.27	4.55	5.13	4.65

Legend: W_1 = Irrigation as Farmers' practices
W_2 = Two irrigations (at CRI and before flowering/anthesis stage of wheat).
W_3 = Three irrigations (at CRI, flag leaf ligule emergence and before flowering/anthesis stage of wheat).

N_0 = No Nitrogen (control) N_1 = 50 kg N ha^{-1}
N_2 = 100 kg N ha^{-1} N_3 = 150 kg N ha^{-1}

Table 72. Effect of different irrigation and N levels on the N content of wheat grown at Barind area (Godagari) during 2011-12.

Treatment		Wheat Grain			Wheat Straw		
		Yield (t ha^{-1})	% N	N yield (kg ha^{-1})	Yield (t ha^{-1})	% N	N yield (kg ha^{-1})
W_1	N_0	2.12	1.32	28.05	2.74	0.33	9.13
	N_1	3.13	1.47	46.12	4.45	0.24	10.83
	N_2	3.57	1.61	57.60	4.35	0.24	10.30
	N_3	4.02	1.61	64.86	5.57	0.29	16.34
W_2	N_0	1.91	1.64	31.39	2.78	0.21	5.75
	N_1	3.59	1.47	52.89	5.57	0.30	16.52
	N_2	4.09	1.30	53.31	5.21	0.32	16.67
	N_3	3.7	1.47	54.27	4.64	0.19	8.97
W_3	N_0	2.17	1.25	27.05	3.13	0.29	9.08
	N_1	3.96	1.19	46.99	5.13	0.32	16.42
	N_2	4.97	1.52	75.54	6.64	0.26	17.26
	N_3	4.36	1.35	58.86	5.62	0.38	21.54

Legend: W_1 = Irrigation as Farmers' practices
W_2 = Two irrigations (at CRI and before flowering/anthesis stage of wheat).
W_3 = Three irrigations (at CRI, flag leaf ligule emergence and before flowering/anthesis stage of wheat).

N_0 = No Nitrogen (control) N_1 = 50 kg N ha^{-1}
N_2 = 100 kg N ha^{-1} N_3 = 150 kg N ha^{-1}

Table 73. Effect of different irrigation and N levels on the content of % N, %SOC and available P in wheat field Barind area (Godagari) during 2011-12.

Treatment		% N in soil		% O.C. in soil		P in soil (ppm)	
		Initial stage	At harvest	Initial stage	At harvest	Initial stage	At harvest
W_1	N_0	0.1	0.10	1.01	0.57	16.0	16.90
	N_1	0.1	0.10	1.01	0.86	16.0	17.55
	N_2	0.1	0.09	1.01	0.65	16.0	17.16
	N_3	0.1	0.09	1.01	0.53	16.0	17.55
W_2	N_0	0.1	0.09	1.01	0.70	16.0	16.51
	N_1	0.1	0.09	1.01	0.54	16.0	17.94
	N_2	0.1	0.11	1.01	0.84	16.0	15.47
	N_3	0.1	0.11	1.01	0.89	16.0	17.42
W_3	N_0	0.1	0.10	1.01	0.79	16.0	23.01
	N_1	0.1	0.09	1.01	0.68	16.0	15.86
	N_2	0.1	0.09	1.01	0.55	16.0	14.68
	N_3	0.1	0.10	1.01	0.61	16.0	12.35

Legend: W_1 = Irrigation as Farmers' practices
W_2 = Two irrigations (at CRI and before flowering/anthesis stage of wheat).
W_3 = Three irrigations (at CRI, flag leaf ligule emergence and before flowering/anthesis stage of wheat).

N_0 = No Nitrogen (control) N_1 = 50 kg N ha^{-1}
N_2 = 100 kg N ha^{-1} N_3 = 150 kg N ha^{-1}

Soil Organic matter dynamics and nutrient cycling on soil physical environment for sustainable crop production

Study the pattern of different crop residue decomposition using "nylon mesh bag technique"

In-situ incubation study was conducted by using Nylon mesh bag technique, during the year of 2011-12 at BINA sub-station farm, Magura, and Rangpur adjacent to the rice field experiment for determining the decomposition rate and nature of different crop residue. Four residue treatments, such as- 1. No residue in nylon bag/control; 2. Lentil residue, 3. Mungbean residue and 4. Soybean residue, were assigned in a RCB design with 3 replications. The nylon bags were retrieved at 7 different times, such as- i) 2 weeks after crop residue application (CRA); ii) 4 weeks after CRA; iii) 6 weeks after CRA; iv) 8 weeks after CRA; v) 10 weeks after CRA; vi) 12 weeks after CRA and vii) 14 weeks after CRA at 15 days intervals over the whole incubation period. For available N and net N release study from residue to soil, samples were collected from beneath the Nylon Mesh bag followed the same sampling time for each station.

The amount of different legume residue remaining in the nylon mesh bag at different sampling intervals during the study is plotted in Fig 9-10. In general, three distinct phases of the legume residue decomposition in the rice field were observed. In the first phase, the legume residue decomposed faster for 2 weeks, followed by the second phase of 6 weeks in which the rate of decompositions slowed. The 3^{rd} phase started after 8^{th} week, in which the rate of decomposition maintained more or less a steady state. The maximum decomposition rate was observed at 15-20 days of residue incubation. The soybean residue decomposed faster comparatively than the other legume residues. Within one month period, the maximum residue decomposition was observed from soybean residue treated soil as 55.33 and 50.0% in Magura and Rangpur, respectively. The minimum results were found from the soil, where mungbean residue was incorporated and the value were 37.67 and 33.67% in Magura and Rangpur, respectively (Fig. 9-10). Remaining of N (%) in different legume residues followed the same order between as the loss of dry weight (Fig. 11-12), i.e. the maximum amount of N released from soybean residue and the minimum was from mungbean. In the 1st phase, the rate of %N remaining decreases comparatively faster than other phases. At Magura within one month period, on an average 51.67% N remained in soybean residue, whereas, in lentil and mungbean the value of % N remaining were 54.60 and 64.67%, respectively. More or less similar trends were observed from the research results of Rangpur area and the %N remained as 50.5%, 54.33% and 67.75% in soybean, lentil and mungbean residue, respectively.

From the N mineralization study, it was noted that, the release pattern of available N followed the same trend at both locations and the maximum value was recorded from soybean residue. In both locations, the maximum amount of net N release from soybean residue was recorded at 8th weeks after incubation (21.05 and 21.15 mgkg^{-1} in Magura and Rangpur), whereas, the minimum value (11.05 and 14.97 mgkg^{-1} in Magura Rangpur) was found from mungbean residue (Fig. 13-16).

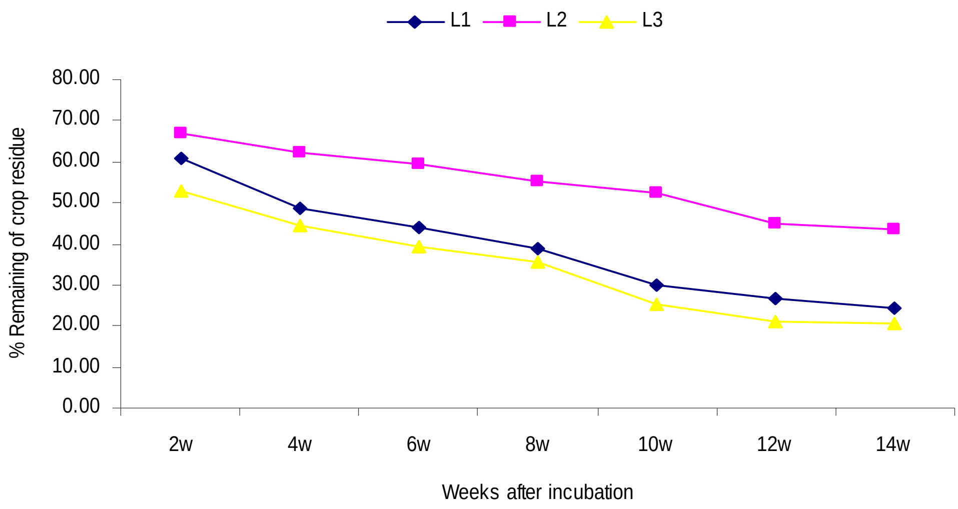


Fig. 9. % Remaining of crop residue at different weeks after incubation at BINA sub-station farm, Magura, 2011.

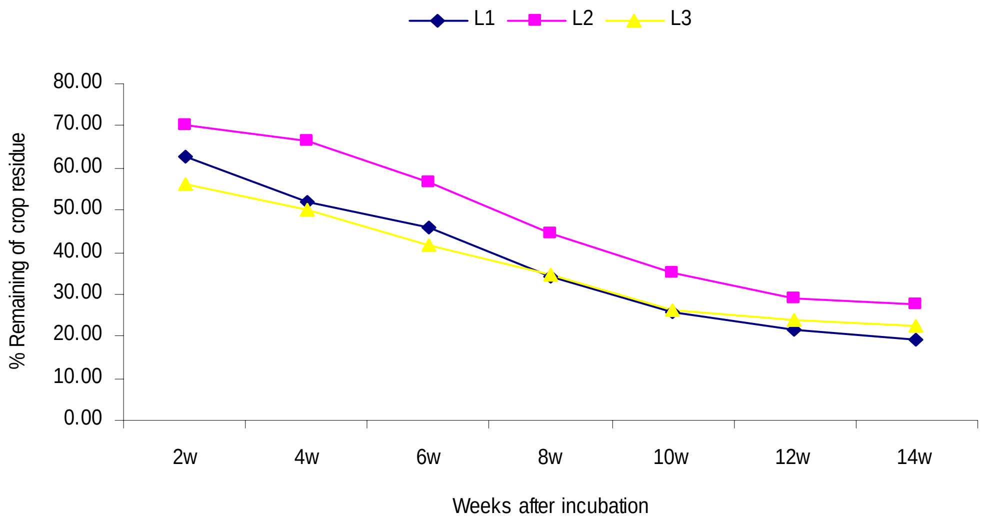


Fig. 10. % Remaining of crop residue at different weeks after incubation at BINA sub-station farm, Rangpur, 2011

Legend:

$L_{1\,=}$ Lentil $L_{2\,=}$ Mungbean $L_{3\,=}$ Soybean

2w = 2 weeks after incubation
4w = 4 weeks after incubation
6w = 6 weeks after incubation
8w = 8 weeks after incubation
10w = 10 weeks after incubation
12w = 12 weeks after incubation
14w = 14 weeks after incubation

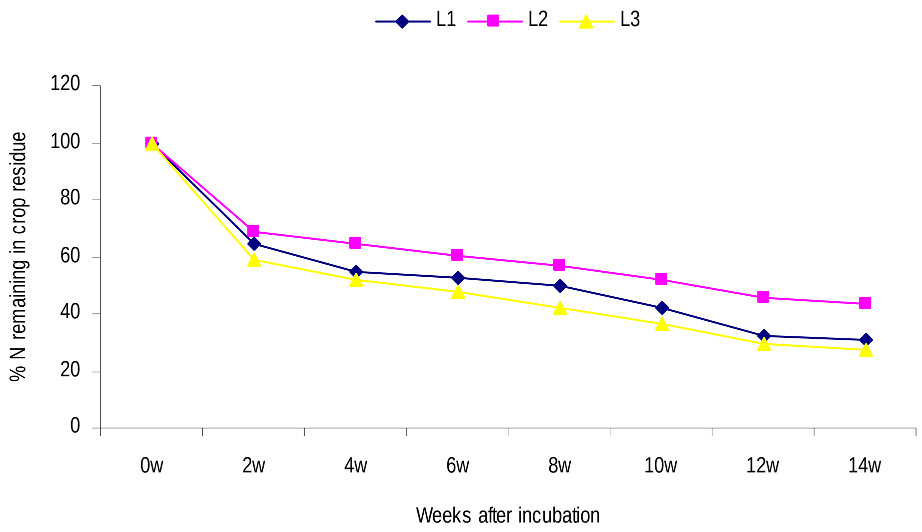


Fig. 11. % Nitrogen remaining from decomposed residue at different weeks after incubation at BINA sub-station farm, Magura, 2011.

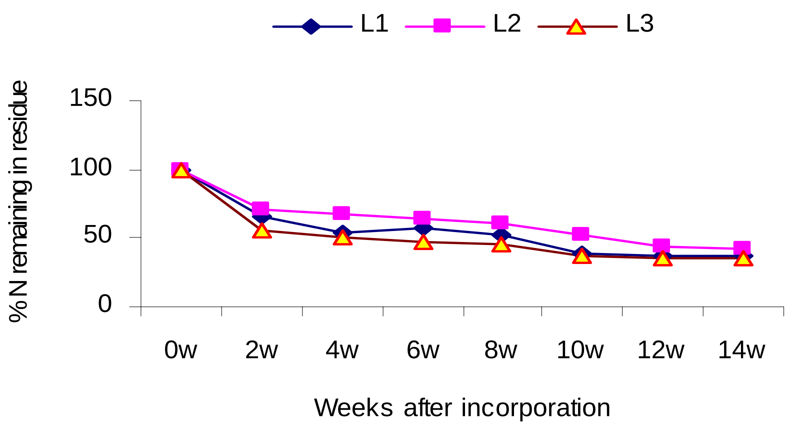


Fig. 12. % Nitrogen remaining from decomposed residue at different weeks after incubation at BINA sub-station farm, Rangpur, 2011.

Legend:

L_1 = Lentil L_2 = Mungbean L_3 = Soybean

2w = 2 weeks after incubation
4w = 4 weeks after incubation
6w = 6 weeks after incubation
8w = 8 weeks after incubation
10w = 10 weeks after incubation
12w = 12 weeks after incubation
14w = 14 weeks after incubation

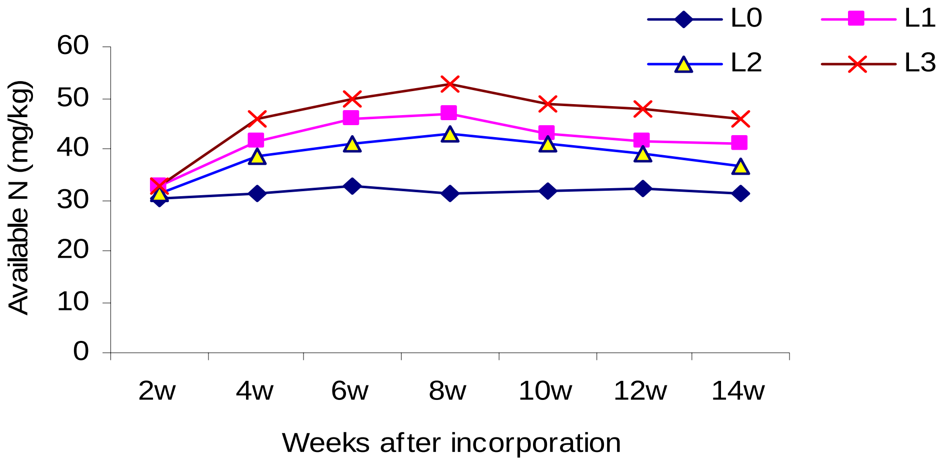


Fig. 13. Amount of available N release from different residue during incubation study at BINA sub-station farm, Magura, 2011.

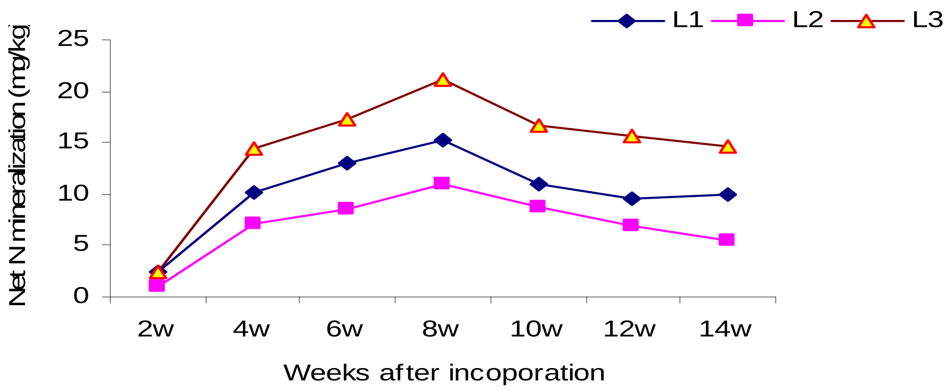


Fig. 14. Amount of net N release from different residue during incubation study at BINA sub-station farm, Magura, 2011.

Legend:

L_{1} = Lentil L_{2} = Mungbean L_{3} = Soybean

2w = 2 weeks after incubation
4w = 4 weeks after incubation
6w = 6 weeks after incubation
8w = 8 weeks after incubation
10w = 10 weeks after incubation
12w = 12 weeks after incubation
14w = 14 weeks after incubation

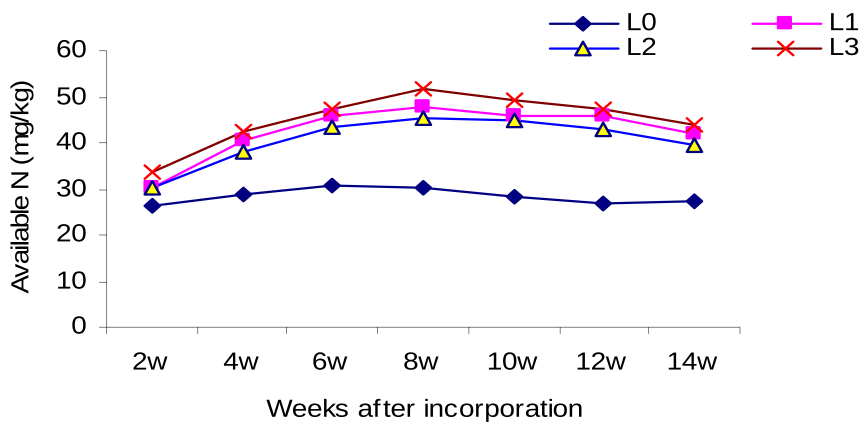


Fig. 15. Amount of available N release from different residue during incubation study at BINA sub-station farm, Rangpur, 2011.

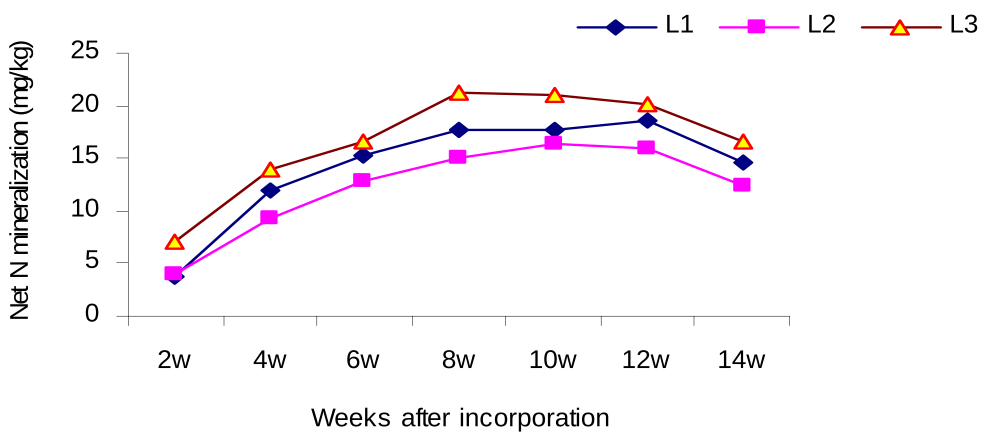


Fig. 16. Amount of net N release from different residue during incubation study at BINA sub-station farm, Rangpur, 2011.

Legend:

L_1 = Lentil L_2 = Mungbean L_3 = Soybean

2w = 2 weeks after incubation
4w = 4 weeks after incubation
6w = 6 weeks after incubation
8w = 8 weeks after incubation
10w = 10 weeks after incubation
12w = 12 weeks after incubation
14w = 14 weeks after incubation

Development of PGPR biofertilizer for rice, wheat and vegetable production

Effect of PGPR biofertilizer incombination with cowdung, poultry manure and chemical nitrogen on growth and yield of rice

Two field experiments were conducted at BINA farm Mymensingh and BINA substation Comilla for evaluating the influence of PGPR biofertilizer in combination with cowdung, poultry manure and chemical nitrogen on growth, yield and yield attributes of rice in Boro season during 2011-2012. There were seven treatments viz., 60% nitrogen (T_1), 60% Nitrogen + PGPR (T_2), 80% N (T_3), 60% N + PGPR + Cowdung (T_4), 60% N + PGPR + poultry manure (T_5), and 80% N + PGPR (T_6) and 100% N (T_7). Soil used in the study contained pH 6.7, organic carbon 1.06%, N 0.07%, P 13 ppm, K 0.20 meq/100 g and S 17 ppm in Mymensingh and pH 6.8, organic carbon 1.09%, N 0.073%, P 14 ppm, K 0.18 meq/100 g and S 16 ppm at BINA substation Comilla. The experiment was laid out in randomized complete block design (RCBD) with four replications. Binadhan-5 was used as test crop variety in both the locations. TSP, MoP, Gypsum, Zink sulphate and Boric acid were applied as basal dose @ P_{25}, K_{70}, S_{20}, Zn_2 and B_1 (kg ha^{-1}), respectively as per Fertilizer Recommendation Guide-2005. Urea was applied @ 140 kg ha^{-1} as full dose of nitrogen. Data on growth, yield and yield attributing parameters were recorded in time.

Results (Table 74-77) revealed that PGPR in combination with cowdung, poultry manure and nitrogen gave significantly higher values of growth, yield and yield contributing parameters of rice over 60% nitrogen (control). The highest grain yield was recorded with 100% N application at Mymensingh where as with 60% N + poultry manure + PGPR at BINA substation, Comilla. Treatment T_4, T_5, T_6 and T_7 showed statistically similar grain yield in both the locations. Growth parameters like plant height and panicle length were found significantly higher with in T_4, T_5, T_6 and T_7 over control. Yield contributing parameters like effective tiller $hill^{-1}$, grains $panicle^{-1}$ and 1000 grain weight were also found significantly higher over control in both the locations. From these experiments it can be concluded that 60% N + cowdung + PGPR or 60% N + poultry manure + PGPR or 80% N + PGPR may be used instead of recommended dose of urea application in rice cultivation.

Table 74. Effect of PGPR biofertilizer incombination with cowdung, poultry manure and chemical nitrogen on growth and yield of Binadhan-5 at Mymensingh

Treatments	Plant height (cm)	Panicle length (cm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1: N60 (Control)	93.75 b	22.85 b	4.10 c	5.26 b
T_2: N60+PGPR	97.50 ab	23.48 b	4.86 bc	6.32 ab
T_3 :N80+PGPR	99.90 ab	24.83 ab	5.00 abc	6.40 ab
T_4: N60+PGPR+CD	104.40 a	25.70 a	5.92 ab	7.36 a
T_5: N60+PGPR+PL	103.10 a	25.73 a	5.96 ab	7.29 a
T_6: N80	103.90 a	25.77 a	6.04 ab	7.24 a
T_7: N100	104.80 a	26.08 a	6.23 a	7.48 a
Sig, level	*	**	**	**
CV (%)	4.33	3.93	10.38	10.09

In a column, having same letter(s) do not differ significantly at 5% level of probability as per DMRT.

** = Significant at 1% level, * = Significant at 5% level

Table 75. Effect of PGPR biofertilizer incombination with cowdung, poultry manure and chemical nitrogen on yield attributes of Binadhan-5 at Mymensingh

Treatments	Effective tiller hill^{-1} (no.)	Grains panicle^{-1} (no.)	1000 grain weight (g)
T_1	9.45 b	57.98 b	23.25 b
T_2	10.50 ab	65.46 ab	24.11 ab
T_3	10.65 ab	67.00 ab	24.16 ab
T_4	11.58 a	69.14 a	24.23 ab
T_5	11.80 a	73.45 a	24.26 ab
T_6	11.73 a	70.93 a	25.07 a
T_7	11.60 a	71.35 a	25.26 a
Sig, level	*	**	*
CV (%)	8.11	6.25	2.98

In a column, having same letter(s) do not differ significantly at 5% level of probability as per DMRT.
** = Significant at 1% level, * = Significant at 5% level

Table 76. Effect of PGPR biofertilizer incombination with cowdung, poultry manure and chemical nitrogen on growth and yield of Binadhan-5 at Comilla

Treatments	Plant height (cm)	Panicle length (cm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	90.94 b	21.51 b	4.46 b	7.70 b
T_2	95.40 ab	22.47 ab	5.36 ab	9.21 ab
T_3	95.63 ab	22.38 ab	5.27 ab	9.25 ab
T_4	99.97 a	23.49 a	6.10 a	10.16 a
T_5	100.20 a	23.70 a	6.44 a	10.34 a
T_6	101.70 a	23.52 a	6.33 a	10.16 a
T_7	100.60 a	23.75 a	6.40 a	10.40 a
Sig, level	*	*	**	**
CV (%)	4.11	4.18	11.49	9.93

In a column, having same letter(s) do not differ significantly at 5% level of probability as per DMRT.
** = Significant at 1% level, * = Significant at 5% level, NS = Not significant

Table 77. Effect of PGPR biofertilizer incombination with cowdung, poultry manure and chemical nitrogen on yield attributes of Binadhan-5 at Comilla

Treatments	Effective tiller hill^{-1} (no.)	Grains panicle^{-1} (no.)	1000 grain weight (g)
T_1	8.63 c	72.40 c	23.74
T_2	9.80 bc	78.50 abc	24.72
T_3	9.70 bc	76.25 bc	25.89
T_4	11.15 ab	85.00 ab	25.54
T_5	11.47 a	87.75 ab	25.80
T_6	11.00 ab	90.00 a	24.89
T_7	11.10 ab	87.25 ab	25.86
Sig, level	**	*	NS
CV (%)	6.77	8.61	6.32

In a column, having same letter(s) do not differ significantly at 5% level of probability as per DMRT.
** = Significant at 1% level, * = Significant at 5% level, NS = Not significant

Biological nitrogen fixation studies in soils and legume crops using ^{15}N tracer technique

Effect of chemical fertilizer (phosphorus, boron and molybdenum) and biofertilizer on growth, nodulation and yield of mungbean

A field experiment was conducted to evatuate the effect of phosphorus, boron and molybdenum in presence and absence of biofertilizer on growth and yield of summar mungbean during 2011-2012. There were nine phosphorus, boron and molybdenum treatment viz. $P_0B_0Mo_0$ (T_1), $P_{16}B_{1.5}oMo_1$(T_2), $P_{16}B_{1.5}Mo_2$ (T_3), $P_{16}B_3Mo_1$ (T_4), $P_{16}B_3Mo_2$ (T_5), $P_{20}B_{1.5}Mo_1$ (T_6), $P_{20}B_{1.5}Mo_2$ (T_7), $P_{20}B_3Mo_1$ (T_8), $P_{20}B_3Mo_2$ (T_9). Two levels of biofertilizer were used i.e. without biofertilizer (B_0) and with biofertilizer (B_m). The soil used in the study was of pH 6.8, organic carbon 1.06%, N 0.072%, P 13 ppm, K 0.18 meq/100 g, and S 16 ppm. The experiment was laid out in a split plot design. Biofertilizer was applied in the main plots and the P, B and Mo treatments were used in subplots with three replications. All the fertilizers were applied at final land preparation before sowing. Data on nodule number, nodule dry weight and plant height were recorded in 50% flowering stage of mungbean. Grain yield was recorded after harvesting of mungbean at ripening.

Results (Table 78 and 79) showed that phosphorus, boron and molybdenum had good effect on mungbean. Combined application of phosphorus, boron and molybdenum showed higher grain yield over control. When molybdenum applied @ 2 kg ha^{-1} recorded statistically higher grain yield over control. When P applied @ 20 kg ha^{-1} grain yield became higher than lower dose. Application of higher dose of P, B and Mo ($P_{20}B_3Mo_2$) showed the highest grain yield (1010 kg ha^{-1}). Higher nodule

Table 78. Effect of chemical fertilizer (phosphorus, boron and molybdenum) and biofertilizer on growth, nodulation and yield of mungbean

Treatment	Plant height (cm)	Nodule $plant^{-1}$ (no.)	Nodule dry wt. (mg $plant^{-1}$)	Grain yield (kg ha^{-1})
Fertilizer				
T_1	46.81 c	12.50 c	55.33 e	831 d
T_2	49.23 bc	15.63 bc	67.33 de	887 cd
T_3	49.23 bc	19.77 ab	77.50 cd	912 bc
T_4	51.10 ab	18.83 ab	91.50 ab	938 abc
T_5	50.97 ab	17.37 ab	90.17 bc	945 abc
T_6	50.52 ab	19.83 ab	85.83 bc	959 abc
T_7	50.87 ab	19.10 ab	93.67 ab	984 ab
T_8	50.57 ab	18.33 ab	93.00 ab	976 ab
T_9	52.93 a	20.83 a	103.80 a	1010 a
Sig, level	*	**	**	**
CV (%)	5.26	13.53	9.24	5.17
Biofertilizer				
B0	47.96 b	7.15 b	31.52b	808 b
Bm	52.53 a	28.00 a	136.96a	1068 a
Sig, level	*	**	**	**
CV (%)	5.26	13.53	9.24	5.17

In a column, having same letter(s) do not differ significantly at 5% level of probability as per DMRT.
** = Significant at 1% level, * = Significant at 5% level

Table 79. Interaction effect of chemical fertilizer (phosphorus, boron and molybdenum) and biofertilizer on growth, nodulation and yield of mungbean

Chem. Fertilizer × Biofertilizer	Plant height (cm)	Nodule number (no. plant^{-1})	Nodule dry wt. (mg plant^{-1})	Grain yield (kg ha^{-1})
$B_0 \times T_1$	44.69	4.67 d	15.67 f	706
$B_0 \times T_2$	46.53	7.13 d	26.33 ef	756
$B_0 \times T_3$	47.87	6.87 d	28.67 ef	778
$B_0 \times T_4$	48.47	6.73 d	34.67 ef	815
$B_0 \times T_5$	49.80	7.07 d	34.67 ef	810
$B_0 \times T_6$	47.30	8.33 d	31.00 ef	828
$B_0 \times T_7$	49.20	8.20 d	32.67 ef	852
$B_0 \times T_8$	48.48	7.33 d	39.33 e	836
$B_0 \times T_9$	49.33	8.00 d	40.67 e	897
$B_m \times T_1$	48.93	20.33 c	95.00 d	957
$B_m \times T_2$	51,93	24.13 bc	108.30 d	1018
$B_m \times T_3$	50.60	32.67 a	126.30 c	1045
$B_m \times T_4$	53,73	30.93 a	148.30 b	1062
$B_m \times T_5$	52.13	27.67 ab	145.70 b	1081
$B_m \times T_6$	53,73	31.67 a	140.70 bc	1090
$B_m \times T_7$	52.53	30.00 a	154.70 ab	1117
$B_m \times T_8$	52.67	29.33 ab	146.70 b	1116
$B_m \times T_9$	56.53	33.67 a	167.00 a	1123
Sig, level	NS	**	**	NS
CV (%)	5.26	13.53	9.24	5.17

In a column, having same letter(s) do not differ significantly at 5% level of probability as per DMRT.
** = Significant at 1% level, NS = Not significant

number, nodule dry weight were recorded with higher PBMo application. Highest nodule number and nodule dry weight were found with $P_{20}B_3Mo_2$ (T_9). Biofertilizer application showed significantly higher plant height, nodule number, nodule dry weight and grain yield of mungbean. There was significant interaction between biofertilizer and P, B and Mo on nodule number and dry weight. The highest values in nodule number, nodule dry weight, plant height and grain yield of mungbean were recorded with the application of treatment cobination biofertilizer and $P_{20}B_3Mo_2$. It may be inferred that $P_{20}B_3Mo_2$ along with biofertilizer might be applied for sustainable mungbean cultivation.

Development of phosphatic biofertilizer for maximizing crop production

Effects of phosphatic biofertilizer with inorganic and organic P on the growth and yield of lentil and chickpea at Ishurdi and Magura

Field experiments were conducted to evaluate the phosphatic biofertilizer with inorganic or organic sources of P on lentil and chickpea at BINA substation, Ishurdi and BINA substation, Magura during 2011-12. The experiments were laid out in a RCB design using eight treatments with three replications. The treatments were as follows: T_1: Control, T_2: 100% P from TSP, T_3: 50% P from TSP, T_4: 50% P from TSP + Phosphatic biofertilizer (PB), T_5: 50% P from TSP + PB, T_6: 50% P from cowdung (CD), T_7: 50% P from CD + PB and T_8: Phosphatic biofertilizer (PB).

Lentil (var. Binamasur-2) and chickpea (Binasola-4) were sown in separate land at both the locations. Letil was sown on 17 and 18 November 2011 at Ishurdi and Magura, respectively while chickpea was sown on 24 November 2011 at Ishurdi and 23 November 2011 at Magura. Lentil was harvested on 14 March 2012 at Ishurdi and 6 March 2012 at Magura. Chickpea was harvested on 12 and 18 April 2012 at Ishurdi and Magura, respectivively. Characteristics of initial soils for both the locations have been given in Table 80 for lentil and chickpea. The fertilizer rates were used on the basis of soil tests (Table 81). In case of cowdung treatments, IPNS was followed. Phosphatic biofertilizer (as liquid inoculant) was applied with the seeds of lentil and chickpea before sowing.

Table 82 shows that the treatment T_5 (50% P from TSP + PB) gave significantly maximum seed yield of lentil (1.62 and 1.36 t ha $^{-1}$) followed by the treatments T_2 (1.51 and 1.21 t ha $^{-1}$**)** at Ishurdi and Magura, respectively. But the treatments T_2 (100% P from TSP) and T_5 (50% P from TSP + PB) gave identical seed yields at both the locations. The treatment T_4 (100% P from TSP + PB) gave similar seed yields with the treatment T_2 (100% P from TSP) but it differed significantly from the treatment T_5 (50% P from TSP + PB) at Ishurdi. At Magura the treatment T_5 showed statistically similar seed yields of lentil with the treatments T_2, T_3 and T_4. The treatment T_6 (50% P from CD) gave insignificantly lower seed yield than the treatment T_3 (50% P from TSP) but they gave identical results with the treatments T_7 (50% P from CD + PB) and T_8 (PB) at both the locations. However phosphatic biofertilizer with 50% P from cowdung gave higher seed yield of lentil to a some extent than 50% P from cowdung alone at both the locations which indicated that phosphate solubilizing bacteria might be stimulated with the application of cowdung. Without P gave significantly the lowest seed yield of lentil at both the locations. Stover yields of lentil (Table 82) also significantly affected with the different treatments at both the locations. The treatment T_6 (50% P from CD) gave significantly maximum stover yield (3.57 and 3.22 t ha^{-1} at Ishurdi and Magura, respectively) of lentil followed by the treatment T_5 (50% P from TSP + PB) and the lowest stover yield (2.39 and 2.45 t ha^{-1} at Ishurdi and Magura, respectively) was recorded with the treatment T_1. The results indicated that phosphatic biofertilizer with reduced rate of P i.e. 50%P from TSP + Phosphatic biofertilizer gave comparable seed yields of lentil to the 100%P from TSP alone.

Table 80. Physical, chemical and microbiological characteristics of initial soils of experimental fields at Ishurdi and Magura for lentil and chickpea during 2011-12

Characteristics	Ishurdi	Magura
Textural class	Loam	Clay Loam
Cation exchange capacity (cmol kg^{-1})	13.6	12.4
Soil pH	7.7	7.6
Organic carbon (%)	0.60	0.65
Total N (%)	0.052	0.064
Available P (mg kg^{-1})	13.33	14.2
Total P (mg kg^{-1})	1454.5	1420.8
Exchangeable K (cmol kg^{-1})	0.237	0.228
Available S (mg kg^{-1})	10.8	11.0
PSB population (cfu g^{-1} dry soil)	1.2×10^4	1.4×10^4

Phosphatic biofertilizer with inorganic and organic sources of P also significantly influenced the seed and stover yields of chickpea at Ishurdi and Magura (Table 83). The treatment T_5 (50% P from TSP + PB) gave significantly maximum seed yields (2.7 and 1.7 t ha^{-1} at Ishurdi and Magura, respectively) of chickpea followed by the treatment T_2 (50% P from TSP) at both the locations. The control treatment T_1 gave significantly the lowest seed yield (1.53 and 0.95 t ha^{-1}) at both the locations. Similar trends were also observed in case of stover yield of chickpea at both the locations. The results revealed that phosphatic biofertilizer with 50% P from TSP can be used for cultivation of chickpea as an alternative of 100% P from TSP alone.

Table 81. Full rates (100%) of nutrients (kg ha^{-1}) and 50% P equivalent CD (t ha^{-1}) for lentil and chickpea crop at Ishurdi and Magura on the basis of soil test values

Locations	Nutrients and CD rate for lentil and chickpea			
	N	P	K	CD
BINA sub-station, Ishurdi	19.0	23.0	17.1	0.58
BINA sub-station, Magura	19.0	22.0	18.0	0.55

Table 82. Effects of phosphatic biofertilizer with inorganic and organic P on seed and stover yields of lentil (Binamasur 2) at Ishurdi and Magura during 2011-12

Treatments	Ishurdi		Magura	
	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1: Control	0.95d	2.39d	0.86c	2.45b
T_2: 100% P from TSP	1.51ab	3.21ab	1.21ab	3.02a
T_3: 50% P from TSP	1.28bc	2.93bc	1.12b	2.81ab
T_4: 100% P from TSP + Phosphatic biofertilizer (PB)	1.36bc	2.88bc	1.16ab	3.12a
T_5: 50% P fromTSP + PB	1.62a	3.07bc	1.36a	3.18a
T_6: 50% P from cowdung	1.23c	3.57a	1.06bc	3.22a
T_7: 50% P from cowdung + PB	1.26c	2.81bcd	1.08b	2.83ab
T_8: PB	1.21c	2.64cd	1.10b	2.95ab
CV (%)	9.81	8.30	10.95	9.34

In a column figures having common letter(s) do not differ significantly at 5% level of significance as per DMRT.

Table 83. Effects of phosphatic biofertilizer with inorganic and organic P on seed and stover yields of chickpea (Binasola-4) at Ishurdi and Magura during 2011-12

Treatments	Ishurdi		Magura	
	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1: Control	1.53e	2.75b	0.95d	3.02b
T_2: 100% P from TSP	2.39ab	3.69a	1.67a	4.08a
T_3: 50% P from TSP	1.94cd	3.52ab	1.30bcd	3.91a
T_4: 100% P from TSP + Phosphatic biofertilizer (PB)	2.26bc	3.87a	1.62ab	4.31a
T_5: 50% P fromTSP + PB	2.70a	4.10a	1.70a	4.26a
T_6: 50% P from cowdung	2.08bcd	3.42ab	1.26bcd	3.47ab
T_7: 50% P from cowdung + PB	2.25bcd	3.55ab	1.54abc	3.99a
T_8: PB	1.90d	3.31ab	1.18cd	3.87a
CV (%)	8.75	11.83	13.88	11.20

In a column figures having common letter(s) do not differ significantly at 5% level of significance as per DMRT

Effects of phosphatic biofertilizer with inorganic and organic P on the growth and yield of boro rice at Ishurdi and Magura

Field experiments were conducted to investigate the effects of phosphatic biofertilizer with inorganic or organic sources of P on boro rice at BINA sub-station, Ishurdi and BINA sub-station, Magura during 20111-12. Eight treatments with three replications for each treatment were used in a Randomized Complete Block Design for the experiments in both the locations. The treatments were as follows: T_1: Control, T_2: 100% P from TSP, T_3:50% P from TSP, T_4: 50% P from TSP + Phosphatic biofertilizer (PB), T_5: 50% P from TSP + PB, T_6: 50% P from cowdung (CD), T_7: 50% P from CD + PB and T_8: Phosphatic biofertilizer (PB).

Thirty-five day old seedlings of boro rice (var. Binadhan 5 for Ishurdi and Iratom 24 for Magura) were transplanted at Ishurdi and Magura on second and third week of February 2012, respectively. Boro rice was harvested on first week of June in each location. Characteristics of initial soils for both the locations have been given in Table 84. N, P and K were applied in the form of urea, triple super phosphate (TSP) and muriate of potash (MoP), repectively on the basis of soil tests (Table 85). In case of cowdung treatments, IPNS was followed. Cowdung was applied seven days before the transplanting of boro rice. All the inorganic fertilizers except urea were applied during the final land preparation. Urea was applied in three equal splits. First split was applied 15 days after transplanting (DAT) and 2nd and 3rd splits were applied at 40 and 55 DAT, respectively in every location. Phosphatic biofertilizer (as liquid inoculant) was applied with the roots of rice seedlings one hour before the transplanting.

Grain and straw yields of boro rice was significantly influenced with the different treatments at Ishurdi and Magura (Table 86). The treatment T_5 (50% P fromTSP + PB) gave the significantly highest grain yield (4.8 and 4.52 t ha^{-1} at Ishurdi and Magura, respectively) of boro rice at both the locations followed by the treatment T_4 (100% P fromTSP + PB) but the treatment $T_{2,}$ T_4 and T_5 gave similar grain yield of boro rice in the both locations. The control treatment T_1 showed the lowest grain yield of boro rice at Ishurdi and Magura. The similar trends were observed in case of straw yields at both the locations. The results indicated that phosphatic biofertilizer with 50% P from TSP can be used for cultivation of boro rice as an alternate of 100% P from TSP alone. However, further investigation is needed for final recommendation.

Table 84. Physical, chemical and microbiological characteristics of initial soils of experimental fields at Ishurdi and Magura for boro rice

Characteristics	Ishurdi	Magura
Textural class	Loam	Clay Loam
Cation exchange capacity (cmol kg^{-1})	13.8	12.0
Soil pH	7.6	7.8
Organic carbon (%)	0.62	0.67
Total N (%)	0.054	0.067
Available P (mg kg^{-1})	13.8	14.6
Total P (mg kg^{-1})	1454.5	1420.8
Exchangeable K (cmol kg^{-1})	0.239	0.223
Available S (mg kg^{-1})	10.4	10.9
PSB population (cfu g^{-1} dry soil)	1.1×10^4	1.3×10^4

Table 85. Full rates (100%) of nutrients (kg ha^{-1}) and 50% P equivalent CD (t ha^{-1}) for boro rice at Ishurdi and Magura on the basis of soil test values

Locations	Nutrients for boro rice			
	N	P	K	CD
BINA sub-station, Ishurdi	136	13	21	0.65
BINA sub-station, Magura	136	12	24	0.60

Table 86. Effects of phosphatic biofertilizer with organic and inorganic fertilizes on grain and straw yields of boro rice at Ishurdi (var. Binadhan 5) and Magura (var. Iratom 24) during 2011-12

Treatments	Ishurdi		Magura	
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1: Control	3.97c	4.88d	3.17c	4.80c
T_2: 100% P from TSP	4.62ab	5.52ab	4.13abc	5.47ab
T_3: 50% P from TSP	4.38abc	5.13cd	3.40bc	5.13abc
T_4: 100% P from TSP + Phosphatic biofertilizer (PB)	4.68ab	5.32bc	4.32ab	5.50a
T_5: 50% P fromTSP + PB	4.80a	5.77a	4.52a	5.60a
T_6: 50% P from cowdung	4.25bc	5.17bcd	3.35bc	4.98bc
T_7: 50% P from cowdung + PB	4.53ab	5.30bc	3.37bc	5.30abc
T_8: PB	4.40abc	4.92d	3.30c	4.87c
CV (%)	5.37	3.64	13.62	5.03

In a column, figures having common letter(s) do not differ significantly at 5% level of significance as per DMRT.

ENTOMOLOGY DIVISION

RESEARCH HIGHLIGHTS

Among the three salt tolerant mutants/variety of rice, the overall infestation by stem borer throughout the cropping season was below the economic injury level (5-10%).

In artificially infested condition, only the mutant PBRC-37 was found to be moderately tolerant (MT) to brown plant hopper.

Between the two submergence tolerant mutants/lines of rice, the lowest leaf area consumed by rice hispa was in the mutant Sumba Mahsuri-Sub-1.

Among the four salt tolerant mutants of rice, the lowest leaf area consumed by rice hispa was in the line PBRC-37 and it was followed by Binadhan-8.

The maximum mortality (100%) of BPH recorded when cartap was used @ 800 gm ha^{-1} and the minimum mortality (50%) recorded when phipronyl and diazinon were used.

Chickpea mutant P-70 was found to perform against pod borer.

The lowest infestation by jassid, whitefly and pod borer was observed in mungbeen mutant MBM-07 though the overall infestation was low.

All the tested mutants of jute having less than one number of knots $plant^{-1}$ were designated as resistant to jute stem weevil.

Among the tested mutants of mustard, the mutant MM- 211 may be regarded as less susceptible to mustard sawfly and the mutant MM-37 was found to be less susceptible to mustard aphid.

Among the eleven mutants/varieties of groundnut, the mutant RS/25/3-1 showed less infested against jassid and leaf roller.

Sesame mutant SM-058 was found to be less infested to pod borer.

Evaluation of salt tolerant mutants/variety of rice for tolerance to major insect pests

Three salt tolerant mutants/variety of rice, viz. PBRC-15, SAL-655 and Binadhan-8 were tested along with one resistant check TKM6 and a susceptible check TN1 against rice stem borer and green leaf hopper under field condition. The experiment was laid out in a randomized complete block design with three replications during the Boro season, 2012 at BINA farm, Mymensingh. No protective measure was taken to control the insect pests. Data were recorded during maximum tillering and heading stage and analyzed statistically.

Among the three salt tolerant mutants/variety of rice the overall infestation by stem borer throughout the cropping season was below the economic injury level (5-10%) (Table 1). In GLH infestation, there was no significant difference among the three mutants/varieties of rice.

Table 1. Mean infestation of rice mutants/variety for tolerance to stem borer and GLH under field condition

Mutants/variety	% Dead heart	% White head	GLH/10 sweeps
PBRC-15	0.26 b	0.23 c	4.33 ab
SAL-655	0.32 b	0.34 bc	3.00 ab
Binadhan-8	0.33 b	0.41 b	2.00 ab
TN1 (Susceptible check)	0.91 a	0.99 a	6.12 a
TKM6 (Resistant check)	0.03 c	0.04 d	1.01 b

Note: GLH = Green leaf hopper

Evaluation of Salt tolerant mutants/variety of rice for tolerance to brown plant hopper under artificially infested condition.

Four salt tolerant mutants/varieties of rice, viz. PBRC-15, PBRC-37, SAL-655 and Binadhan-8 were tested along with one resistant check T27A and a susceptible check TN1 against brown plant hopper under artificial infested condition. The experiment was laid out in a completely randomized design with three replications. Data were recorded timely and analyzed statistically.

Among the four salt mutants/varieties of rice only the mutant PBRC-37 was found to be moderately tolerant (MT) and Binadhan-8 & SAL-655 were moderately susceptible and PBRC-15 was susceptible to brown plant hopper (Table 2).

Table 2. Mean infestation of salt tolerant mutants/variety of rice for tolerance to brown plant hopper under artificial infested condition

Mutants/variety	Damage scale (0-9)	Level of resistant
TN1 (Susceptible check)	7	S
TKM6	7	S
PBRC-15	7	S
Binadhan-8	5	MS
SAL-655	5	MS
PBRC-37	3	MT
T27A (Resistant check)	0	HT

Note: S = Susceptible, MS = Moderately Susceptible, MT = Moderately Tolerant, HT = Highly Tolerant.

Evaluation of some submergence tolerant mutants/lines of rice for resistance to rice hispa under artificially infested condition.

Two submergence tolerant mutant/lines of rice, viz. Ciherang Sub-1 and Sumba Mahsuri-Sub-1 were tested along with two resistant check T27A and TKM6 and a susceptible check TN1 against rice hispa under artificially infested condition. The experiment was laid out in a completely randomized design with three replications. Data were recorded timely and analyzed statistically.

Between the two submergence tolerant mutants/lines of rice, the lower leaf area consumed by rice hispa was in the mutant Samba Mahsuri-sub-1 (Table 3).

Table 3. Mean infestation of submergence tolerant mutants/lines of rice for tolerance to rice hispa under artificial infested condition

Mutants/varieties	Leaf area consumed by rice hispa (cm^2)
Ciherang-Sub-1	2.6 c
Samba Mahsuri-Sub-1	2.8 c
TKM6 (Resistant check)	4.5 b
T27A (Resistant check)	5.5 b
TN1 (Susceptible check)	8.1a

Evaluation of salt tolerant mutants/variety of rice for tolerant to rice hispa under artificial infested condition

Four salt tolerant mutants/variety of rice, viz. PBRC-15, PBRC-37, SAL-655 and Binadhan-8 were tested along with one resistant check T27A and a susceptible check TN1 against rice hispa under artificially infested condition. The experiment was laid out in a completely randomized design with three replications. Data were recorded timely and analyzed statistically.

Among the four salt tolerant mutants of rice the lowest leaf area consumed by rice hispa was in the line PBRC-37 and this was followed by Binadhan-8.

Table 4. Mean infestation of salt tolerant mutants/variety of rice for tolerance to rice hispa under artificial infested condition

Mutants/varieties	Leaf area consumed by rice hispa (cm^2)
SAL-655	5.1 b
Binadhan-8	4.3 bc
PBRC-15	6.2 b
PBRC-37	3.0 c
T27A (Resistant check)	2.4 c
TN1 (Susceptible check)	8.3 a

Effect of insecticides to control different insect pests of rice

Experiment was conducted during the year, 2012 When at Entomology growth room to evaluate the effect of some insecticides to control brown plant hopper of rice. The insecticides, viz., carbosulfun, prophenophos, phipronyl, cartap, carbofuran and diazinon were applied at 45 days old seedling of rice at the recommended doses supply by the company. A control treatment was maintained which received no insecticide. The experiment was laid out in a completely randomized design with three replications. Data were recorded timely specify (10 days after spraying) and analyzed statistically.

The maximum mortality (100%) of BPH recorded when cartap was used @ 800 gm ha^{-1} and minimum mortality (50%) recorded when phipronyl and diazinon were used (Table 5). This indicates that among the six insecticides, cartap group of insecticides was most effective for controlling BPH.

Table 5. Efficacy of different insecticides against brown plant hopper

Group of insecticides	Effective dose	% Mortality
Carbosulfun	1.5 litre ha^{-1}	93
Prophenophos	1 litre ha^{-1}	90
Phipronyl	10 kg ha^{-1}	50
Cartap	800 g ha^{-1}	100
Carbofuran	16 kg ha^{-1}	90
Diazinon	16.8 kg ha^{-1}	50
Control	1.5 litre ha^{-1}	0

Screening of chickpea mutants/varieties for resistance to pod borer under field condition

Two mutants/strains of chickpea along with 2 check varieties were tested for their resistance to pod borer (*Helicoverpa armigera*) during the rabi season of 2011-12 at BINA substation farm, Jamalpur and farmer’s field Godagari, Rajshahi under the pesticide free open field condition for natural pest infestation. Randomized complete block design with three replications were followed for setting the experiments. Data on the pod borer infestation was recorded from 10 randomly selected plants per plot at harvest. Recorded data were statistically analyzed and presented in Table 6.

Among the advanced mutants/varieties of chickpea, the lowest pod infestation by pod borer was observed in mutant P-70 and highest infestation was observed in check variety BARI Chola-5 though no significant differences were found among the tested materials.

Table 6. Reaction of some mutants/strains of chickpea to pod borer at two locations

Mutants/varieties	% pod infested	
	Jamalpur	Rajshahi
P 70	8.41a	7.56b
CPM-860	10.33a	7.74b
Binasola-4	11.05a	12.13a
BARI Chola-5	11.42a	13.49a

Means in a column followed by same letter are not significantly different at 5% level by DMRT.

Screening of summer mungbean mutants/varieties for resistance to major insect pests under field condition

Two advance mutants of summer mungbean and two check varieties were evaluated for resistance to jassid, whitefly and pod borer under field condition during summer season of 2012. The experiments were conducted in a randomized complete block design with three replications at BINA substation farm, Ishurdi and Rangpur. Unit plot size was 3 m × 4 m. Seeds were sown on 6 March at Ishurdi and 14 March at Rangpur. The field was exposed to natural attack of insects and no control measure was taken. To assess the percentage of presence of jassid and whitefly data were taken by using cage (1 case = 40 cm × 45 cm = 6 plants) at the vegetative stage. Ten plants per plot were selected randomly for assessing percentage of pod borer infestation before harvest. The data were analyzed statistically.

The overall infestations by the jassid, whitefly and pod borer were very low in both the locations. Specially the presence of whitefly was very low and no significant differences were observed. Significant differences were observed among the mutants/varieties with respect to jassid/cage and pod borer infestation (Table 10). The jassid/cage was comparatively lower at Ishurdi than Rangpur and Binamoog-8 showed the highest at Rangpur. Pod borer infestation was lower at Rangpur thant that of Ishurdi and the highest infestation was found in Binamoog-8 at both the locations.

Table 7. Reaction of summer mungbean mutants to jassid, whitefly and pod borer at two locations Ishurdi and Rangpur

Mutants/variety	% Infestation					
	Jassid		Whitfly		Pod borer	
	Ishurdi	Rangpur	Ishurdi	Rangpur	Ishurdi	Rangpur
MBM-07	0.73a	3.33b	0.60a	0.47a	4.18a	2.95b
MBM-L-88	0.73a	3.40b	1.00a	0.67a	5.92a	4.93ab
Binamoog-5	0.87a	3.67b	1.07a	0.80a	7.06a	6.18ab
Binamoog-8	0.87a	6.60a	1.13a	1.00a	8.53a	7.32a

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Evaluation of tossa jute mutants for resistance to jute stem weevil under field condition

Five mutants of jute along with one check variety 0-9897 were evaluated for resistance to jute stem weevil. The experiments were set up at two locations BINA farm, Mymensingh and BINA sub-station farm Rangpur. The fields were exposed to natural infestation and no control measures were taken against this pest. The data on weevil infestation were taken at 120 days after sowing. The data were expressed into percentage of weevil infested plants and average number of knots per plant was calculated. All the data were analyzed statistically.

Significant differences were observed among the mutants in respect to percent plant infested and number of knots/plant by weevil at both the locations and mean of locations except at Rangpur in respect to percent plant infested by weevil (Table 8 and 9). The lowest percent plant infested and the lowest number of knots/plant by weevil was recorded in the mutant 25(3) at both the locations. Mean of locations showed similar results. All the tested mutants were found to be less infested than the check variety 0-9897. However, all the mutants having less than one number of knots plant^{-1} were designated as resistant to jute stem weevil.

Table 8. Reaction of jute mutants to jute stem weevil at Mymensingh and Rangpur

Mutants/variety	% plant infested by stem weevil		
	Mymensingh	Rangpur	Mean of location
25(3)	6.67 c	20.00	13.33 c
58(2)	20.00 b	33.33	26.67 b
72(3)	33.33 b	20.00	26.67 b
86(3)	33.33 b	33.33	33.33 b
200(3)	26.67 b	26.67	26.67 b
0-9897	46.67 a	46.67	46.67 a

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Table 9. Reaction of some mutants to jute stem weevil at Mymensingh and Rangpur

Variety/mutants	No. of knots $plant^{-1}$		
	Mymensingh	Rangpur	Mean of location
25(3)	0.07 b	0.43 c	0.25 d
58(2)	0.60 a	0.67 b	0.64 b
72(3)	0.47 a	0.40 c	0.44 c
86(3)	0.33 ab	0.33 c	0.33 cd
200(3)	0.40 ab	0.40 c	0.40 c
0-9897	0.67 a	0.87 a	0.77 a

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Screening of tomato mutants/strains for resistance to their major insect pests under field condition

Four advance mutants of tomato along with three check varieties were tested against the tomato fruit borer *Helicoverpa armigera* at BINA farm, Mymensingh during the rabi season of 2011. The experiment was laid out in a randomized complete block design with three replications. No protective measures were taken to control the pest and the plants were exposed to natural infestation. Ten plants per plot were randomly selected before the fruits were harvested and data on the fruit borer infestation was recorded. All the data were analyzed statistically.

No significant differences were found among the mutants (Table 10). The infestation ranged from 2.19% to 6.41%. The average fruit borer attack was comparatively lowest in the mutant TM-134 (2.19%) than the other mutants.

Table 10. Reaction of advance tomato mutants/lines to fruit borer infestation

Mutants/varieties	% fruit borer infestation
TM-110	4.97
TM-131	3.72
TM-134	2.19
TM-219	2.27
Binatomato-4	6.41
Binatomato-5	2.93
BARI Tomato-14	2 .51
LSD (<5%)	NS

Evaluation of advanced mustard/rapeseed mutants for their resistance to major insect pests under field condition

Six mutants of mustard along with two check varieties Binasharisha-4 and Binasharisha-5 were evaluated against sawfly and aphid in the field at three locations BINA farm, Mymensingh, BINA substation farm Rangpur and Magura. The experiments were laid out in a randomized block design with three replications. The unit plot size was 4 m × 5 m. Spacing between plant to plant and row to row were 5 cm and 20 cm, respectively. The plants were exposed to natural infestation. No protective measures were taken against these pests. Number of aphids plant^{-1} were recorded. Percentage of plant infested by aphid and sawfly was collected from 5 randomly selected rows plot^{-1}. Seed yield (kg ha^{-1}) was also recorded from Mymensingh and Magura. All the data were analyzed statistically.

In Mymensingh, the lowest infestation was recorded in the variety Binasharisa-4 followed by the mutant MM-211. No statistical variation was observed between this mutant and to the variety. No significant differences were observed among the tested mutants/varieties with respect to per cent plant infestation by sawfly at Rangpur, Magura and to the mean of per cent plant infestation at three locations. For the mean of percent plant infestation, the mutant and the variety with lowest infestation by sawfly was same at Mymensingh region (Table-11).

Table. 11 Reaction of mustard mutants to sawfly at three locations

Mutants/varieties	% plant infested by sawfly			
	Mymensingh	Rangpur	Magura	Mean
MM-10	41.15 a	26.83	22.96	30.31
MM-35	40.86 a	31.17	20.13	30.72
MM-37	32.77 dc	31.91	24.50	29.73
MM-210	36.05 bc	27.20	20.02	27.91
MM-211	31.62 e	28.36	21.76	27.25
MM-256	34.58 cd	28.79	21.87	28.41
Binasharisa-4	31.24 e	28.35	24.15	27.91
Binasharisa-5	38.28 b	27.48	21.08	28.95

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

The infestation by aphid was very high at Magura throughout the cropping season. Significantly the lowest infestation by aphid was recorded in the mutant MM-37 at Mymensingh and Magura. Though no significant differences were observed among the mutants/varieties with respect to percent plant infested by aphid at Rangpur. Significantly lowest number of aphid was also found in the mutant MM-37 and at mean of location (Table 12 and 13). The mutant MM-37 also produced highest seed yield at Mymensingh and Magura though no significant differences were observed among the tested mutants with respect to seed yield of mustard. The conclusion of the experiment was that the mutant MM-37 may be regarded as tolerant or less susceptible to mustard aphid.

Table 12. Reaction of mustard mutants to aphid at three locations

Varieties/mutants	% plant infested by aphids			
	Mymensingh	Rangpur	Magura	Mean
MM-10	10.61 b	7.36	97.34 a	38.43 a
MM-35	3.60 e	5.23	97.43 a	35.42 a
MM-37	1.85 e	3.99	79.88 b	29.07 b
MM-210	9.63 bc	7.30	95.73 a	37.55 a
MM-211	8.97 bc	5.49	100.00 a	38.15 a
MM-256	15.16 a	6.27	100.00 a	40.48 a
Binasharisa-4	5.87 d	4.83	100.00 a	36.90 a
Binasharisa-5	7.65 cd	8.86	100.00 a	38.84a

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Table 13. Number of aphid in mustard mutants at three locations

Varieties/mutants	Number of aphids plant^{-1}			Mean Location
	Mymensingh	Rangpur	Magura	
MM-10	45.4 a	9.97 c	67.80 a	41.06
MM-35	18.13 ab	24.37 a	47.53 c	30.01
MM-37	5.67 c	8.87 c	36.06 d	16.86
MM-210	13.6 bc	10.43 bc	48.13 c	24.05
MM-211	17.87 ab	22.13 ab	58.13 abc	32.71
MM-256	6.20 bc	15.53 abc	68.73 a	30.15
Binasharisa-4	21.02 ab	26.67 a	62.67 ab	36.84
Binasharisa-5	10.08 bc	15.53 abc	48.60 bc	24.98

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Table 14. Seed yield of mustard at two locations

Varieties/mutants	Seed yield (kg ha^{-1})		Mean
	Mymensingh	Rangpur	
MM-10	1200.00	1183.33	1191.67
MM-35	1111.11	1216.67	1163.89
MM-37	1266.67	1250.00	1258.34
MM-210	1066.67	1216.67	1141.67
MM-211	1022.22	1167.67	1094.95
MM-256	1111.11	1200.00	1155.56
BINA Sharisa-4	1155.56	1167.67	1161.62
BINA Sharisa-5	1088.89	1216.67	1152.78

Feeding response of mustard aphid *Lipaphis erisimi (*Kalt) on mustard mutants

Six mutants of mustard along with two check varieties Binasharisha-4 and Binasharisha-5 were evaluated against the feeding responses of mustard aphid. For this purpose honey dew, droplets excreted by the aphid were collected in a feeding chamber consisted of an inverted transparent plastic cup. Para film was stretched over the base of inverted cup. Three 5th instar nymphs previously starved for 2 hours were released into the excised twig of mustard plant. After the nymphs settled on, the twig was placed into the feeding chamber through a hole at the top of the cup. A cotton pad was then placed in the hole to prevent escape of the insect. The nymphs were allowed to feed for 24 hours. After 24 hours, the honey dew droplets were counted from the stretched Para film under binocular microscope at 6 x magnification. Thirty two feeding chamber were used for maintenance four replications for each treatment.

The mutants/varieties showed significant difference in respect of excreted honeydew by aphid when feeding on mustard plant. The insect fed on the mutant MM-37 excreted lowest number of honeydew droplets followed by the mutant MM-35. No statistical variation was observed among these two mutants (Table 15). So, these two mutants may be regarded as less susceptible to aphid than other mutants/variety.

Table 15. Number of droplets excreted by mustard aphid in 24 hours

Mutants/variety	Mean no. of honeydew droplets
MM-10	10.77 b
MM-35	3.75 ef
MM-37	2.00 f
MM-210	8.23 bc
MM-211	6.85 cd
MM-256	15.79 a
Binasharisha-4	5.13 de
Binasharisha-5	8.52 bc

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Evaluation of advanced sesame mutants for their resistance to hairy caterpillar and pod borer

Three mutants of sesame along with one check variety Baritil-2 were evaluated against hairy caterpillar and pod borer in the field at two locations BINA sub-station farm, Magura and Rangpur. The experiments were laid out in a randomized block design with three replications. The unit plot size was 5 m × 3 m. Spacing between plant to plant and row to row were 5 cm and 25 cm respectively. The plants were exposed to natural infestation and no protective measures against pests were taken. Data on leaf area consumed by hairy caterpillar were measured by transparent checker scale. Data on percentage of pod infested by pod borer was taken from 10 randomly selected plants plot^{-1} after harvest. All the data were analyzed statistically.

Significantly the lowest leaf area consumed by hairy caterpillar was recorded in the mutant SM-10-04 followed by the mutants SM-067 and SM-058 at Rangpur and Magura. Same trend was followed in the mean of leaf area consumed by caterpillar (Table 16). So, the mutant SM-10-04 may be regarded as less susceptible to hairy caterpillar.

The overall infestation by pod borer was low throughout the cropping season. The lowest per cent pod infested by pod borer was found in the mutant SM-058 at both the locations and at mean of per cent infested by pod borer (Table 16). Significant differences were observed among the mutants/variety with respect to percent pod infested by pod borer at Magura only. So, the mutant SM-058 may be regarded as less susceptible to pod borer than other mutants/variety.

Table 16. Reaction of sesame mutants/variety to hairy caterpillar and pod borer at two locations

Mutants/variety	leaf area (mm^2) consumed by caterpillar		Mean	% pod infested by pod borer		Mean
	Rangpur	Magura		Rangpur	Magura	
SM-058	19.57 b	26.13 a	22.85 b	3.73	0.50 c	2.12
SM-067	16.73 b	25. 1 b	20.92 b	3.97	0.93 b	2.45
SM-10-04	15.23 b	20. 56 c	17.89 b	4.55	1.08 b	2.82
BINA Til-2	33.13 a	29.16 a	31.15 a	5.64	1.48 a	3.56

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Evaluation of advanced lines of soybean for resistance to major insect pests

Four advanced lines and one check variety of soybean were evaluated against cabbage looper hairy caterpillar and pod borer in the field at two locations, BINA sub-station farm Magura and farmer's field, Noakhali. The experiments were laid out in a randomized complete block design with three replications Data on percent plant infested by cabbage looper was taken. Data on leaf area consumed by hairy caterpillar was measured by transparent chequer scale and percentage of pod infested by pod borer was recorded from 10 randomly selected plants per plot after harvest.

The overall infestation by cabbage looper and hairy caterpillar was very high at Noakahali. Significantly the lowest percent of plant infested by cabbage looper was observed in the variety Binasoybean-1 followed by the mutant SBM-23. No statistical variation was found between this variety and the mutant at Noakhali. Mean of % plant infested by cabbage looper of locations showed similar results (Table 17). But at Magura significantly the lowest infestation by cabbage looper was recorded in the mutant SMB-22.

In case of hairy caterpillar significantly lowest leaf area consumed by caterpillar was recorded in the mutant SBM-23 followed by the mutant SBM-18 and SBM-15 at Noakhali (Table 18). No statistical variation were found among these three mutants. No. significant differences were observed among the tested mutants/variety with respect to leaf area consumed at Magura and mean of locations (Table 18). No conclusion was drawn among the tested mutants against hairy caterpillar. So this experiment will be repeated next year.

The overall infestation by pod borer was low at Noakhali and Magura (Table 19). Significantly the lowest infestation by pod borer was recorded in the mutant SBM-22 followed by the variety BINA-Soy-1, and the mutant SBM-15 at Noakhali. No significant variation was observed among the tested mutant mutants/variety with respect to percent plant infested by pod borer at Magura and mean of locations though the lowest infestation by pod borer were found in the mutant SBM-22 (Table 19).

Table 17. Reaction of advanced line of Soybean to cabbage lopper

Variety/mutants	% Plant infested by cabbage lopper		
	Noakhali	Magura	Mean
SBM-15	92.88b	28.16 d	60.52 a
SBM-18	92.46b	29.83 b	61.14 a
SBM-22	100.00a	22.42 e	61.21 a
SBM-23	81.07c	32.02 a	56.54 b
BINA-Soy-1	79.69c	29.33 c	54.51 b

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Table 18. Reaction of advanced line of Soybean to hairy caterpillar

Variety/mutants	Leaf area (mm^2) consumed by caterpillar		
	Noakhali	Magura	Mean of location
SBM-15	98.83 b	65.10	81.96
SBM-18	94.43 b	64.00	79.21
SBM-22	127.50 a	50.63	83.06
SBM-23	88.23 b	79.83	82.63
BINA-Soy-1	115.56 a	49.10	82.33

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Table. 19 Reaction of advanced lines of soybean to pod borer

Variety/mutants	% Pod infested by pod borer		
	Noakhali	Magura	Mean
SBM-15	2.48 bc	1.25	2.03
SBM-18	2.96 b	1.01	1.98
SBM-22	2.07 c	0.42	1.24
SBM-23	3.95 a	0.87	2.42
BINA-Soy-1	2.18 bc	0.62	1.40

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

Evaluation of groundnut mutants for resistant to major insect pest under field condition

Nine advanced mutants along with two check varieties Dacca-1 and Zingabadam were evaluated against jassid, leaf roller and hairy caterpillar under field conditions at BINA sub-station farm, Ishurdi. The experiments were laid out in a randomized complete black design with three replications. The unit plot size was 4 m × 5 m. Seeds were sown at 15 cm distance within rows 30 cm apart on 1st week of December, 2011, respectively. The plants were exposed to natural infestation and no protective measure was taken against any insect pests. Data on percent plant infested by leaf roller was collected from 5 randomly selected plants per row and leaf area consumed by hairy caterpillar was measured by transparent check scale. Data on no. of jassid/cage was recorded. All data were analyzed statistically.

Table 20. Reaction of groundnut mutants to jassid leaf roller and hairy caterpillar at Ishurdi

Mutants/varieties	Number of jassids/case	% Leaf infested by leaf roller	Leaf area (mm^2) consumed by hairy caterpillar
D1/20/17-1	0.60	4.87d	23.90b
GC(1)-4-1	1.01	19.23 a	20.97 bcd
GC(1)24-1-1-1	1.22	6.83 cd	10.20 f
GC(1) 32-1-1-1	1.22	10.77 bc	17.27 cde
GC(1) 32-2-1-1	0.93	4.86 d	15.73 de
GC(1) 32-3-2-1-1	1.22	12.45 b	21.43 bc
GC(1)35-1-1	0.88	12.20 b	16.83 cde
PK-1	0.89	5.85 d	16.25 cde
RS/25/3-1	0.44	2.26 e	15.23 e
Dacca-1	1.22	7.07 cd	16.33 cde
Zingabadam	0.55	19.07 a	31.10 a

Means in a column followed by the same letter are not significantly different at 5% level by DMRT.

The infestation by jassid was very low throughout the cropping season. The lowest number of jassids per case was recorded in the mutant RS/25/3-1 though no significant differences were observed among the mutants/varieties with respect to no. of jassids/case (Table 20). The lowest infestation by leaf roller was also observed in the mutant RS/25/3-1. Significant differences were found among the tested mutants/varieties with respect to percent leaf infested by leaf roller. All the mutants except the mutant GC-(1)4-1 showed lower infested by leaf roller than the check varieties. On the other hand significantly the lowest infestation by hairy caterpillar was recorded in the mutant GC(1)24-1-1-1 (Table 20). Followed by the mutants/variety GC(1) 32-2-1-1, PK-1, Dacca-1 and GC(1) 35-1. All the tested mutants were lower infestation by hairy caterpillar than the check variety Zingabadam. It was concluded that the mutant RS/25/3-1 may be regarded as less susceptible against jassid and leaf roller.

PLANT PATHOLOGY DIVISION

RESEARCH HIGHLIGHTS

Among the 12 mutants and advanced lines of rice tested 3 and 5 were found to be moderately resistant to sheath blight and bacterial leaf blight, respectively during Aman season. However, the mutants RM-200(c)-1-9 and RM-200(c)-1-10 showed moderately resistant reaction to bacterial leaf blight during Boro season

The organic amendments and biopesticides reduced sheath blight severity and increased grain yield significantly, but foliar fungicide Tilt showed the best performance for reducing the severities of sheath blight of boro rice (cv. Iratom-24) and increased grain yield (more than 40%) over control.

Thirty two advanced mutants of lentil were evaluated against stemphylium blight. Twenty four mutants were found to be tolerant to *Stemphylium* blight. Twenty six mutants/varities were found to be tolerant to root rot under field condition.

Three chickpea genotypes were evaluated against root rot and botrytis gray mold. All the mutants were found to be susceptible to root rot and tolerant to botrytis gray mold under field condition.

Two promising lines of mungbean were assessed for their resistance to yellow mosaic and *Cercospora* leaf spot. All the lines/varieties were found moderately resistant to tolerant against yellow mosaic and *Cercospora* leaf spot.

An isolate of *Trichoderma* was evaluated to control root rot of lentil and sheath blight of rice using seed and soil treated method. The result reveled that the soil treatment using *Trichoderma* is the best method to control root rot of lentil and sheath blight of rice.

A promising mutant TM-110 of tomato was evaluated against fusarium wilt, late blight and yellow mosaic. The mutant TM-110 showed moderately resistant to fusarium wilt in Rangpur and Magura but susceptible in Mymensingh. The mutant showed tolerant to late blight. The genotype CLN-2777B showed moderately resistant to *Fusarium* wilt and tolerant to late blight.

An experiment was conducted to manage *Fusarium* wilt of tomato and it was observed that the integrated application of *Trichoderma* (soil treated), MOC and Provax (seed treated) showed lowest disease incidence.

Thirteen mutants were evaluated against purple blotch of onion. Six mutants BP_2/75/2, BP_2/75/3, BP_2/75/5, BP_2/75/11, BP_2/100/12 and BP_2/125/1 showed tolerant to the disease.

Two promising mutants viz. D_1/20/17-1 and RS/20/3-1 of groundnut exhibited tolerant reaction to collar rot, susceptible to rust and highly susceptible to *Cercospora* leaf spot at Ishurdi.

Among the eleven mutants of groundnut tested GC(1)-4-1 and GC(1)-3-2 were moderately resistant to *Cercospora* leaf spot, 5 mutants were moderately resistant and 6 mutants were tolerant to rust and 9 were tolerant to collar rot at Ishurdi.

Amongst 6 promising mutants of rapeseed, all were graded as tolerant to *Alternaria* blight at Mymensingh, Magura and Rangpur.

Seven promising mutants of soybean were tested against brown leaf spot and rust at Mymensingh and Magura and farmer's field of Noakhali. All the mutants showed moderately resistant reaction to brown leaf spot at all the locations. All the mutants showed moderately resistant at Mymensingh and 4 mutants were moderately resistant and 3 were tolerant to rust at Mymensingh and Noakhali. Seven mutants showed moderately resistant at Mymensingh while at Noakhali 4 mutants showed moderately resistant reaction and 3 showed tolerant reaction to rust.

The integrated use of Antacol (2g kg^{-1} seed**),** or Dithane M-45 (4g kg^{-1} seed**)** as seed treatment, *Trichoderma* sp **(**30 g m^{-1} long row) and mustard oil cake (200 kg ha^{-1}) significantly decreased the incidence and severity of collar rot and brown leaf spot and increased seed yield of soybean.

Screening and evaluation of breeding materials against major diseases

Evaluation of some promising germplasms of rice for bacterial leaf blight and sheath blight during aman season

Eleven promising germplasms along with three check varieties and one susceptible check variety of rice were assessed for bacterial leaf blight (BLB) (*Xanthomonas oryzae* pv. *oryzae*) and sheath blight (ShB) (*Rhizoctonia solani*) resistance during aman season of 2011 under inoculated field condition. The experiment was conducted in a randomized block design with three replications at BINA farm, Mymensingh. The unit plot size was 3 m × 2 m. The spacing between lines and hills were 25 cm and 15 cm, respectively. The seedlings were transplanted on 25 August 2011. The fertilizers were applied as per recommended doses. Ten hills in each plot were inoculated at the booting stage with the culture of *X. oryae* pv. *oryzae* by clipping method. For sheath blight, ten hills were inoculated in each plot with *R. solani* at booting stage of plant growth. Plants were assessed for BLB and ShB severity after two and three weeks of inoculation, respectively following the indices developed at IRRI.

Mean BLB incidence and severity ranged from 26.3-90.0% and 2.7-6.2, respectively (Table 1). Five mutants/advanced line and 2 check varieties were found to be moderately resistant and others were moderately susceptible to BLB. Mean sheath blight severity ranged from 2.8 to 7.5. Three mutants and Binadhan-4 were recorded as moderately resistant to ShB and others were moderately susceptible to susceptible. Grain yield ranged from 335.8 to 660.3 g m^{-2}.

Table 1. Mean incidences and severities of sheath blight and bacterial leaf blight and grain yield of some mutants of rice during aman season of 2011 at Mymensingh

Mutant/variety	Bacterial leaf blight			Sheath blight			Grain yield
	Incidence (%)	Severity	DR	Incidence (%)	Severity	DR	(g m^{-2})
RM-200(c) -1-1	66.7cd	2.7	MR	86.7cd	5.3	MS	481.3ghi
RM-200(c) -1-3	53.3ef	2.9	MR	80.0de	3.4	MR	541.3efg
RM-200(c) -1-9	66.7cd	3.1	MR	80.0de	3.1	MR	543.2efg
RM-200(c) -1-10	53.3ef	2.8	MR	90.0bc	4.2	MS	494.1fghi
RM-200(c) -1-13	70.0c	4.0	MS	80.0de	2.9	MR	579.2bcde
RM-200(c) -1-17	66.7cd	4.0	MS	80.0de	4.6	MS	559.3def
RM-200(c) -1-18	63.3cde	3.6	MS	80.0de	5.1	MS	558.5def
RC-43-2-5-3-3	85.0ab	5.2	MS	90.0bc	5.8	S	617.7abcd
RM-250-112	60.0de	4.0	MS	86.7cd	4.0	MS	660.3a
BINA Aroma-9	63.3cde	4.2	MS	96.7ab	6.3	S	432.2hi
IR-50 (48)	50.0f	3.6	MS	100.0a	6.7	S	652.7ab
BINA Aroma-5	61.7cde	3.2	MR	93.3abc	5.2	MS	641.8ab
BINA Aroma-8	60.0de	5.4	MS	100.0a	5.9	S	504.7fgh
Binadhan-4	53.3cde	3.0	MR	76.7e	2.8	MR	528.0efg
Binadhan-7	63.3cde	4.4	MS	90.0bc	5.8	S	590.5abcde
BRRI dhan32	90.0a	5.3	MS	66.7f	3.7	MR	566.9cdef
Shorna	40.0g	3.3	MR	90.0bc	3.7	MS	635.5abc
Kalozira	26.7h	3.5	MS	63.3f	4.2	MS	335.8j
TN-1	80.0b	6.2	S	96.7ab	7.5	HS	424.8i

Note: DR = Disease reaction, MS = Moderately susceptible, S = Susceptible and HS = Highly susceptible

Evaluation of some promising mutants of rice for sheath blight and bacterial leaf blight during boro season

Three promising germplasms along with 4 check varieties of rice were assessed for bacterial leaf blight (BLB) and sheath blight (ShB) resistance during boro season of 2011-12 under inoculated field condition. The experiments were conducted in a randomized block design with three replications at BINA farm, Mymensingh. The unit plot size was 3 m × 2 m. The spacing between lines and hills were 25 cm and 15 cm, respectively. The seedlings were transplanted on 31 January 2012. The fertilizers were applied at recommended doses. The method of inoculation and assessment of the disease were similar to the previous experiment of rice.

Mean bacterial leaf blight severity ranged from 2.9 to 6.5 (Table 2). Mutants RM-200(c)-1-9 and RM-200(c)-1-10 and 2 check varieties were found to be moderately resistant to BLB. Mean sheath blight severity ranged from 2.6 to 6.9. The mutant RM-200-1-10 showed moderately susceptible reaction to ShB. Grain yield ranged from 412 to 766.7 g m^{-2} was obtained.

Table 2. Mean incidences and severities of sheath blight and bacterial leaf blight and grain yield of some mutants of rice during boro season of 2011-12 at Mymensingh

Mutant/variety	Bacterial leaf blight			Sheath blight			Grain yield ($g\ m^{-2}$)
	Incidence (%)	Severity	DR	Incidence (%)	Severity	DR	
RM-200(c)-1-9	80.0	2.9	MR	100.0	6.0	S	594.5
RM-200(c)-1-10	56.7	3.0	MR	93.3	5.1	MS	621.5
RM-200(c)-1-17	63.3	4.2	MS	100.0	5.7	S	649.7
Iratom-24	66.7	4.6	MS	90.0	6.0	S	664.5
Binadhan-5	63.3	3.3	MR	90.0	3.1	MR	645.7
Binadhan-6	80.0	3.3	MR	83.3	2.6	MR	766.7
TN-1	93.3	6.5	S	100.0	6.9	S	412.0
$LSD_{0.05}$	21.3	0.89		9.64	0.73		45.9

Note: DR = Disease reaction, MR = Moderately resistant, MS = Moderately susceptible and S = Susceptible

Field evaluation of induced mutants of soybean for resistance to brown leaf spot and rust

Seven mutants of M_7 generation along with three check varieties viz. Binasoybean-1, Binasoybean-2 and BARI soybean-5 were tested against brown leaf spot and rust under field condition. The experiments were conducted in a randomized complete block design with three replications at BINA farm, Mymensingh, farmer’s field, Noakhali and BINA sub-station farm, Magura during January to May 2012. The unit plot size was 3.0 m × 1.0 m each. The fertilizers were applied at recommended doses. No fungicide was used in order to ensure natural incidence of the diseases. With the appearance of visible symptoms observation on disease parameters was made at harvesting stage. Mutants/ varieties were graded as resistant and susceptible following (1-9) indexing scale for brown leaf spot and (0-9) for rust.

The mean disease incidence of brown leaf spot differed among the tested materials of soybean at Mymensingh, Noakhali and Magura (Table 3). However, the least disease incidence was exhibited in the variety Binasoybean-1 at all the locations. The highest disease incidence was recorded in the mutants SBM-22 at Mymensingh and Magura while SBM-17 at Noakhali. All the mutants showed moderately resistant reaction at Magura. Two varieties (Binasoybean-1 and BARI Soybean-5) showed moderately resistant reaction and the rest showed tolerant reaction at Mymensingh and Noakhali.

Table 3. Disease reaction of some induced mutants of soybean to brown leaf spot at Mymensingh, Noakhali and Magura

Mutants/varieties	Mymensingh			Noakhali			Magura		
	Disease Incidence (%)	Disease severity	Disease reaction	Disease Incidence (%)	Disease severity	Disease reaction	Disease Incidence (%)	Disease severity	Disease reaction
Binasoybean-1	8.3e	1.8	MR	26.7c	2.8	MR	13.3c	2.2	MR
Binasoybean-2	--	--	--	60.0b	3.3	MR	--	--	--
BARI Soybean-5	23.3d	2.1	T	--	--	--	25.0a	2.5	MR
SBM-9	70.0b	4.1	T	63.3b	4.0	T	--	--	--
SBM-15	63.3bc	4.2	T	73.3a	5.4	T	--	--	--
SBM-17	66.6b	4.1	T	80.0a	5.0	T	15.0c	2.6	MR
SBM-18	66.6b	4.2	T	60.0b	4.8	T	20.0b	2.4	MR
SBM-20	56.6c	3.6	T	73.3a	5.3	T	20.0b	2.3	MR
SBM-23	63.3bc	3.9	T	63.3b	4.5	T	--	--	--
SBM-22	80.0a	4.6	T	60.0b	4.5	T	25.0a	3.0	MR

Note: MR = Moderately resistant, T = Tolerant

The incidence of rust ranged from 5.0-20% and 3.3-26.7% at Myemnsingh and Noakhali, respectively (Table 4). All the mutants/varieties showed moderately resistant reaction to rust at Mymensingh and Noakhali excluding three mutants (SBM-9, SBM-20 and SBM-23) at Noakhali which were tolerant.

Table 4. Disease incidence and severity of rust of soybean at Mymensingh and Noakhali

Mutants/varieties	Mymensingh			Noakhali		
	Disease Incidence (%)	Disease severity	Disease reaction	Disease Incidence (%)	Disease severity	Disease reaction
Binasoybean-1	-	-	-	13.3e	2.7	MR
Binasoybean-2	-	-	-	3.3g	2.2	MR
BARI Soybean-5	-	-	-	-	-	-
SBM-9	20.0a	2.9	MR	20.0b	3.9	T
SBM-15	6.6e	2.2	MR	16.7cd	3.3	MR
SBM-17	10.0c	1.9	MR	16.7cd	3.1	MR
SBM-18	8.3d	1.8	MR	8.3f	2.4	MR
SBM-20	5.0f	1.7	MR	26.7a	4.7	T
SBM-22	16.7b	2.6	MR	15.0de	3.2	MR
SBM-23	16.7b	2.5	MR	18.3bc	3.7	T

Note: MR = Moderately resistant, T = Tolerant

Field evaluation of M_8 mutants of soybean against brown leaf spot and rust

Three mutants of M_8 generation along with 2 check varieties Binasoybean-1 and BARI soybean-6 were tested against brown leaf spot and rust under natural epipytotic field condition. The unit plot size was 5 m × 4 m each. The experiments were conducted in a randomized complete block design with three replications at BINA farm, Mymensingh, BINA sub-station farms, Rangpur and Magura from January to May 2012. The procedure of sowing and assessment of diseases were similar to the previous experiment of soybean.

The incidence of brown leaf spot ranged from 6.7-38.3% in Mymensingh, 2.0-2.2 in Rangpur and 2.0-46.7 in Magura (Table 5). The least disease incidence was recorded in the mutant AVRDC-73 and the highest was recorded in the mutant AVRDC-70 followed by AVRDC-78 at Mymensingh and Magura. The mutants/varieties developed slight disease incidence (2.0-2.2) and severity (1.9-2.3) at Rangpur. All the mutants/varieties showed moderately resistant reaction to the disease at all the locations.

Table 5. Disease reaction of soybean mutants and varieties to brown leaf spot during 2011-12 at Mymensingh, Rangpur and Magura

Mutants/varieties	Mymensingh			Rangpur			Magura		
	Disease Incidence (%)	Disease severity	Disease reaction	Disease Incidence (%)	Disease severity	Disease reaction	Disease Incidence (%)	Disease severity	Disease reaction
AVRDC-73	6.7	1.8	MR	2.2	1.9	MR	20.0	2.4	MR
Binasoybean-1	20.0	2.5	MR	2.0	2.0	MR	20.0	2.7	MR
BARI Soyban-6	26.7	2.6	MR	--	--	--	26.7	2.6	MR
AVRDC-78	36.7	3.4	MR	2.0	2.0	MR	26.7	2.7	MR
AVRDC-70	38.3	3.0	MR	2.0	2.3	MR	46.7	3.4	MR
$LSD_{0.01}$	3.4	--	--	--	--	--	4.7	--	--

Note: MR = Moderately resistant

Disease incidence of rust ranged from 0.0-13.3% and 2.02-2.3% at Mymensingh and Rangpur, respectively. The mutant AVRDC-73 was graded as resistant having no infection caused by rust under natural field condition at Mymensingh (Table 6). All the mutants/varieties showed moderately resistant reaction at both the locations excluding AVRDC-73 at Mymensingh.

Table 6. Disease reaction of soybean mutants and varieties to rust during 2011-12 at Mymensingh and Rangpur

Mutants/varieties	Mymensingh			Rangpur		
	Disease Incidence (%)	Disease severity	Disease reaction	Disease Incidence (%)	Disease severity	Disease reaction
AVRDC-70	10.0	2.2	MR	2.3	2.6	MR
AVRDC-73	0.0	0.0	R	2.0	2.1	MR
AVRDC-78	13.3	2.8	MR	2.3	2.2	MR
Binasoybean-1	6.7	1.9	MR	2.3	2.3	MR
BARI Soyban-6	10.0	2.3	MR	-	-	-
$LSD_{0.05}$	2.6	0.52		--	0.36	

Note: R = Resistant, MR = Moderately resistant

Screening of M_7 mutants/varieties of groundnut against collar rot, cercospora leaf spot and rust

Two mutants along with two check varieties of groundnut were screened against collar rot, cercospora leaf spot and rust under epiphytotic condition at BINA sub-station farm, Ishurdi. The experiments were conducted in a randomized block design with three replications in collaboration with Plant Breeding Division. The unit plot size was 4.0 m × 3.0 m. Spacing between rows and plants were 30 cm and 15 cm, respectively. Seeds were sown on 11 October 2011. Recommended cultural practices were done. The mutants were categorized for their resistance on the basis of rating scale (1-9) developed by ICRISAT for the diseases.

Both the mutants and a check variety were tolerant to collar rot (Table 7). In case of cercospora leaf spot, all the mutants/varieties were highly susceptible. For rust, the mutants were susceptible and test varieties were moderately susceptible.

Table 7. Disease reaction of some mutants/varieties of groundnut to collar rot, cercospora leaf spot and rust under epiphytotic conditions at Ishurdi during 2011-12

Mutants/varieties	Collar rot		Cercospora leaf spot		Rust	
	Mean mortality (%)	Disease reaction	Disease severity (1-9)	Disease reaction	Disease severity (1-9)	Disease reaction
D_1/20/17-1	18.3	T	8.8	HS	5.8	S
RS/25/3-1	19.6	T	8.6	HS	5.6	S
Dacca-1	18.0	T	9.0	HS	5.3	MS
PK-1	21.9	MS	8.0	HS	4.9	MS
$LSD_{0.05}$	2.79		0.47		0.21	

Note: T = Tolerant MS = Moderately susceptible, S = Susceptible, HS = Highly susceptible

Field evaluation of advance lines/varieties of groundnut against collar rot, cercospora leaf spot and rust under field conditions

Eleven mutants along with two check varieties Dacca-1 and Zingabadam of groundnut were evaluated for their resistance to collar rot, cercospora leaf spot and rust under field conditions at Ishurdi during 2011-12. The experiments were set up in a randomized block design with three replications in collaboration with Plant Breeding Division. The unit plot size was 2.10 m × 1.05 m. Spacing between rows and plants within rows were 30 cm and 15 cm, respectively. Seeds were sown on 11 October 2011. Recommended cultural practices were done. The mutants were categorized for their resistance on the basis of rating scale (1-9) developed by ICRISAT.

All the mutants and check varieties were tolerant and other ones were moderately susceptible to collar rot (Table 8). Two mutants GC(1)-32-3-1-2, GC(1)-4-1 and GC(1)-35-1-1 were graded as tolerant and rest of the mutants and check varieties were susceptible to highly susceptible to cercospora leaf spot. In case of rust, four mutants and one check variety were moderately resistant and rest of the mutants and check varieties were tolerant.

Table 8. Disease reaction of mutants/varieties of groundnut to collar rot, cercospora leaf spot and rust under field conditions at Ishurdi during 2011-12

Mutants/varieties	Collar rot		Cercospora leaf spot		Rust	
	Mean mortality (%)	Disease reaction	Disease severity (1-9)	Disease reaction	Disease severity (1-9)	Disease reaction
GC(1)-3-2-2-1	11.33g	T	5.56de	S	3.56bcd	T
GC(1)-32-2-1-1	11.33g	T	5.93cd	S	3.93bc	T
GC(1)-32-3-1-2	11.63fg	T	5.04f	T	3.02de	MR
GC(1)-32-1-1-1	12.33efg	T	6.36b	S	4.01b	T
Dacca-1	12.53efg	T	6.09b	S	4.06b	T
GC(1)-32-3-2-1-1	14.06efg	T	6.06bc	S	4.00b	T
GC(1)-39-1-2	14.36efg	T	6.03bcd	S	3.93bc	T
Zingabadam	15.33def	T	6.43b	S	3.43cd	MR
GC(1)-32-3-1-1	16.06cde	T	5.63cde	S	3.36cd	MR
GC(1)-4-1	18.86bcd	T	5.23ef	T	3.01de	MR
GC(1)-24-1-1-1	20.26bc	T	7.53 a	HS	5.06a	T
GC(1)-24-1-1-2	21.00ab	MS	7.26a	S	4.07b	T
GC(1)-35-1-1	24.06a	MS	5.06f	T	2.83e	MR

Note: MR = Moderately resistant, T = Tolerant, MS = Moderately susceptible, S = Susceptible

Field evaluation of M_8 rapeseed mutants against alternaria blight

Six rapeseed mutants along with one check varieties were evaluated for the reaction of alternaria blight (*Alternaria brassicae*) under natural condition at BINA farm, Mymensingh and BINA sub-station farms Ishurdi, Magura and Rangpur during 2011-12. The experiments were conducted in a randomized block design with three replications in collaboration with Plant Breeding Division. The unit plot size was 5.0 m × 3.0 m. Seeds were sown in October, 2011. The severity scale of 0-5 was followed for screening the disease at early pod maturity stage.

Mean leaf area diseased of alternaria blight ranged from 18.6-27.7%. All the mutants and check varieties were tolerant to the disease (Table 9).

Table 9. Reaction of rapeseed (*B. napus*) mutants (M_8)/varieties to alternaria blight under natural conditions at different locations in Bangladesh during 2011-12

Mutants/variety	Leaf area diseased (%)					Disease reaction
	Mymensingh	Ishurdi	Magura	Rangpur	Mean	
MM-10	23.2e	20.4b	18.3cd	22.2c	21.0	T
MM-35	37.1a	20.2b	16.9e	15.5e	22.4	T
MM-37	22.3e	15.9c	17.1de	24.7b	20.0	T
MM-256	23.4de	17.7c	17.1de	16.0e	18.6	T
MM-210	25.5d	17.0c	21.9a	20.7cd	21.3	T
MM-211	28.1c	17.2c	20.9ab	19.0d	21.3	T
BARI Sarisha-4	33.6b	28.6a	19.7bc	28.8a	27.7	T

Note: T = Tolerant

Evaluation of a promising mutant of winter tomato against *Fusarium* wilt, late blight and yellow mosaic virus

One promising mutant (TM-110) and two check varieties (BARI Tomato-5 and BARI Tomato-13) of tomato were evaluated against fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*), late blight (*Phytophthora infestans*) and yellow mosaic (Yellow Mosaic Virus) under natural field conditions. The experiments were conducted during winter of 2011-12 at BINA farm, Mymensingh and BINA sub-station farms Rangpur, Magura and Ishurdi in collaboration with Plant Breeding Division. Experiments were done in randomized complete block design with three replications. Unit plot size was 4 m × 5 m. The disease incidence and severity was recorded at 55 and 75 days after transplanting.

Disease incidence of fusarium wilt ranged from 11.3-22.1% (Table 10). The mutant (TM-110) and the two check varieties showed moderately resistant reaction to fusarium wilt in Rangpur and Magura. In Mymensingh, the mutant (TM-110) and BARI Tomato-13 showed susceptible reaction while BARI Tomato-5 showed moderately resistant reaction to fusarium wilt. For late blight disease, there was 100% disease incidence in Mymensingh and Rangpur (Table 11). The mutant (TM-110) as well as the check varieties showed tolerant reaction to late blight. The yellow mosaic virus incidence ranged from 45.7-60.3% (Table 12). Late blight and yellow mosaic virus were not observed in Magura.

Table 10. Reaction of a promising mutant of winter tomato to fusarium wilt in 2001-12

Mutant/varieties	Mymensingh		Rangpur		Magura	
	Disease incidence (%)	Disease reaction (0-5)	Disease incidence (%)	Disease reaction (0-5)	Disease incidence (%)	Disease reaction (0-5)
TM-110	22.1	S	12.0	MR	14.5	MR
BARI Tomato-5	15.8	MR	12.1	MR	16.1	MR
BARI Tomato-13	21.1	S	15.1	MR	11.3	MR

Note: MR = Moderately resistant S = Susceptible

Table 11. Reaction of a promising mutant of winter tomato to late blight in 2011-12

Mutant/varieties	Mymensingh			Rangpur		
	Disease incidence (%)	Disease severity (0-6)	Disease reaction	Disease incidence (%)	Disease severity (0-6)	Disease reaction
TM-110	100	3.0	T	100	3.0	T
BARI Tomato-5	100	3.0	T	100	3.0	T
BARI Tomato-13	100	3.0	T	100	3.0	T

Note : T = Tolerant

Table 12. Mean incidence of a promising mutant of winter tomato to yellow mosaic virus in 2011-12

Mutant/varieties	Disease incidence (%)	
	Mymensingh	Rangpur
TM-110	56.1	53.2
BARI Tomato-5	58.2	50.0
BARI Tomato-13	45.7	60.3

Screening of five genotypes of tomato against fusarium wilt, late blight and yellow mosaic during the winter season of 2011-12

Five genotypes (CLN-2777B, CLN-2777G, CLN-2777H, D_6-12 and D_6-18) along with two check varieties (Binatomato-6 and Binatomato-7) of tomato were evaluated against fusarium wilt (*Fusarium oxysporum*), late blight (*Phytophthora infestans*) and yellow mosaic (Yellow Mosaic Virus) under field condition. The experiments were conducted in BINA farm, Mymensingh during winter season of 2011-12 in collaboration with Plant Physiology Division. The experiment was laid out in randomized complete block design with three replications. Unit plot size was 5 m × 3 m. Seedlings were transplanted on 14 November, 2011. Disease incidence was recorded at 55 and 75 days after transplanting.

The genotype CLN-2777B and the two check varieties (Binatomato-6 and Binatomato-7) showed moderately resistant reaction while the rest four genotypes showed susceptible reaction to fusarium wilt. All genotypes and the check varieties except D_6-12 and the check varieties showed tolerant reaction to late blight disease (Table 13). The yellow mosaic disease incidence ranged from 0-52.28% where the genotype D_6-18 had the highest incidence.

Table 13. Disease reaction of five genotypes of tomato to fusarium wilt, late blight and yellow mosaic during winter season of 2011-12 at Mymensingh

Genotypes/varieties	Fusarium wilt		Late blight			Yellow mosaic incidence (%)
	Disease incidence (%)	Disease reaction	Disease incidence (%)	Disease severity (0-6)	Disease reaction	
CLN-2777B	16.3	MR	100	3	T	0.0
CLN-2777G	30.3	S	100	3	T	33.8
CLN-2777H	21.0	S	100	3	T	40.0
D_6-12	22.2	S	100	4	S	0.0
D_6-18	25.1	S	100	3	T	52.2
Binatomato-6	15.1	MR	100	3	T	30.0
Binatomato-7	14.2	MR	100	3	T	41.1

Note: MR = Moderately resistant, T = Tolerant, S = Susceptible

Field screening of thirteen mutants of onion against purple blotch disease

Thirteen mutants along with two check varieties (BARI Piaj-2 and BARI Piaj-3) were evaluated against purple blotch (*Alternaria porri*) under natural field condition during winter season of 2011-12. The experiments were conducted at BINA farm, Mymensingh and BINA sub-station farm, Rangpur in collaboration with Plant Breeding Division. Experiments were conducted in randomized complete block design with three replications. Unit plot size was 2 m × 6 m. Seeds were sown on 26 October and transplanting was done on 8 December, 2011. The disease severity was assessed following (0-5) scale (Sharma, 1986).

Six mutants (BP_2/75/2, BP_2/75/3, BP_2/75/5, BP_2/75/11, BP_2/100/12 and BP_2/125/1) showed tolerant reaction to purple blotch in both Mymensingh and Rangpur (Table 14). The mutants BP_2/75/13, BP_2/100/1 and BP_2/100/5 and the two check varieties (BARI Piaj-2 and BARI Piaj-3) showed susceptible reaction in Mymensingh while these showed tolerant reaction in Rangpur. The mutants BP_2/75/6, BP_2/75/12, BP_2/100/2 and BP_2/125/5 showed susceptible reaction in both locations.

Table 14. Disease reaction of thirteen mutants of onion to purple blotch in Mymensingh and Rangpur during winter season of 2011-12

Mutants/varieties	Mymensingh		Rangpur	
	Disease severity (0-5)	Disease reaction	Disease severity (0-5)	Disease reaction
BP_2/75/2	3	T	3	T
BP_2/75/3	3	T	3	T
BP_2/75/5	3	T	3	T
BP_2/75/6	4	S	4	S
BP_2/75/11	3	T	3	T
BP_2/75/12	4	S	4	S
BP_2/75/13	4	S	3	T
BP_2/100/1	4	S	3	T
BP_2/100/2	4	S	4	S
BP_2/100/5	4	S	3	T
BP_2/100/12	3	T	3	T
BP_2/125/1	3	T	3	T
BP_2/125/5	4	S	4	S
BARI Piaj-2	4	S	3	T
BARI Piaj-3	4	S	3	T

Note: T = Tolerant, S = Susceptible

Evaluation of lentil mutants against *Stemphylium* blight and root rot

Thirty two advanced mutants along with one check variety of lentil were evaluated against root rot (*Fusarium* sp.) and *Stemphylium* blight (*Stemphylium sarciniformis*) at BINA sub-station farms Ishurdi and Magura during the winter season of 2011-12 under field condition in collaboration with Plant Breeding Division. The experiments were conducted in randomized complete block design with three replications. The seeds were sown in rows on early November, 2011. Distance between rows and seed were 30 cm and 5-6 cm, respectively.

The mean severities of *Stemphylium* blight and root rot ranged from 3-4 and 5-7, respectively. The mutants LM-21-1, LM-101-8, LM-48-1, LM-24-3, LM-14-2, LM-75-4, LM-185-2, LM-132-7, LM-156-1, LM-28-2, LM-67-7, LM-123-7, LM-99-4, LM-15-9, LM-13-1, LM-20-3, ICA-23128, ICA-23105, ICA-23211, ICA-23136, IVA-23126, ICA-23118, SL-129, SL-110, SL-137, BARI masur-4 were found tolerant and the rest were susceptible to root rot (Table 15). The mutants LM-21-1,

LM-24-3, LM-14-2, LM-185-2, LM-156-1, LM-28-2, LM-67-7, LM-123-7, LM-99-4, LM-15-9, LM-13-1, LM-20-3, LM-37-8, LM-93-3, ICA-23128, ICA-23105, ICA-23211, ICA-23136, IVA-23126, ICA-23118, SL-129, SL-107, SL-30 and SL-137 were found tolerant and the rest were susceptible to *Stemphylium* blight (Table 16).

Table 15. Severity of root rot on some mutants of lentil at Magura and Ishurdi

Mutants/varieties	Severity (1-9)	Disease reaction
LM-21-1, LM-101-8, LM-48-1, LM-24-3, LM-14-2, LM-75-4, LM-185-2, LM-132-7, LM-156-1, LM-28-2, LM-67-7, LM-123-7, LM-99-4, LM-15-9, LM-13-1, LM-20-3, ICA-23128, ICA-23105, ICA-23211, ICA-23136,IVA-23126, ICA-23118, SL-129, SL-110, SL-137, BARI masur-4	5	Tolerant
LM-93-3, LM-37-8, SL-9, ICA-23121, SL-30, SL-107	7	Susceptible

Table 16. Severity of stemphylium blight on some mutants of lentil at Magura and Ishurdi

Mutants/varieties	Severity (0-5)	Disease reaction
LM-21-1, LM-24-3, LM-14-2, LM-185-2, LM-156-1, LM-28-2, LM-67-7, LM-123-7, LM-99-4, LM-15-9,LM-13-1, LM-20-3, LM-37-8, LM-93-3, ICA-23128, ICA-23105, ICA-23211, ICA-23136,IVA-23126, ICA-23118, SL-129, SL-107, SL-30, SL-137	3	Tolerant
LM-101-8, LM-48-1, LM-75-4, LM-132-7, ICA-23121, SL-110, SL-9 SL-2, BARI masur-4	4	Susceptible

Evaluation of chickpea mutants against root rot/wilt and botrytis gray mold

Two chickpea mutants (CPC-860 and P-70) and one (BARI sola-5) check variety were evaluated against root rot (*Fusarium solani*) and botrytis gray mold (*Botrytis cinerea*) under natural field conditions. The experiments were conducted in a randomized block design with three replications during winter season, 2011-12 in collaborated with Plant Breeding Division.

The mean severity of root rot and botrytis gray mold of the tested materials were 7 and 5, respectively. All the mutants were found susceptible to root rot and tolerant to botrytis gray mold (Table 17).

Table 17. Mean severity of root rot and botrytis gray mold of some mutants of chickpea at Magura and Rajshahi during 2011-12

Mutants/strains	Root rot		Botrytis gray mold	
	Severities (1-9)	Disease reaction	Severities (1-9)	Disease reaction
CPC-860	7	Susceptible	5	Tolerant
P-70	7	Susceptible	5	Tolerant
BARI sola-5	7	Susceptible	5	Tolerant

Evaluation of mungbean mutants against yellow mosaic and cercospora leaf spot

Two promising mutants along with two check varieties of mungbean were assessed for their resistance to yellow mosaic (MYMV) and *Cercospora* leaf spot (*Cercospora sp.*) at Rajshahi and Natore in collaborated with Plant Breeding Division in the summer season of 2012 under field condition. The experiments were conducted in a RCB design with three replications. The seeds were sown on mid March 2012. The unit plot size was 10 m × 8 m each. The recommended doses of fertilizer were applied and normal cultural practices were followed. The incidence and severities of the diseases were recorded at maximum pod ripening stage of crop growth.

The mean incidences of yellow mosaic and *Cercospora* leaf spot ranged from 45.4-62.5% and 87.5-100%, respectively. All the mutants/varieties were found to be moderately resistant to tolerant against yellow mosaic and *Cercospora* leaf spot according the severity scale (Table 18).

Table 18. Mean incidence of yellow mosaic and cercospora leaf spot in some mutants of summer mungbean at Rajshahi and Natore in 2011-12

Mutant/variety	Disease incidence (%)		Disease severity (0-9)		Disease reaction of	Disease reaction of
	MYM	CLS	MYM	CLS	MYM	CLS
MBM-88	52.6	100	5	5	T	T
MBM-07-3y-1	36.6	87.5	3	3	MR	MR
Binamoog-8	45.4	95.2	3	5	MR	T
BARI Moog-6	62.5	95.0	3	5	MR	T

Note: MR = Moderately resistant, T = Tolerant

Integrated Management of Major Diseases of Cereals, Pulses, Oilseed, Vegetable and Spices

Effect of pulse bran, poultry refuge, biopesticides and tilt on Sheath blight in boro rice

The single and combined applications of pulse bran, poultry refuge, *Trichoderma* based biopesticides and fungicide were assessed during boro season of 2011-12 to find out the suitable strategy for the integrated management of sheath blight (ShB) of rice (cv. Iratom24) at BINA sub-station farms Magura and Ishurdi. The treatments were : T_1 = Pulse Bran (3 t ha^{-1}), T_2 = Poultry Refuge (5 t ha^{-1}), T_3 = IPM Lab Biopesticide (125 kg ha^{-1}), T_4 = BINA Biopesticide (200 kg ha^{-1}), $T_5 = T_1 + T_2$, $T_6 = T_2 + T_3$, $T_7 = T_2 + T_4$, T_8 = Muriate of potash (40 kg ha^{-1}), T_9 = Tilt (2 ml L^{-1} two time), T_{10} = Control (only inoculum). The experiments were conducted in RCB design with three replications. The unit plot size was 3 m × 2 m and the spacing between lines and plants within lines were 25 and 15 cm, respectively. The recommended doses of fertilizers were applied and cultural practices were followed. Pulse bran, poultry refuge and biopesticides were applied to each plot 2 weeks before transplanting of seedlings. The inoculum of *R. solani* was previously grown on sterilized rice hull-husk media were applied in soil @ 50 g m^{-2} at the booting stage. Muriate of potash was sprayed at two splits at 15 days interval starting from maximum tillering stage and Tilt was sprayed 2 times starting from panicle initiation stage. Plants were assessed for severity at ripening stage. The grain yield and agronomic parameters were recorded after harvest.

The mean disease incidence, relative lesion height, per cent disease index (PDI) and grain yield significantly varied among the treatments in both the locations (Table 19 and 20). The highest disease development was recorded in control plots where pathogen inoculation was made and the lowest was recorded in tilt treated plots. The maximum PDI reduced in the plots where fungicide tilt were sprayed compared to inoculated control, 50% PDI reduced in other treatments. The grain yield varied from 3.90 to 5.83 t ha^{-1} and 4.13 to 6.06 t ha^{-1} in Magura and Ishurdi, respectively. About fifty per cent yield was increased in tilt treated plots than control plots. Though organic amendments and biopesticides reduced sheath blight severity and increased grain yield, the fungicide tilt was more effective to manage the disease in both the locations.

Table 19. Effects of pulse bran, poultry refuge, biopesticides and Tilt on sheath blight in boro rice (cv. Iratom-24) during 2011-12 at Magura

Treatment	Incidence (%)	RLH (%)	PDI (%)	PDI decreased over control (%)	Grain yield (t/ha)	Grain yield increase over control (%)
Pulse bran (T_1)	10.1	13.6	39.3	49.7	4.74	21.5
Poultry refuge (T_2)	10.1	15.3	37.7	51.7	4.71	20.7
IPM Biopesticide (T_3)	11.0	17.1	42.4	45.7	4.77	22.3
BINA Biopesticide (T_4)	10.3	13.7	39.0	50.1	4.79	22.9
$T_1 + T_2$ (T_5)	10.4	13.7	39.7	49.2	5.21	33.5
$T_2 + T_3$ (T_6)	10.8	15.7	40.3	48.5	5.04	29.3
$T_2 + T_4$ (T_7)	9.7	15.7	40.1	48.6	5.24	34.4
Muriate of potash (T_8)	9.6	15.7	40.2	48.5	4.63	18.6
Tilt (T_9)	6.6	9.5	16.9	78.4	5.83	49.5
Control (T_{10})	52.9	25.0	78.1	--	3.90	--
$LSD_{0.05}$	2.01	1.89	3.05		0.14	

Note: RLH = Relative lesion height, PDI = Per cent disease index

Table 20. Effects of pulse bran, poultry refuge, biopesticides and Tilt on sheath blight in boro rice (cv. Iratom-24) during 2011-12 at Ishurdi

Treatment	Incidence (%)	RLH (%)	PDI (%)	PDI decreased over control (%)	Grain yield (t/ha)	Grain yield increase over control (%)
Pulse bran (T_1)	10.9	13.9	41.0	44.8	5.00	21.0
Poultry refuge (T_2)	11.1	13.8	43.1	41.9	4.99	20.9
IPM biopesticide (T_3)	10.9	15.1	40.3	45.7	4.95	19.8
BINA biopesticide (T_4)	11.0	14.8	40.6	45.3	4.85	17.3
$T_1 + T_2$ (T_5)	11.7	14.5	38.8	47.7	5.35	29.5
$T_2 + T_3$ (T_6)	9.8	14.4	39.1	47.2	5.47	32.4
$T_2 + T_4$ (T_7)	9.7	15.0	38.4	48.2	5.53	34.0
Muriate of potash (T_8)	10.0	14.2	41.9	43.6	4.92	19.1
Tilt (T_9)	7.8	10.7	23.9	67.8	6.06	46.7
Control (T_{11})	47.0	22.8	74.2	0.0	4.13	0.0
$LSD_{0.05}$	1.48	1.65	3.67	--	0.24	--

Note: RLH = Relative lesion height, PDI = Per cent disease index

Integrated management of collar rot of soybean

Single and combined application of three integrated disease management components viz. cultural (Mustard oil cake (MOC), chemical (Antacol and Dithane M-45) and bio-agent (*Trichoderma* sp.) along with control were assessed to find out a suitable strategy for the management of collar rot caused by *Sclerotium rolfsii* of soybean. The seeds of Binasoybean-2 were directly sown in rows on 20 December of 2011. The experiments were conducted in a randomized complete block design with four replications at BINA farm, Mymensingh and BINA sub-station farm, Magura. The experiment contained seven treatments viz. (T_1) Antacol (2g kg^{-1} seed), (T_2) Dithane M-45 (4g kg^{-1} seed), (T_3) *Trichoderma* sp. (30 g m^{-1} long row), (T_4) Mustard oil cake (200 kg ha^{-1}), (T_5) Antacol + *Trichoderma* sp. + MOC, (T_6) Dithane M-45 + *Trichoderma* sp. + MOC and (T_7) control (without treatment). Bio-agent was applied in rows before sowing. Soybean seeds were treated separately by Antacol or Dithane M-45. MOC powder was applied in the soil 3 days before sowing. Weeding and irrigation were done as and when necessary. Data were taken at harvesting stage.

Significantly the least disease incidence and severity of collar rot and highest yield of soybean were recorded in the integrated treatment of Antacol + *Trichoderma* sp. + Mustard oil cake at both the locations Mymensingh and Magura (Table 21). Disease incidence flared up to 28% and 70% at Mymensingh and Magura, respectively at harvesting stage. All the treatments including control showed moderately resistant reaction at Mymensingh while only two treatments observed tolerant reaction and the rest exhibited moderately susceptible reaction at Magura to the disease.

Table 21. Disease reaction of soybean cultivar as affected by integrated treatments to collar rot during 2011-12 at Mymensingh and Magura

Treatment	Mymensingh				Magura			
	Disease incidence (%)	Disease severity	Disease reaction	Yield (kg ha^{-1})	Disease incidence (%)	Disease severity	Disease reaction	Yield (kg ha^{-1})
T_1	12cd	2.6	MR	1181d	70a	6.4	MS	1923.8c
T_2	28a	3.0	MR	981.8e	61b	6.9	MS	1887.5c
T_3	14c	2.4	MR	1206.3cd	61b	5.6	MS	1881.3c
T_4	21b	2.3	MR	1284.3bc	54bc	4.9	T	2062.5b
T_5	11d	2.3	MR	1456.3a	51c	5.4	T	2162.5a
T_6	12cd	3.0	MR	1346.8b	70a	6.3	MS	1793.8d
T_7	23b	4.9	T	1196.8cd	70a	6.7	MS	1771.3d

Note: MR = Moderately resistant, T = Tolerant, MS = Moderately susceptible

Combined application of Dithane M-45 + *Trichoderma* sp. + Mustard oil cake was considerably superior to the treatments in reducing the incidence of brown leaf spot of soybean at both the locations. However, at Mymensingh the effect of Dithane M-45 + *Trichoderma* sp. + Mustard oil cake and single application of Mustard oil cake was same. On the other hand the efficacy of Mustard oil cake (single) and Antacol + *Trichoderma* sp. + Mustard oil cake was statistically identical. The highest incidence and severity were recorded in control treatment at both the locations at Magura. The single application of Antacol, Dithane M-45 and *Trichoderma* sp. was statistically identical. All the treatments excluding control showed moderately resistant reaction at Magura to the disease (Table 22).

Table 22. Disease reaction of soybean cultivar as affected by integrated treatments to brown leaf spot during 2011-12 at Mymensingh and Magura

Treatment	Mymensingh			Magura		
	Disease incidence (%)	Disease severity	Disease reaction	Disease incidence (%)	Disease severity	Disease reaction
T_1	13.0b	2.5	MR	40.0cd	2.6	MR
T_2	8.8c	2.3	MR	40.0cd	2.5	MR
T_3	12.5b	2.5	MR	40.0cd	2.6	MR
T_4	6.3d	2.2	MR	46.3b	2.5	MR
T_5	10.0c	2.2	MR	43.8bc	2.4	MR
T_6	6.3d	2.1	MR	37.5d	2.2	MR
T_7	23.8a	3.0	MR	57.5a	3.6	T

Note: MR = Moderately resistant, T = Tolerant

Integrated management of fusarium wilt of tomato

An experiment was conducted to find out a suitable strategy for the management of fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*) of tomato at BINA farm, Mymensingh during winter season of 2011-12. The treatments were: T_1 = Soil application of *Trichoderma harzianum* (50 g inoculum m^{-2}), T_2 = Soil amendment with MOC (200 kg ha^{-1}), T_3 = Seedling treatment with Provax before transplanting (2 g L^{-1} water), T_4 = Integration of T_1, T_2 and T_3 and T_5 = Control. The experiments were laid out in randomized complete block design with three replications. The variety used in the experiment was Binatomato-5. The unit plot size was 2 m × 2 m. Line to line and plant to plant spacing was 50 cm. Disease incidence was recorded at 40, 55 and 75 days after transplanting.

The wilt disease incidence ranged from 2.3-12.7% (Table 23). The lowest disease incidence (2.3%) was recorded in T_5 **(**integration of T_1, T_2 and T_3**)** followed by T_1 **(**soil application of *T. harzianum***)** compared to the control (12.7%). The effect of two other treatments T_2 (soil amendment with MOC) and T_3 (seedling treatment with Provax before transplanting) on disease suppression was almost same and that was 6.5% and 5.5%, respectively. The experiment indicated that integration of different treatments was better in fusarium wilt management than the application of a single treatment.

Table 23. Mean incidence of fusarium wilt of tomato in response to different treatments at Mymensingh during winter season of 2011-12

Treatments	Mean incidence (%)
T_1 (Soil application of *T. harzianum*)	4.38
T_2 (Soil amendment with MOC)	6.53
T_3 (Seedling treatment with Provax)	5.53
T_4 (Integration of T_1, T_2 and T_3)	2.30
T_5 (Control)	12.76
$LSD_{0.05}$	3.28

Development biocontrol measures for the management of major diseases of crop plants

Evaluation of antagonistic *Trichoderma* sp. against foot and root rot of lentil

An experiment was done at Ishurdi to evaluate *Trichoderma* for controlling foot and root rot of lentil during winter season of 2011-12. The experiment contained three treatments viz. (i) seed treatment with antagonist (*Trichoderma,*) (ii) soil treatment with *Trichoderma* and (iii) control without *Trichoderma*. The experiments were conducted in a randomized block design with four replications. Replication to replication distance was 50cm. The unit plots size, row to row and plant to plant distance were 3 m × 3 m, 25 cm and 5-6 cm, respectively. The seed were sown on early November 2011.

Disease incidence was significantly different among the methods of application of *Trichoderma* sp. (Table 24). In soil treatment, the disease incidence (10.1%) was the lowest and the highest was in control. Therefore, soil application with *Trichoderma* sp. was found more effective than seed treatment in reducing root rot.

Table 24. Effect of *Trichoderma* sp. on foot and root rot incidence of lentil at Ishurdi

Treatments	Disease incidence (%)	% Decreased over Control
Soil treatment	10.1	60.8
Seed treatment	15.4	40.3
Control	25.8	-
$LSD_{0.05}$	4.3	-

Evaluation of antagonistic *Trichoderma* sp. against sheath blight of rice

An experiment was done to evaluate *Trichoderma* for controlling sheath blight (*Rhizoctonia solani*) of rice during amon season, 2011-12 at Ishurdi. The experiment contained four treatments viz. (i) Seedling treated with *Trichoderma* sp. (ii) Control (without pathogen) (iii) Soil treated + Seedling treated with *Trichoderma* (iv) Control (with pathogen). The experiment was conducted in a RCB design with three replications. Replication to replication distance was 1 m. The unit plots size, row to row and plant to plant distance were 3 m × 3 m, 30 cm and 15 cm, respectively. The seedlings were transplanted on early July 2011. Data were taken at grain filling stage.

The mean incidence and severity of sheath blight of the treatments ranged from 17.4 - 65.8% and 3-7, respectively (Table 25). Among the treatments the incidence and severity of the disease were significantly different. However, the highest incidence and severity was recorded in control while the lowest was observed in the treatment of soil and seedlings treated with *Trichoderma* sp.

Table 25. Effect of *Trichoderma* sp. on disease incidence and severity during 2011-12 at Ishurdi and Magura

Treatments	Disease incidence (%)	Disease severity (0-9)
Soil Treatment + Seedling treatment	17.4	3
Seedling treatment	35.3	3
Control (without pathogen)	47.1	5
Control (with pathogen)	65.8	7
$LSD_{0.05}$	5.2	1.2

AGRICULTURAL ENGINEERING DIVISION

RESEARCH HIGHLIGHTS

At Mymensingh (BINA Farm), the highest seed yield of soybean (2.97 t ha^{-1}, in Kharif-1 season) was obtained with one supplemental irrigation at vegetative stage.

Water quality parameters at BINA sub-stations were found within permissible limit for irrigation. At Satkhira, the parameters showed slight seasonal variation. At different locations of Mymensingh Sadar, the parameters were found within the permissible limit.

At Satkhira, Binadhan-8 produced the highest yield (9.83 t ha^{-1}) under alternate wetting and drying (10 cm lowering of WL from the surface, when irrigation water salinity varied from 4.32 to 7.05 dS/m.

At Satkhira (Kharibila village, Satkhira Sadar), sunflower produced higher yield (2.82 to 2.95 t ha^{-1}) with higher BCR when canal water (EC of 0.93 to 7.86 dS/m) or groundwater (EC of 4.32 to 6.40 dS/m) was used as a source of irrigation following three irrigations in the growing period, compared to non-irrigated plot (2.38 t ha^{-1}).

Maize produced higher yield (8.38 to 9.61 t ha^{-1}) and higher BCR when canal water (0.93 to 8.00 dS/m) or groundwater (EC of 4.32 to 6.94 dS/m) was used as a source of irrigation following three or four irrigations in the growing period, compared to non-irrigated plot.

Soybean yielded 1.94 to 2.00 t ha^{-1} (with BCR 1.39 to 2.35) when it was irrigated (3 nos.) by canal water (having EC of 1.48 to 7.86 dS/m) or groundwater (EC of 5.22 to 6.94 dS/m).

Trend analysis of climatic parameters for Mymensingh, Faridpur and Jessore districts by MAKESENS software using 30 yrs (1981-2010) data, showed increasing or decreasing trend, and the rate of change differed with locations.

Three cropping patterns i.e. T. aman–Fallow–Boro, T. aman–Mustard–Boro, and T. aman–Wheat–T. aus for Mymensingh district and T. aman–Lentil–Sesame, T. aman–Mustard–Mungbean, and T. aman – Chickpea – Jute for Magura district were successfully implemented.

The farmers preferred pattern was T. aman–Mustard–Boro at Mymensingh, and T. aman–Lentil–Sesame at Magura.

Results from five different cropping pattern experiments revealed that T. aman (Binadhan-7)–Rabi (Potato/Wheat) - Kharif-1 (Sesame/Mungbean) was the best pattern for increasing cropping intensity, higher yield and water saving at Rajbari farm, Dinajpur.

At BINA Farm, Mymensingh, NERICA rice lines (NERICA-1 and NERICA-10) produced 1.04 to 1.67 t ha^{-1} grain under drought stress condition (Alternate flooding and drying at 5 to 9 days after disappearance of 5 cm ponded water). From one year experiment, NERICA rice seemed low yield potential under the imposed drought stress at this location.

Water requirement and irrigation scheduling of different crops in different cropping systems

Effects of drought stress on growth and yield of two NERICA rice lines

This experiment was conducted to determine the drought effects on grain yield, optimum water requirement and water productivity of two NERICA rice lines at BINA farm Mymensingh during January-May, 2012. Experimental design was RCBD with split-plot arrangement of the treatments, having three replications. Main plot treatments were: T_1 = Continuous ponding 3-5 cm, T_2 = Alternate flooding and drying at 5 days after disappearance (DAD) of 5 cm ponded water, T_3 = Alternate flooding and drying at 7 DAD of 5 cm ponded water and T_4 = Alternate wetting and drying (AWD) at 9 DAD of 5 cm ponded water, and sub plot treatments were: V_1 = NERICA-1, V_2 = NERICA-10 and V_3 = Binadhan-8. The experimental plot fertilized with required dose of fertilizers before final land preparation. Fifty six days rice seedlings of NERICA-1 and NERICA-10 and forty seven days rice seedlings of Binadhan-8 were transplanted on 9th February 2012. Treatments were started fifteen days after transplanting and it continued up to flowering stage and again treatment started after flowering stage and continued up to around 2 weeks before harvesting. Cultural practices were followed as per need and recommendation. NERICA-10 and Binadhan-8 were harvested on 17th May 2012 and NERICA-1 was harvested on 20th May 2012. At the harvest time, yield and yield attributing characters were collected and analyzed.

Interaction effect of irrigation treatments and varieties on yield and yield attributing characters of NERICA rice lines is presented in Table 1. Interaction effect of AWD irrigation treatment and varieties had significant effect on plant height, number of tiller, panicle length, grain and straw yield. The highest grain yield was observed in T_1V_3 i.e., Binadhan-8 produced the highest yield in continuous ponding treatment. The NERICA rice lines also produced higher yield in continuous ponding method treatment. Irrigation frequency was higher in more watered plots compared to the delayed irrigated plots (Table 2). It also elucidated that 5 to 9 days AWD irrigation method (T_2, T_3 and T_4) saved about 41 to 52% irrigation water compared to continuous ponding treatment. Hence, water productivity was obviously higher with reduced irrigation at 5 to 9 days alternate wetting and drying in T_2, T_3 and T_4 treatment plots. Rainfall pattern during the growing period of NERICA rice lines and Binadhan-8 is presented in Fig. 1.

Table 1. Interaction effect of AWD irrigation treatment and varieties on yield and yield attributing characters of NERICA rice lines

Treatment × Variety	Plant height (cm)	No. of tiller	Panicle length (cm)	Grain panicle^{-1} (no.)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1V_1	81.93 ab	9.33 a	18.40 bc	115.87 a	32.43 ab	3.67 c	8.17 b
T_1V_2	80.53 bc	7.40 ab	18.47 cd	95.07 ab	27.11 d	3.41 c	6.33 c
T_1V_3	87.47 a	9.87 a	21.39 a	115.00 ab	26.49 d	7.33 a	10.50 a
T_2V_1	73.07 de	5.60 b	18.50 cd	84.60 bcd	34.06 a	1.67 d	4.17 ef
T_2V_2	70.40 de	7.13 ab	16.43 e	58.20 d	27.39 d	1.50 d	2.83 gh
T_2V_3	76.80 bcd	8.20 ab	20.39 ab	90.73 abc	27.36 d	4.92 b	6.33 c
T_3V_1	70.13 de	5.40 b	17.53 cde	59.00 d	31.26 b	1.33 d	4.58 de
T_3V_2	68.93 e	5.67 b	17.13 de	58.33 d	28.13 cd	1.33 d	3.00 fgh
T_3V_3	75.73 b-e	9.33 a	21.83 a	103.67 ab	26.15 d	3.75 c	5.59 cd
T_4V_1	69.40 e	5.67 b	17.93 cde	62.00 cd	31.75 ab	1.04 d	4.04 efg
T_4V_2	61.87 f	6.87 ab	16.67 de	57.4 d	30.07 bc	1.13 d	2.58 h
T_4V_3	74.07 cde	8.27 ab	20.40 ab	86.27 a-d	26.41 d	3.75 c	5.50 cd
$LSD_{0.05}$	6.34	3.08	1.72	27.49	2.41	0.76	0.43

Table 2. Effect of different AWD irrigation techniques on water saving and water productivity of Boro rice

Treatments	Water applied (cm)	Irrigation numbers	Effective rainfall (cm)	Water requirement (cm)	Water saving compared to T_1 (%)	Grain yield (t ha^{-1})	Water productivity (L kg^{-1})
T_1	66.50	21	21.48	87.98	-	4.81	1829
T_2	30.50	7	21.48	51.98	41	2.69	1932
T_3	25.50	6	21.48	46.98	47	2.14	2195
T_4	20.50	5	21.48	41.98	52	1.97	2130

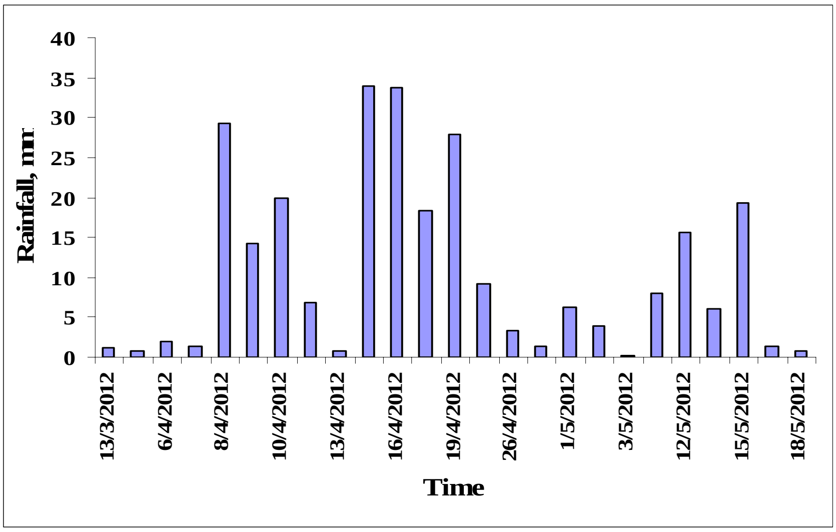


Fig. 1. Rainfall pattern during the growing period of NERICA-1, NERICA-10 and Binadhan-8 in Mymensingh

Determination of optimum water requirement of some lines of soybean

The experiment was conducted at BINA farm, Mymensingh during January-May, 2012 to determine the optimum irrigation water requirement of some mutant lines of soybean. The experimental design was RCBD. The irrigation treatments were assigned in main plots and the soybean cultivars were in the sub-plots. Irrigation treatments were: T_0 = Control (No irrigation); T_1 = Irrigation at vegetative stage up to field capacity (FC); T_2 = Irrigation at flowering stage up to FC; and T_3 = Irrigation at vegetative and flowering stages up to FC. Variety/lines were: V_1 = AVRDC-78; V_2 = BAU-S/70 and V_3 = Binasoybean-1. After land preparation, application of basal dozes of fertilizer, the seeds of soybean were sown on 16th January, 2012. Required row (30 cm) and plant spacing (5 cm) were also maintained. First irrigation was applied at vegetative stage and the next irrigation (scheduled at flowering stage) was omitted due to rainfall. Soil moisture was measured by gravimetric method up to 60 cm for every 15 cm increment at the time of sowing and harvest. Other cultural practices were followed as and when necessary. The crop was harvested on 15th May 2012. All agronomic data were collected at the harvest time.

The crop during its growing period received about 209 mm rainfall which is graphically shown in Fig. 2. The irrigation treatments showed significant differences in plant height and 100 seed weight, and varietal treatment showed significant differences in plant height, 100 seed weight, and straw yield (Table 2). The highest yield was obtained in treatment T_3. Amount of irrigation water requirement and water productivity of soybean are shown in Table 4. From Table 4, it is observed that irrigation water productivity is highest in T_3 treatment.

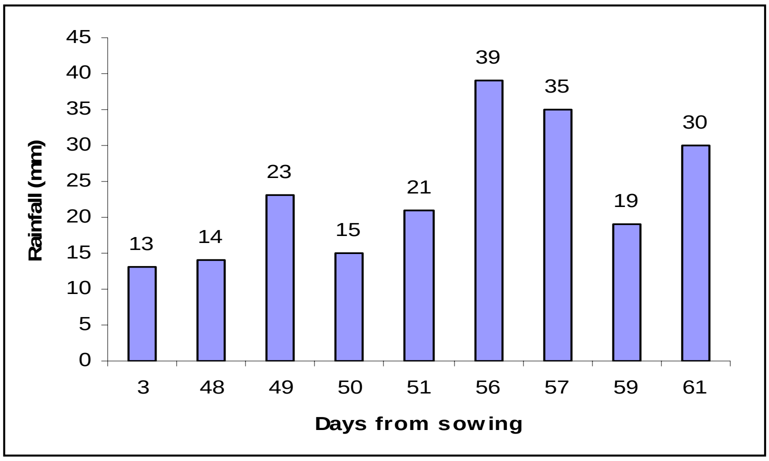


Fig. 2. Rainfall distribution during the growing period of soybean at BINA farm, Mymensingh

Table 3. Yield and yield attributing characters of soybean at BINA farm, Mymensingh

Treatments	Plant height (cm)	Pods plant^{-1} (no.)	Seed pod^{-1} (no.)	100 seed weight (g)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	53.04	62.47	2.27	131.68	2.44	2.93
T_1	55.51	68.69	2.27	139.60	2.81	2.73
T_2	44.56	58.80	2.40	140.62	2.34	2.47
T3	54.02	60.57	2.51	140.08	2.97	3.11
$LSD_{0.05}$	5.38	NS	NS	5.87	NS	NS
V_1	41.40	67.93	2.42	143.65	2.48	2.59
V_2	73.83	60.38	2.23	136.99	2.66	3.30
V_3	40.17	59.58	2.43	133.34	2.78	2.55
$LSD_{0.05}$	6.13	NS	NS	7.12	NS	0.47

NS = Non-significant.

Table 4. Water requirement and irrigation water productivity of soybean at BINA farm, Mymensingh

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re +ΔS (cm)	Yield (kg ha^{-1})	Irrigation water productivity (kg ha^{-1}cm^{-1})
T_0	0	20.9	-0.34	20.56	2440	118.67
T_1	3.0		-2.79	21.11	2810	133.11
T_2	0		-1.22	19.68	2340	118.90
T_3	3.0		-0.90	20.00	2970	148.50

Studies on groundwater for its sustainable use of irrigation

Studies on the surface and groundwater quality for irrigation suitability

The study was conducted to determine the surface and ground water quality and pollution rate at BINA sub-stations of Ishurdi, Magura, Rangpur, Satkhira BINA Head-quarter, Mymensingh and SPGR-335 project area at Mymensingh and Magura. The water samples were collected at three distinct seasons as before irrigation period in November/December, during the peak irrigation period in February/March to observe the seasonal effects on the water quality due to the irrigation pumping, monsoon recharge and agricultural practices. Different water quality parameters such as p^H, EC, CO_3^{--}, HCO_3^-, and Cl^- were analyzed. Arsenic (As) was also tested using field kit method.

The quality parameters for the period 2011-12 at different locations results are presented in Table 5. Results showed that the parameters were within the permissible limit for irrigation. Same parameters showed slight seasonal variation at Satkhira at the time of Boro season (during February) and Cl^- showed higher values than other locations. As and CO_3^{--} was not traced anywhere.

Table 5. Water quality parameters of BINA farm, Mymensingh and its sub-stations

Parameters / Locations	Source of water	p^H		EC (dS/m)		HCO_3^- (mg/l)		Cl^- (mg/l)	
		Feb. 2011	Dec. 2011	Feb. 2011	Dec. 2011	Feb. 2011	Dec. 2011	Feb. 2011	Dec. 2011
BINA	DTW	6.75	8.16	0.37	0.43	1.97	5.94	0.32	1.73
Mymensingh	HTW	7.52	8.40	0.25	0.33	2.13	2.48	0.81	1.73
Rahmatpur	DTW	-	7.30	-	0.39	-	3.35	-	2.60
Mymensingh	Pond	-	6.56	-	0.18	-	1.47	-	1.35
North Alalpur	STW	-	7.20	-	0.34	-	1.85	-	3.10
Mymensingh	Pond	-	7.22	-	0.30	-	2.47	-	1.48
South Alalpur	STW	-	7.34	-	0.32	-	2.35	-	1.98
Mymensingh	Pond	-	5.70	-	0.30	-	1.23	-	6.85
BINA sub-station	DTW	7.01	7.66	0.59	0.75	4.39	6.62	1.05	1.85
Ishurdi	STW	6.92	7.64	0.62	0.83	5.17	6.43	1.21	1.98
BINA sub-station	DTW	6.76	6.47	0.28	0.46	1.50	0.73	0.98	1.60
Rangpur	STW	6.48	7.13	0.31	0.26	1.13	1.35	1.32	1.35
BINA sub-station	HTW	7.11	8.14	0.70	0.63	2.79	4.10	0.90	1.85
Magura	STW	7.06	7.52	0.51	0.62	3.31	4.86	0.77	1.78
Ramnogor	STW	-	6.87	-	0.86	-	7.10	-	3.60
Magura sadar	Pond	-	7.68	-	0.51	-	3.60	-	1.85
Sachni	STW	-	7.21	-	0.59	-	4.73	-	1.73
Magura sadar	Pond	-	6.24	-	0.46	-	3.48	-	4.10
Raotola	STW	-	7.23	-	0.56	-	4.73	-	1.98
Magura sadar	Pond	-	7.35	-	0.39	-	3.48	-	1.73
BINA sub-station	STW	6.82	-	1.02	-	7.52	-	4.19	-
Satkhira	HTW	7.01	7.17	0.78	0.77	7.2	6.68	7.19	2.10
	Pond	7.09	7.36	3.19	1.42	3.12	2.43	26.0	1.98
	River	7.03	7.76	15.2	2.77	3.09	3.10	305	12.10
Permissible limit		< 8		< 3 dS/m		< 8.5 mg/l		< 5 mg/l	

Assessment of aquifer exploitation due to irrigation during dry season

The study was conducted at BINA sub-stations of Ishurdi, Magura, Rangpur, Satkhira and BINA head-quarters, Mymensingh to assess the surface and ground water withdrawal pattern from water table data for its sustainable use. Observation wells were installed earlier at the sub-stations at Ishurdi, Magura, Rangpur and BINA head-quarter at Mymensingh. Using water level indicator, WT data were monitored fortnightly which were then interpreted to see the seasonal as well as yearly WT dynamics. Long-term (1992-2011) water table data were also recorded from earlier installed observation wells at the above locations.

Monthly WT study at BINA Head-quarters at Mymensingh and its sub-stations

Monthly WT fluctuation pattern in the yearly cycle of 2011-12 (May 2011 to April 2012) showed within the suction limit (< 8m) of STW at Rangpur and Magura but it went below the suction limit at Ishurdi from March to June. On the other hand, at Mymensingh, maximum WT sharply went below the suction limit from January and on-ward till the onset of monsoon in June/July (Fig. 3).

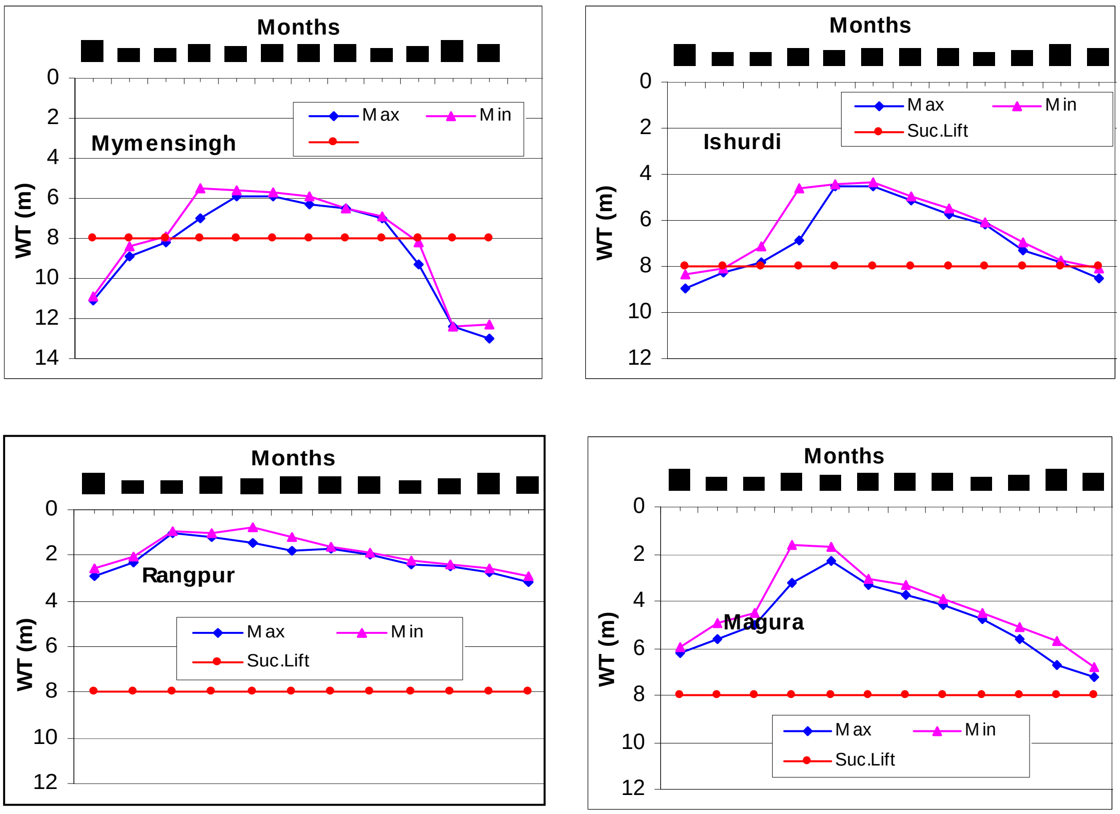


Fig. 3. Monthly WT fluctuation pattern at BINA Head quarter and its sub-stations

Long-term yearly WT study at BINA Head-quarters at Mymensingh and its sub-stations:

Long-term yearly WT fluctuation at BINA head-quarters at Mymensingh and its sub-stations are shown in Fig. 4. It showed that at Mymensingh all along from 1992-2011, WT went below the suction limit of STW. But at Ishurdi, WT was within the suction limit up to 2007 which then had a transition state and from 2010 it went below the suction limit of STW. At other locations, though data missing but was very much within the suction limit of STW.

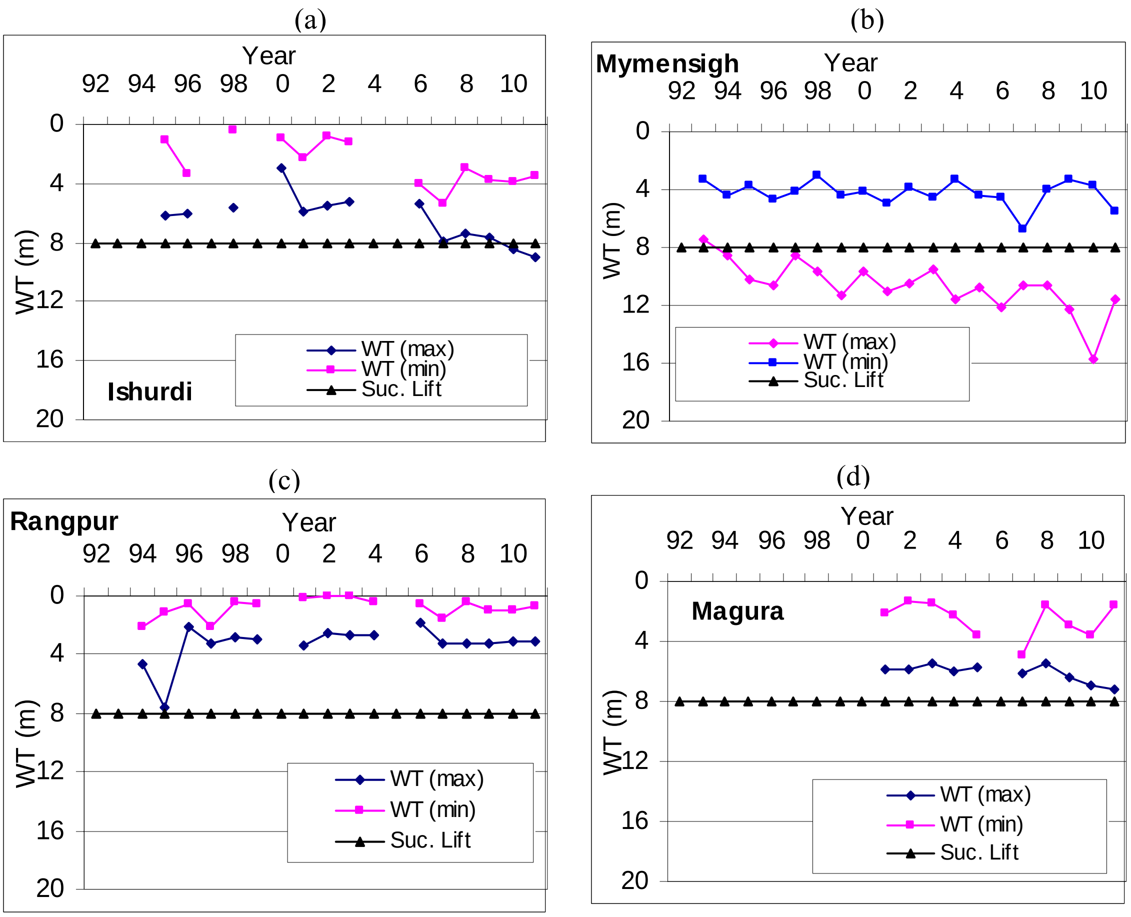


Fig. 4. Long term yearly (1992-2011) WT fluctuation pattern of BINA sub-stations at (a) Ishurdi, (b) Magura, (c) Rangpur and (d) BINA Head quarter, Mymensingh

Studies on the surface and groundwater quality for irrigation suitability (SPGR Part)

The study was conducted to determine the surface and ground water quality and pollution rate at SPGR-335 project area at Mymensingh and Magura.

Methodology

The water samples were collected before irrigation in November/December, and during the peak irrigation period in February/March to observe the seasonal effects on the water quality due to the irrigation pumping, monsoon recharge and agricultural practices. Different water quality parameters such as p^H, EC, CO_3^{--}, HCO_3^- and Cl^- were analyzed. Arsenic (As) was also tested using field kit method.

Results

The quality parameters for the period 2012 at different locations studied are presented in Table 6. Results showed that the parameters were within the permissible limit for irrigation.

Table 6. Water quality parameters collected from different locations

Parameters / Locations	Source of water	p^H	EC (dS/m)	HCO_3^- (mg/l)	Cl^- (mg/l)
		Dec. 2011	Dec. 2011	Dec. 2011	Dec. 2011
BINA	DTW	8.16	0.43	5.94	1.73
Mymensingh	HTW	8.40	0.33	2.48	1.73
Rahmatpur	DTW	7.30	0.39	3.35	2.60
Mymensingh	Pond	6.56	0.18	1.47	1.35
North Alalpur	STW	7.20	0.34	1.85	3.10
Mymensingh	Pond	7.22	0.30	2.47	1.48
South Alalpur	STW	7.34	0.32	2.35	1.98
Mymensingh	Pond	5.70	0.30	1.23	6.85
BINA sub-station	HTW	8.14	0.63	4.10	1.85
Magura	STW	7.52	0.62	4.86	1.78
Ramnogor	STW	6.87	0.86	7.10	3.60
Magura sadar	Pond	7.68	0.51	3.60	1.85
Sachni	STW	7.21	0.59	4.73	1.73
Magura, sadar	Pond	6.24	0.46	3.48	4.10
Raotola	STW	7.23	0.56	4.73	1.98
Magura, sadar	Pond	7.35	0.39	3.48	1.73
Permissible limit		< 8	< 3 dS/m	< 8.5 mg/l	< 5 mg/l

Development of appropriate water management practices for increasing crop productivity in saline area

Studies on optimum water requirement of salt tolerant rice variety Binadhan-8

The experiment was conducted at farmers field of Kharibila village, Satkhira Sadar, Satkhira, during January-May, 2012 to determine the optimum water requirement and water productivity of salt tolerant rice variety Binadhan-8 in saline area. Experimental design was RCBD having three replications. Irrigation treatments were: T_1 = Continuous ponding (3-5 cm), T_2 = AWD 10cm, T_3 = AWD 15 cm and T_4 = AWD 20cm. After land preparation, required dose of fertilizers was applied. Thirty-five day old rice seedlings were transplanted on 23rd January 2012. Treatments were started 15 days after transplanting and continued up to flowering stage. Intercultural practices were followed as per need and recommendation. Binadhan-8 was harvested on 1st May 2012. At the harvest time, yield and yield attributing characters were collected and analyzed. Also, other necessary data e.g. agro-meteorological data, amount of water applied at each irrigation, EC of plot water and EC of irrigation water were collected and recorded. Analysis of EC of soil is under process.

Effects of different AWD irrigation techniques on yield and different yield attributes of Binadhan-8 are presented in Table 7. The highest yield was observed in T_2 treatment which was not statistically significant with other treatments. In T_2 treatment, irrigation was applied by 41.35 cm, and water savings compared to T_1 treatment was 7% (Table 8). The highest water savings was in T_4 treatment. Water productivity was the highest in T_1 treatment followed by T_4, T_3 and T_2 treatments. In T_1 treatment plot, salinity was increased in ponding water (Fig. 5). Irrigation water salinity varied from 4.32 to 7.05 dS/m (Fig. 6). Rainfall was occurred 141.50 cm during the growing period of Binadhan-8 and effective rainfall was 7.28 cm (Fig. 7). From the experimental findings, it is found that Binadhan-8 creates an opportunity to increase rice production and improving food security in the saline area irrespective to yield and prevailing soil and water condition. This experiment should be repeated in the next year to confirm the findings.

Table 7. Effect of different AWD irrigation techniques on yield and different yield attributes of Binadhan-8

Treatments	Plant height (cm)	No. of tillers/hill	Panicle length (cm)	1000 seed wt. (gm)	Grain yield (t ha^{-1})
T_1	103.60	9.87	24.93	29.67 a	9.42
T_2	102.53	9.67	23.40	26.00 b	9.83
T_3	99.47	9.33	22.67	24.67 b	8.65
T_4	98.40	9.00	22.87	26.00 b	7.92
LSD	2.61	NS	NS	2.85	NS

Table 8. Effect of different AWD irrigation techniques on water saving and water productivity of boro rice

Treatments	Water applied (cm)	Effective rainfall (cm)	Water requirement (cm)	Water saving compared to T_1 (%)	Grain yield (t ha^{-1})	Water productivity (L kg^{-1})
T_1	45.23	7.28	52.51	-	9.42	557
T_2	41.35	7.28	48.63	7	9.83	495
T_3	38.68	7.28	45.96	12	8.65	531
T_4	36.35	7.28	43.63	17	7.92	551

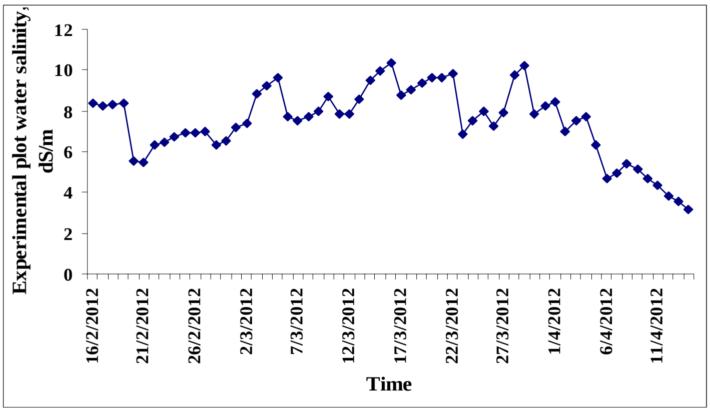


Fig. 5. EC of ponding water during the growing period of Binadhan-8 in continuous ponding water plot

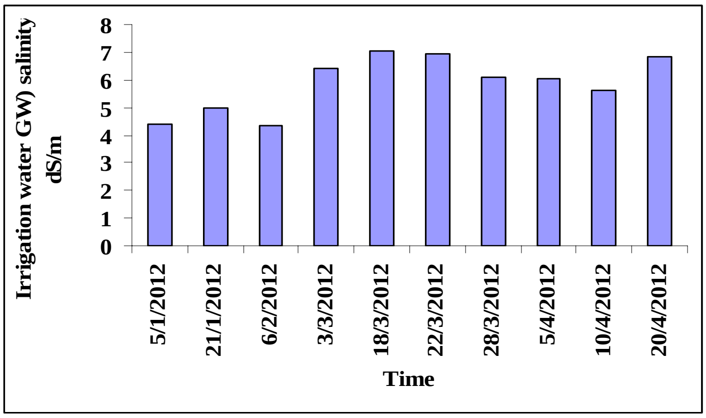


Fig. 6. EC of groundwater during the growing period of Binadhan-8

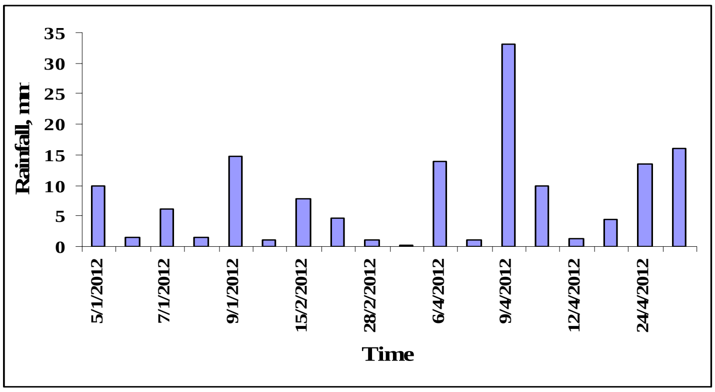


Fig. 7. Rainfall pattern during the growing period of Binadhan-8

Development of appropriate irrigation and water management technologies for growing upland crops in selected saline area of Satkhira district (KGF funded Project)

Potentialities of using surface and ground water for sunflower cultivation in saline area

The objective of this experiment was to find out the possibility of growing sunflower after harvesting T. aman rice in saline soil, and evaluate productivity and economics of growing sunflower using variable sources of irrigation water. The experiment was conducted at Kharibila village, Satkhira Sadar, Satkhira, during January-April, 2012. The experimental design was RCBD with four replications. Irrigation treatments were: T_1 = No irrigation, T_2 = Canal water irrigation, and T_3 = Ground water irrigation. After land preparation, the experimental plots were fertilized with urea 95 kg ha^{-1}, triple super phosphate 170 kg ha^{-1}, muriate of potash 160 kg ha^{-1}, gypsum 160 kg ha^{-1}, zinc sulphate 19 kg ha^{-1}, boric acid 11 kg ha^{-1}, magnesium sulphate 90 kg ha^{-1} and cowdung 9000 kg ha^{-1} as basal dose. Additional 95 kg ha^{-1} of urea was applied before flowering stage (45-50 DAS). The seeds of sunflower (BARI Surjamukhi-2) were sown on 5th January 2012 maintaining required row (50 cm) and plant spacing within the row (30 cm). Irrigation water was applied up to field capacity as per treatment. Soil moisture was measured by gravimetric method up to 60 cm depth with 15 cm increment from the soil surface, at 10 days interval from sowing to harvest time. Other cultural practices were followed as and when necessary. Other necessary crop and yield data, agro-meteorological data, amount of water applied at each irrigation, and phenological events (germination, vegetative, flowering and ripening stages etc.) were recorded. At 15 days interval, soil sample was collected up to 45 cm for every 15 cm increment for EC and pH determination. In addition, irrigation water was collected for EC determination. Sunflower was harvested on 12th April, 2012. At the harvest time, necessary data were collected and analyzed.

Irrigation water sources had significant effect on plant height, head diameter, seed per head, 1000 seed weight, seed yield and straw yield of sunflower (Table 9). The highest seed yield of sunflower was found in T_3 treatment (2954 kg ha^{-1}) which received three irrigations from groundwater. There was no significant seed yield difference among the treatments (T_2 and T_3). Also reasonable yield was found in T_1 treatment due to rainfall and higher profile soil moisture (Fig. 8-9). The highest water use efficiency of sunflower was also found in T_3 treatment (Table 10). Electrical conductivity (EC) of canal water and groundwater varied from 0.93 to 7.86 and 4.32 to 6.09 dS m^{-1} during the growing period (Table 11). The soil moisture was increased with the increase of soil depth (Fig. 9-11). The highest salinity was observed at the top soil (5.84 dS/m) followed by 15 cm soil depth (4.07 dS/m), 30 cm soil depth (2.42 dS/m), 45 cm soil depth (2.01 dS/m) and 60 cm soil depth (1.81 dS/m). Soil salinity was decreased with increasing soil depth (Fig. 12-14). Soil pH varied from 7.39 to 7.87, 7.61 to 7.87 and 7.59 to 7.83 in different depths of soil profile at the total growing period of sunflower (Fig. 15-17). The total number of human labour used for producing sunflower was 168 man-days/ha and per hectare cost was Tk. 42,000.00 which is 51% of total variable cost of sunflower production. The highest number of human labour (24%) occupied in harvesting, carrying and drying purpose followed by land preparation (18%), weeding (15%), seed sowing (14%), manuring (8%), thinning and storing (6%), irrigation (4%), application of chemical fertilizer and top dressing (3%) and application of insecticide and pesticide (2%), respectively (Table 12). Per hectare cost of tractor and power tiller was Tk. 6000.00 which was 7% of total variable cost (Table 13). Per hectare material cost was Tk. 34,730.00 which was 42% of total variable cost (Table 14). The highest material cost was for chemical fertilizer (58%) followed by cowdung (13%), soil treatment (12%), irrigation water (9%), insecticide and pesticide (6%) and seed (4%).

Table 9. Yield and yield attributes of sunflower for different irrigation treatments

Treatment	Plant height (cm)	Head diameter (cm)	Seeds head^{-1} (no.)	Seed weight/head (gm)	1000 seed weight (gm)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	130.34	14.13	528.50	42.75	80.15	2383	5615
T_2	147.19	15.94	602.92	47.83	84.01	2821	6911
T_3	140.32	15.31	562.00	44.10	81.10	2954	7426
LSD $_{0.05}$	6.36	0.52	31.21	NS	2.68	0.026	NS

Table 10. Water requirement and water use efficiency of sunflower in different irrigation treatments

Treatment	Life irrigation (cm)	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion (cm)	Water requirement (cm)	Seed yield (kg ha^{-1})	Water use efficiency (kg ha^{-1}cm^{-1})
T_1	-	-	3.84	5.30	9.14	2383	260.83
T_2	-	9	3.84	-0.42	12.42	2821	227.13
T_3	-	9	3.84	-0.42	12.42	2954	237.84

Table 11. EC of different sources of irrigation water during the different growing stages of sunflower

Treatments	Different growing periods of sunflower	Depth of irrigation (cm)	Sources of irrigation water	EC of irrigation water (dS/m)
T_2	Vegetative stage	3	Canal water	0.93
	Flowering stage	3		2.03
	Pod development stage	3		7.86
T_3	Vegetative stage	3	Ground water	4.32
	Flowering stage	3		6.40
	Pod development stage	3		6.09

Table 12. Per hectare cost of human labour for producing sunflower

Input	Human labour (nos. ha^{-1})	Per hectare cost (Tk.)
Land preparation	30	7500.00
Manuring	14	3500.00
Chemical fertilizer and top dressing	5	1250.00
Seed sowing	24	6000.00
Thinning	10	2500.00
Weeding	25	6250.00
Pest management	4	1000.00
Irrigation	6	1500.00
Harvesting, carrying and drying	40	10000.00
Storing	10	2500.00
Total	168	42000.00

Table 13. Per hectare cost of tractor and power tiller of sunflower production

	Number of cultivation (nos./cultivation)	Unit cost (Tk.)	Total per hectare cost of tractor and power tiller (Tk.)
Tractor and power tiller	4	1500.00	6000.00

Table 14. Per hectare material cost of sunflower production

Item of material cost	Quantity (kg)	Unit rate (Tk.)	Total cost (Tk.)
Seed	14	90	1260
Urea	95	20	1900
TSP	170	30	5100
MP	160	22	3520
Zypsum	160	10	1600
ZnSO4	9	150	1350
Borax	11	100	1100
Cowdung	9000	0.5	4500
MgSO4	90	60	5400
Soil treatment			4000
Irrigation water			3000
Pesticide			2000
Total			34730

Rental value of land for total growing period of sunflower was estimated as Tk. 4885.38 which constituting 81% of total fixed cost and the rest was interest on operating capital (19%) (Table 15). Total per hectare cost of sunflower production was Tk. 88728.79 which constituted per hectare of human labour cost (47%), power tiller and tractor cost (7%), material cost (39%) and fixed cost (7%), respectively (Table 16). Benefit cost ratio was 1.86 and 1.70 for using irrigation water from canal and groundwater, respectively (Table 17), implying one taka investment in sunflower production, brought Tk. 1.74 and Tk. 1.83 in return, respectively.

Table 15. Fixed cost per hectare of sunflower production

Item of fixed cost	Total cost (Tk.)
Land use cost	4885.38
Interest on operating capital	1113.41
Total fixed cost	5998.79

Table 16. Total per hectare cost of sunflower production

Item	Total (Tk.)
Per hectare cost of human labour	42000.00
Per hectare cost of tractor and power tiller	6000.00
Per hectare material cost	34730.00
Fixed cost per hectare	5998.79
Total per hectare cost	88728.79

Table 17. Yield and return of sunflower production

	Irrigation from canal water			Irrigation from groundwater		
	(kg ha^{-1})	Unit price (Tk.)	Total cost (Tk.)	(kg ha^{-1})	Unit price (Tk.)	Total cost (Tk.)
Seed yield	2821	50	141050	2954	50	147700
By product	6911	2	13822	7426	2	14852
Gross return/ha			154872			162552
Total cost			88851			88851
Gross margin/ha			72142			79822
Net return/ha			66020			73700
Benefit cost ratio			1.74			1.83

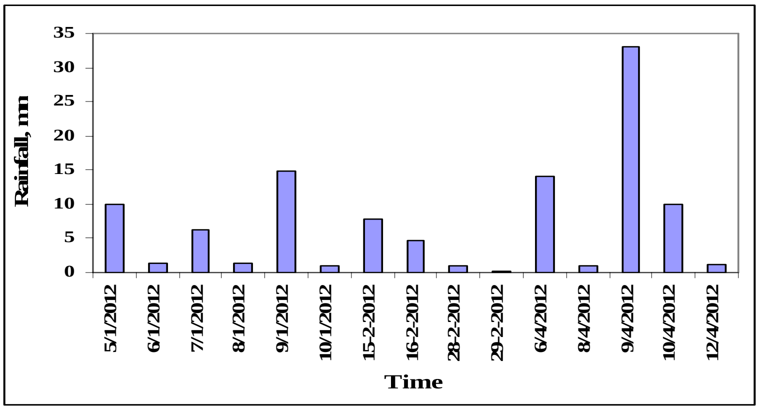


Fig. 8. Rainfall (mm) pattern during the growing periods of sunflower

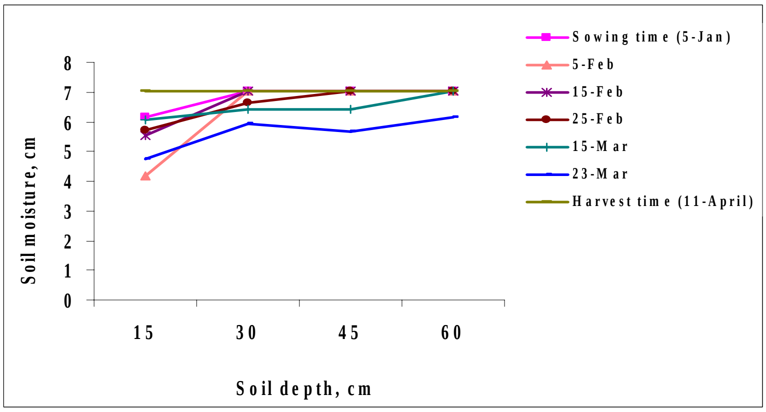


Fig. 9. Volume basis soil moisture at different soil profiles during the growing periods of sunflower affected by no irrigation

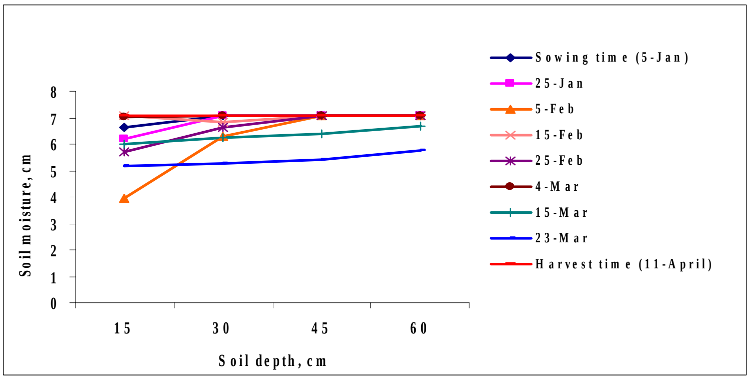


Fig. 10. Volume basis soil moisture at different soil profiles during the growing periods of sunflower affected by canal water irrigation

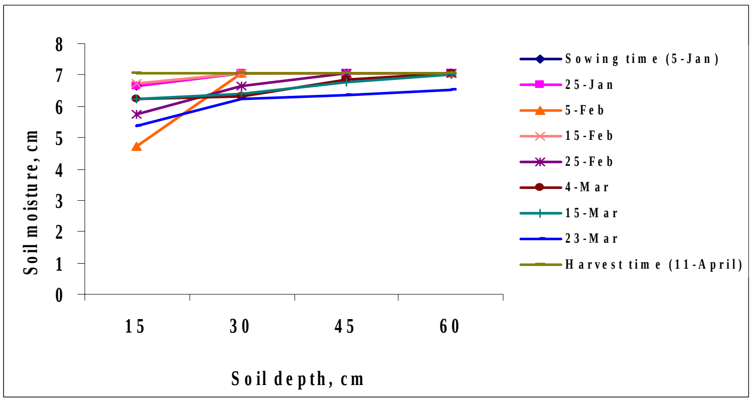


Fig. 11. **Volume basis soil moisture at different soil profiles during the growing periods of sunflower affected by groundwater irrigation**

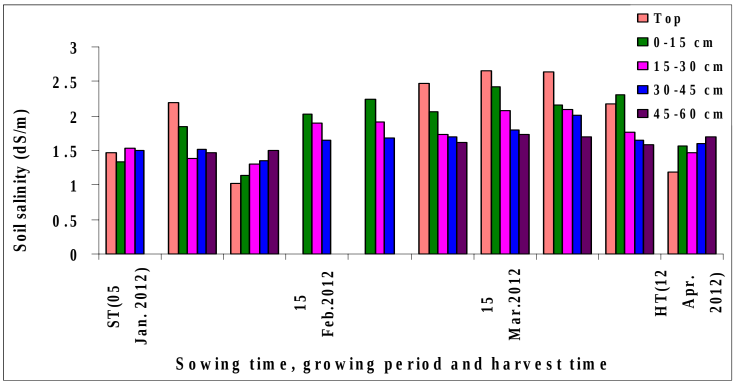


Fig. 12. **EC in different depths of soil profile during the growing period of sunflower affected by no irrigation**

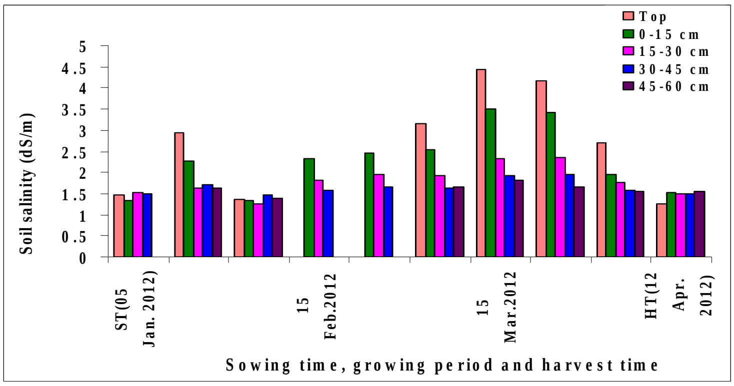


Fig. 13. **EC in different depths of soil profile during the growing period of sunflower affected by canal water irrigation**

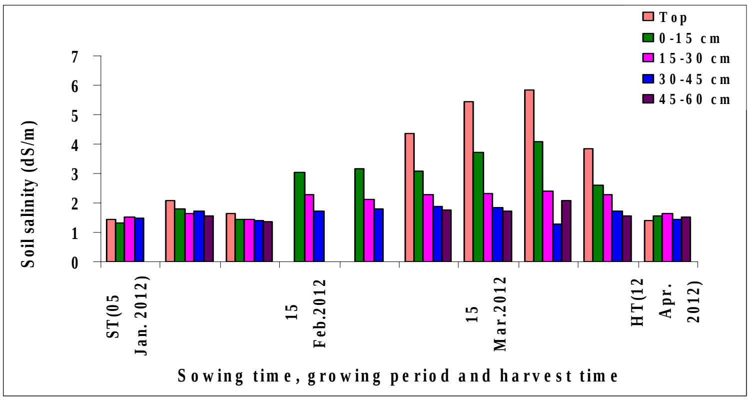


Fig. 14. EC in different depths of soil profile during the growing period of sunflower affected by groundwater irrigation

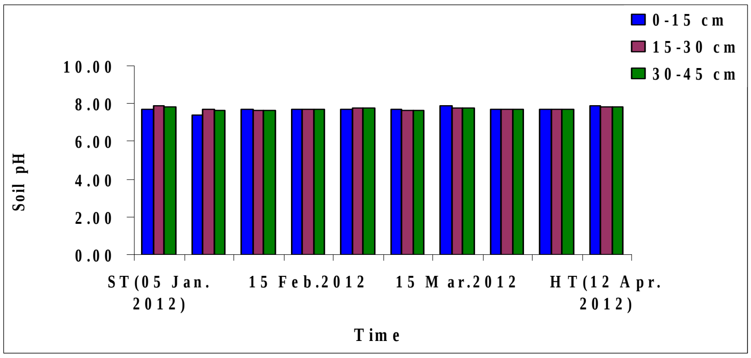


Fig. 15. pH in different depths of soil profile during the total growing period of sunflower affected by no irrigation

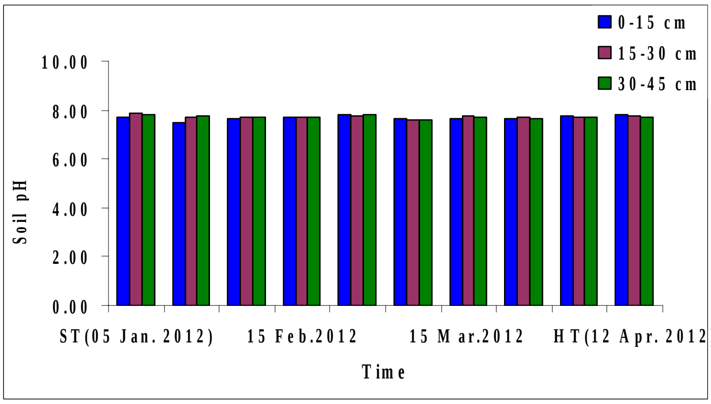


Fig. 16. pH in different depths of soil profile during the total growing period of sunflower affected by canal water irrigation

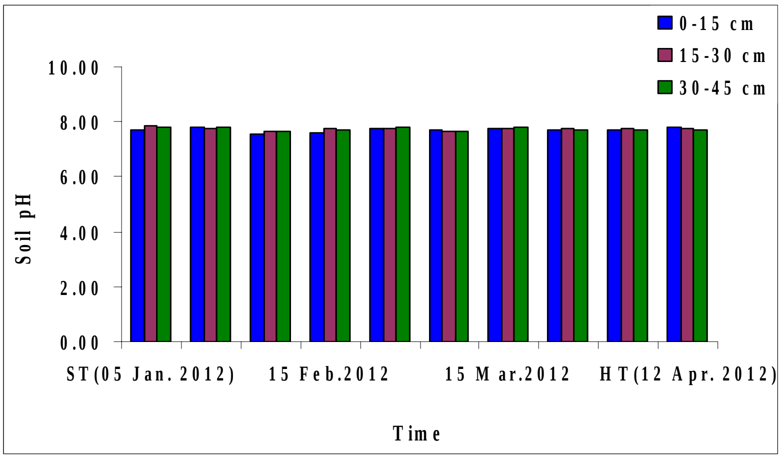


Fig. 17. pH in different depths of soil profile during the total growing period of sunflower affected by groundwater irrigation

Potentialities of using surface and ground water for maize cultivation in saline area

The objective of this experiment was to find out the possibility of growing maize after harvesting T. aman rice in saline soil and evaluate productivity and economics of growing maize using variable sources of irrigation water. This experiment was set at farmers' field located at Kharibila village, Satkhira Sadar, Satkhira during January-May 2012. Maize crop was replicated among four selected farmers and experimental design was RCBD. After land preparation, applying required dozes of fertilizer, the seeds of maize (Pacific 60) were sown on 5th January 2012 maintaining required row (76 cm) and plant spacing within row (25 cm). As per treatment (T_1 = no irrigation, T_2 = canal water irrigation, and T_3 = groundwater), irrigation water was applied up to field capacity. Soil moisture was measured by gravimetric method up to 60 cm for every 15 cm increment at the 10 days interval from sowing to harvest time. Other cultural practices were followed as per schedule and when necessary. Agro-meteorological data, amount of water applied at each irrigation, and phenological events (e.g. germination, vegetative, flowering, tesseling and silking stage and maturity etc.) were recorded. Soil sample was collected for analyzing different types of data, EC and pH of surface and groundwater before each irrigation, EC and pH data at different depths of root zone at 15 days interval. Maize crop harvested on 16th May, 2012. At the harvest time, yield and yield attributing characters of maize were recorded and soil samples were collected. Yield and yield attributing data were analyzed by MSTAT-C programme.

Treatments had significant effect on yield and yield attributes of maize (Table 18). The highest grain yield was obtained from T_2 treatment (9.61 t ha^{-1}) followed by T_3 treatment (8.38 t ha^{-1}). Yield attributing characters showed better performance in T_2 and T_3 treatments than T_1 treatment. Reasonable maize yield was found in T_1 treatment due to rainfall and contribution of profile soil moisture (Fig. 18-19). The highest water use efficiency was observed in T_2 followed by T_1 and T_3 treatments. T_2 and T_3 treatments received three irrigations in vegetative stage, tesseling and silking stage, and yield formation stage, respectively from canal water and groundwater source (Table 19-20). Soil moisture depletion was the highest in T_1 treatment plot (Table 19, Fig. 19-21). Electrical conductivity (EC) of canal water and groundwater varied from 0.93 to 8.00 and 4.32 to 6.94 dS/m during the growing period of maize. The highest salinity was observed at the top soil (6.08 dS/m) followed by 15 cm soil depth (3.59 dS/m), 30 cm soil depth (2.93 dS/m), 45 cm soil depth (2.07 dS/m) and 60 cm soil depth (2.03 dS/m) (Fig. 22-24). Soil salinity was decreased with the increasing soil depth. Soil pH varied from 7.51 to 7.92, 7.68 to 7.89, 7.70 to 7.89 and 7.63 to 7.88 in different depths of soil profile at the growing period of maize (Fig. 25-27). The total number of human labour used for producing maize was 204 man-days ha^{-1} and per hectare human cost Tk. 51000.00 which is 51% of total variable cost of maize production. The highest number of human labour (25%) occupied in land preparation and harvesting, carrying and drying purpose followed by weeding and shelling and storing (12%), seed sowing and guarding (9%), manuring and irrigation (7%), pest management and earthing up (6%), Chemical fertilizer and top dressing and thinning (3%), respectively (Table 21). Per hectare cost of tractor and power tiller was Tk. 6000.00 which was 6% of total variable cost. (Table 22). Per hectare material cost was Tk. 43,706.00 which was 43% of total variable cost (Table 23). The highest material cost was for chemical fertilizer (66%) followed by soil treatment and irrigation water (9%), seed and cowdung (6%) and insecticide and pesticide (5%), respectively. Rental value of land for total growing period of maize was estimated as Tk. 6655.00 which constituted 78% of total fixed cost and the rest was interest on operating capital (22%) (Table 24). Total per hectare cost of maize production was Tk. 109207.30 which constituting per hectare of human labour cost 47%, power tiller and tractor cost 5%, material cost 40% and fixed cost 8%, respectively (Table 25). Benefit cost ratio was 1.94 and 1.74 implying one taka investment in maize production, returned Tk. 1.94 and Tk. 1.70 using irrigation water from canal and groundwater, respectively (Table 26).

Table 18. Yield and yield attributes of maize for different treatments

Treatment	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Ear height (cm)	Cob length (cm)	Seeds cob^{-1} (no.)	1000-seed wt. (gm)	Grain yield ($t\ ha^{-1}$)
T_1	192.27	89.13	7.11	88.93	11.83	405.40	342.67	7.16
T_2	211.47	98.67	7.86	101.53	14.80	502.67	358.67	9.61
T_3	202.13	94.67	7.50	95.07	13.40	467.47	351.67	8.38
$LSD_{0.05}$	6.99	4.73	0.63	8.28	0.71	46.16	3.46	1.35

Table 19. Irrigation water application, water use and water use efficiency of maize

Treatment	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion (cm)	Water requirement (cm)	Grain yield ($t\ ha^{-1}$)	Water use efficiency ($kg\ ha^{-1}cm^{-1}$)
T_1	-	13.61	10.88	24.49	7.16	292
T_2	9	13.61	9.72	32.33	9.61	297
T_3	9	13.61	10.30	32.91	8.38	255

Table 20. EC of different sources of irrigation water in different treatments during the different growth stages of maize

Treatments	Different growing periods of maize	Depth of irrigation (cm)	Sources of irrigation water	EC of irrigation water (dS m^{-1})
T_2	Vegetative stage	3	Canal water	0.93
	Tesseling and silking stage	3		7.86
	Yield formation stage	3		8.00
T_3	Vegetative stage	3	Ground water	4.32
	Tesseling and silking stage	3		6.94
	Yield formation stage	3		6.02

Table 21. Per hectare cost of human labour for producing maize

Item	Human labour (nos. ha^{-1})	Total per hectare cost (Tk.)
Land preparation	40	10000
Manuring	12	3000
Chemical fertilizer & top dressing	5	1250
Seed sowing	15	3750
Thinning	5	1250
Weeding	20	5000
Insecticide and pesticide	10	2500
Earthing up	10	2500
Irrigation	12	3000
Guarding	15	3750
Harvesting, carrying and drying	40	10000
Shelling and storing	20	5000
Total	204	40800

Table 22. Per hectare cost of tractor and power tiller of maize production

	Number of cultivation (nos. ha^{-1})	Unit cost (Tk.)	Total per hectare cost of tractor and power tiller (Tk.)
Tractor and power tiller	4	1500.00	6000.00

Table 23. Per hectare material cost of maize production

Material	Quantity (kg)	Unit rate (Tk.)	Total cost (Tk.)
Seed	16	160	2560
Urea	555	20	11100
TSP	286	30	8580
MP	113	22	2486
Zypsum	276	10	2760
ZnSO4	17	150	2550
Borax	12	100	1200
Cowdung	4940	0.5	2470
Soil treatment			4000
Irrigation water			4000
Pesticide			2000
Total			43706

Table 24. Fixed cost per hectare of maize production

Item of fixed cost	Total cost (Tk.)
Land use cost	6655.00
Interest on operating capital	1846.28
Total fixed cost per hectare	8501.28

Table 25. Total per hectare cost of maize production

Item	Total cost (Tk.)
Per hectare cost of human labour	51000
Per hectare cost of tractor and power tiller	6000
Per hectare material cost	43706
Fixed cost per hectare	8501.28
Total per hectare cost	109207.3

Table 26. Yield and return of maize production

	Irrigation from canal water			Irrigation from groundwater		
	(kg ha^{-1})	Unit price (Tk.)	Total cost (Tk.)	(kg ha^{-1})	Unit price (Tk.)	Total cost (Tk.)
Cob yield	9610	20	192200	8380	20	167600
By product	10000	2	20000	9000	2	18000
Gross return/ha			212200			185600
Total cost			109207			109207
Gross margin/ha			111494			84894
Net return/ha			102992			76392
Benefit cost ratio			1.94			1.7

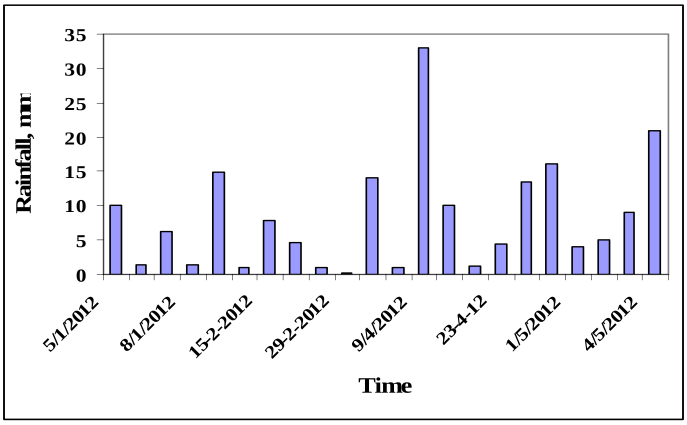


Fig. 18. Rainfall (mm) pattern during the growing periods of maize

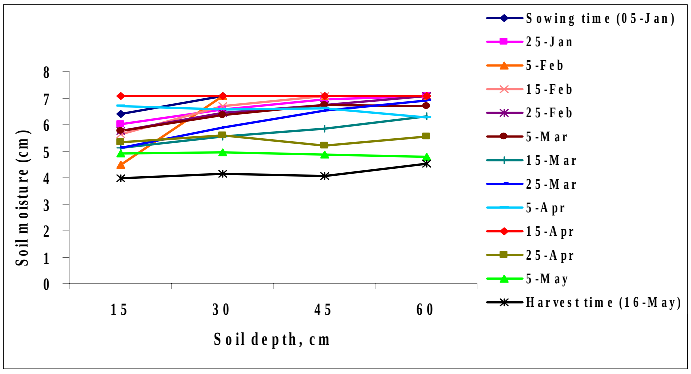


Fig. 19. Volume basis soil moisture at different soil profiles during the growing periods of maize affected by no irrigation

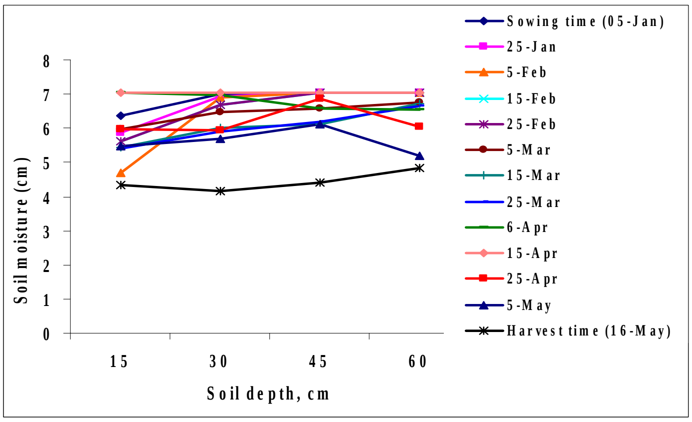


Fig. 20. Volume basis soil moisture at different soil profiles during the growing periods of maize affected by canal water irrigation

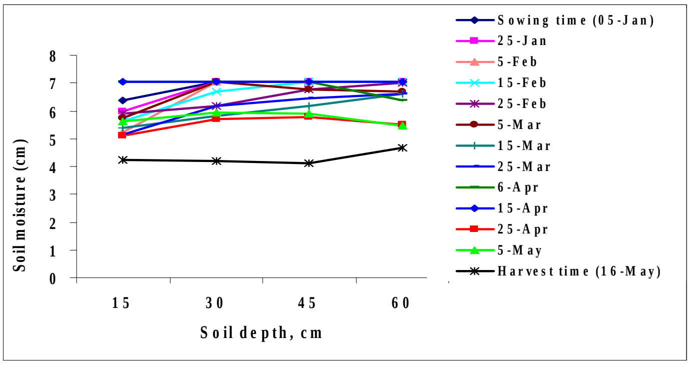


Fig. 21. Volume basis soil moisture at different soil profiles during the growing periods of maize affected by groundwater irrigation

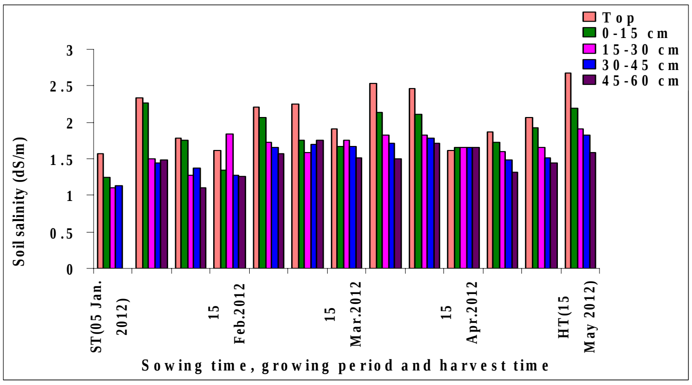


Fig. 22. EC in different depths of soil profile during the different growing stages of maize in affected by no irrigation

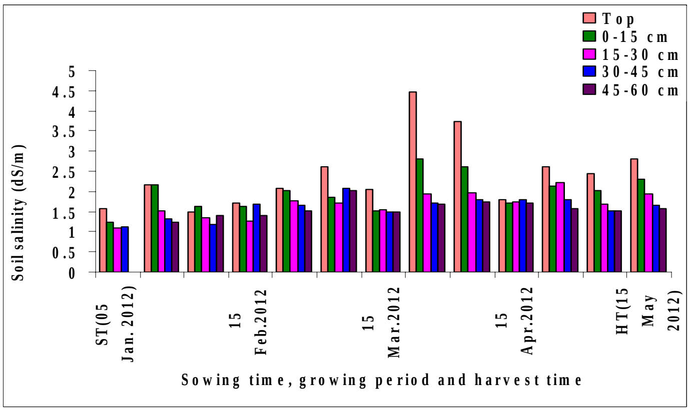


Fig. 23. EC in different depths of soil profile during the different growing stages of maize affected by canal water

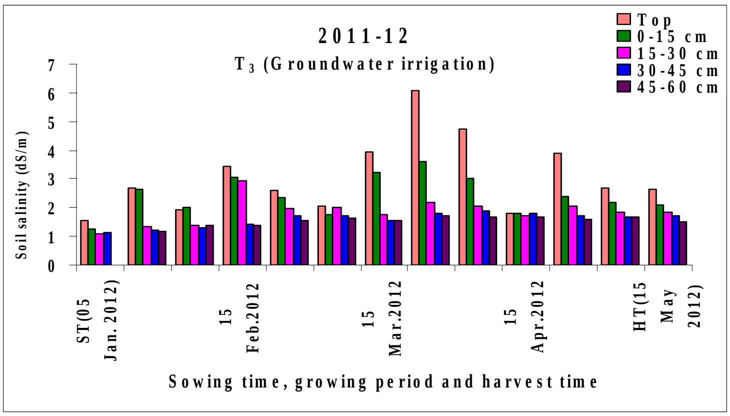


Fig. 24. **EC in different depths of soil profile during the different growing stages of maize affected by groundwater**

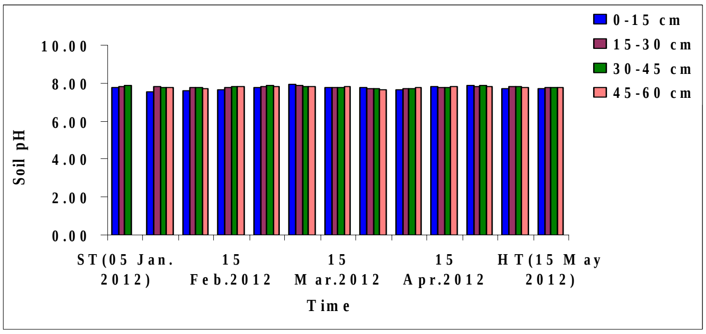


Fig. 25. **pH in different depths of soil profile during the total growing period of maize affected by no irrigation**

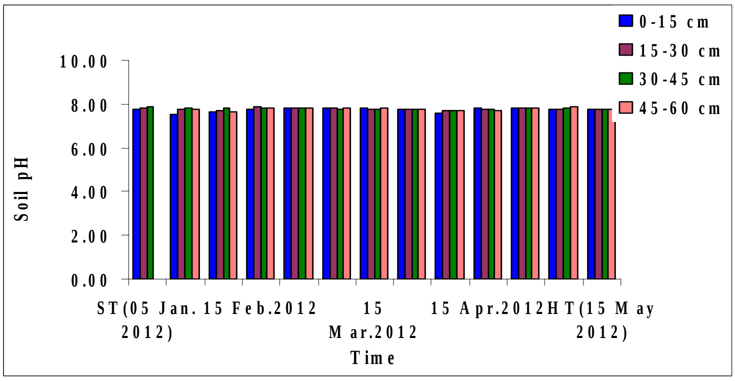


Fig. 26. **pH in different depths of soil profile during the total growing period of maize affected by canal water irrigation treatment plot**

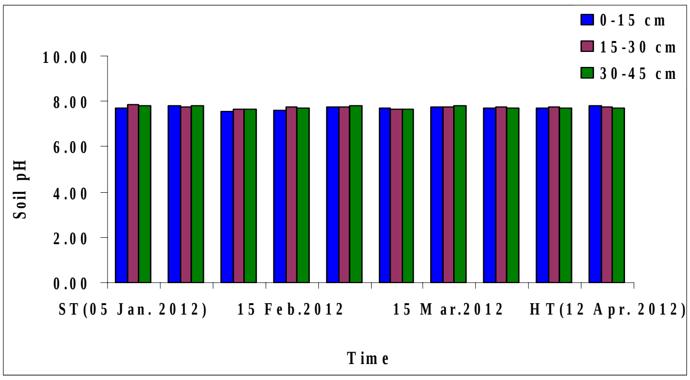


Fig. 27. pH in different depths of soil profile during the total growing period of maize affected by groundwater irrigation

Potentialities of using surface and ground water for soybean cultivation in saline area

The objective of this experiment was to find out the possibility of growing soybean after harvesting T. aman rice in saline soil and evaluate productivity and economics of growing soybean using variable sources of irrigation water. The experiment was conducted at Kharibila village, Satkhira Sadar, Satkhira during January-May, 2012. The experimental design was RCBD, replicated among four selected farmers and each replication was half bigha. Irrigation treatments were: T_1 = no irrigation, T_2 = canal water irrigation and T_3 = ground water irrigation. After land preparation, applying required dozes of fertilizer, the seeds of soybean (BARI Soybean-5) were sown on 21st January 2012 maintaining required row (30 cm) and plant spacing (5 cm). Irrigation water was applied up to field capacity as per treatment, growth stages and soil moisture condition. Soil moisture was measured by gravimetric method up to 60 cm for every 15 cm increment at the 10 days interval from sowing to harvest time. Other cultural practices were followed as and when necessary. Necessary data, EC and pH of surface and groundwater before each irrigation, EC and pH data at different depths of root zone at 15 days interval, agro-meteorological data and amount of water applied were collected and recorded. Soybean was harvested on 2nd May, 2012. At the harvest time, yield and yield attributes of soybean, soil moisture, electrical conductivity and other necessary data were collected. Yield and yield attributing data were analyzed by MSTAT-C program.

Irrigation treatments had no significant effect on yield and yield attributing characters of soybean except number of pods per plant (Table 27). The highest seed yield was found in T_2 treatment followed by T_3 and T_1 treatments, respectively. The highest water use efficiency was observed in T_3 followed by T_1 and T_2 treatments, respectively (Table 28). T_2 and T_3 treatments received three irrigations in vegetative stage, flowering and pod formation stage, and pod development stage, respectively, from canal water and groundwater source (Table 28-29). From Fig. 28-31 and Table 28, it was observed that profile soil moisture contributed more during the growing period of soybean. Electrical conductivity (EC) of canal water and groundwater varied from 2.50 to 4.33 and 4.80 to 5.53 dS/m during the growing period of soybean. Highest salinity was observed at the top soil (7.07 dS/m) followed by 15 cm soil depth (5.66 dS/m), 30 cm soil depth (3.26 dS/m), 45 cm soil depth (2.25 dS/m) and 60 cm soil depth (1.90 dS/m), respectively (Fig. 32-34). Soil salinity was decreased with the increasing soil depth. Soil pH varied from 7.41 to 7.77, 7.57 to 7.82, 7.60 to 7.84 and 7.56 to 7.77 in different depths of soil profile at the growing period of soybean (Fig. 35-37). The total number of human labour used for producing soybean was 144 man-days ha^{-1} and per hectare cost Tk. 36000.00 which is 62% of total variable cost of soybean production. The highest number of human labour (21%) occupied in land preparation followed by seed sowing (17%), weeding and harvesting, carrying and drying purpose (14%), thinning, nirani, irrigation and storing (7%) and application of chemical fertilizer and top dressing and insecticide and pesticide (3%), respectively (Table 30). Per hectare cost of tractor and power tiller was Tk. 4500.00 which was 8% of total variable cost (Table 31). Per hectare material cost was Tk. 17190.00 which was 30% of total variable cost (Table 32). The highest material cost was for chemical fertilizer (55%) followed by irrigation water (17%), seed (16%), and insecticide and pesticide (12%). Rental value of land for total growing period of soybean was estimated as Tk. 5097.13 which constituted 86% of total fixed cost and the rest was interest on operating capital (14%) (Table 33). Benefit cost ratio was 2.35 and 2.28 implying one taka investment in soybean production, returned Tk. 2.35 and Tk. 2.28 using irrigation water from canal and groundwater, respectively (Table 34).

Table 27. Yield and yield attributes of soybean for different irrigation treatments

Treatment	Plant height (cm)	Pods/Plant (nos.)	Pod length (cm)	Seeds pod^{-1} (nos.)	1000 seed wt. (gm)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	35.59	26.73	3.83	2.40	101.67	1486.00	3111.00
T_2	36.93	41.20	4.03	2.80	110.67	2000.00	3583.33
T_3	38.47	45.53	3.93	2.53	105.00	1944.33	3611.33
$LSD_{0.05}$	NS	11.96	NS	NS	NS	NS	NS

Table 28. Irrigation water application, water requirement and water use efficiency of soybean

Treatment	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion (cm)	Water requirement (cm)	Seed yield (kg ha^{-1})	Water use efficiency (kg $ha^{-1}cm^{-1}$)
T_1	-	7.36	10.84	18.20	1486	82
T_2	9	7.36	8.16	24.52	2000	82
T_3	9	7.36	10.88	27.24	1944	71

Table 29. EC of different sources of irrigation water in different treatments during the growing stages of soybean

Treatments	Different growing periods of soybean	Depth of irrigation (cm)	Sources of irrigation water	EC of irrigation water (dS/m)
T_2	Vegetative stage	3	Canal water	1.48
	Flowering and pod formation stage	3		2.03
	Pod development stage	3		7.86
T_3	Vegetative stage	3	Groundwater	5.36
	Flowering and pod formation stage	3		6.40
	Pod development stage	3		6.94

Table 30. Per hectare cost of human labour for producing soybean

Item	Human labour (nos. ha^{-1})	Per hectare cost (Tk.)
Land preparation	30	7500
Chemical fertilizer & top dressing	5	1250
Seed sowing	25	6250
Thinning	10	2500
Weeding	20	5000
Insecticide and pesticide	4	1000
Nirani	10	2500
Irrigation	10	2500
Harvesting, carrying and drying	20	5000
Storing	10	2500
Total	144	36000

Table 31. Per hectare cost of tractor and power tiller of soybean production

	Number of cultivation (nos. ha^{-1})	Unit cost (Tk.)	Total per hectare cost of tractor and power tiller (Tk.)
Tractor and power tiller	3	1500.00	4500.00

Table 32. Per hectare material cost of soybean production

Item of material cost	Quantity (kg)	Unit rate (Tk.)	Total cost (Tk.)
Seed	56	50	2800.00
Urea	55	20	1100.00
TSP	163	30	4890.00
MP	110	22	2420.00
Gypsum	98	10	980.00
Pesticide			2000.00
Irrigation water			3000.00
Total per hectare material cost			17190.00

Table 33. Fixed cost per hectare of soybean production

Item of fixed cost	Total cost (Tk.)
Land use cost	5097.13
Interest on operating capital	810.01
Total fixed cost per hectare	5907.14

Table 34. Total per hectare cost of soybean production

Item of total cost per hectare	Total cost (Tk.)
Per hectare cost of human labour	36000.00
Per hectare cost of tractor and power tiller	4500.00
Per hectare material cost	17190.00
Fixed cost per hectare	5907.14
Total per hectare cost	63597.14

Table 35. Yield and return of soybean production

	Irrigation from canal water			Irrigation from groundwater		
	(kg ha^{-1})	Unit price (Tk.)	Total cost (Tk.)	(kg ha^{-1})	Unit price (Tk.)	Total cost (Tk.)
Seed yield	2000	71	142000	1944.33	71	138047.4
By product	3583.33	2	7166.66	3611.33	2	7222.66
Gross return ha^{-1}			149166.7			145270.1
Total cost			63597.14			63597.14
Gross margin ha^{-1}			91476.7			87580.1
Net return ha^{-1}			85569.56			81672.96
Benefit cost ratio			2.35			2.28

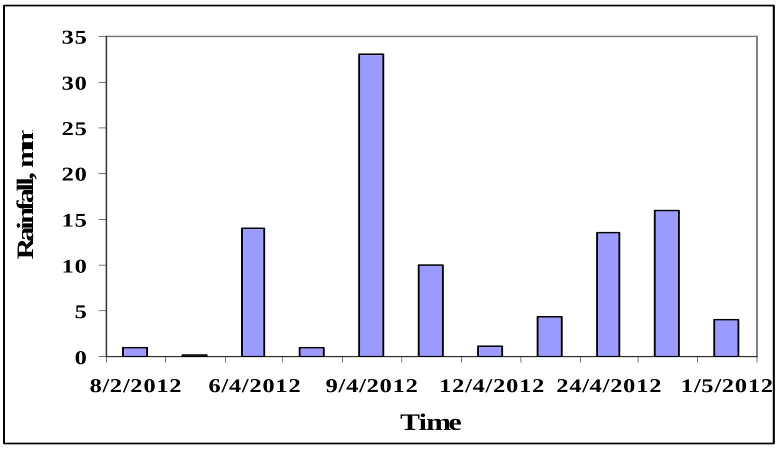


Fig. 28. Rainfall (mm) pattern during the growing periods of soybean

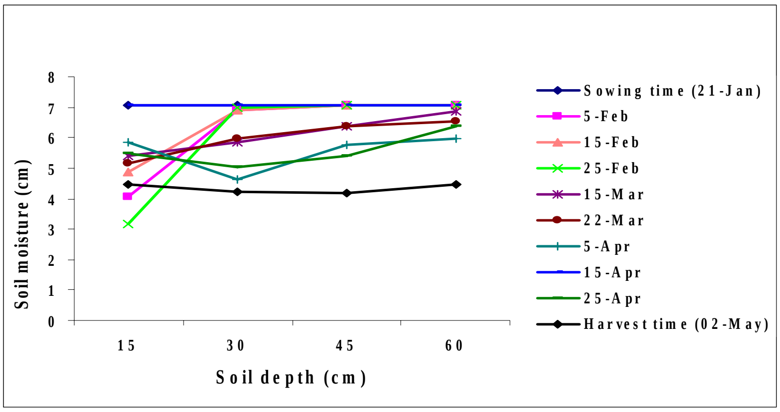


Fig. 29. Volume basis soil moisture at different soil profiles during the growing periods of soybean affected by no irrigation

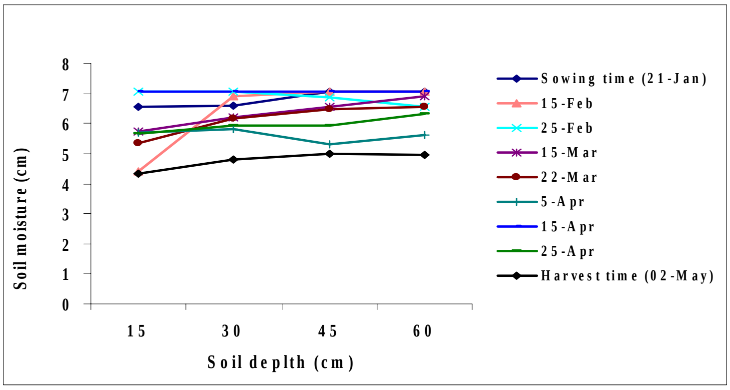


Fig. 30. Volume basis soil moisture at different soil profiles during the growing periods of soybean affected by canal water irrigation

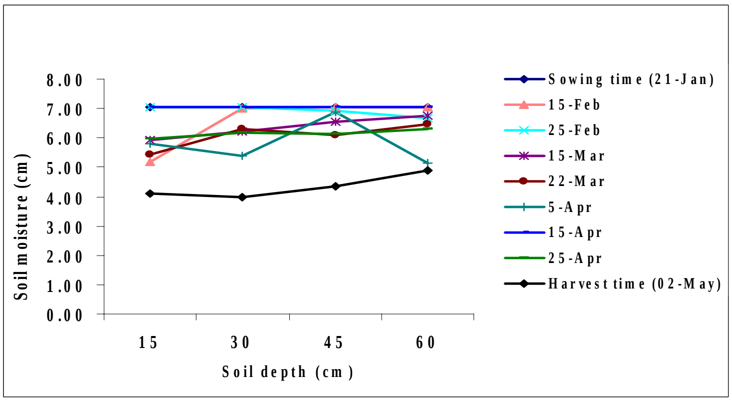


Fig. 31. Volume basis soil moisture at different soil profiles during the growing periods of soybean affected by groundwater irrigation

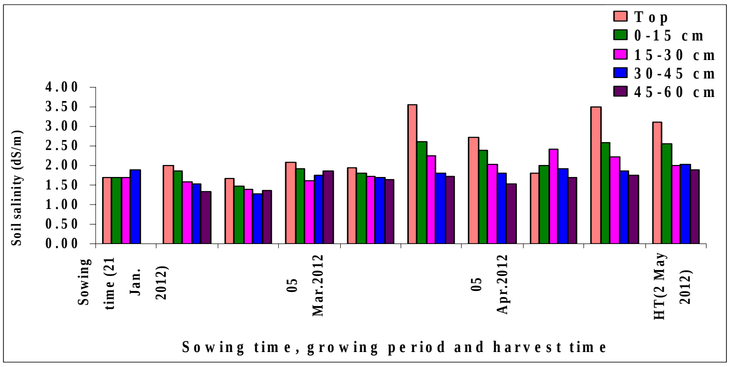


Fig. 32. EC in different depths of soil profile during the growing period of soybean affected by no irrigation

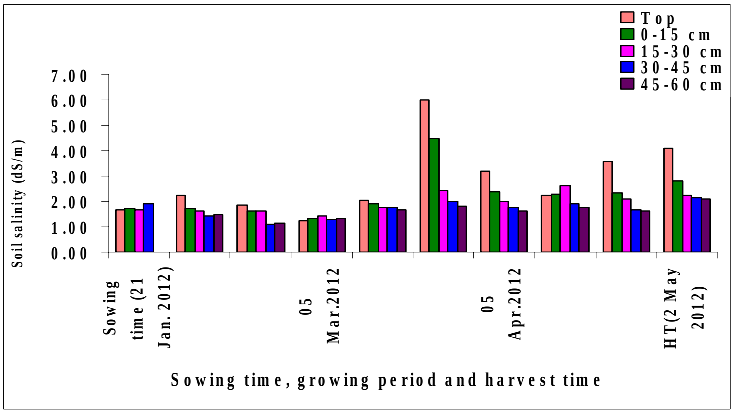


Fig. 33. EC in different depths of soil profile during the growing period of soybean affected by canal water irrigation

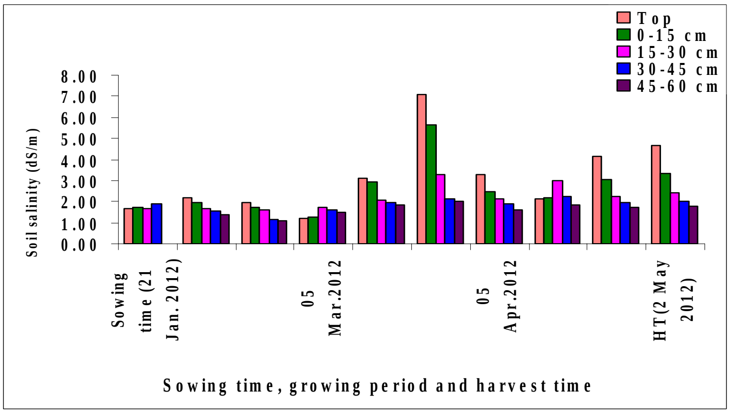


Fig. 34. EC in different depths of soil profile during the growing period of soybean affected by groundwater irrigation

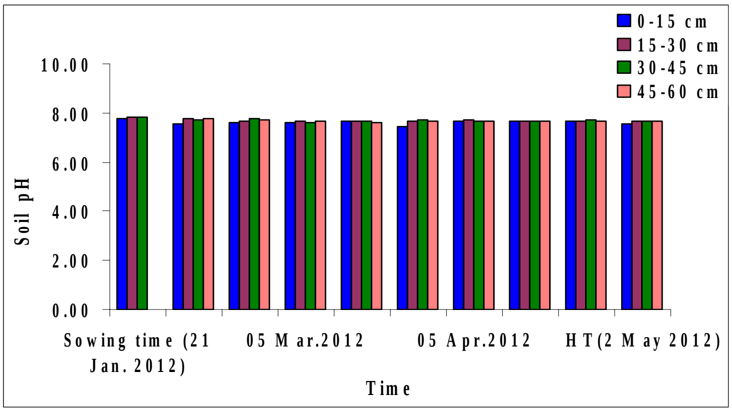


Fig. 35. pH in different depths of soil profile during the total growing period of soybean affected by no irrigation

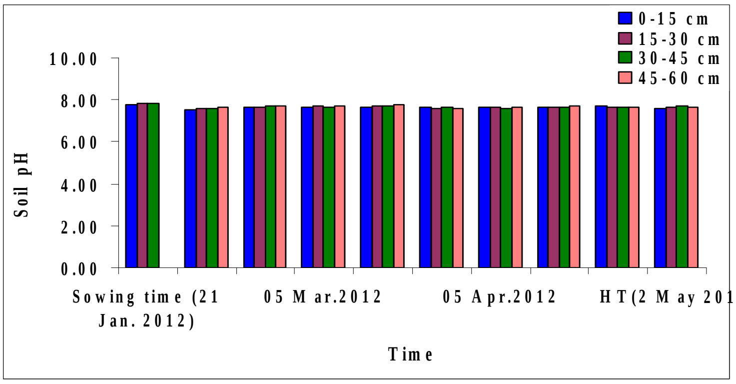


Fig. 36. pH in different depths of soil profile during the total growing period of soybean affected by canal water irrigation

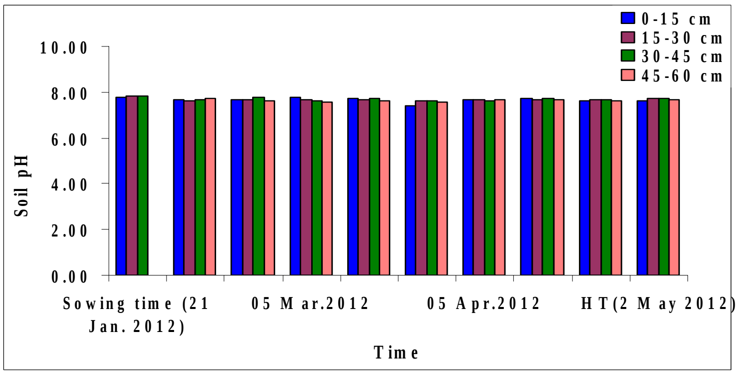


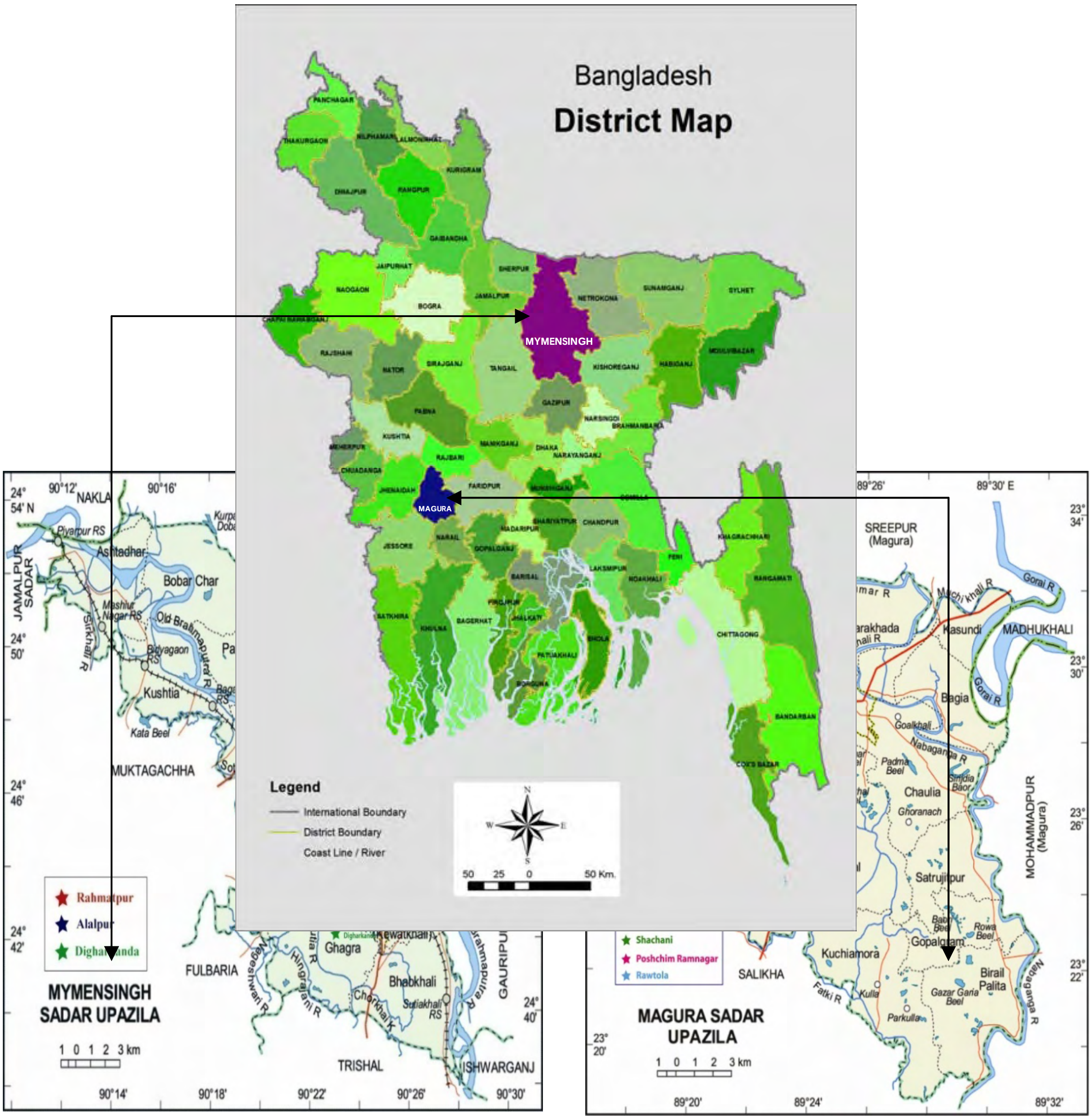
Fig. 37. pH in different depths of soil profile during the total growing period of soybean affected by groundwater irrigation

Water management for enhancing crop production under changing climate (SPGR Funded Project: BINA Component)

Baseline survey in Mymensingh and Magura district

A baseline survey questionnaire was conducted at Mymensingh Sadar, Mymensingh district and Magura Sadar, Magura district for collection of basic information on farmers' socio-economic conditions, existing cropping pattern, cultivated land, irrigation practices and knowledge about climatic change in different experimental site of SPGR sub-project. Digharkanda, Alalpur and Rahmatpur of Mymensingh Sadar Upazila, Mymensingh and Poshchim Ramnagar, Shachani and Rawtola of Magura Sadar Upazila, Magura district were selected for the baseline survey (Fig. 38). Random sampling procedure was followed in the survey. Farmers' details (names and addresses) were collected from Upazila Krishi Office, Mymensingh Sadar, Mymensingh and Magura Sadar, Magura. The farmers were grouped as large (2%), medium (31%), marginal (18%) and small (48%) in three villages for Mymensingh and farmers were grouped as large (4%), medium (26%), marginal (20%) and small farmer (50%) in three villages for Magura. A total of 130 farmers in Mymensingh and 120 farmers in Magura were drawn randomly from the 250 large, medium, marginal and small farmers in Mymensingh and from the 180 large, medium, marginal and small farmers in Magura. Moreover, a reserve list of 50 farmers in Mymensingh and 40 farmers in Magura were maintained in order to minimize the difficulties due to farmers' unavailability or absence during data collection. Thus, the sample size was 130 in Mymensingh and 120 in Magura for the baseline survey. The PIs and Co-PIs prepared a survey questionnaire considering the project theme and actual situation of the study area. Necessary care and attention were given in developing questionnaire in general and the questionnaire was prepared in Bengali for better understanding of the farmers. Later, the project consultant, in a consultative meeting with project coordinator, co-project coordinator and PIs finalized a unified questionnaire for the baseline survey. Assistant Scientific Officer, Scientific Assistant-1 of BINA and Sub-Assistant Agriculture Officer of Upazila Agriculture office conducted face to face interviews from 1st October to 6th October 2011 at Mymensingh and from 16th October to 21st October at Magura (Fig 39). The interviewers collected information within stipulated time frame. In order to get valid and relevant information from the farmers, all possible efforts were made to achieve the purpose of the survey. Whenever any farmer felt difficulty in understanding any question, the interviewer took utmost care to explain and clarify properly. The data collected from the selected farmers were systematically recorded, edited, compiled, tabulated and analyzed. The software MS Excel was used to analyze the data. Descriptive statistical measures such as ranges and percentage distribution were used in describing the variables of the survey.

The age of the selected farmers at Mymensingh Sadar and Magura Sadar ranged from 20 to 75 years and 22 to 75 years, respectively and number of their family members ranged from 1 to 10 and 1 to 8, respectively. The personal educational levels of the farmers at Mymensingh Sadar and Magura Sadar are presented in Table 36. The educational qualification of majority of the farmers ranged from class-I to class-V. The majority of the selected farmers are involved in agriculture as a means of their livelihood. Rest of them are in agriculture and others, and agriculture and business. The occupation pattern of the farmers at Mymensingh Sadar and Magura Sadar are presented in Table 37. Majority of the respondents have their own land and cultivate by self initiatives and homestead both at Mymensingh and Magura Sadar. There is a little fallow land (1%) in both the study area. No fish gher was found in the study area of Magura. Type of land owner and farm size of farmers are presented in Table 38. The percentage shares of the households' and others assets are illustrated in Tables 39-40. There are variations in housing type like half-bricked building, brick building, tin shed house and straw shed and tin made house at Mymensingh Sadar and Magura Sadar. About 50% farmers in both the study area live in tin shed house. About 100% of the household have separate cooking shed. Electricity connection certainly represents the standard of living and capacity of utilizing energy. Eighty six percent of surveyed households at Mymensingh Sadar have access to electric power where as 54% at Magura Sadar. Most of the farmers use self hand tubewell and hygienic latrine in both locations. The loan taken by the farmers from different banks and NGOs are presented in Table 41. Most of the farmers (50-68%) have taken loan from Government Bank; few farmers (12-17%) have taken loan from non-Government Bank and rest of them have taken loan from NGOs/person. The land type of the selected farmers are high land, medium high land, medium low land, low land and very low land (Table 42). Majority of the farmers have medium high land in both the locations. Farmer's yearly income, production cost and net profit from agriculture and non-agriculture sources are presented in Table 43. Farmers yearly income ranged from Tk. 14,000 to Tk. 19,83,000 from agricultural and non-agricultural sources and net profit ranged from Tk. 4,000 to Tk.6,55,000 at Mymensingh Sadar. At Magura Sadar, yearly income ranged from Tk. 3,400 to Tk. 9,22,800 from agricultural and non-agricultural sources and net profit ranged from Tk. 2000 to Tk. 3,42,800. Farmers cropped lands at Mymensingh Sadar and Magura Sadar ranged from 0.01 to 9.06 acres and 0.11 to 6.97 acres, respectively. Majority of the farmers have twice crop-growing land at both Upazila. But there is no thrice crop-growing land at Mymensingh Sadar Upazila (Table 44). The principal cropping patterns followed by the selected farmers are Aman-fallow-Boro (97%) at Mymensingh Sadar and rice-mustard, lentil-jute (71%) at Magura Sadar. But wide variations were found in the cropping patterns at Magura Sadar (Table 45). The most popular varieties in aman and boro season are BR11 and Boroafgi, and BRRI dhan28 and BRRI dhan29, respectively for Mymensingh. Life cycle (transplanting to harvest) of aman and boro rice varied from 110 to 190 and 105 to 190 days, respectively. Aman and Boro rice production varied from 0.12 to 5.75 t ha^{-1} and 2.87 to 8.14 t ha^{-1}, respectively. Majority (88%) of the farmers are informed about the changes of climate. In both the season, they are facing various problems due to climate changes as unavailability of rainfall in peak period, excess rainfall, higher insect and diseases infestation, stagnant growth of rice plant, unavailability of irrigation water due to declining of groundwater table, drought problem, foggy weather, cold wave, water logging, etc due to climate changes. Majority (80%) of the farmers opined that they cultivated aman rice in rainfed condition and rest of the farmers informed that rainfall was not sufficient for aman rice cultivation. So, they met-up their water need by applying supplemental irrigation in aman field. Hundred percent of the farmers were found to depend on irrigation water for Boro rice cultivation. Majority (80%) of the selected farmers reported that they did not apply irrigation water. Rest of the farmers irrigated their land 1 to 3 times and irrigation coverage ranged from 0.01 to 3.22 acres in aman season. Hundred percent of farmers' irrigated their land 9 to 60 times in boro season and irrigated land ranged from 0.01 to 7.85 acres, respectively. Majority (92%) of the farmers opined that they were facing various problems when they applied irrigation water in boro season at Mymensingh Sadar upazila. They faced problems for unavailability of irrigation water due to conflict within the members of the irrigation societies and mechanical disturbance, high price of diesel and electricity, load shedding, irrigation water losses due to earthen canal and unavailability of irrigation water due to depletion of groundwater table. Opinions of the farmers for problems of application of irrigation water in aman and boro seasons are presented below in Table 46. Majority of the selected farmers reported availability of the irrigation system as about normal. The cropped lands were irrigated by self-management and other management. Mainly, those farmers who had STW and LLP, they used to irrigate their lands by self-management. Forty six percent selected farmers at Mymensingh Sadar Upazila used STW irrigation systems while 40% of the farmer used DTW. But 100% selected farmers at Magura Sadar Upazila used STW (Table 47). In respect to farmer's familiarity with advanced water management technology in aman and boro season, majority of the farmers (65 to 73%) opined that they were not familiar with advanced technology and rest of the farmers were familiar with only AWD technology in aman and boro season. Opinions of the farmers for irrigation cost in all seasons are presented in Table 49. In respect to cost of irrigation in aman and boro season it was observed that farmer's opinion were different. Majority of the farmers (52%) opined that the irrigation cost was very high in aman season. On the other hand, 64% farmers informed that the irrigation cost was high in boro season in Mymensingh. But in Magura, majority of the farmers opined that the irrigation cost was very high in aus and Kharif-1 seasons. The irrigation cost varied from Tk. 200 to 800 per bigha i.e. 33 decimal for varied irrigation frequencies in aman and boro season. Sources of irrigation water are given in Table 48. In respect to the source of irrigation water it was observed that most of the farmers used groundwater for crop cultivation. Sometimes farmers lifted groundwater and gathered in the pond. Usually they used their pond (100%) mainly in domestic purpose, fish cultivation and duck farming, etc. There are lots of problems in agricultural development in both the study areas. In respect to problems, farmers' opinions are: High price of electricity, high price of chemical fertilizer, high cost of production but low market price, problems in taking agricultural loan from the scheduled bank, high load shedding, lack of technical knowledge, lack of modern agricultural machinery, unavailability of agricultural labour during the peak season, unfavorable weather, water logging condition, depletion of organic matter in the soil, lack of organized training for the farmers, adulteration of fertilizer and seed, depletion of groundwater table, unavailability of irrigation equipments, and water loss due to earthen canal. To address the said agricultural problems, farmer's opinions were: Per unit electricity and diesel price should be reduced for irrigation use, supply of good seed should be ensured to the farmers without middle men, Government subsidy in respect to seed, fertilizer and agricultural machinery should be increased just to minimize the cost of production, ensure supply of pure fertilizer, market price of the agricultural products should be fixed in accordance with cost of production, remediation of water logging condition in the agricultural land, educate farmer through organizing training on improved practices, innovations and technology, ensuring supply of electricity and implementation of improved water distribution system.



(a) Mymensingh Sadar **(b) Magura Sadar**

Fig. 38. Locations of the study area

Fig. 39. Photographic views of baseline survey

Table 36. Educational qualification of the farmers

Study area	Education level (%)						
	No education	Sign only	1-5 class	6-10 class	SSC	HSC	HSC<
Mymensingh Sadar	18	11	24	22	17	2	6
Magura Sadar	1	1	41	36	16	3	2

Table 37. Present occupational pattern of the farmers

Study area	Occupation (%)		
	Agriculture	Agriculture and others	Agriculture and business
Mymensingh Sadar	89	5	6
Magura Sadar	98	1	1

Table 38. Farm sizes of the farmers

Type of land owner	Mymensingh Sadar		Magura Sadar	
	Farm size (acre)	Percentage (%)	Farm size (acre)	Percentage (%)
Own land under own cultivation	0.01 to 6.04	27	0.08 to 9.76	23
Land taken from other on 'Borga'	0.30 to 5.03	7	0.12 to 3.38	16
Land taken from other on lease	0.10 to 4.13	7	0.15 to 1.39	7
Homestead	0.03 to 0.65	31	0.01 to 1.26	27
Pond	0.02 to 3.52	15	0.07 to 1.39	6
Own land given to others on Borga	0.10 to 5.03	2	0.16 to 6.97	4
Own land given to others on lease	0.10 to 1.61	3	0.18 to 1.92	2
Garden	0.03 to 0.81	5	0.12 to 20.91	14
Fish gher	0.03 to 4.63	2	0.00	0
Fallow land	0.05 to 0.20	1	0.32	1

Table 39. The percentage shares of the households

	Assets name	Mymensingh Sadar	Magura Sadar
Type of House	Half bricked building	28	18
	Brick building	12	3
	Tin shed house	49	59
	Straw shed & tin made house	12	20
Hand Tube well	Self	89	81
	Others	2	0
	Jointly	5	16
	None	4	3
Latrine	Hygienic	89	69
	Non hygienic	11	31
Others	Cooking shed	100	98
	Cow shed	63	92
	Electricity connection	86	54

Table 40. The percentage shares of the others assets

Assets name	Mymensingh Sadar	Magura Sadar
Irrigation pump	49	38
Power tiller	10	6
Thresher	1	24
Plough	2	19
Sprayer	5	33
Fishing net	20	6
Fish trap	2	5
Shop	10	18

Table 41. Farmers received loan from different Bank and NGOs

Study area	Name of the Bank/NGOs					
	Sonali Bank	Bangladesh Agricultural Bank	BRAC Bank	Grameen Bank	AB Bank	NGO/ Person
Mymensingh Sadar	29	21	05	10	02	33
Magura Sadar	0	68	8	4	0	21

Table 42. Land type and size of land of farmers in different location

Land type	Mymensingh Sadar		Magura Sadar	
	Farm size (acre)	Percentage (%)	Farm size (acre)	Percentage (%)
High land	0.01 to 4.23	32	0.12 to 0.70	26
Medium high land	0.01 to 7.53	33	0.14 to 20.91	54
Medium low land	0.01 to 3.62	19	0.11 to 2.83	11
Low land	0.10 to 3.02	1	0.24 to 2.09	8
Very low land/others	0.40 to 3.62	15	0.32 to 1.39	1

Table 43. Farmer's yearly income, productions cost and net profit from agricultural and non-agriculture sources

Sources		Mymensingh Sadar			Magura Sadar		
		Total yearly income (Tk.)	Total production cost (Tk.)	Net yearly profit (Tk.)	Total yearly income (Tk.)	Total production cost (Tk.)	Net yearly Profit (Tk.)
Agricultural	1. Crop	13,040-4,80,600	6,000-3,45,000	4,000-3,15,500	4000-584600	800-1152400	2000-2278400
	2. Livestock	1,000-1,50,000	200-40,000	800-1,25,000	10000-130000	2000-30000	6000-114300
	3. Fisheries	5,000-10,00,000	1200-7,00,000	4,000-3,00,000	4000-5000	1000-3000	200-3000
	4. Poultry	500-33,000	200-1,80,000	200-15,000	500-2000	100-1000	300-2000
	Total (Tk.)	13,040-14,83,000	7,000-8,28,000	4,000-6,55,000	3200-442800	2000-188000	2000-342800
Non-agricultural	1. Agricultural labours	5,000-1,00,000	-	-	2000-5000	-	-
	2. Service	10,000-2,28,000	-	-	10000-180000	-	-
	3. Trade and business	5,000-10,00,000	-	-	2000-10000	-	-
	4. Non-agricultural labours	2,000-75,000	-	-	200-72000	-	-
	5. Others	800-1,20,000	-	-	3500-10000	-	-
Total (Tk.)		800-10,00,000	-	-	2000-480000	-	-
Total yearly income (Tk.) from agricultural and non-agricultural source		14,000-19,83,000	-	-	3400-922800	-	-

Table 44. **Different types of the farmers' crop lands**

Study area	Single crop land		Double crop land		Triple crop land	
	Farm size (acre)	Percentage (%)	Farm size (acre)	Percentage (%)	Farm size (acre)	Percentage (%)
Mymensingh Sadar	0.10 to 8.45	10	0.01 to 9.06	90	-	-
Magura Sadar	0.11 to 3.65	13	0.28 to 6.97	68	0.24 to 3.49	19

Table 45. Existing cropping pattern of the farm

Area	Cropping pattern	Percentage (%)
Mymensingh Sadar	T. aman-Fallow-Boro	97
	T. aman-Fallow-Fallow	1
	Boro-Fallow-Fallow	2
Magura Sadar	T. aman-Mustard, Lentil-Jute	71
	T. aman-Mustard, Lentil-Fallow	17
	Fallow-Mustard, Lentil-Jute	4
	T. aman-Vegetable-Jute	1
	T. aman-Mustard-Boro	1
	T. aman-Wheat-Fallow	2
	Wheat-Fallow-Fallow	2
	Mustard, Lentil	2

Table 46. Opinions of the farmers for problems of application of irrigation water in aman and boro season

Study area	Season	Yes	No
Mymensingh Sadar	Aman	41%	59%
	Boro	92%	8%
Magura Sadar	Aman	48%	52%
	Boro	72%	28%

Table 47. Farmers used irrigation systems

Study area	Irrigation system (%)				
	DTW	STW	LLP	LLP & STW	LLP & DTW
Mymensingh Sadar	40	46	6	2	6
Magura Sadar	0	100	0	0	0

Table 48. Source of irigation water in percentage

Area	Drain Water	Pond water	Rain water	Tubewell water	Other source
Mymensingh Sadar	0.00	0.00	0.00	100	0.00
Magura Sadar	7.56	0.00	0.00	92.00	0.00

Table 49. Opinions of the farmers for irrigation cost in all season

Area	Irrigation cost	Opinions of the farmers in percentage (%)				
		Aman season	Rabi season	Boro season	Aus season	Kharif-1 season
Mymensingh Sadar	Very Costly	52	-	4	-	-
	Costly	28	-	64	-	-
	Medium	7	-	23	-	-
	Reasonable	14	-	9	-	-
Magura Sadar	Very Costly	43	39	53	57	70
	Costly	35	30	29	14	10
	Medium	20	8	9	10	10
	Reasonable	13	23	10	19	10

Studies on long term agro-climatic parameters to assess the change of climate

This study was aimed to know the trend of climate change for the last 30 years (1981-2010) and assess the impact of micro-climatic variations on crop production at two different locations of Bangladesh. Daily agro-climatic parameters like rainfall, maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, wind speed and sunshine duration of Mymensingh, Faridpur and Jessore districts for a period of 30 years (1981-2010) were collected from the Bangladesh Meteorological Department. Daily agro-climatic parameters of Faridpur and Jessore districts were computed by arithmetic mean method for Magura district. Monthly daily agro-climatic parameters were arranged and then reduced to mean. The trend of computed month wise agro-climatic parameters was detected and estimated by MAKESENS trend model. The MAKESENS is a software computer model, which was developed using Microsoft Excel-97 and the macros were coded with Microsoft Visual Basic. MAKESENS performed two types of statistical analyses. First the presence of a monotonic increasing or decreasing trend was tested with the nonparametric Mann-Kendall test and secondly, the slope of a linear trend was estimated with the nonparametric Sen's method. MAKESENS tested the significance levels α were 0.001, 0.01, 0.05 and 0.10. Changes of agro-climatic parameters were calculated based on trend analysis results was as: Agro-climatic parameter = B + Q (Simulation year-Base year). Where, B = the intercept, Q = the slope of the line.

From the results it is observed that agro-climatic parameters changed due to changes of climate and rate of changes and increase or decrease of changes of agro-climatic parameters differed at different times in Mymensingh and Magura district. Maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, rainfall, sunshine duration and wind speed monthly increase, decreases and long time prediction are shown in Table 50-63. It is observed that maximum relative humidity increased at the rate of 0.41% $year^{-1}$ at first decade of March in Mymensingh and 0.14% $year^{-1}$ at third decade of February in Magura. The predicted scenarios of maximum relative humidity is found approximately 100% in the month of October, November, December, January and February in the year of 2020, 2025, 2030 for Mymensingh compared to the present maximum relative humidity. At Magura, the predicted maximum relative humidity is the maximum in January. It is observed that maximum temperature decreased at the rate of 2.78^{o}C year^{-1} at first decade of April and increased at the rate of 2.12^{o}C year^{-1} at second decade of May in Mymensingh district. In Magura district, this rate is 2.1^{o}C at first decade of April and 2.67^{o}C at second decade of May, respectively. Maximum temperature in 2012 was observed 33.59^{o}C at second decade of May and 36.25^{o}C at third decade of April in Mymensingh and Magura districts, respectively. The predicted maximum temperature in the year 2020, 2025 and 2030 are 34.18, 34.54, 34.91^{o}C in Mymensingh and 36.05, 36.38, 36.70^{o}C in Magura at decade of May, respectively. Long term (1981-2010) average annual rainfall are about 2054 mm and 1801mm in Mymesingh and Magura, respectively, while the national average is 2030 mm. Approximately 82% rainfall in Mymensingh and 78% rainfall in Magura occurred in monsoon season (during the months from May to September). It is observed that rainfall decreased at the rate of 4.89 cm year^{-1} in September and increased at the rate of 4.0 cm year^{-1} in June in Mymensingh district while, in Magura district, rainfall decreased at the rate of 0.09 cm year^{-1} in May and increased at the rate of 0.02 cm year^{-1} in July. The predicted maximum rainfall is in June for Mymensingh and in July for Magura in 2020, 2025 and 2030, respectively.

Table 50. Rate of change (% year^{-1}), change from 1981 to 2010 and prediction of maximum relative humidity (%) for different months and decades in Mymensingh district

Months	Rate of change (% year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	0.300 **	0.300 **	0.250 ***	0.276 **	8.70	8.70	7.25	8.01	100.25	98.70	97.74	98.76
February	0.300 ***	0.319 ***	0.331 ***	0.307 ***	8.70	9.24	9.59	8.91	98.25	97.58	97.58	97.62
March	0.412 ***	0.228 ***	0.256 ***	0.304 ***	11.94	6.61	7.43	8.82	98.72	95.66	95.85	96.55
April	0.254 ***	0.245 ***	0.170 **	0.220 ***	7.36	7.11	4.93	6.38	96.05	96.27	94.58	95.71
May	0.125 **	0.041	0.153 ***	0.110 **	3.63	1.19	4.45	3.22	95.25	94.01	96.13	95.21
June	0.100 **	0.071**	0.114 ***	0.100 ***	2.90	2.07	3.31	2.90	96.25	96.05	96.71	96.53
July	0.017	0.147 ***	0.043	0.070 *	0.50	4.27	1.26	2.04	95.68	97.36	95.54	96.44
August	0.143 ***	0.140 ***	0.109 ***	0.114 ***	4.14	4.06	3.16	3.33	96.08	97.01	97.13	96.62
September	0.100 *	0.100 *	0.111 *	0.100 *	2.90	2.90	3.22	2.90	96.90	96.95	97.64	96.83
October	0.129 ***	0.147 ***	0.174 ***	0.138 ***	3.73	4.25	5.05	4.02	98.53	98.83	99.08	98.65
November	0.212 ***	0.225 ***	0.231***	0.211 ***	6.16	6.53	6.71	6.12	99.54	99.73	99.66	99.61
December	0.258 ***	0.217 ***	0.230 **	0.233 ***	7.48	6.28	6.66	6.78	99.59	99.29	98.88	99.45

Predicted maximum relative humidity (%) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	100.00	100.00	99.74	100	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
February	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
March	100.00	97.48	97.90	98.98	100.00	98.62	99.18	100.00	100.00	99.76	100.00	100.00
April	98.08	98.23	95.94	97.47	99.35	99.45	96.79	98.57	100.62	100.68	97.64	99.67
May	96.25	94.34	97.36	96.09	96.88	94.55	98.13	96.65	97.50	94.75	98.89	97.20
June	97.05	96.62	97.63	97.33	97.55	96.98	98.20	97.83	98.05	97.34	98.77	98.33
July	95.82	98.54	95.89	97.00	95.90	99.27	96.11	97.35	95.99	100.01	96.32	97.71
August	97.22	98.13	98.00	97.53	97.94	98.83	98.55	98.11	98.65	99.53	99.09	98.68
September	97.70	97.75	98.53	97.63	98.20	98.25	99.08	98.13	98.70	98.75	99.64	98.63
October	99.56	100.00	100.00	99.76	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
November	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
December	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 51. Rate of change (% year $^{-1}$), change from 1981 to 2010 and prediction of minimum relative humidity (%) for different months and decades in Mymensingh district

Months	Rate of change (% year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	0.230	0.214	0.280 +	0.305 **	6.67	6.20	8.11	8.85	57.32	54.24	51.18	56.89
February	0.033	0.117	0.259	0.107	0.97	3.38	7.52	3.11	47.30	43.97	48.14	47.14
March	0.100	0.263	0.561 **	0.247 **	2.90	7.61	16.26	7.15	41.55	48.36	62.54	50.39
April	0.731 ***	0.426 *	0.033	0.420 **	21.19	12.36	0.97	12.17	69.06	66.72	64.17	66.43
May	-0.133	-0.262 *	-0.033	-0.120	-3.87	-7.58	-0.96	-3.48	62.83	60.86	70.68	64.84
June	0.013	-0.062	0.000	-0.031	0.36	-1.80	0.00	-0.91	74.51	74.95	76.85	74.86
July	-0.200 +	0.150	-0.248 *	-0.126 *	-5.80	4.35	-7.18	-3.66	74.70	79.18	71.94	74.36
August	-0.115	0.229 +	-0.136	-0.046	-3.35	6.63	-3.95	-1.33	72.43	78.49	73.11	73.47
September	-0.264 +	-0.173	0.000	-0.127 +	-7.65	-5.01	0.00	-3.67	71.27	71.46	74.45	72.71
October	0.124	0.000	0.396 *	0.134 +	3.59	0.00	11.49	3.90	73.30	68.05	68.14	69.53
November	0.155 +	0.305 *	0.238 *	0.195 *	4.48	8.85	6.90	5.65	59.90	59.16	53.98	57.58
December	0.225 *	-0.014	0.051	0.068	6.53	-0.41	1.46	1.97	53.45	49.63	52.68	52.47

Predicted minimum relative humidity (%) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	59.16	55.95	53.42	59.34	60.31	57.02	54.82	60.86	61.46	58.09	56.22	62.39
February	47.57	44.90	50.22	48.00	47.73	45.48	51.51	48.54	47.90	46.07	52.81	49.08
March	42.35	50.46	67.02	52.36	42.85	51.78	69.83	53.60	43.35	53.09	72.63	54.83
April	74.90	70.13	64.43	69.79	78.56	72.26	64.60	71.88	82.21	74.39	64.77	73.98
May	61.77	58.77	70.41	63.88	61.10	57.46	70.25	63.28	60.43	56.15	70.08	62.68
June	74.61	74.46	76.85	74.61	74.68	74.15	76.85	74.45	74.74	73.84	76.85	74.29
July	73.10	80.38	69.96	73.35	72.10	81.13	68.72	72.72	71.10	81.88	67.48	72.09
August	71.51	80.32	72.02	73.10	70.93	81.46	71.34	72.88	70.36	82.61	70.66	72.65
September	69.16	70.08	74.45	71.70	67.84	69.21	74.45	71.07	66.52	68.35	74.45	70.43
October	74.29	68.05	71.31	70.60	74.90	68.05	73.29	71.27	75.52	68.05	75.27	71.95
November	61.14	61.60	55.89	59.14	61.91	63.13	57.08	60.11	62.69	64.65	58.27	61.09
December	55.25	49.51	53.08	53.01	56.38	49.44	53.33	53.35	57.50	49.37	53.59	53.69

Table 52. Rate of change (ºC Year $^{-1}$) change from 1981 to 2010 and prediction of maximum temperature (ºC) for different months and decades in Mymensingh district

Months	Rate of change (ºC Year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	-0.033	-0.034	-0.089 *	-0.047 **	-0.95	-0.99	-2.59	-1.36	23.29	23.51	23.63	23.65
February	-0.001	0.010	0.029	0.014	-0.03	0.29	0.84	0.41	25.73	28.00	28.27	27.39
March	0.010	-0.038	-0.032	-0.020	0.29	-1.09	-0.92	-0.57	29.79	30.44	31.17	30.17
April	-0.096 *	0.003	0.031	-0.006	-2.78	0.08	0.89	-0.19	30.74	31.83	31.96	31.87
May	0.066	0.073 *	-0.025	0.027	1.91	2.12	-0.73	0.80	32.62	33.59	31.35	32.50
June	-0.024	0.022	0.006	0.005	-0.70	0.63	0.17	0.14	30.92	31.93	31.54	31.49
July	0.028	-0.015	0.046 *	0.018	0.82	-0.44	1.34	0.53	31.45	30.98	32.08	31.35
August	0.049 *	-0.047 +	0.025	0.010	1.41	-1.38	0.74	0.30	32.43	30.92	32.03	31.91
September	0.046	0.037	0.025	0.035 +	1.34	1.07	0.72	1.02	32.04	32.23	31.20	31.92
October	0.005	0.029	-0.009	0.006	0.15	0.85	-0.25	0.17	31.71	32.08	30.97	31.51
November	0.027	-0.010	-0.008	0.002	0.77	-0.29	-0.24	0.07	30.98	29.17	28.41	29.50
December	0.001	0.015	0.001	0.007	0.03	0.45	0.02	0.20	27.32	26.39	25.41	26.21

Predicted maximum temperature (ºC) for different years

Month	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	23.03	23.23	22.91	23.28	22.86	23.06	22.47	23.04	22.70	22.89	22.02	22.81
February	25.72	28.08	28.50	27.51	25.72	28.13	28.65	27.58	25.71	28.18	28.79	27.65
March	29.87	30.14	30.91	30.02	29.92	29.95	30.75	29.92	29.97	29.76	30.59	29.82
April	29.98	31.85	32.20	31.82	29.50	31.86	32.36	31.79	29.02	31.88	32.51	31.76
May	33.15	34.18	31.14	32.72	33.48	34.54	31.02	32.86	33.81	34.91	30.89	32.99
June	30.73	32.10	31.59	31.53	30.61	32.21	31.62	31.55	30.49	32.32	31.65	31.58
July	31.68	30.86	32.46	31.49	31.82	30.79	32.69	31.59	31.96	30.71	32.92	31.68
August	32.82	30.54	32.23	31.99	33.06	30.31	32.36	32.04	33.31	30.07	32.48	32.10
September	32.41	32.53	31.40	32.20	32.64	32.71	31.53	32.38	32.87	32.90	31.65	32.55
October	31.75	32.32	30.90	31.56	31.78	32.46	30.86	31.59	31.80	32.61	30.82	31.61
November	31.20	29.09	28.34	29.52	31.33	29.04	28.30	29.54	31.46	28.99	28.26	29.55
December	27.33	26.52	25.42	26.26	27.33	26.59	25.42	26.30	27.34	26.67	25.43	26.33

Table 53. Rate of change (ºC Year $^{-1}$), change from 1981 to 2010 and prediction of minimum temperature (ºC) for different months and decades in Mymensingh district

Months	Rate of change (º C year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	-0.005	0.026	0.011	-0.047 **	-0.15	0.76	0.31	-1.36	11.91	12.17	12.40	12.15
February	0.004	0.033	0.078 *	0.014	0.13	0.96	2.27	0.41	13.88	15.54	17.25	15.47
March	0.078 *	-0.006	0.020	-0.020	2.25	-0.18	0.59	-0.57	17.99	18.69	20.45	19.28
April	0.009	0.017	0.026	-0.006	0.25	0.50	0.76	-0.19	21.96	22.77	22.45	22.55
May	0.042 +	0.044 *	0.006	0.027	1.23	1.28	0.17	0.80	23.58	24.64	24.34	24.21
June	-0.022	0.001	0.017	0.005	-0.63	0.04	0.49	0.14	24.71	25.90	26.40	25.64
July	0.028 **	0.014	0.022 *	0.018	0.81	0.41	0.63	0.53	26.61	26.40	26.47	26.51
August	0.036 **	0.004	0.009	0.010	1.04	0.13	0.26	0.30	27.05	26.43	26.30	26.45
September	0.024 *	0.024 +	0.020	0.035 +	0.69	0.68	0.58	1.02	26.40	26.16	25.55	26.10
October	0.003	0.009	0.000	0.006	0.10	0.25	0.00	0.17	24.75	24.09	21.49	23.31
November	0.018	0.016	-0.001	0.002	0.53	0.46	-0.04	0.07	20.62	18.57	16.21	18.37
December	0.028	0.027	0.009	0.007	0.81	0.77	0.26	0.20	15.15	14.04	12.50	13.73

Predicted minimum temperature (ºC) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	11.87	12.38	12.48	12.23	11.84	12.51	12.54	12.27	11.81	12.64	12.59	12.32
February	13.91	15.81	17.87	15.79	13.93	15.97	18.26	15.98	13.96	16.14	18.65	16.18
March	18.61	18.64	20.61	19.52	19.00	18.61	20.72	19.68	19.39	18.58	20.82	19.83
April	22.03	22.91	22.67	22.70	22.07	23.00	22.80	22.79	22.12	23.08	22.93	22.88
May	23.91	24.99	24.39	24.42	24.13	25.21	24.42	24.56	24.34	25.44	24.44	24.69
June	24.54	25.91	26.53	25.62	24.43	25.92	26.62	25.60	24.32	25.93	26.70	25.59
July	26.83	26.51	26.64	26.68	26.97	26.59	26.75	26.79	27.11	26.66	26.86	26.89
August	27.34	26.47	26.37	26.54	27.51	26.49	26.42	26.59	27.69	26.51	26.46	26.64
September	26.59	26.35	25.71	26.30	26.71	26.47	25.81	26.43	26.82	26.59	25.91	26.55
October	24.78	24.16	21.49	23.33	24.79	24.21	21.49	23.34	24.81	24.25	21.49	23.35
November	20.77	18.70	16.20	18.44	20.86	18.78	16.19	18.48	20.95	18.86	16.19	18.53
December	15.38	14.25	12.57	13.85	15.52	14.39	12.62	13.92	15.66	14.52	12.66	13.99

Table 54. Rate of change (cm Year $^{-1}$), change from 1981 to 2010 and prediction of rainfall (cm) for different months and decades in Mymensingh district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	2.00	16.00	2.50
February	0.333	-0.125	-1.000	-0.40	9.67	-3.63	-29.00	-11.60	18.83	48.13	29.50	6.30
March	-0.857	-2.889 +	1.222	0.00	-24.86	-83.78	35.44	0.00	73.00	36.22	148.22	25.50
April	1.667	0.240	1.600	0.35	48.33	6.96	46.40	10.15	141.17	105.22	142.70	129.15
May	-3.308	1.636	-4.500	-2.20	-95.92	47.45	-130.50	-63.80	85.08	147.45	68.50	303.90
June	-0.640	2.458 +	-1.600	4.00	-18.56	71.29	-46.40	116.00	81.76	120.67	98.70	438.00
July	-1.000	-3.000 +	-0.423	-4.80	-29.00	-87.00	-12.27	-139.20	69.50	45.00	89.73	405.80
August	0.818	-0.786 +	0.000	0.65	23.73	-22.79	0.00	18.96	104.73	9.32	3.00	338.85
September				-4.89	0.00	0.00	0.00	-141.78	0.00	0.00	0.00	218.28
October				0.25	0.00	0.00	0.00	7.25	0.00	0.00	0.00	186.00
November				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
December				0.00 +	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Predicted rainfall (cm) for different years

	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	0.00	2.00	16.00	2.50	0.00	2.00	16.00	2.50	0.00	2.00	16.00	2.50
February	21.50	47.13	21.50	3.10	23.17	46.50	16.50	1.10	24.83	45.88	11.50	-0.90
March	66.14	13.11	158.00	25.50	61.86	-1.33	164.11	25.50	57.57	-15.78	170.22	25.50
April	154.50	107.14	155.50	131.95	162.83	108.34	163.50	133.70	171.17	109.54	171.50	135.45
May	58.62	160.55	32.50	286.30	42.08	168.73	10.00	275.30	25.54	176.91	-12.50	264.30
June	76.64	140.33	85.90	470.00	73.44	152.63	77.90	490.00	70.24	164.92	69.90	510.00
July	61.50	21.00	86.35	367.40	56.50	6.00	84.23	343.40	51.50	-9.00	82.12	319.40
August	111.27	3.04	3.00	344.08	115.36	-0.89	3.00	347.35	119.45	-4.82	3.00	350.62
September	0.00	0.00	0.00	179.17	0.00	0.00	0.00	154.72	0.00	0.00	0.00	130.28
October	0.00	0.00	0.00	188.00	0.00	0.00	0.00	189.25	0.00	0.00	0.00	190.50
November	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
December	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 55. Rate of change (hr Year $^{-1}$), change from 1981 to 2010 and prediction of sunshine duration (hr) for different months and decades in Mymensingh district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	-0.058 *	-0.081 **	-0.053 +	-0.072 ***	-1.68	-2.34	-1.55	-2.10	5.12	4.77	5.59	5.01
February	-0.001	0.001	-0.024	-0.018	-0.02	0.04	-0.70	-0.52	7.07	7.56	7.29	7.00
March	-0.002	-0.039	-0.074 +	-0.036 *	-0.07	-1.12	-2.15	-1.04	7.38	6.99	5.69	6.63
April	-0.022	0.009	0.022	-0.006	-0.63	0.28	0.64	-0.17	6.74	7.24	7.20	7.02
May	0.028		-0.040	0.001	0.81	0.00	-1.17	0.03	7.46	0.00	5.09	6.29
June	-0.054	-0.013	-0.003	-0.018	-1.57	-0.38	-0.08	-0.53	3.68	3.44	3.08	3.48
July	0.036	-0.064 +	0.090 +	0.023	1.04	-1.86	2.62	0.65	3.98	2.31	5.20	4.11
August	0.037	-0.115 +	0.003	-0.017	1.07	-3.34	0.09	-0.50	5.27	2.64	3.79	4.35
September	0.049	0.018	0.008	0.018	1.41	0.52	0.24	0.53	5.02	4.35	4.27	4.68
October	-0.049 +	-0.013	-0.072 +	-0.033 +	-1.43	-0.36	-2.08	-0.95	4.37	6.35	6.55	6.05
November	-0.002	-0.040	-0.030	-0.025	-0.06	-1.16	-0.86	-0.74	7.72	6.88	7.32	7.16
December	-0.044	-0.042	-0.024	-0.045 *	-1.27	-1.22	-0.70	-1.29	7.00	6.48	5.92	6.29

Predicted rainfall (cm) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	4.65	4.12	5.16	4.43	4.36	3.72	4.89	4.07	4.08	3.31	4.63	3.71
February	7.07	7.57	7.10	6.85	7.07	7.58	6.98	6.76	7.06	7.59	6.86	6.67
March	7.36	6.68	5.10	6.34	7.35	6.49	4.73	6.16	7.34	6.30	4.36	5.98
April	6.56	7.31	7.38	6.98	6.46	7.36	7.49	6.95	6.35	7.41	7.60	6.92
May	7.68	0.00	4.77	6.29	7.82	0.00	4.57	6.30	7.96	0.00	4.36	6.30
June	3.24	3.33	3.06	3.33	2.97	3.27	3.05	3.24	2.70	3.20	3.03	3.15
July	4.27	1.79	5.92	4.30	4.45	1.47	6.37	4.41	4.63	1.15	6.83	4.52
August	5.56	1.72	3.82	4.22	5.75	1.15	3.83	4.13	5.93	0.57	3.85	4.04
September	5.41	4.50	4.34	4.82	5.65	4.59	4.38	4.92	5.90	4.68	4.42	5.01
October	3.98	6.25	5.97	5.79	3.73	6.19	5.62	5.63	3.48	6.13	5.26	5.46
November	7.71	6.56	7.08	6.96	7.69	6.36	6.94	6.83	7.68	6.16	6.79	6.71
December	6.65	6.14	5.73	5.93	6.43	5.93	5.60	5.71	6.21	5.72	5.48	5.49

Table 56. Rate of change (m sec $^{-1}$ year $^{-1}$), change from 1981 to 2010 and prediction of wind speed (m sec $^{-1}$) for different months and decades in Mymensingh district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	-0.023 **	-0.019 ***	-0.021 ***	-0.020 ***	-0.66	-0.55	-0.60	-0.59	0.81	0.91	0.78	0.89
February	-0.030 ***	-0.023 **	-0.032 ***	-0.027 ***	-0.87	-0.66	-0.93	-0.79	0.85	1.00	0.86	0.94
March	-0.028 ***	-0.041 ***	-0.042 **	-0.038 ***	-0.82	-1.18	-1.22	-1.10	0.92	0.86	1.22	1.01
April	-0.038 **	-0.051 ***	-0.040 **	-0.046 ***	-1.10	-1.49	-1.16	-1.32	1.37	1.40	1.52	1.40
May	-0.061 ***	-0.048 **	-0.043 **	-0.056 ***	-1.77	-1.39	-1.26	-1.62	1.01	1.26	1.28	1.15
June	-0.046 ***	-0.044 ***	-0.070 ***	-0.055 ***	-1.34	-1.28	-2.03	-1.59	1.16	1.38	1.13	1.18
July	-0.043 ***	-0.045 ***	-0.042 ***	-0.042 ***	-1.26	-1.30	-1.21	-1.22	1.19	1.22	1.22	1.20
August	-0.061 ***	-0.021 *	-0.039 ***	-0.042 ***	-1.78	-0.61	-1.14	-1.22	0.89	1.50	1.03	1.16
September	-0.037 ***	-0.028 **	-0.032 ***	-0.029 ***	-1.06	-0.83	-0.93	-0.84	1.04	1.07	0.96	1.06
October	-0.013	-0.024 ***	-0.011 +	-0.016 **	-0.38	-0.70	-0.33	-0.47	1.11	0.77	0.96	0.96
November	-0.021 ***	-0.013 **	-0.024 ***	-0.021 ***	-0.61	-0.39	-0.70	-0.60	0.74	0.90	0.62	0.75
December	-0.019 ***	-0.021 ***	-0.019 ***	-0.019 ***	-0.55	-0.60	-0.56	-0.57	0.70	0.74	0.70	0.76

Predicted rainfall (cm) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	0.62	0.75	0.61	0.72	0.51	0.66	0.51	0.62	0.40	0.56	0.41	0.52
February	0.61	0.82	0.61	0.72	0.46	0.70	0.45	0.58	0.31	0.59	0.29	0.45
March	0.70	0.54	0.89	0.71	0.55	0.33	0.68	0.52	0.41	0.13	0.47	0.33
April	1.06	0.99	1.20	1.03	0.87	0.73	1.01	0.81	0.68	0.47	0.81	0.58
May	0.52	0.87	0.93	0.71	0.21	0.63	0.71	0.43	-0.09	0.39	0.49	0.15
June	0.79	1.02	0.57	0.75	0.56	0.80	0.22	0.47	0.32	0.58	-0.13	0.20
July	0.84	0.86	0.89	0.86	0.62	0.64	0.68	0.65	0.41	0.42	0.47	0.44
August	0.39	1.33	0.71	0.82	0.09	1.22	0.52	0.61	-0.22	1.12	0.32	0.40
September	0.75	0.84	0.71	0.83	0.56	0.70	0.55	0.68	0.38	0.55	0.39	0.54
October	1.00	0.58	0.87	0.83	0.94	0.46	0.82	0.75	0.87	0.33	0.76	0.67
November	0.57	0.79	0.43	0.58	0.47	0.72	0.31	0.48	0.36	0.65	0.19	0.37
December	0.55	0.57	0.54	0.60	0.46	0.47	0.45	0.50	0.36	0.36	0.35	0.41

Table 57. Rate of change (% Year $^{-1}$), change from 1981 to 2010 and prediction of maximum relative humidity (%) for different months and decades in Magura district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	0.068	0.073^{+}	0.070	0.069	1.97	2.11	2.04	2.00	96.63	96.91	96.44	96.44
February	0.100^{+}	0.077	0.135^{+}	0.109^{+}	2.90	2.24	3.93	3.17	96.53	95.75	96.29	96.11
March	0.079^{+}	0.042	0.080	0.057^{+}	2.28	1.21	2.31	1.66	94.95	93.76	94.48	94.35
April	0.111^{**}	0.090^{+}	0.000	0.052	3.21	2.61	0.00	1.52	95.06	94.69	93.25	94.14
May	-0.042	-0.015	0.023	-0.012	-1.21	-0.43	0.66	-0.35	93.40	93.55	94.38	93.68
June	-0.006	-0.040	-0.050^{**}	-0.034^{+}	-0.17	-1.16	-1.45	-0.99	94.73	94.91	95.33	95.01
July	-0.037^{*}	-0.011	-0.070^{***}	-0.046^{**}	-1.09	-0.31	-2.04	-1.33	95.70	95.86	95.01	95.21
August	-0.037	0.006	-0.032^{+}	-0.020	-1.07	0.18	-0.92	-0.58	95.02	95.68	95.08	95.24
September	-0.035^{+}	-0.007	-0.021	-0.003	-1.00	-0.19	-0.60	-0.09	95.44	96.22	96.08	96.15
October	0.017	0.009	0.030	0.023	0.48	0.26	0.88	0.67	96.77	96.35	96.64	96.54
November	0.023	0.002	0.042	0.010	0.67	0.07	1.23	0.30	96.19	96.34	96.62	96.33
December	0.038	0.021	0.050	0.042	1.09	0.62	1.44	1.22	96.89	96.31	96.86	96.63

Predicted rainfall (cm) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	97.17	97.49	97.00	96.99	97.51	97.85	97.35	97.33	97.85	98.22	97.70	97.68
February	97.33	96.37	97.38	96.99	97.83	96.76	98.05	97.53	98.33	97.14	98.73	98.08
March	95.58	94.09	95.11	94.80	95.98	94.30	95.51	95.09	96.37	94.51	95.91	95.38
April	95.94	95.41	93.25	94.56	96.49	95.86	93.25	94.82	97.05	96.31	93.25	95.08
May	93.07	93.44	94.56	93.58	92.86	93.36	94.67	93.52	92.65	93.29	94.78	93.46
June	94.69	94.59	94.93	94.74	94.66	94.39	94.68	94.57	94.63	94.19	94.43	94.40
July	95.40	95.78	94.45	94.84	95.21	95.72	94.10	94.62	95.03	95.67	93.74	94.39
August	94.72	95.73	94.83	95.08	94.54	95.77	94.67	94.99	94.35	95.80	94.51	94.89
September	95.17	96.16	95.91	96.12	94.99	96.13	95.81	96.10	94.82	96.10	95.70	96.09
October	96.90	96.42	96.88	96.73	96.98	96.47	97.03	96.84	97.07	96.51	97.18	96.96
November	96.37	96.36	96.96	96.42	96.49	96.38	97.17	96.47	96.60	96.39	97.38	96.52
December	97.19	96.49	97.26	96.97	97.38	96.59	97.51	97.18	97.56	96.70	97.76	97.39

Table 58. Rate of change (% Year $^{-1}$), change from 1981 to 2010 and prediction of minimum relative humidity (%) for different months and decades in Magura district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	-0.006	0.154	0.133	0.081	-0.17	4.46	3.85	2.34	50.07	50.87	47.82	49.35
February	0.050	-0.053	0.002	-0.023	1.45	-1.55	0.06	-0.68	43.60	40.29	38.03	41.93
March	0.019	0.006	0.273	0.102	0.54	0.16	7.91	2.96	35.96	38.12	47.61	42.21
April	0.484*	0.230	-0.205	0.142	14.04	6.67	-5.95	4.11	54.85	52.55	51.28	50.32
May	-0.358*	-0.347**	-0.086	-0.252*	-10.39	-10.06	-2.49	-7.31	51.12	54.19	61.85	55.57
June	-0.104	-0.154	-0.250**	-0.125*	-3.01	-4.47	-7.25	-3.63	65.45	69.88	70.53	69.20
July	-0.100	-0.061	-0.221**	-0.136**	-2.90	-1.76	-6.40	-3.95	74.80	73.92	71.02	72.86
August	-0.250***	0.033	-0.234***	-0.152**	-7.25	0.97	-6.78	-4.41	69.73	74.45	69.86	71.41
September	-0.250**	-0.071	-0.064	-0.108^{+}	-7.25	-2.06	-1.86	-3.14	69.60	69.57	69.60	70.08
October	0.186	-0.017	0.287	0.072	5.40	-0.48	8.32	2.08	71.08	63.12	61.62	63.70
November	0.077	-0.041	0.035	0.027	2.23	-1.18	1.03	0.77	55.40	49.91	48.05	51.76
December	0.075	0.169	-0.009	0.043	2.18	4.90	-0.26	1.23	47.54	51.16	47.39	48.45

Predicted rainfall (cm) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	50.03	52.10	48.88	50.00	50.00	52.87	49.55	50.40	49.97	53.64	50.21	50.81
February	44.00	39.87	38.05	41.75	44.25	39.60	38.06	41.63	44.50	39.33	38.07	41.51
March	36.11	38.17	49.80	43.03	36.21	38.19	51.16	43.54	36.30	38.22	52.52	44.05
April	58.73	54.39	49.64	51.45	61.15	55.54	48.61	52.16	63.57	56.69	47.59	52.87
May	48.25	51.42	61.16	53.55	46.46	49.68	60.73	52.29	44.67	47.95	60.30	51.03
June	64.62	68.65	68.53	68.20	64.10	67.88	67.28	67.58	63.58	67.11	66.03	66.95
July	74.00	73.44	69.25	71.77	73.50	73.13	68.15	71.09	73.00	72.83	67.05	70.41
August	67.73	74.72	67.99	70.19	66.48	74.88	66.82	69.43	65.23	75.05	65.66	68.67
September	67.60	69.00	69.08	69.21	66.35	68.65	68.76	68.67	65.10	68.29	68.44	68.13
October	72.57	62.98	63.91	64.27	73.50	62.90	65.35	64.63	74.43	62.82	66.78	64.98
November	56.01	49.58	48.33	51.97	56.40	49.38	48.51	52.10	56.78	49.18	48.68	52.24
December	48.14	52.51	47.31	48.79	48.51	53.36	47.27	49.01	48.89	54.20	47.22	49.22

Table 59. Rate of change (ºC Year $^{-1}$), change from 1981 to 2010 and prediction of maximum temperature (ºC) for different months and decades in Magura district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	-0.004	0.018	-0.050^{+}	-0.018	-0.10	0.53	-1.45	-0.51	24.40	25.04	24.50	24.85
February	0.015	0.039	0.073*	0.042	0.44	1.12	2.11	1.21	27.20	29.33	31.18	29.10
March	0.037	-0.035	0.021	0.018	1.09	-1.02	0.62	0.53	32.13	32.73	34.46	33.35
April	-0.073^{+}	-0.033	0.058*	0.004	-2.11	-0.97	1.68	0.11	33.67	35.14	36.26	34.97
May	0.044	0.065**	0.005	0.038^{+}	1.28	1.88	0.13	1.09	35.52	35.53	34.54	35.10
June	0.016	0.038	0.048**	0.037*	0.47	1.12	1.38	1.07	34.52	33.42	33.10	33.75
July	0.029^{+}	0.029	0.045***	0.036***	0.85	0.85	1.31	1.05	32.46	32.56	32.71	32.60
August	0.092***	0.004	0.060***	0.052***	2.67	0.13	1.75	1.50	33.90	32.23	33.38	33.12
September	0.065***	0.029	0.010	0.036**	1.89	0.84	0.28	1.05	33.45	33.18	32.68	32.95
October	0.001	0.023	-0.001	0.013	0.04	0.67	-0.02	0.37	32.52	32.74	31.46	32.29
November	0.035	0.037^{+}	0.033*	0.036**	1.02	1.08	0.96	1.05	31.53	30.45	29.13	30.38
December	0.025	-0.001	0.009	0.012	0.72	-0.03	0.26	0.34	27.88	26.40	25.56	26.61

Predicted rainfall (cm) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	24.37	25.19	24.10	24.71	24.35	25.28	23.85	24.62	24.33	25.37	23.60	24.53
February	27.32	29.64	31.76	29.44	27.39	29.84	32.13	29.65	27.47	30.03	32.49	29.85
March	32.43	32.45	34.63	33.49	32.62	32.27	34.74	33.59	32.81	32.10	34.84	33.68
April	33.09	34.87	36.72	35.00	32.73	34.70	37.01	35.02	32.36	34.53	37.30	35.04
May	35.87	36.05	34.57	35.40	36.09	36.38	34.60	35.59	36.31	36.70	34.62	35.78
June	34.65	33.72	33.48	34.05	34.73	33.91	33.72	34.23	34.81	34.11	33.96	34.42
July	32.69	32.79	33.07	32.89	32.84	32.94	33.30	33.07	32.98	33.08	33.53	33.25
August	34.64	32.27	33.86	33.53	35.10	32.29	34.17	33.79	35.56	32.31	34.47	34.05
September	33.97	33.41	32.76	33.24	34.30	33.56	32.81	33.43	34.63	33.70	32.85	33.61
October	32.53	32.93	31.46	32.39	32.53	33.04	31.45	32.46	32.54	33.16	31.45	32.52
November	31.81	30.75	29.40	30.67	31.99	30.93	29.57	30.85	32.16	31.12	29.73	31.03
December	28.07	26.39	25.63	26.71	28.20	26.39	25.68	26.77	28.32	26.38	25.72	26.83

Table 60. Rate of change (°C Year $^{-1}$), change from 1981 to 2010 and prediction of minimum temperature (°C) for different months and decades in Magura district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	-0.037	-0.020	-0.002	-0.036	-1.07	-0.58	-0.05	-1.04	11.09	11.37	12.29	11.16
February	-0.009	0.026	0.096*	0.029^{+}	-0.27	0.77	2.78	0.84	13.35	15.69	18.01	15.26
March	0.050	-0.012	0.061	0.032	1.46	-0.34	1.78	0.94	18.33	19.57	22.30	20.08
April	0.053	0.096*	0.075**	0.066**	1.53	2.78	2.19	1.91	23.78	25.56	24.88	24.57
May	0.063*	0.057*	0.018	0.037**	1.82	1.66	0.53	1.06	25.12	25.88	25.88	25.45
June	-0.004	0.027^{+}	0.034*	0.016	-0.11	0.78	1.00	0.46	25.84	26.33	26.60	26.12
July	0.033*	0.023^{+}	0.017^{+}	0.026*	0.96	0.65	0.49	0.76	26.48	26.52	26.41	26.49
August	0.035**	0.008	0.017	0.017*	1.02	0.22	0.48	0.48	26.57	26.33	26.44	26.38
September	0.021^{+}	0.016^{+}	0.019	0.018^{+}	0.62	0.47	0.54	0.52	26.26	26.00	25.84	25.99
October	0.011	0.031	0.032	0.016	0.32	0.89	0.92	0.46	25.16	24.59	22.63	23.88
November	0.048	0.044	0.042	0.040	1.40	1.28	1.23	1.15	21.33	19.28	17.16	19.30
December	0.024	0.043	0.018	0.010	0.69	1.26	0.51	0.28	14.97	14.05	12.72	13.33

Predicted rainfall (cm) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	10.79	11.21	12.28	10.87	10.61	11.11	12.27	10.69	10.42	11.01	12.26	10.52
February	13.28	15.90	18.78	15.49	13.23	16.03	19.26	15.64	13.18	16.17	19.74	15.78
March	18.73	19.47	22.79	20.34	18.99	19.42	23.10	20.50	19.24	19.36	23.41	20.66
April	24.21	26.32	25.48	25.10	24.47	26.80	25.86	25.43	24.74	27.28	26.24	25.76
May	25.62	26.33	26.02	25.74	25.93	26.62	26.11	25.93	26.25	26.91	26.20	26.11
June	25.81	26.54	26.87	26.25	25.80	26.68	27.04	26.33	25.78	26.81	27.22	26.41
July	26.74	26.70	26.54	26.69	26.90	26.81	26.63	26.82	27.07	26.93	26.71	26.95
August	26.85	26.39	26.58	26.51	27.03	26.43	26.66	26.60	27.21	26.47	26.74	26.68
September	26.43	26.13	25.99	26.13	26.54	26.21	26.08	26.22	26.65	26.29	26.18	26.31
October	25.25	24.83	22.88	24.01	25.31	24.99	23.04	24.09	25.36	25.14	23.20	24.17
November	21.71	19.63	17.50	19.62	21.95	19.85	17.71	19.81	22.20	20.07	17.92	20.01
December	15.16	14.39	12.86	13.41	15.28	14.61	12.95	13.46	15.40	14.83	13.04	13.51

Table 61. Rate of change (cm Year $^{-1}$), change from 1981 to 2010 and prediction of rainfall (cm) for different months and decades in Magura district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.50	0.25	0.00	5.00
February	0.000	0.000	0.000	-0.002	0.00	0.00	0.00	-6.77	1.00	2.00	1.50	14.15
March	0.000	-0.100	-0.239	-0.032*	0.00	-2.90	-6.93	-32.28	2.00	0.45	12.14	22.40
April	-0.036	-0.857*	-2.167*	-0.078*	-1.04	-24.86	-62.83	-101.50	19.41	3.93	15.58	33.25
May	-1.453+	-1.368+	0.250	-0.086*	-42.14	-39.68	7.25	-104.06	23.21	47.54	78.50	136.53
June	1.457	-0.806	-0.813	0.001	42.24	-23.36	-23.56	-14.50	99.82	60.91	97.59	288.00
July	3.306*	1.538+	-1.700	0.022	95.86	44.62	-49.30	142.28	183.28	97.15	75.10	404.86
August	-2.000*	1.750*	-1.667+	-0.063	-58.00	50.75	-48.33	-89.90	55.25	101.63	44.33	215.05
September	-0.318	0.056	0.500	-0.027	-9.23	1.61	14.50	-11.35	62.77	57.47	89.50	217.68
October	1.375	-0.900	0.231	0.015	39.88	-26.10	6.69	46.72	74.38	16.50	15.62	169.91
November	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	6.00	0.50	0.00	8.33
December	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	6.00	0.00	0.00	6.25

Predicted rainfall (cm) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	0.50	0.25	0.00	5.00	0.50	0.25	0.00	5.00	0.50	0.25	0.00	5.00
February	1.00	2.00	1.50	12.28	1.00	2.00	1.50	11.12	1.00	2.00	1.50	9.95
March	2.00	-0.35	10.23	13.50	2.00	-0.85	9.03	7.93	2.00	-1.35	7.84	2.37
April	19.13	-2.93	-1.75	5.25	18.95	-7.21	-12.58	-12.25	18.77	-11.50	-23.42	-29.75
May	11.58	36.59	80.50	107.82	4.32	29.75	81.75	89.88	-2.95	22.91	83.00	71.94
June	111.47	54.47	91.09	284.00	118.75	50.44	87.03	281.50	126.03	46.41	82.97	279.00
July	209.72	109.46	61.50	444.11	226.25	117.15	53.00	468.64	242.78	124.85	44.50	493.17
August	39.25	115.63	31.00	190.25	29.25	124.38	22.67	174.75	19.25	133.13	14.33	159.25
September	60.23	57.92	93.50	214.55	58.64	58.19	96.00	212.60	57.05	58.47	98.50	210.64
October	85.38	9.30	17.46	182.80	92.25	4.80	18.62	190.86	99.13	0.30	19.77	198.91
November	6.00	0.50	0.00	8.33	6.00	0.50	0.00	8.33	6.00	0.50	0.00	8.33
December	6.00	0.00	0.00	6.25	6.00	0.00	0.00	6.25	6.00	0.00	0.00	6.25

Table 62. Rate of change (hr Year $^{-1}$), change from 1981 to 2010 and prediction of sunshine duration (hr) for different months and decades in Magura district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	-0.022	-0.017	-0.036	-0.036	-0.63	-0.48	-1.05	-1.01	6.36	6.63	6.80	6.08
February	-0.001	-0.040	-0.017	-0.017	-0.03	-1.16	-0.49	0.18	7.54	6.10	7.76	7.80
March	0.014	-0.005	-0.023	-0.023	0.41	-0.14	-0.66	-0.16	8.17	7.99	7.08	7.56
April	-0.012	0.017	0.042*	0.042*	-0.35	0.49	1.21	0.57	7.79	8.31	8.66	8.29
May	0.008	-0.011	-0.023	-0.023	0.24	-0.31	-0.66	0.01	7.49	7.90	6.61	7.16
June	-0.046	0.077*	0.039	0.039	-1.34	2.22	1.13	-0.23	5.18	8.59	4.49	4.53
July	0.008	-0.002	0.050	0.050	0.24	-0.06	1.44	0.53	3.46	4.37	5.41	4.24
August	0.074*	-0.068+	0.035	0.035	2.15	-1.97	1.03	0.31	5.98	3.40	5.16	4.85
September	0.057+	-0.045	-0.033	-0.033	1.66	-1.31	-0.94	-0.03	5.37	3.58	4.40	4.60
October	-0.061	-0.071**	-0.060+	-0.060+	-1.76	-2.06	-1.74	-1.31	4.84	4.01	6.32	5.94
November	-0.010	-0.053+	-0.034+	-0.034+	-0.29	-1.54	-0.99	-0.66	7.39	6.14	7.12	7.15
December	-0.035	-0.006	-0.011	-0.011	-1.02	-0.17	-0.33	-0.89	6.85	7.20	6.74	6.48

Predicted rainfall (cm) for different years

Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	6.18	6.50	6.51	5.81	6.07	6.42	6.33	5.63	5.97	6.33	6.15	5.46
February	7.53	5.78	7.63	7.86	7.52	5.58	7.54	7.89	7.51	5.38	7.46	7.92
March	8.28	7.95	6.90	7.51	8.35	7.93	6.78	7.49	8.42	7.90	6.67	7.46
April	7.69	8.44	8.99	8.45	7.63	8.53	9.20	8.54	7.57	8.62	9.41	8.64
May	7.55	7.82	6.43	7.16	7.60	7.76	6.31	7.16	7.64	7.71	6.20	7.16
June	4.82	9.20	4.80	4.47	4.58	9.58	5.00	4.43	4.35	9.96	5.19	4.39
July	3.52	4.36	5.81	4.39	3.57	4.35	6.06	4.48	3.61	4.34	6.31	4.57
August	6.57	2.85	5.44	4.93	6.94	2.52	5.62	4.98	7.31	2.18	5.80	5.04
September	5.83	3.22	4.14	4.59	6.12	2.99	3.97	4.59	6.40	2.77	3.81	4.58
October	4.35	3.45	5.84	5.58	4.05	3.09	5.54	5.35	3.75	2.74	5.24	5.13
November	7.31	5.72	6.85	6.97	7.26	5.45	6.68	6.85	7.21	5.19	6.51	6.74
December	6.57	7.15	6.65	6.23	6.40	7.12	6.60	6.08	6.22	7.09	6.54	5.93

Table 63. Rate of change (m sec $^{-1}$ year $^{-1}$), change from 1981 to 2010 and prediction of wind speed (m sec $^{-1}$) for different months and decades in Magura district

Months	Rate of change (cm year $^{-1}$)				Change from 1981 to 2010				Present value in 2012			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	-0.025	-0.052***	-0.013	-0.027*	-0.74	-1.51	-0.39	-0.80	2.67	2.25	3.14	2.67
February	-0.034^{+}	-0.019	-0.044^{+}	-0.036**	-0.98	-0.55	-1.27	-1.05	2.78	3.39	3.28	3.07
March	-0.028^{+}	-0.075**	-0.037	-0.038**	-0.81	-2.17	-1.08	-1.11	3.77	3.36	4.57	3.79
April	-0.064^{+}	-0.071	-0.052^{+}	-0.061*	-1.85	-2.07	-1.49	-1.77	4.67	4.66	5.46	5.19
May	-0.092**	-0.036	-0.036	-0.047*	-2.67	-1.04	-1.05	-1.36	4.44	5.37	5.23	4.99
June	-0.064*	-0.062^{+}	-0.073**	-0.070**	-1.86	-1.80	-2.11	-2.03	4.26	4.56	4.08	4.37
July	-0.076***	-0.063*	-0.057**	-0.073***	-2.21	-1.82	-1.66	-2.13	3.81	4.35	4.26	4.20
August	-0.071***	-0.075***	-0.052***	-0.068***	-2.07	-2.16	-1.52	-1.96	3.92	3.94	4.03	3.86
September	-0.060***	-0.068*	-0.052^{+}	-0.053**	-1.74	-1.96	-1.51	-1.54	3.70	3.20	3.21	3.50
October	-0.046	-0.063**	-0.035^{+}	-0.047**	-1.34	-1.82	-1.01	-1.37	2.63	1.89	2.14	2.18
November	-0.072	-0.058**	-0.075***	-0.069***	-2.10	-1.67	-2.19	-2.00	1.27	1.52	1.06	1.11
December	-0.088	-0.075***	-0.037*	-0.064***	-2.55	-2.18	-1.07	-1.85	0.65	1.23	2.05	1.44
Predicted rainfall (cm) for different years												
Months	2020				2025				2030			
	FD	SD	TD	Monthly	FD	SD	TD	Monthly	FD	SD	TD	Monthly
January	2.47	1.83	3.04	2.45	2.34	1.57	2.97	2.31	2.21	1.31	2.90	2.18
February	2.51	3.24	2.93	2.78	2.34	3.14	2.71	2.60	2.18	3.05	2.49	2.42
March	3.54	2.76	4.27	3.49	3.40	2.38	4.09	3.29	3.26	2.01	3.90	3.10
April	4.16	4.09	5.04	4.71	3.84	3.74	4.79	4.40	3.52	3.38	4.53	4.10
May	3.70	5.09	4.94	4.61	3.24	4.91	4.76	4.38	2.78	4.73	4.58	4.15
June	3.75	4.07	3.50	3.80	3.43	3.76	3.14	3.45	3.11	3.45	2.78	3.10
July	3.20	3.84	3.80	3.61	2.82	3.53	3.52	3.25	2.44	3.21	3.23	2.88
August	3.35	3.34	3.61	3.32	2.99	2.97	3.35	2.98	2.63	2.59	3.09	2.64
September	3.22	2.66	2.80	3.07	2.92	2.32	2.54	2.81	2.62	1.98	2.28	2.54
October	2.27	1.39	1.86	1.80	2.03	1.07	1.69	1.57	1.80	0.76	1.51	1.33
November	0.70	1.05	0.45	0.56	0.33	0.77	0.08	0.21	-0.03	0.48	-0.30	-0.13
December	-0.05	0.63	1.75	0.93	-0.49	0.25	1.57	0.61	-0.93	-0.12	1.38	0.29

The symbol ***, **, * and + indicate significance at levels α were 0.001, 0.01, 0.05 and 0.10, respectively.

FD, SD, TD, means first decade second decade and third decade, respectively.

Studies on irrigation schedules of rice and non-rice crops for optimum yield and water use

The objectives of this experiment was to make the effective use of profile soil moisture for the cultivation of Rabi crops with minimum supplemental irrigation, effective utilization of water resources (surface water, rainfall and ground water), determine critical stages, time and amount of irrigation need for optimum yield and increased water use efficiency of different crops, and identify and recommend most profitable cropping pattern for the area. Digharkanda, Alalpur and Rahmatpur of Mymensingh Sadar Upazilla, Mymensingh and Ramnagar, Rautola and Sachani of Magura Sadar Upazilla, Magura were selected for different on-farm experiments. Three cropping patterns i.e., T. aman – Fallow –Boro, T. aman–Mustard – Boro and T. aman-Wheat-T. aus for Mymensingh district, and T. aman – Lentil – Sesame, T. aman – Mustard – Mungbean and T. aman-Chickpea-Jute for Magura district were followed. In all the cropping patterns, T. aman rice (popular varieties) was transplanted on July. All the cultural practices were followed and data were collected and recorded as per need. According to all the cropping patterns, T. aman experiments were conducted under normal and rain fed condition in Mymensingh and Magura districts and all cultural practices were followed as per need. Binadhan-7 was harvested on last week of October 2011 and Binadhan-4 was harvested on second week of November 2011. At the harvest time, necessary yield and meteorological data were collected and analyzed.

After T. aman harvest, mustard and wheat seeds were sown on 5th and 20th November 2011 in Mymensingh district and lentil, mustard and chickpea seeds were sown on 15th November 2011 in Magura district. The experimental design was RCBD with split plot arrangement of the treatments, having irrigation treatments in main plots and mustard varieties in sub-plots. In mustard experimental plots, irrigation treatments were: T_1 = Irrigation at vegetative stage up to field capacity; T_2 = Irrigation at vegetative stage and flowering stage up to field capacity and T_3 = Irrigation at vegetative stage, flowering stage and pod development stage up to field capacity. The varieties were: V_1 = Binasarisha-3; V_2 = Binasarisha-4 and V_3 = BARI Sarisha-15. In wheat experimental plot, irrigation treatments were: T_1 = Irrigation at CRI stage up to field capacity ; T_2 = Irrigation at CRI stage and maximum tillering stage up to field capacity and T_3 = Irrigation at CRI stage, maximum tillering stage and booting and heading stage up to field capacity. The wheat varieties were: V_1 = Bijoy; V_2 = Prodip and V_3 = BARI Gom-26. In lentil experimental plots, irrigation treatments were T_1 = Irrigation at vegetative stage up to field capacity, T_2 = Irrigation at vegetative stage and flowering stage up to field capacity and T_3 = Irrigation at vegetative stage, flowering stage and pod development stage up to field capacity. The varieties were: V_1 = Binamasur-2; V_2 = BARI Masur-5 and V_3 = Binamasur-6. In chickpea experimental plots, irrigation treatments were T_1 = Irrigation at vegetative stage up to field capacity, T_2 = Irrigation at vegetative stage and flowering stage up to field capacity and T_3 = Irrigation at vegetative stage, flowering stage and pod development stage up to field capacity. The varieties were: V_1 = Binasola-4; V_2 = Binasola-5 and V_3 = BARI Sola-5. Irrigation water was applied up to field capacity as per treatment. Soil moisture was measured by gravimetric method up to 60 cm for every 15 cm increments at the time of sowing, before and after irrigation and at harvest time. Other cultural practices were followed as and when necessary. BARI Sarisa-15, Binasarisa-4 and Binasarisa-3 were harvested on 28th January and 5th February 2012, respectively. Binamasur-2, BARI Masur-5 and

Binamasur-6 were harvested on 6th March 2012. Binasarisa-3, Binasarisa-4 and BARI Sarisa-15 were harvested on, 21st February 2012, 19th February 2012 and 12th February 2012 respectively. Binasola-4, Binasola-5 and BARI Sola-5 were harvested on 27th March 2012 and wheat was harvested on 18th March 2012.

After mustard and wheat harvest, boro rice and transplanted aus rice were transplanted in Mymensingh. In T. aman–Fallow–Boro cropping pattern, boro rice was transplanted on 17th January 2012 and harvested on 25th April to 11th May 2012. In T. aman–Mustard–Boro cropping pattern, boro rice was transplanted on 11th February 2012 and harvested on 8th to 18th May 2012. In all the rice experiments, main plot treatments were T_1 = Continuous ponding 3-5 cm, T_2 = AWD 20 cm, T_3 = AWD 30 cm and T_4 = AWD 40 cm. Popular boro rice varieties were V_1 = Binadhan-5, V_2 = Binadhan-7 and V_3 = BRRI dhan28. All cultural practices were done as per recommendation. In T. aman-Wheat-T. aus cropping pattern, T. aus rice was transplanted on 9th April 2012 and harvested on 1th September 2012. In all the rice experiments, main plot treatments were T_1 = Continuous ponding 3-5 cm, T_2 = AWD 20 cm, T_3 = AWD 30 cm and T_4 = AWD 40 cm. Popular T. aus rice varieties were V_1 = BR26 and V_2 = BRRI dhan 48. All cultural practices were done as per recommendation. All agronomic data were collected at the harvest time. After lentil, mustard and chickpea harvest, sesame and mungbean seeds were sown on 20th March 2012 and jute seed was sown on 5th April 2012 in Magura districts according to cropping pattern T. aman–Lentil–Sesame, T. aman–Mustard–Mungbean and T. aman– Chickpea – Jute. The experimental design was split plot having irrigation treatments in main plots and varieties in subplots. In mungbean experimental plot, irrigation treatments were T_1 = Irrigation at vegetative stage up to field capacity, T_2 = Irrigation at vegetative stage and flowering stage up to field capacity and T_3 = Irrigation at vegetative stage, flowering stage and pod development stage up to field capacity. The varieties were: V_1 = Binamoog-5; V_2 = Binamoog-8 and V_3 = Barimoog-5. In sesame experimental plot, irrigation treatments were T_1 = Irrigation at vegetative stage up to field capacity, T_2 = Irrigation at vegetative stage and flowering stage up to field capacity and T_3 = Irrigation at vegetative stage, flowering stage and pod development stage up to field capacity. The varieties were: V_1 = Binatil-1; V_2 = Binatil-2 and V_3 = BARI Til-3. In jute experimental plot, irrigation treatment were T_1 =No supplementary irrigation, T_2 = Irrigation at vegetative stage up to field capacity and T_3 = Irrigation at fiber development stage up to field capacity. The variety was Bonkim. Binamoog-8, Binamoog-5 and BARI Moog-5 were harvested on 31st May 2012, 1st June 2012 and 10th June 2012, respectively. Sesame was harvested on 10th May 2012 and jute was harvested on 4th August 2012. All the cultural practices were done as per recommendation. All agronomic data were collected at the harvest time. Meteorological data (maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, sunshine hour, and rainfall) were also collected. Effective rainfall was determined by FAO method: Re = 0.8 × R-25 mm when R>75 mm month^{-1}; Re = 0.6 × R-0 mm when R<75 mm month^{-1}. Irrigation water productivity kg ha^{-1}cm^{-1} was calculated as the ratio of yield and irrigation water.

From the experimental findings, it was found that Binadhan-7 was harvested on last week of October 2011 completing their life cycle within 113 to 116 days and soil moisture was about 40% by volume (Table 64). Yield of Binadhan-7 was found about 5.06 to 6.38 t ha^{-1}. On the other hand, Binadhan-4 was harvested on 2nd week of November 2011 by completing its life cycle 127 to 131 days i.e. just two weeks later than the Binadhan-7 and soil moisture was 30% by volume. Yield of Binadhan-4 varied from 6.30 to 6.64 t ha^{-1} at different locations. Profiles of agro-meteorological parameters during the growing period of T. aman are presented in Table 65. It was observed that about 28.49, 74.10, 23.95 and 1.71 cm rainfall occurred in July, August, September and October, respectively. During the growing period of T. aman, maximum temperature varied from 27.5 to 36.5°C and minimum temperature was 26.5 to 20°C, respectively. The average maximum and minimum relative humidity varied from 92 to 100% and 41 to 92%, respectively. Sunshine hour varied from 3.55 to 7.39 hours, respectively.

Mean effect of irrigation and varieties on yield and yield attributing characters of mustard at Mymesingh sadar upazila is presented in Table 66. Irrigation treatments had no significant effect on yield attributing characters of mustard except plant height but varieties had significant effect on plant height, pod length, number of seeds per pod, 1000 seed wt, seed yield and straw yield of mustard. The highest seed yield was obtained from T_2 treatment which received two irrigations and Binasarisha-3 produced the highest yield (1726.80 kg ha^{-1}) followed by Binasarisha-4 and BARI Sarisha-15, respectively (Table 66). Interaction effect of treatments and varieties on yield and yield attributing characters of mustard at Mymesingh sadar upazila are presented in Table 67. The highest yield was obtained 1871.25 kg ha^{-1} in treatment T_2V_1 and the lowest was 1299.87 kg ha^{-1} in treatment T_3V_3. Higher water use efficiency was also found in T_2 treatment (Table 68). Profiles of agro-meteorological parameters during the growing period of mustard in Mymensingh are presented in Table 69. It was observed that about 1.8 cm rainfall was occurred in January and no rainfall occurred in November, December and February. During the growing period of mustard, maximum temperature varied from 31.7 to 25.2°C and minimum temperature 14 to 9.4°C, respectively. The average maximum and minimum relative humidity varied from 99 to 100% and 71.97 to 83.58%, respectively. Sunshine hour varied from 4.66 to 7.51 hours, respectively. Irrigation treatment had no significant effect on wheat yield and no varietals yield differences was observed (Table 70-71). The highest water use efficiency was observed in T_1 treatment where only one irrigation was applied at crown root initiation stage (Table 72). Profiles of agro-meteorological parameters during the growing period of wheat are presented in Table 73. It was observed that about 1.92 cm rainfall was occurred in January and March and no rainfall occurred in November, December and February. During the growing period of wheat, maximum temperature varied from 19.0 to 32.5°C and minimum temperature 8.0 to 22.0°C, respectively. The average maximum and minimum relative humidity varied from 99 to 100% and 71.97 to 83.58%, respectively. Sunshine hour varied from 4.66 to 7.51 hours, respectively.

Mean effect of irrigation and varieties on yield and yield attributing characters of boro (T. aman-Fellow-Boro) rice at Mymesingh sadar upazila are presented in Table 74. Highest yield of 6.18 tha^{-1} and 5.84 t ha^{-1} was obtained in treatment T_1 (continuous ponding) and variety V_1 (Binadhan-7), respectively. Interaction effect of treatment and varieties on yield and yield attributing characters of boro rice at Mymesingh sadar upazila are presented in Table 75. Highest yield of 6.54 t ha^{-1} was obtained in treatment T_1V_1 and lowest of 5.12 t ha^{-1} was obtained in treatment T_4V_1. The total water inputs (rainfall and irrigation) ranged from 107.45 cm to 70.93 cm (Table 76). To maintain continuous standing water, maximum irrigation water needed was 107.45 cm, but in AWD treatments 87.92 cm (applying irrigation when AWD 20 cm), 78.09 cm (applying irrigation when AWD 30 cm) and 70.93 cm (applying irrigation when AWD 40 cm) was applied. Due to applying AWD method it was found that yield of rice decreased in other treatments over treatment T_1. About 4.21, 10.52 and 13.59 percent yield was decreased in treatment T_2, T_3 and T_4 over T_1, respectively.

Mean effect of irrigation and varieties on yield and yield attributing characters of boro rice (T. aman-Mustard-Boro) at Mymesingh sadar upazila are presented in Table 77. Highest yield was obtained 6.10 t ha^{-1} and 5.54 t ha^{-1} in treatment T_1 (continuous ponding) and variety V_1 (Binadhan-7), respectively. Interaction effect of treatment and varieties on yield and yield attributing characters of boro rice at Mymesingh sadar upazila are presented in Table 78. Highest yield was obtained 6.37 t ha^{-1} in treatment T_1V_1 and lowest was 4.48 t ha^{-1} in treatment T_4V_1. The total water inputs (rainfall and irrigation) ranged from 109.26 cm to 68.76 cm in Table 79. To maintain continuous standing water, maximum irrigation water needed was 109.26 cm, but in AWD treatments 85.91 cm (applying irrigation when AWD 20 cm), 77.22 cm (applying irrigation when AWD 30 cm) and 68.76 cm (applying irrigation when AWD 40 cm) was applied. Due to applying AWD method it was found that yield of rice decreased in other treatments over treatment T_1. About 5.72, 14.22 and 20.92 percent yield was decreased in treatment T_2, T_3 and T_4 over T_1, respectively.

Mean effect of irrigation and varieties on yield and yield attributing characters of T. aus rice at Mymesingh sadar upazila are presented in Table 80. Highest yield was obtained 1.59 t ha^{-1} and 1.5 t ha^{-1} in treatment T_1 (continuous ponding) and variety V_1 (BR-26), respectively. Interaction effect of treatment and varieties on yield and yield attributing characters of T. aus rice at Mymesingh sadar upazila are presented in Table 81. Highest yield of 1.53 tha^{-1} was obtained in treatment T_3V_1 and lowest of 1.33 t ha^{-1} was obtained in treatment T_3V_2. Due to applying AWD method it was found that yield of rice decreased in other treatments over treatment T_1. About 4.40, 8.18 and 11.32 percent yield was decreased in treatment T_2, T_3 and T_4 over T_1, respectively (Table 82).

In Magura district, average profile soil moisture was found 41% by volume at the harvest time. It also showed that yield of Binadhan-7 was found about 5.6 to 7.5 t ha^{-1} in different locations of Magura district (Table 83). From meteorological data it was observed that there was total 46.5 cm effective rainfall during the crop growing period (Fig. 40). Maximum temperature varied from 28 to 38.8^oC and minimum temperature varied from 19 to 34.4^oC. Average temperature varied from 31.30 to 34.2^oC (Table 84). Average relative humidity varied from 78.51% to 84.27%. Average sunshine hour was 3.22 hours up to 32 DAT and increased to 5.92 hours on last 28 DAT (Fig. 41).

Mean effect of irrigation and varieties on yield and yield attributing characters of lentil at Magura sadar upazila was presented in Table 85. Irrigation treatments had no significant effect on yield attributing characters of lentil except plant height but varieties had significant effect on seed yield of lentil. Highest seed yield was obtained from T_1 treatment which received one irrigation and Binamasur-6 produced highest yield (1699.04 kg ha^{-1}). Profiles of agro-meteorological parameters during the growing period of lentil are presented in Table 87. It was observed that about 5.7 cm rainfall occurred in January and no rainfall occurred in November, December and February. During the growing period of lentil, maximum temperature varied from 35.9 to 14.8°C and minimum temperature 19 to 6°C, respectively. The average relative humidity varied from 99 to 63%. Mean effect of irrigation and varieties on yield and yield attributing characters of mustard at Magura sadar upazila was presented in Table 88. Irrigation treatments had significant effect on plant height, seed per plot and seed yield of mustard and varieties had significant effect on plant height, seed per pod, branch per plant and seed yield of mustard. Highest seed yield was obtained from T_2 treatment which received two irrigation and Binasarisa-3 produced highest yield (1911.95 kg ha^{-1}). Profiles of agro-meteorological parameters during the growing period of mustard are presented in Table 90. It was observed that about 5.7 cm rainfall occurred in January and no rainfall occurred in November, December and February. During the growing period of mustard, maximum temperature varied from 32.5 to 14.8°C and minimum temperature was 19 to 6.1°C, respectively. The average relative humidity varied from 98 to 65%.

Mean effect of irrigation and varieties on yield and yield attributing characters of chickpea at Magura sadar upazila is presented in Table 91. Irrigation treatments had significant effect on grain yield and straw yield of chickpea and varieties had significant effect on seed per pod and seed yield of chickpea. Highest seed yield was obtained from T_1 treatment which received one irrigation and Binasola-5 produced highest yield (1663.20 kg ha^{-1}). Profiles of agro-meteorological parameters during the growing period of mustard are presented in Table 93. It was observed that about 5.7 cm rainfall occurred in January and no rainfall occurred in November, December February and March. During the growing period of chickpea, maximum temperature varied from 37 to 14.8°C and minimum temperature was 21.8 to 6.1°C, respectively. The average relative humidity varied from 98 to 61%. Mean effect of irrigation and varieties on yield and yield attributing characters of sesame at Magura sadar upazila was presented in Table 94. Irrigation treatments had significant effect on seed yield of sesame and varieties had significant effect on branch per plant, seed per pod and seed yield of sesame. Highest seed yield was obtained from T_2 treatment which received two irrigation and Binatil-2 produced highest yield (2100 kg ha^{-1}). Profiles of agro-meteorological parameters during the growing period of sesame are presented in Table 95. It was observed that about 46.44 cm rainfall occurred in April to June and no rainfall occurred in March. One irrigation at T_2 at vegetative stage was applied. Due to excessive rainfall T_3 treatment was not applied. During the growing period of sesame, maximum temperature varied from 39.9 to 29.0°C and minimum temperature was 28.7 to 16.8°C, respectively. The average relative humidity varied from 84.18 to 63.02%.

Mean effect of irrigation and varieties on yield and yield attributing characters of mungbean at Magura sadar upazila is presented in Table 96. Irrigation treatments had significant effect on seed yield of mungbean and varieties had significant effect on plant height and seed yield of mungbean. Highest seed yield was obtained from T_2 treatment which received two irrigation and Binamoog-8 produced highest yield (1327 kg ha^{-1}). Profiles of agro-meteorological parameters during the growing period of mungbean are presented in Table 97. It was observed that about 20.54 cm rainfall occurred in April to May and no rainfall occurred in March. One irrigation was applied in T_2 at vegetative stage. Due to excessive rainfall irrigation was not applied in T_3 treatment. During the growing period of mungbean, maximum temperature varied from 32.5 to 14.8°C and minimum temperature varied from 19 to 6.1°C, respectively. The average relative humidity varied from 76.21 to 63.02%. Mean effect of irrigation and varieties on yield and yield attributing characters of jute at Magura sadar upazila was presented in

Table 98. Irrigation treatments had significant effect on plant height, fiber weight and stick weight of jute. Highest fiber weight was obtained from T_2 treatment which received one irrigation produced highest fiber weight 6.77 t ha^{-1} (Table 98). Profiles of agro-meteorological parameters during the growing period of jute are presented in Table 99. It was observed that about 61.51cm rainfall occurred in April to August (Table 99). One irrigation was applied in T_2 at vegetative stage. Due to excessive rainfall irrigation was not applied in T_3 treatment. During the growing period of jute, maximum temperature varied from 39.9 to 28.4^{o}C and minimum temperature from 29 to 21.4^{o}C, respectively. The average relative humidity varied from 84.27 to 70.32%.

Table 64. Life cycle, yield and yield attributing characters of Binadhan-7 and Binadhan-4 at different locations of Mymensingh Sadar Upazilla

T. aman rice varieties	Locations	Life cycle (days)	Plant height (cm)	Tiller (no.)	Panicle length (cm)	Seed $panicle^{-1}$	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Binadhan-7	Rahamatpur	113	97.17	14.00	25.85	129.35	6.38	11.90
	Digharkanda	116	102.00	11.50	18.50	169.25	5.85	20.76
	Alalpur	113	101.50	12.50	24.91	121.61	5.06	6.46
Binadhan-4	Rahamatpur	127	132.60	8.80	27.10	136.45	6.30	31.21
	Digharkanda	127	131.83	14.50	29.00	199.50	6.64	30.62
	Alalpur	131	133.33	14.85	29.78	216.32	6.57	29.58

Table 65. Profiles of agro-meteorological parameters during the growing season of T. aman rice (Binadhan-7 and Binadhan-4) at Mymensingh Sadar Upazila

Months	Rain-fall (cm)	Maximum temperature (°C)		Minimum temperature (°C)		Sun shine (hour)	Relative humidity (%)		
		Range	Ave.	Range	Ave.		Max.	Min.	Ave.
July	28.49	34.5-28.0	31.69	28.0-24.0	26.15	3.55	97-94	90-63	86.55
August	74.10	35.5-28.2	31.32	29.2-24.8	28.80	3.85	99-93	92-51	86.94
September	23.95	36.5-27.5	32.17	27.2-24.5	26.08	5.70	99-92	92-55	84.43
October	1.71	35.0-29.0	32.34	26.5-20.0	23.78	7.39	100-94	76-53	76.45
November	0.00	31.7-25.5	28.75	20.4-15.0	16.87	7.00	100-97	69-41	82.23

Table 66. Mean effect of irrigation and varieties on yield and yield attributing characters of mustard at Mymesingh Sadar Upazila

Treatment	Plant height (cm)	Branch $plant^{-1}$ (no.)	Pod length (cm)	Pods $plant^{-1}$ (no.)	Seeds pod^{-1} (no.)	1000 seed wt. (gm)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	93.46	5.59	5.94	81.35	26.76	3.38	1484.93	1576.11
T_2	98.32	5.67	5.75	78.14	25.68	3.45	1587.29	1663.82
T_3	94.30	5.87	5.78	82.61	26.68	3.47	1503.33	1613.75
$LSD_{0.05}$	3.71	NS	NS	NS	NS	NS	NS	NS
V_1	93.33	4.88	6.54	75.97	27.51	3.77	1726.80	1790.41
V_2	93.02	6.08	6.70	81.77	28.31	3.95	1637.50	1798.26
V_3	99.73	6.18	4.23	84.36	23.31	2.58	1211.25	1265.00
$LSD_{0.05}$	3.71	NS	0.43	NS	2.73	0.25	216.2	248.50

Table 67. Interaction effect of treatment and varieties on yield and yield attributing characters of mustard at Mymensingh Sadar Upazila

Treatment	Plant height (cm)	Branch plant^{-1} (no.)	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000 seed wt. (gm)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1V_1	90.80 c	5.64	6.80 a	86.80	27.06 abc	3.76 a	1620.00 ab	1805.21 a
T_1V_2	89.53 c	5.26	6.63 a	76.13	28.80 a	3.87 a	1650.41 a	1678.75 ab
T_1V_3	100.06 ab	5.88	4.40 b	81.12	24.44 abc	2.50 b	1184.37 c	1244.37 b
T_2V_1	96.33 bc	4.33	6.36 a	64.47	26.00 abc	3.71 a	1871.25 a	1863.96 a
T_2V_2	95.20 bc	6.19	6.86 a	76.06	27.93 ab	4.02 a	1653.12 a	1877.91 a
T_2V_3	103.43 a	6.50	4.03 b	93.91	23.11 bc	2.63 b	1237.51 bc	1249.58 b
T_3V_1	92.86 c	4.66	6.46 a	76.66	29.46 a	3.84 a	1689.16 a	1702.08 ab
T_3V_2	94.33 bc	6.80	6.60 a	93.13	28.20 ab	3.95 a	1608.96 bc	1838.12 a
T_3V_3	95.70 bc	6.16	4.27 b	78.05	22.39 c	2.61 b	1299.87 c	1301.04 b

Table 68. Amount of irrigation water requirement and water productivity of mustard at Mymensingh Sadar Upazila

Treatments	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion (cm)	Water requirement (cm)	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} cm^{-1})
T_1	2.44	1.8	9.12	13.36	1484.93	111
T_2	3.56	1.8	5.98	11.34	1587.29	140
T_3	3.56	1.8	5.44	10.8	1503.33	139

Table 69. Profiles of agro-meteorological parameters during the growing season of mustard at Mymensingh Sadar Upazila

Months	Rain-fall (cm)	Maximum temperature (°C)		Minimum temperature (°C)		Sun shine (hour)	Relative humidity (%)		
		Range	Ave.	Range	Ave.		Max.	Min.	Ave.
November	0.00	31.7-25.2	28.75	16.7-14.5	16.87	6.96	99	36	82.23
December	0.00	29.0-19.0	24.48	14.0-9.4	13.64	5.01	100	28	83.58
January	1.80	27.2-19.0	23.16	16.3-8.0	12.43	4.66	100	29	80.03
February	0.00	31.3-24.0	27.40	17.5-9.4	13.94	7.51	100	23	71.97

Table 70. Mean effect of irrigation and varieties on yield and yield attributing characters of wheat at Mymensingh Sadar Upazila

Treatment	Plant height (cm)	Tiller hill^{-1} (no.)	Spike length (cm)	Grains spike^{-1} (no.)	1000 seed wt. (gm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	94.68	8.75	11.39	36.28	47.34	3.38	2.96
T_2	94.79	9.55	11.25	48.59	46.27	3.34	3.06
T_3	96.95	10.05	11.44	47.67	42.68	3.41	3.56
$LSD_{0.05}$	0.83	0.74	NS	1.51	1.89	NS	0.16
V_1	94.46	9.20	11.77	41.03	48.94	3.22	3.25
V_2	97.07	9.96	11.60	45.11	44.43	3.37	3.02
V_3	94.91	9.19	10.71	46.41	42.92	3.52	3.32
$LSD_{0.05}$	1.44	0.74	0.72	1.51	1.89	NS	0.16

Table 71. Interaction effect of treatment and varieties on yield and yield attributing characters of wheat at Mymensingh Sadar Upazila

Treatment	Plant height (cm)	Tiller hill^{-1} (no.)	Spike length (cm)	Grains spike^{-1} (no.)	1000 seed wt. (gm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1V_1	94.31 d	9.03 bc	12.26 a	32.35 e	54.28 a	3.23 ab	3.33 b
T_1V_2	95.36 bcd	9.48 ab	10.95 ab	42.49 cd	44.69 bc	3.39 ab	2.67 c
T_1V_3	94.36 cd	7.72 c	10.95 ab	34.02 e	43.05 bc	3.51 ab	2.89 c
T_2V_1	94.46 cd	8.99 bc	11.24 ab	48.48 b	51.19 a	3.35 ab	2.91 c
T_2V_2	97.09 abc	9.59 ab	11.95 ab	45.00 c	46.14 b	3.35 ab	2.88 c
T_2V_3	92.82 d	10.07 ab	10.56 b	52.29 a	41.46 c	3.32 ab	3.40 ab
T_3V_1	94.59 cd	9.58 ab	11.81 ab	42.25 d	41.34 c	3.09 b	3.50 ab
T_3V_2	98.75 a	10.80 a	11.89 ab	47.85 b	42.45 c	3.38 ab	3.51 ab
T_3V_3	97.51 ab	9.77 ab	10.63 b	52.92 a	44.25 bc	3.74 a	3.68 a

Table 72. Amount of irrigation water requirement and water productivity of wheat at Mymensingh Sadar Upazila

Treatments	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion (cm)	Water requirement (cm)	Grain yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} cm^{-1})
T_1	2.51	1.92	7.77	12.2	3380	277.05
T_2	5.53	1.92	6.37	13.82	3340	241.68
T_3	9.67	1.92	4.16	15.75	3410	216.51

Table 73. Profiles of agro-meteorological parameters during the growing season of wheat at Mymensingh Sadar Upazila

Months	Rainfall (cm)	Maximum temperature (°C)		Minimum temperature (°C)		Sun shine (hour)	Relative humidity (%)		
		Range	Ave.	Range	Ave.		Max.	Min.	Ave.
November	0.00	30.2-27.3	28.75	16.7-14.5	16.87	6.96	99	36	82.23
December	0.00	29.0-19.0	24.48	14.0-9.4	13.64	5.01	100	28	83.58
January	1.80	27.2-19.0	23.16	16.3-8.0	12.43	4.66	100	29	80.03
February	0.00	31.3-24.0	27.40	17.5-9.4	13.94	7.51	100	23	71.97
March	0.12	32.5-28.0	31.37	22.0-14.5	19.17	7.16	100	26	73.84

Table 74. Mean effect of irrigation and varieties on yield and yield attributing characters of Boro rice (T. aman-Fellow-Boro) at Mymensingh Sadar Upazila

Treatment	Plant height (cm)	Tiller hill^{-1} (no.)	Panicle length (cm)	Seeds panicle^{-1} (no.)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	106.7 a	13.48 a	23.07 a	134.53 a	25.69 a	6.18 a	12.97 a
T_2	105.96 a	12.97 ab	23.27 a	120.11 b	25.49 a	5.92 b	12.60 a
T_3	103.36 b	12.24 ab	22.31 ab	104.60 c	25.09 b	5.53 c	11.40 b
T_4	101.5 b	11.48 b	21.77 b	94.33 d	24.64 c	5.34 d	11.38 b
$LSD_{0.05}$	2.21	1.57	1.18	3.18	0.20	0.11	0.43
V_1	119.95 a	11.41 b	22.07 a	145.66 a	26.48 a	5.84 a	14.14 a
V_2	91.43 c	12.83 a	22.70 a	96.56 b	24.94 b	5.64 c	10.84 c
V_3	101.76 b	13.40 a	23.05 a	97.95 b	24.26 c	5.74 b	11.29 b
$LSD_{0.05}$	3.42	1.09	0.95	3.23	0.23	0.06	0.32

Table 75. Interaction effect of treatment and varieties on yield and yield attributing characters of boro rice in the T. aman-Fellow-Boro cropping pattern at Mymesingh sadar upazila

Treatment	Plant height (cm)	Tiller hill^{-1} (no.)	Panicle length (cm)	Seeds panicle^{-1} (no.)	1000 seed weight (gm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1V_1	123.86 a	12.73 abc	23.40 a	173.53 a	27.20 a	6.54 a	15.59 a
T_1V_2	93.60 de	13.33 abc	23.00 a	112.13 e	25.25 cd	5.76 cd	11.18 efg
T_1V_3	102.63 c	14.40 a	22.83 ab	117.93 de	24.61 efg	6.24 b	12.16 d
T_2V_1	121.20 ab	11.60 bcd	22.53 ab	155.00 b	27.01 a	6.27 b	14.76 b
T_2V_2	93.46 de	14.00 ab	23.70 a	101.80 f	25.07 cde	5.66 de	11.36 ef
T_2V_3	103.23 c	13.33 abc	23.60 a	103.53 f	24.38 fgh	5.84 c	11.68 de
T_3V_1	116.73 d	11.20 cd	21.56 ab	134.00 c	26.26 b	5.44fg	13.14 c
T_3V_2	90.13 e	12.33 abcd	22.56 ab	88.60 gh	24.87 def	5.61 e	10.28 h
T_3V_3	103.23 c	13.20 abc	22.80 ab	91.20 g	24.14 gh	5.53 ef	10.79 fgh
T_4V_1	118.00 ab	10.13 d	20.80 b	120.13 d	25.43 c	5.12 h	13.06 c
T_4V_2	88.53 e	11.66 bcd	21.53 ab	83.73 hi	24.57 efg	5.53 ef	10.56 gh
T_4V_3	97.96 cd	12.66 abc	23.00 a	79.13 i	23.91 h	5.37 g	10.53 gh
$LSD_{0.05}$	5.92	2.17	1.90	6.46	0.47	0.13	0.65

Table 76. Mean effect of irrigation treatments on yield and yield attributing characters of boro rice in the T. aman-Fellow- Boro cropping pattern at Mymesingh Sadar upazila

Treatment	No. of irrigation	Applied water (cm)	Rainfall (cm)	Total water (cm)	% water saved over T_1	Yield (t ha^{-1})	% of yield decrease over T_1
T_1	15	86.77	20.68	107.45	-	6.18	-
T_2	12	67.24	20.68	87.92	22.03	5.92	4.21
T_3	10	57.41	20.68	78.09	30.75	5.53	10.52
T_4	8	50.25	20.68	70.93	37.10	5.34	13.59

Table 77. Mean effect of irrigation and varieties on yield and yield attributing characters of Boro rice in the T. aman-Mustard- Boro cropping pattern at Mymesingh sadar upazila

Treatment	Plant height (cm)	Tiller plant^{-1} (no.)	Panicle length (cm)	Seeds panicle^{-1} (no.)	1000 seed wt. (gm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	108.22 a	13.28 a	23.92 a	135.68 a	25.63 a	6.10 a	12.94 a
T_2	104.53 b	12.00 b	23.07 a	121.53 b	25.30 b	5.77 b	12.07 b
T_3	101.71 bc	11.11 bc	20.34 a	103.77 c	25.03 c	5.25 c	11.73 c
T_4	98.88 c	10.42 c	21.95 a	91.86 d	24.59 d	4.84 d	11.15 d
$LSD_{0.05}$	2.95	1.20	4.14	3.29	0.18	0.09	0.34
V_1	116.01 a	11.15 a	21.70 a	145.55 a	26.16 a	5.44 a	14.18 a
V_2	92.33 c	12.21 b	22.35 a	97.71 b	24.98 b	5.52 a	10.40 c
V_3	101.66 b	11.75 ab	22.92 a	96.35 b	24.28 c	5.51 a	11.33 b
$LSD_{0.05}$	2.14	0.64	3.10	5.65	0.46	0.08	0.22

Table 78. Interaction effect of treatment and varieties on yield and yield attributing characters of boro rice in the T. aman-Mustard- Boro at Mymesingh sadar upazila

Treatment	Plant height (cm)	Tiller plant^{-1} (no.)	Panicle length (cm)	Seeds panicle^{-1} (no.)	1000 seed wt. (gm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1V_1	122.20 a	13.26 a	25.10 a	174.53 a	26.91 a	6.37 a	15.45 a
T_1V_2	97.66 de	13.93 a	23.33 a	116.963 d	25.34 bcd	5.69 bc	11.07 f
T_1V_3	104.80 c	12.66 ab	23.33 a	115.60 d	24.63 def	6.25 a	12.30 d
T_2V_1	118.33 a	11.80 bc	23.56 a	160.53 d	26.32 ab	5.83 b	14.16 b
T_2V_2	93.66 ef	12.66 ab	22.60 ab	101.53 e	25.15 cde	5.63 c	10.51 g
T_2V_3	101.60 cd	11.53 bc	23.06 ab	102.53 e	24.44 bef	5.85 b	11.55 e
T_3V_1	112.93 b	10.06 de	16.20 b	132.66 c	26.02 abc	5.11 f	13.72 c
T_3V_2	90.13 fg	11.53 bc	21.86 ab	89.13 f	24.90 de	5.45 d	10.21 gh
T_3V_3	102.06 cd	11.73 bc	22.96 ab	89.40 f	24.19 ef	5.19 ef	11.26 ef
T_4V_1	110.60 b	9.46 e	21.93 ab	114.46 d	25.39 bcd	4.48 h	13.39 c
T_4V_2	87.86 g	10.73 cde	21.60 ab	83.26 f	24.53 def	5.30 de	9.82 h
T_4V_3	98.20 d	11.06 cd	22.33 ab	77.86 f	23.85 f	4.74 g	10.23 gh
$LSD_{0.05}$	4.28	1.29	6.21	11.31	0.93	0.16	0.44

Table 79. Mean effect of irrigation treatments on yield and yield attributing characters of boro rice in the T. aman-Mustard-Boro cropping pattern at Mymesingh Sadar upazila

Treatment	Irrigation (no.)	Applied water (cm)	Rainfall (cm)	Total water (cm)	% water saved over T_1	Yield (t ha^{-1})	% of yield decrease over T_1
T_1	16	88.58	20.68	109.26	-	6.12	-
T_2	12	65.23	20.68	85.91	23.81	5.77	5.72
T_3	9	56.54	20.68	77.22	31.52	5.25	14.22
T_4	8	48.08	20.68	68.76	39.02	4.84	20.92

Table 80. Mean effect of irrigation and varieties on yield and yield attributing characters of T. aus rice at Mymensingh Sadar Upazila

Treatment	Plant height (cm)	Tiller plant^{-1} (no.)	Panicle length (cm)	Seeds panicle^{-1} (no.)	1000 seed wt. (gm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	98.16	10	22.00	26.06	24.00	1.43	9.25
T_2	96.33	10	22.35	25.46	23.91	1.52	9.35
T_3	95.60	10	22.08	25.53	23.35	1.46	9.07
T_4	95.86	10	21.91	23.00	23.62	1.41	8.77
$LSD_{0.05}$	0.23	NS	0.06	2.34	0.09	0.11	0.45
V_1	97.83	10	22.14	23.86	24.02	1.51	9.46
V_2	95.15	11	22.03	26.16	23.42	1.40	8.76
$LSD_{0.05}$	0.34	1.65	NS	0.67	0.34	0.07	0.12

Table 81. Interaction effect of treatment and varieties on yield and yield attributing characters of T. aus rice at Mymensingh Sadar Upazila

Treatment	Plant height (cm)	Tiller plant^{-1} (no.)	Panicle length (cm)	Seeds panicle^{-1} (no.)	1000 seed wt. (gm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1V_1	98.86	10.13	22.16	24.46	24.35	1.50	9.75
T_1V_2	97.46	10.26	21.83	27.66	23.65	1.37	8..75
T_2V_1	97.66	10.20	22.63	24.20	24.27	1.54	9.70
T_2V_2	95.00	10.60	22.06	26.73	23.55	1.50	9.00
T_3V_1	97.46	10.26	21.96	23.66	23.77	1.58	9.50
T_3V_2	93.73	10.53	22.20	27.40	22.94	1.33	8.65
T_4V_1	97.33	10.13	21.80	23.13	23.71	1.41	8.90
T_4V_2	94.40	10.73	22.03	22.86	23.54	1.41	8.65
$LSD_{0.05}$	0.82	0.01	0.06	0.13	0.032	0.07	0.08

Table 82. Mean effect of irrigation treatments on yield and yield attributing characters of T. aus rice at Mymesingh Sadar upazila

Treatment	No. of irrigation	Applied water (cm)	Rainfall (cm)	Total water	% water saved over T_1	Yield (t ha^{-1})	% of yield decrease over T_1
T_1	9	62.68	18.45	81.13	-	1.59	-
T_2	8	46.00	18.45	64.45	20.56	1.52	4.40
T_3	7	43.31	18.45	61.76	23.88	1.46	8.18
T_4	5	36.49	18.45	54.94	32.28	1.41	11.32

Table 83. Yield and yield attributing characters of Binadhan-7 in at different locations of Magura

Location	Plant height (cm)	Tiller hill^{-1} (no.)	Panicle length (cm)	Grain per panicle (no)	Average grain yield (t ha^{-1})	Average straw yield (t ha^{-1})
Ramnagar	88.4	20	24.2	134	7.55	12.76
Rautola	100	17.2	24.6	109.4	6.01	11.62
Sachani	94	15.8	22.6	100.2	5.59	12.1

Table 84. Climatic parameters during the growing days of Binadhan-7 from transplanting to harvest at different locations of Magura

Growing period	Maximum temperature (°C)		Minimum temperature (°C)		Relative humidity (%)		
	Range	Average	Range	Average	Max.	Min.	Average
First 31 days	24.0-38.8	31.30	24.2-34.4	27.23	90-98	70-97	82.82
Second 31 days	26.8-36.6	32.37	24.2-27.4	25.57	93-98	68-95	84.27
Last 29 days	30.2-36.2	34.21	19-25.8	23.71	91-97	63-88	78.51

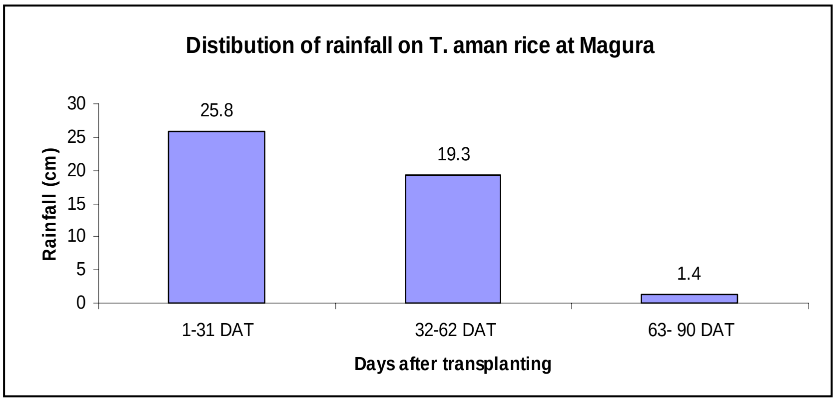


Fig. 40. Distribution of rainfall during T. aman rice growing period at Magura

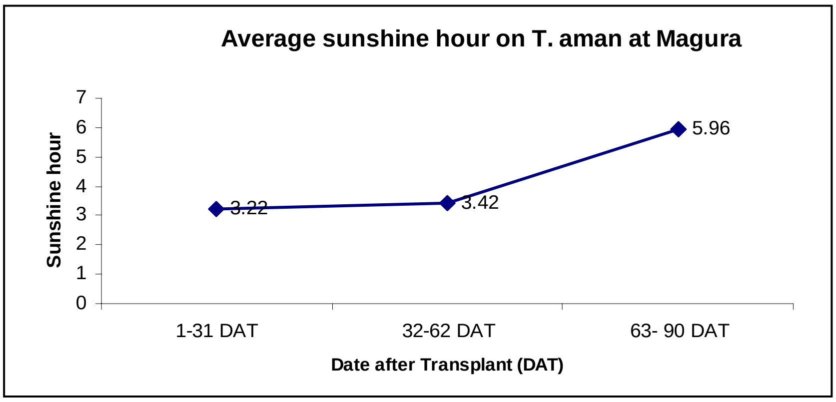


Fig. 41. Distribution of sunshine hour during T. aman rice growing period at Magura

Table 85. Mean effect of irrigation and varieties on yield and yield attributing characters of lentil at Magura Sadar Upzilla

Treatments	Plant height (cm)	Branch plant^{-1} (no.)	Pods plant^{-1}	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	38.27 a	2.96	87.69	1787.89	1306.94
T_2	36.20 b	2.89	75.98	1550.91	1320.51
T_3	38.80 a	3.11	91.87	1539.06	1282.73
$LSD_{0.05}$	2.03	NS	NS	NS	NS
V_1	36.64	2.71 b	71.78	1484.03 b	1361.40
V_2	37.89	3.08 ab	93.27	1694.79 a	1272.44
V_3	38.73	3.16 a	90.49	1699.04 a	1276.34
$LSD_{0.05}$	NS	0.05	NS	162.6	NS

Table 86. Water requirement and water use efficiency of lentil at Magura Sadar Upazila

Treatments	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion (cm)	Water requirement (cm)	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} cm^{-1})
T_1	2.25	5.7	7.12	15.07	1787.89	118.64
T_2	3.75	5.7	5.22	14.67	1550.91	105.72
T_3	4.75	5.7	4.80	15.25	1539.06	100.92

Table 87. Climatic parameters during the growing days of lentil from seeding to harvest at different locations of Magura

Growing period (Month)	Days after seeding (DAS)	Temperature (°C)			Relative humidity (%)		Rainfall (cm)
		Max.	Min.	Avg.	Range	Average	
November	0-17	32.5-27.8	19-12.7	23.04	65-91	79	0
December	18-47	31.0-14.8	17.9-6.1	15.98	99-72	87.74	0
January	48-78	19.4-28.7	16.1-6.8	16.84	98-74	86.1	5.7
February	79-107	34.1-24.3	18.3-8.3	19.66	89-66	76.96	0
March	108-113	35.9-32.3	18.9-13.8	23.57	79-63	69.83	0

Table 88. Mean effect of irrigation and varieties on yield and yield attributing characters of mustard at Magura Sadar Upzilla

Treatments	Plant height (cm)	Branch plant^{-1} (no.)	Pod plant^{-1} (no.)	Seed pod^{-1} (no.)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	103.80 a	2.28	58.66	29.06 ab	1557.63 b	1490.17
T_2	102.53 a	2.40	54.08	28.30 b	2023.16 b	1440.40
T_3	97.69 b	2.50	51.36	29.97 a	2020.30a	1427.17
$LSD_{0.05}$	4.43	NS	NS	1.40	80.03	NS
V_1	99.63 b	2.02 b	63.67 a	32.33 a	1911.95 a	1448.31
V_2	99.82 b	1.92 b	58.46 a	31.09a	1902.97 a	1491.52
V_3	104.58 a	3.23 a	41.97 b	23.90 b	1786.16 b	1417.89
$LSD_{0.05}$	4.65	1.05	12.48	3.60	58.92	NS

Table 89. Water requirement and water use efficiency of mustard at Magura Sadar Upazila

Treatments	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion (cm)	Water requirement (cm)	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} cm^{-1})
T_1	2.75	5.7	8.42	16.87	1557.63	92.33
T_2	4.55	5.7	5.48	15.73	2023.16	128.62
T_3	4.55	5.7	5.44	15.69	2020.30	128.73

Table 90. Climatic parameters during the growing days of mustard from seeding to harvest at different locations of Magura

Growing period (Month)	Days after seeding (DAS)	Temperature (°C)			Relative humidity (%)		Rainfall (cm)
		Max.	Min.	Avg.	Range	Average	
November	0-17	32.5-27.8	19-12.7	23.04	65-91	79	0
December	18-47	31.0-14.8	17.9-6.1	15.98	99-72	87.74	0
January	48-78	19.4-28.7	16.1-6.8	16.84	98-74	86.1	5.7
February	79-99	31.0-24.3	18.3-8.03	18.74	89-66	78.52	0

Table 91. Mean effect of irrigation and varieties on yield and yield attributing characters of chickpea **at Magura Sadar Upzilla**

Treatments	Plant height (cm)	Branch plant^{-1} (no.)	Pod plant^{-1} (no.)	Seed pod^{-1} (no.)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	68.78	3.58	59.00	1.72	1659.69 a	1797.16 a
T_2	69.47	3.89	65.37	1.88	1573.15 b	1465.49 b
T_3	67.89	3.93	53.82	1.79	1540.95 b	1381.21 b
$LSD_{0.05}$	NS	NS	NS	NS	57.88	291.2
V_1	70.29	3.87	55.89	1.86 a	1589.13 ab	1676.97 a
V_2	66.18	3.53	58.51	1.83 ab	1663.20 a	1419.59 b
V_3	69.67	4.00	63.79	1.71 b	1521.46 b	1547.30 ab
$LSD_{0.05}$	NS	NS	NS	0.39	1.81	200.6

Table 92. Water requirement and water use efficiency of chickpea at Magura Sadar Upazila

Treatments	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion (cm)	Water requirement (cm)	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} cm^{-1})
T_1	2.30	5.7	6.12	14.12	1659.69	117.54
T_2	3.80	5.7	4.98	14.48	1573.15	108.64
T_3	3.80	5.7	4.44	13.94	1540.95	110.54

Table 93. Climatic parameters during the growing days of chickpea from seeding to harvest at different locations of Magura.

Growing period (Month)	Days after seeding (DAS)	Temperature (°C)			Relative humidity (%)		Rainfall (cm)
		Max.	Min.	Avg.	Range	Average	
November	0-17	32.5-27.8	19.0-12.7	23.04	65-91	79	0
December	18-47	31.0-14.8	17.9-6.1	15.98	99-72	87.74	0
January	48-78	19.4-28.7	16.1-6.8	16.84	98-74	86.1	5.7
February	79-107	34.1-24.2	18.3-8.3	19.66	89-66	76.96	0
March	108-134	37.0-22.7	21.8-13.8	24.5	98-61	72.74	0

Table 94. Mean effect of irrigation and varieties on yield and yield attributing characters of sesame at Magura Sadar Upzilla

Location	Treatments	Plant height (cm)	Pod plant^{-1} (nos.)	Branch plant^{-1} (nos.)	Pod Length (cm)	Seed pod^{-1} (nos.)	Seed yield (kg ha^{-1})
Rawtola	T_1	110.72	28.72	1.13	2.96	65.08	1412
	T_2	119.16	33.64	1.66	3.28	69.66	1543
	T_3	105.03	26.17	1.60	3.12	68.53	1472
	$LSD_{0.05}$	6.559**	NS	0.718**	0.255	NS	83.49
	V_1	118.11	26.93	1.40	3.33	74.52	1528
	V_2	111.01	29.78	2.08	2.80	64.33	1709
	V_3	105.80	31.82	1.91	3.17	64.42	1293
	$LSD_{0.05}$	5.654**	1.863**	0.408**	NS	7.903	46.03**
Ramnagor	T_1	111.66	40.82	1.93	3.24	72.57	1871
	T_2	120.84	63.73	2.37	3.19	76.70	2039
	T_3	111.31	42.66	2.00	3.22	71.88	1990
	$LSD_{0.05}$	2.210**	4.48**	NS	NS	NS	76.16**
	V_1	118.26	43.52	1.40	4.13	84.51	1808
	V_2	112.17	53.61	2.08	2.82	65.66	2100
	V_3	113.38	50.08	1.91	2.70	70.92	1992
	$LSD_{0.05}$	NS	4.88**	0.408**	0.334**	4.38**	75.33**
Sachani	T_1	123.09	34.66	1.77	2.92	69.35	1732
	T_2	122.88	34.97	1.88	2.98	73.04	1861
	T_3	128.00	34.11	1.60	3.00	70.35	1836
	$LSD_{0.05}$	NS	NS	0.180	NS	NS	26.80**
	V_1	124.71	32.93	0.33	3.64	87.86	1877
	V_2	122.76	36.26	2.80	2.65	62.68	1890
	V_3	126.51	36.95	2.28	2.66	62.27	1662
	$LSD_{0.05}$	NS	NS	0.504**	0.482**	6.754**	60.50**

** indicating significant level 0.01

Table 95. Climatic parameters during the growing days of sesame from seeding to harvest at different locations of Magura.

Growing period (Month)	Days after seeding (DAS)	Temperature (°C)			Relative humidity (%)			Rainfall (cm)
		Max.	Min.	Avg.	Max.	Min.	Average	
March	0-12	38-32.3	27.2-16.8	28.55	98-83	56-16	63.02	0
April	13-42	39.9-33.5	28.1-21.4	31.07	96-85	56-16	70.32	3.60
May	43-73	36.6-29.0	28.7-22.5	29.78	96-87	64-22	76.21	16.94
June	74-83	34.9-29.2	27.7-24.8	29.66	97-91	77-44	84.18	25.90

Table 96. Mean effect of irrigation and varieties on yield and yield attributing characters of mungbean at Magura Sadar Upzilla

Location	Treatments	Plant height (cm)	Pod plant^{-1} (nos.)	Branch plant^{-1} (no.)	Pod length (cm)	Seed pod^{-1} (nos.)	Seed yield (kg ha^{-1})
Rawtola	T_1	79.80	20.16	2.28	8.44	11.0	1020
	T_2	82.29	21.22	2.42	8.70	11.2	1436
	T_3	79.67	21.56	2.24	8.64	11.2	1343
	$LSD_{0.05}$	NS	NS	NS	NS	NS	42.82
	V_1	86.56	20.86	2.37	8.59	11.22	1296
	V_2	71.96	21.64	2.47	8.71	11.36	1327
	V_3	83.24	20.42	2.10	8.49	10.82	1178
	$LSD_{0.05}$	6.33**	NS	0.142**	NS	0.39	46.68**
Ramnagor	T_1	76.53	19.77	2.34	8.73	10.84	1039
	T_2	79.75	20.77	2.62	8.97	11.13	1256
	T_3	78.29	19.23	2.42	8.70	10.90	1148
	$LSD_{0.05}$	NS	NS	NS	NS	NS	69.49**
	V_1	84.56	20.02	2.45	8.91	10.84	1167
	V_2	80.31	20.38	2.52	8.88	11.29	1283
	V_3	69.71	19.36	2.41	8.61	10.74	1094
	$LSD_{0.05}$	6.69**	NS	NS	NS	0.39	37.56**
Sachani	T_1	74.68	20.82	2.51	8.4	11.4	1019
	T_2	77.11	23.13	2.40	8.9	11.4	1190
	T_3	74.88	21.22	2.54	8.7	11.3	1088
	$LSD_{0.05}$	NS	NS	NS	NS	NS	60.72
	V_1	82.24	22.71	2.40	8.8	11.3	1148
	V_2	77.11	23.56	2.54	8.8	11.7	1168
	V_3	67.33	21.06	2.51	8.4	11.1	1080
	$LSD_{0.05}$	7.89	NS	NS	NS	NS	24.71

** indicating significant level 0.01

Table 97. Climatic parameters during the growing days of mungbean from seeding to harvest at different locations of Magura

Growing period (Month)	Days after seeding (DAS)	Temperature (°C)			Relative humidity (%)			Rainfall
		Max.	Min.	Avg.	Max.	Min.	Average	(cm)
March	0-12	32.5-27.8	19-12.7	28.55	98-83	56-16	63.02	0
April	13-42	31.0-14.8	17.9-6.1	31.07	96-85	56-16	70.32	3.60
May	43-73	19.4-28.7	16.1-6.8	29.78	96-87	64-22	76.21	16.94

Table 98. Mean effect of irrigation and varieties on yield and yield attributing characters of Jute **at different locations of Magura Sadar Upzilla**

Location	Treatments	Plant height (cm)	Plant diameter (cm)	Fiber weight (t ha^{-1})	Stick weight (t ha^{-1})
	T_1	246.18	0.95	5.56	9.53
Rautola	T_2	268.12	1.30	6.65	11.50
	T_3	250.23	1.02	5.68	9.30
$LSD_{0.05}$		5.118*	NS	0.346	1.770
	T_1	283.33	1.24	5.78	10.15
Ramnogor	T_2	298.55	1.33	6.77	12.53
	T_3	285.35	1.29	5.80	10.50
$LSD_{0.05}$		7.959*	NS	0.441*	0.705*
	T_1	243.88	0.98	5.05	7.66
Sachani	T_2	265.88	1.14	5.68	8.77
	T_3	245.68	0.93	4.98	7.60
$LSD_{0.05}$		10.37*	0.134	0.095*	0.232*

* indicating significant level 0.01

Table 99. Climatic parameters during the growing days of jute from seeding to harvest at different locations of Magura

Growing period (Month)	Days after seeding (DAS)	Temperature (°C)			Relative humidity (%)			Rainfall (cm)
		Max.	Min.	Avg.	Max.	Min.	Average	
April	0-26	39.9-33.5	28.1-21.4	31.07	96-85	56-16	70.32	3.60
May	27-57	36.8-28.4	29.0-21.6	29.78	96-87	64-22	76.21	16.94
June	58-87	36.6-29.0	28.7-22.5	29.66	97-91	77-44	84.18	25.90
July	88-118	34.9-29.2	27.7-24.8	29.67	97-92	88-61	83.37	14.95
August	119-122	35.8-28.6	28.8-24.2	28.92	98-93	91-56	84.27	0.12

Studies on the water table fluctuation and its impact on ground water utilization for irrigation

This study was aimed to know the trend of water table for the last 30 years and assess the impact on ground water utilization for irrigation at different locations of Bangladesh. Long-term (1980-2010) WT data of observation wells (OW) of different upazillas in Mymensingh and Magura districts were collected from the Bangladesh Water Development Board (BWDB). Rainfall data of Mymensingh, Faridpur and Jessore districts for a period of 30 years (1981-2010) were collected from the Bangladesh Meteorological Department. Rainfall data of Faridpur and Jessore districts were computed by arithmetic mean method for Magura district. Yearly maximum water table (WT) depth data of different observational wells were arranged. The trend of maximum water table (WT) depth was detected and estimated by MAKESENS trend model. The MAKESENS is a software computer model and performed two types of statistical analyses. First the presence of a monotonic increasing or decreasing trend was tested with the nonparametric Mann-Kendall test and secondly, the slope of a linear trend was estimated with the nonparametric Sen's method. MAKESENS tested significance levels α were 0.001, 0.01, 0.05 and 0.10. Changes of maximum water table were calculated based on trend analysis as; Maximum water table (WT) depth = B + Q (Simulation year-Base year). Where, B = the intercept, Q = the slope of the line, Simulation years were considerations 2020, 2025 and 2030.

Rate of change of maximum water table depth (m/year) and prediction of maximum water table depth (m) for different years in different upazillas of Mymensingh and Magura district are presented in Table 100-101, respectively. From table, it was observed that maximum WT was increased significantly in all the observation wells except two observation wells of Bhaluka and Phulpur upazila in Mymensingh and three observation wells of Magura Sadar upazila. It was evidenced that maximum WT depth change varied from 19.86 m to -0.30 m in Mymensingh and 6.51 to -0.11m in Magura during 1981-2010. Predicted WT depth dropped below the suction lifts in most of the observation wells in different upazilla of Mymensingh and Magura districts. Yearly maximum WT depth (1980-2010) in different upazillas of Mymensingh and Magura districts are presented in Fig. 42-43.

Table 100. Rate of change of maximum water table depth (m/year) and prediction of maximum water table depth (m) for different years in different Upazillas of Mymensingh district

Name of Upazilla	Observation well	Rate of change of maximum water table (m $year^{-1}$)	Maximum WT change from 1980 to 2010	Maximum WT in 2012	Prediction of maximum water table (WT) depth in different year		
					2020	2025	2030
Mymensingh Sadar	GT6152020	0.287***	8.61	13.13	15.42	16.86	18.29
	GT6152021	0.308***	9.25	14.63	17.10	18.64	20.18
Fulbaria	GT6120005	0.662***	19.86	23.97	29.26	32.57	35.88
	GT6120006	0.225***	6.75	11.05	12.85	13.98	15.10
	GT6120007	0.138***	4.15	9.97	11.08	11.77	12.46
Gouripur	GT6123011	0.004	0.11	4.00	4.03	4.05	4.07
	GT6123012	0.061***	1.83	6.20	6.69	7.00	7.30
Haluaghat	GT6124013	0.363***	10.89	18.00	20.90	22.72	24.53
	GT6124014	0.075**	2.24	7.64	8.24	8.61	8.98
	GT6124015	0.121***	3.63	9.25	10.22	10.82	11.43
Gaffargaon	GT6122008	0.205***	6.14	10.46	12.09	13.11	14.14
	GT6122009	0.020	0.60	7.92	8.08	8.18	8.28
	GT6122010	0.205***	6.16	10.84	12.48	13.50	14.53
Muktagacha	GT6165022	0.108***	3.25	9.23	10.09	10.63	11.17
Bhaluka	GT6113001	0.173***	5.20	8.77	10.16	11.03	11.89
	GT6113002	-0.010	-0.31	7.18	7.09	7.04	6.99
	GT6113003	0.134***	4.01	9.23	10.30	10.96	11.63
	GT6113004	0.062***	1.85	8.64	9.13	9.44	9.75
Ishwarganj	GT6131016	0.031***	0.94	4.41	4.67	4.82	4.98
	GT6131017	0.092***	2.75	6.69	7.42	7.88	8.34
	GT6131018	0.187***	5.60	9.92	11.42	12.35	13.28
Nandail	GT6172026	0.364***	10.91	14.22	17.13	18.95	20.76
	GT6172027	0.008	0.24	6.03	6.09	6.13	6.17
	GT6172028	0.398***	11.94	16.78	19.97	21.96	23.95
	GT6172029	0.130***	3.90	8.30	9.34	9.99	10.64
	GT6172030	0.080*	2.40	6.15	6.79	7.19	7.59
Phulpur	GT6181031	0.058***	1.73	4.44	4.90	5.18	5.47
	GT6181032	0.048^{+}	1.45	7.27	7.65	7.89	8.13
	GT6181033	-0.010	-0.30	4.01	3.93	3.88	3.83
	GT6181034	0.045***	1.35	5.51	5.87	6.10	6.32
	GT6181035	0.036***	1.08	6.11	6.40	6.58	6.76
Trisal	GT6194036	0.047*	1.43	11.79	12.17	12.41	12.65
	GT6194037	0.540***	16.20	21.52	25.84	28.54	31.24
	GT6194038	0.022	0.65	6.94	7.12	7.22	7.33

Table 101. Rate of change of maximum water table depth (m/year) and prediction of maximum water table depth (m) for different years in different Upazillas of Magura district

Upazillas of Magura district	Observation well	Rate of change of maximum water table (m $year^{-1}$)	Maximum WT change from 1981 to 2010	Maximum WT in 2012	Prediction of maximum water table (WT) depth in different year		
					2020	2025	2030
Mohammadpur	GT5566006	0.067***	1.93	8.22	8.75	9.09	9.42
	GT5566007	0.073***	2.13	7.68	8.26	8.63	9.00
	GT5566502	0.022+	0.63	7.51	7.69	7.80	7.90
	GT5566503	0.027**	0.79	7.47	7.68	7.82	7.96
Sadar	GT5557001	0.068	1.97	8.45	8.99	9.33	9.67
	GT5557002	-0.004**	-0.11	7.41	7.38	7.36	7.34
	GT5557003	0.101	2.93	7.92	8.73	9.24	9.74
	GT5557004	0.018***	0.51	7.69	7.83	7.91	8.00
	GT5557005	0.030	0.87	7.69	7.93	8.08	8.23
	GT5557501	0.020**	0.57	6.20	6.35	6.45	6.55
Sreepur	GT5595009	0.063***	1.84	8.92	9.43	9.75	10.06
	GT5595010	0.094**	2.71	7.27	8.02	8.48	8.95
	GT5595011	0.069***	2.01	9.15	9.71	10.06	10.40
	GT5595012	0.224***	6.51	11.15	12.94	14.06	15.18
	GT5595013	0.055*	1.60	8.53	8.97	9.24	9.52
	GT5595014	0.069**	1.99	8.67	9.22	9.57	9.91
	GT5595015	0.083***	2.42	9.21	9.87	10.29	10.71
Shalikha	GT5566006	0.067***	1.93	8.22	8.75	9.09	9.42

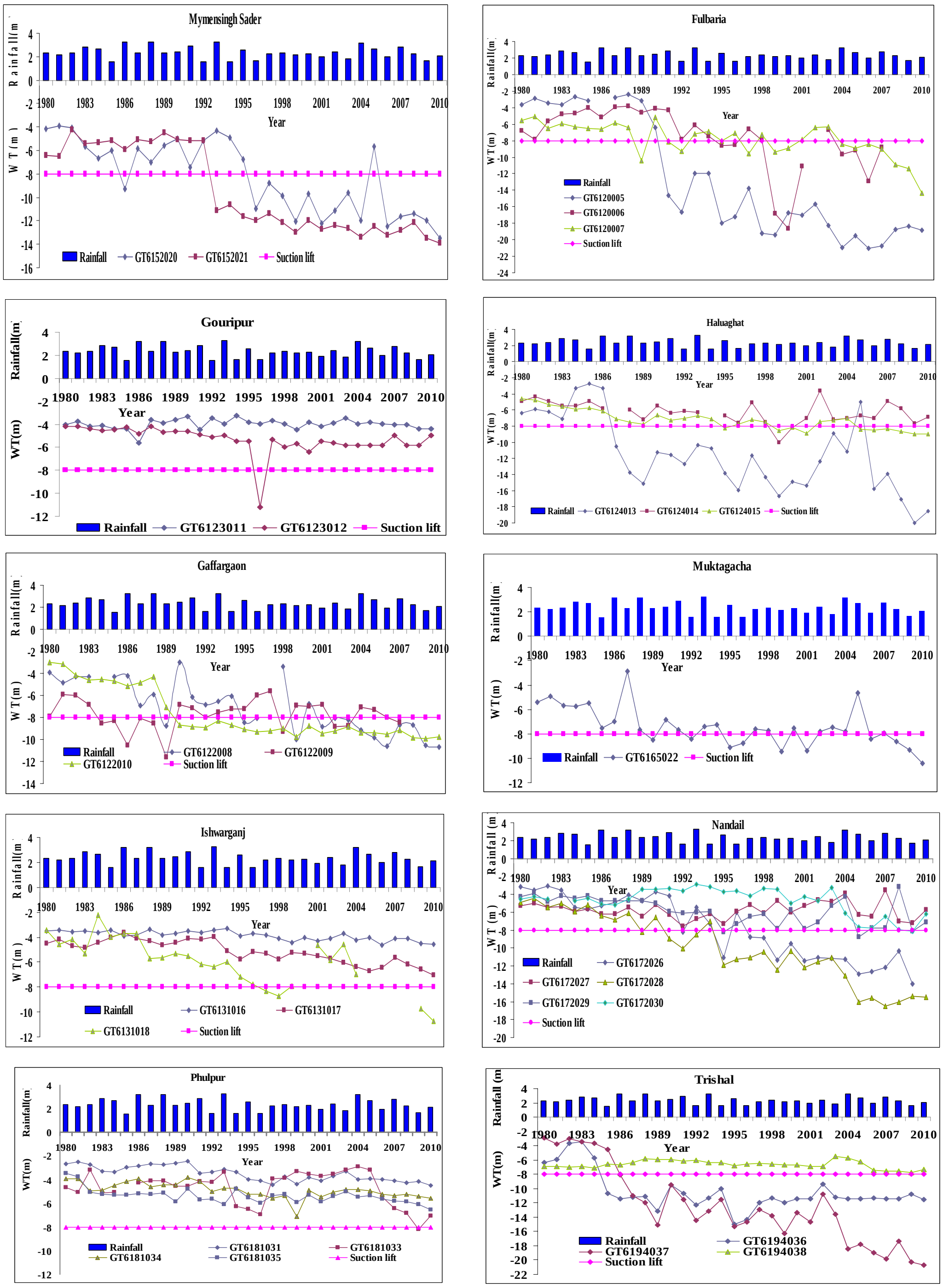


Fig. 42. Yearly maximum WT depth (1980-2010) in different Upazilas of Mymensingh district

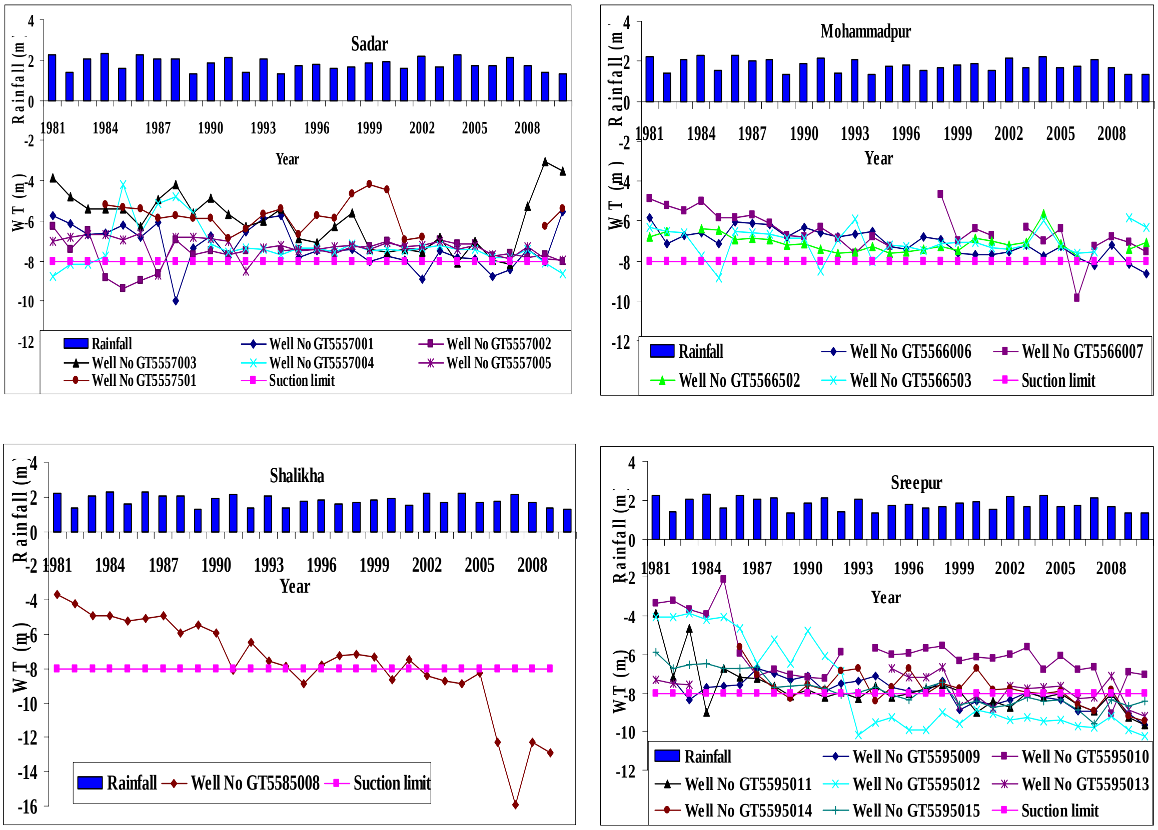


Fig. 43 Yearly maximum WT depth (1981-2010) in different upazilas of Magura district

Studies on the surface and groundwater quality for irrigation suitability

The study was conducted to determine the surface and ground water quality and pollution rate at SPGR-335 project area at Mymensingh and Magura. The water samples were collected as before irrigation period in November/December, at during the peak irrigation period in February/March to observe the seasonal effects on the water quality due to the irrigation pumping, monsoon recharge and agricultural practices. Different water quality parameters such as p^H, EC, CO_3^{--}, HCO3 $^-$, and Cl^- were analyzed. Arsenic (As) was also tested using field kit method.

The quality parameters for the period 2012 at different locations studied are presented in Table 102. Results showed that the parameters were within the permissible limit for irrigation.

Table 102. Water quality parameters of BINA farm and other locations its sub-stations

Parameters / Location		Source of water	pH Dec. 2011	EC (dS m^{-1}) Dec. 2011	HCO_3^- (mg l^{-1}) Dec. 2011	Cl^- (mg l^{-1}) Dec. 2011
Mymensingh	BINA Head office	DTW	8.16	0.43	5.94	1.73
		HTW	8.40	0.33	2.48	1.73
	Rahmatpur	DTW	7.30	0.39	3.35	2.60
		Pond	6.56	0.18	1.47	1.35
	North Alalpur	STW	7.20	0.34	1.85	3.10
		Pond	7.22	0.30	2.47	1.48
	South Alalpur	STW	7.34	0.32	2.35	1.98
		Pond	5.70	0.30	1.23	6.85
Magura	BINA sub-station	HTW	8.14	0.63	4.10	1.85
		STW	7.52	0.62	4.86	1.78
	Ramnogor	STW	6.87	0.86	7.10	3.60
		Pond	7.68	0.51	3.60	1.85
	Sachni	STW	7.21	0.59	4.73	1.73
		Pond	6.24	0.46	3.48	4.10
	Raotola	STW	7.23	0.56	4.73	1.98
		Pond	7.35	0.39	3.48	1.73
Permissible limit			< 8	< 3 dS m^{-1}	< 8.5 mg l^{-1}	< 5 mg l^{-1}

Integrated soil and water management approaches using nuclear techniques to increase crop productivity in drought prone areas of Bangladesh (IAEA Funded project)

Optimizing water use for higher crop water productivity under various soil moisture regimes and mulching practices in the existing cropping sequence

The objective of this experiment was to determine the response of different dry-land crops to varying levels of soil moisture regime and mulching practices during Kharif-II (July-November), Rabi (November-March) and Kharif-I (March-June) seasons. The experiment was conducted at Rajbari farm, Dinajpur. There were two cropping patterns e.g.; pattern I: T. aman (Binadhan-7)-Mustard (BARI Sharisha-14) - Boro (BRRI dhan28) and pattern II: T. aman (BRRI dhan 49)-Potato (Cardinal) - Sesame (Binatil-1) using mulching practices in potato. In pattern-I, thirty days old seedling of a short duration T. aman rice (Binadhan-7) T. aman was transplanted on 28 July, 2011. There were no irrigation treatments but the plots were made as per design of the next crops. The crop was grown under rainfed condition and normal cultural and management practices, and harvested on 20 October 2011 (110 days life cycle). After T. aman rice (Binadhan-7), the same plot and layout were used for the successive crop mustard. Seeds of mustard were sown on 1 November 2011. The treatments were as follows: T_0 = No supplementary irrigation, T_1 = One irrigation at vegetative stage (20-25 DFS), T_2 = One irrigation at flowering stage (32-36 DFS) and T_3 = One irrigation at vegetative stage and one irrigation at flowering stage. The crop was harvested on 31 January, 2012. After harvest of mustard, the same plot and layout were used for the successive crop boro rice. Forty five day old seedling of Boro rice (BRRI dhan28) was transplanted on 7 February, 2012. The treatments were as follows; T_0 =

Normal farmer's practice (continuous ponding), T_1 = AWD (5 cm ponding to saturation), T_2 = 3-5 days AWD (5 cm ponding), T_3 = 5-7 days AWD (5 cm ponding). The crop was harvested on 14 May 2012. In pattern-II, after T. aman rice (BRRI dhan49), the same plot and layout were used for the successive crop potato. Seeds of potato were transplanted on 22 November 2011. The treatments were as follows: T_0 = No supplementary irrigation, T_1 = One irrigation at vegetative stage (25-30 DFS), T_2 = One irrigation at yield formation stage (50-60 DFS), and T_3 = One irrigation at vegetative stage and one irrigation at yield formation stage. The crop was harvested on 24 February, 2012. After harvest of potato, the same plot and layout were used for the successive crop sesame. The treatments for sesame were as follows: T_0 = No irrigation (control), T_1 = One irrigation at vegetative stage (20-25 DFS), T_2 = One irrigation at flowering stage (35-40 DFS), T_3 = One irrigation at vegetative stage and one irrigation at flowering stage. Soil moisture was recorded at sowing time, before and after irrigation, and at harvest time of crop using gravimetric method and neutron probe (Troxler) in all Rabi and Kharif-I crops. All the cultural practices were followed as and when necessary. Yield and yield attributes were recorded which were then statistically analyzed.

The yield and yield attributing characters of rice in pattern-I is presented in Table 103. It is found that in all plots yield is almost identical and produced a yield of 5.46-5.66 t ha^{-1} under rainfed condition. Profile soil moisture pattern at different depth of irrigation treatments of mustard (BARI Sharisha-14) crop are shown in Fig. 44. At sowing time, the soil moisture at different depths (0-15, 15-30, 30-45 and 45-60 cm) was high ranging from about 30 to 40% (by volume), and at harvest time it declined to15 to 22 % (by volume). Effect of irrigation practices on the yield and yield attributing characters of mustard is presented in Table 104. Irrigation showed significant effect on number of seed/pod and straw yield. The highest seed yield (1.99 t ha^{-1}) was obtained in irrigation treatment T_2. Amount of irrigation water requirement and water productivity of mustard are shown in Table 105. From table, it is observed that irrigation water productivity is highest in T_2 treatment (irrigation at flowering stage). The effect of different AWD irrigation treatments on the yield and yield contributing characters of boro rice is shown in Table 106. The AWD method showed significant effect on plant height. The highest yield of 7.34 t ha^{-1} was obtained in continuous ponding plots (T_0). It is observed that after transplanting, about 32 cm water was applied for crop establishment (Table 107). Almost in every alternate 3 days, irrigation was applied in the continuous ponding plots (T_0), and 4, 7 and 11 days after irrigation, irrigations were applied in treatments T_1, T_2 and T_3, respectively. Accordingly, water requirement was the highest 85.00 cm in T_0 and lowest (57.00 cm) in T_3. It also elucidated that 5 to 7 days AWD irrigation method saved about 37 to 49% irrigation water compared to continuous ponding and saturation irrigation method, producing insignificant yield differences.

In cropping Pattern-II, yield and yield attributing characters of rice (BRRI dhan49) are presented in Table 108. It is found that in the entire plots yield are almost identical (4.55-4.91 t ha^{-1}) under rainfed condition. Profile soil moisture distribution at sowing time to harvest time of potato at various depths of soil is shown in Fig. 45. At sowing time, soil moisture was high (about 30 to 40% by vol.). Periodical moisture in control plots showed a very gradual decreasing trend during its growing period. Yield and yield attributing characters of potato is presented in Table 109. The highest yield of 30.29 t ha^{-1} was obtained in treatment T_3. Amount of irrigation water requirement and water productivity of potato is shown in Table 110. From table, it is observed that irrigation water productivity is highest in T_0 treatment (control). Yield and yield attributing characters of sesame are presented in Table 111. Irrigation did not show any effect on the yield and its parameters. The highest yield of 1134.58 kg ha^{-1} was obtained in treatment T_2. Amount of irrigation water requirement and water productivity of sesame are shown in Table 112 From table, it is observed that irrigation water productivity is highest in T_2 treatment.

Table 103. Yield and yield attributing characters of T. aman rice (Binadhan-7) at Wheat Research Research sub-station, Rajbari farm, Dinajpur district under rainfed condition

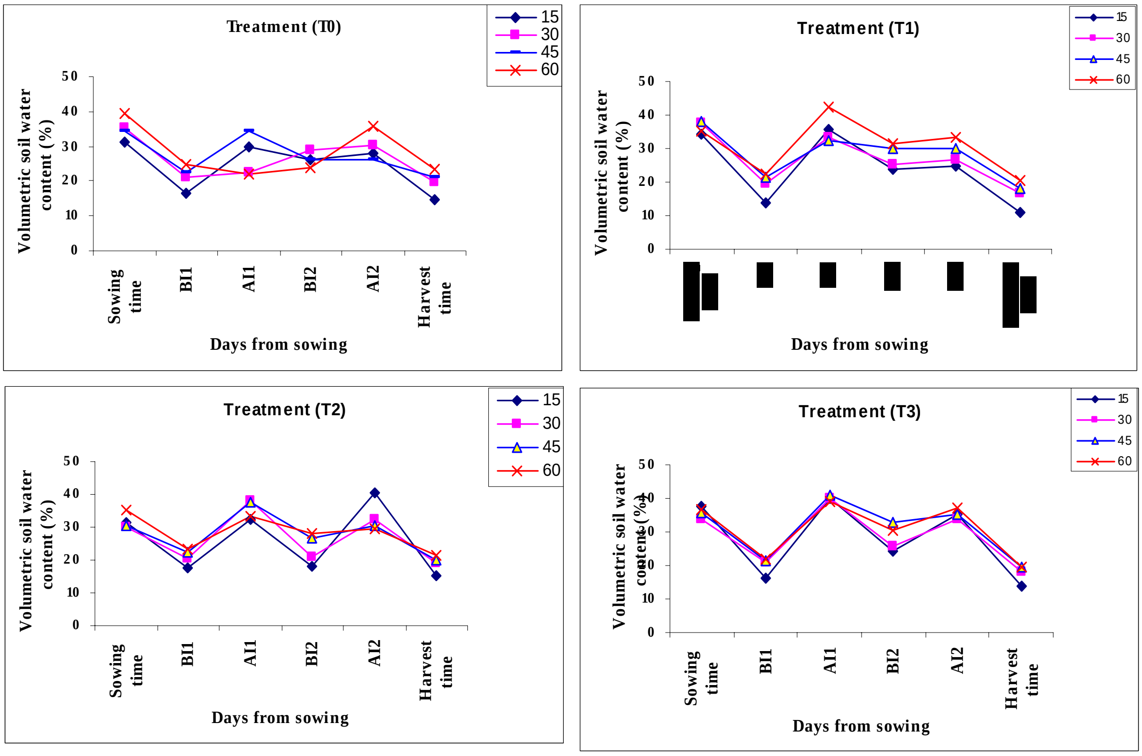
Treatments	Plant height (cm)	Tiller hill^{-1} (no.)	Panicle length (cm)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	99.17	13.50	24.66	26.16	5.56	4.06
T_1	97.60	12.30	24.34	25.58	5.46	4.33
T_2	95.40	12.20	23.68	26.10	5.66	3.93
T_3	98.20	12.30	24.58	26.25	5.59	4.25
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS

Table 104. Yield and yield attributing characters of mustard (BARI Sharisha-14) at Wheat Research Sub-station, Rajbari farm, Dinajpur district

Treatments	Plant height (cm)	Branch Plant (no.)	Pod plant^{-1} (no.)	Pod length (cm)	Seed pod^{-1} (no.)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	82.60	5.733	59.53	3.51	23.93	3.92	1.52	1.53
T_1	97.73	7.933	84.33	4.08	33.40	3.85	1.62	1.61
T_2	86.33	6.933	84.13	4.80	29.07	3.87	1.99	1.91
T_3	98.47	7.53	86.00	4.67	32.27	3.67	1.67	1.75
$LSD_{(0.05)}$	NS	NS	NS	NS	5.72	NS	NS	0.25

Table 105. Water requirement and irrigation water productivity of mustard (BARI Sharisha-14) at Wheat ResearchResearch Sub-station, Rajbari farm, Dinajpur

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re +ΔS (cm)	Yield (t ha^{-1})	Irrigation water productivity (kg ha^{-1}cm^{-1})
T_0	0	0	9.18	9.18	1520	165.57
T_1	3	0	11.81	14.81	1620	109.38
T_2	3	0	7.78	10.78	1990	184.60
T_3	6	0	10.91	16.91	1670	98.76



* BI1= Before 1st irrigation, AI1= After 1st irrigation, BI2= Before 2nd irrigation and AI2= After 2nd irrigation

Fig. 44. Volumetric soil water content (%) at various stages from sowing to harvest of mustard at Wheat Research Research Sub-station, Rajbari farm, Dinajpur

Table 106. Effect of AWD methods on the yield and yield attributing characters of boro rice at Wheat Research Research Sub-station, Rajbari farm, Dinajpur district

Treatments	Plant height (cm)	Tiller hill^{-1} (no.)	Panicle length (cm)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	11.6.26	13.00	24.76	24.88	7.34	6.49
T_1	109.80	12.67	23.88	24.24	7.29	6.44
T_2	105.63	12.76	23.83	24.33	6.93	5.98
T_3	100.16	11.60	23.65	24.73	6.17	6.24
$LSD_{(0.05)}$	5.43	NS	NS	NS	NS	NS

Table 107. Effect of different AWD methods on irrigation frequency, water saving and water productivity of rice

Treatments	Water applied for crop establishments (cm)	Irrigation frequency (days)	Number of irrigation	Total water applied (cm)	Effective rainfall (cm)	Water requirements (cm)	Water saving compared to T_0 (%)	Yield ($t\ ha^{-1}$)	Water productivity ($kg\ ha^{-1}cm^{-1}$)
T_o		3	12	48		85.00	-	7.34	86.35
T_1		4	8	40		77.00	10.38	7.29	94.67
T_2		7	5	25	5.00	62	37.09	6.93	111.77
T_3	32	11	4	20		57	49.12	6.17	108.24

Table 108. Yield and yield attributing characters of T. Aman (BRRI dhan49) rice at Wheat Research Research Sub-station, Rajbari farm, Dinajpur under rainfed condition

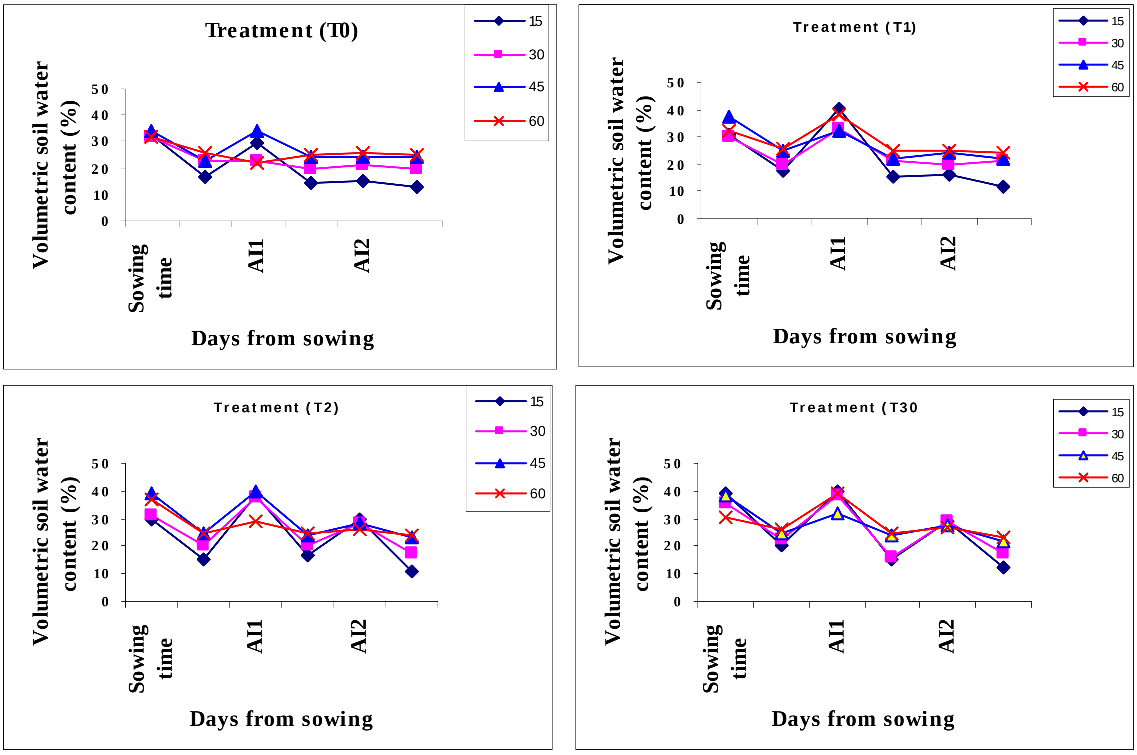
Treatments	Plant height (cm)	Tiller $hill^{-1}$ (no.)	Panicle length (cm)	1000 seed wt. (g)	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)
T_0	85.00	10.00	22.60	25.90	4.50	5.57
T_1	102.00	12.00	24.00	24.88	4.70	5.85
T_2	96.10	13.00	24.50	25.20	4.91	5.88
T_3	90.25	11.00	24.21	23.78	4.80	5.75
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS

Table 109. Yield and yield attributing characters of potato (cardinal) at Wheat Research Research Sub-station, Rajbari farm, Dinajpur

Treatments	Plant height (cm)	Stem $hill^{-1}$ (no.)	Tuber $plant^{-1}$ (no.)	Wt. of tuber $plant^{-1}$ (g)	yield of tuber ($t\ ha^{-1}$)	Dry wt. stem ($t\ ha^{-1}$)
T_0	10.23	4.85	7.55	343.33	24.16	10.23
T_1	12.77	4.33	7.98	403.78	29.22	12.77
T_2	12.48	4.42	8.15	443.22	29.13	12.48
T_3	13.88	4.37	8.05	387.75	30.29	13.88
$LSD_{(0.05)}$	NS	NS	NS	50.46	NS	NS
Msulch	13.17	4.47	8.15	402.47	28.36	13.17
Nomulch	11.52	4.52	7.72	386.58	28.03	11.52

Table 110. Water requirement and irrigation water productivity of potato (cardinal) at Wheat Research Research Sub-station, Rajbari farm, Dinajpur

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re + ΔS (cm)	Yield ($t\ ha^{-1}$)	Irrigation water productivity ($kg\ ha^{-1}cm^{-1}$)
T_0	0	0	7.28	7.28	24.16	3318.68
T_1	4	0	7.71	11.71	29.22	2495.30
T_2	4	0	9.15	13.15	29.13	2215.09
T_3	8	0	10.37	18.37	30.29	1648.88



*BI1 = Before 1st irrigation, AI1 = After 1st irrigation, BI2 = Before 2nd irrigation and AI2 = After 2nd irrigation

Fig. 45. Volumetric soil water content (%) at various stages from sowing to harvest of potato at Wheat Research Sub-station, Rajbari, Dinajpur

Table 111. Yield and yield attributing characters of sesame at Wheat Research Sub-station, Rajbari farm, Dinajpur under rainfed condition

Treatments	Plant Height (cm)	Branch plant^{-1} (no.)	Pod length (cm)	Pod plant^{-1} (no.)	Seed pod^{-1} (no.)	Grain yield (kg ha^{-1})
T_0	157.83	1.10	4.30	77.00	83.50	971.25
T_1	160.50	0.77	4.76	60.43	73.30	1123.58
T_2	153.13	1.47	4.51	73.83	78.07	1134.58
T_3	146.63	1.43	4.38	64.93	72.73	939.17
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS

Table 112. Water requirement and irrigation water productivity of sesame (Binatil-1) at Wheat Research Sub-station, Rajbari farm, Dinajpur

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re + ΔS (cm)	Yield (t ha^{-1})	Irrigation water productivity (kg ha^{-1}cm^{-1})
T_0	0	13.0	8.91	24.91	971.25	38.99
T_1	3.0	13.0	3.12	22.12	1123.58	50.79
T_2	0	13.0	9.58	25.58	1134.58	44.35
T_3	3.0	13.0	2.14	21.14	939.17	44.42

* includes 3cm post sowing irrigation

Studies on the water and nitrogen use efficiency for sustaining productivity of different dry land crops under varying soil moisture regimes using ^{15}N tracer technique

The objective of this experiment was to know the effect of different N levels on the growth, yield and N uptake in a given cropping pattern during Kharif-II (July-November), Rabi (November-March) and Kharif-I (March-June) season. The experiment was conducted at Rajbari farm, Dinajpur district. A single cropping pattern e.g.; T. aman (BRRI dhan49)–Wheat (BARI Gom-26)-Mungbean (Binamoog-8). Thirty day old seedling of (BRRI dhan49) T. aman rice was transplanted on 28 July, 2011. There were no irrigation treatments but the plots were made as per design of the next crops. The crop was grown under rainfed condition and normal cultural and management practices and harvested on 17 November 2011 (138 days life cycle). After T. aman rice (BRRI dhan49), the same plot and layout were used for the successive crop wheat. Seeds of wheat (BARI Gom-26) were sown on 14 December 2011. The main plot treatments were as follows: T_0 = No irrigation (control), T_1 = Irrigation at CRI stage (20-25 DFS) up to field capacity ,T_2 = Irrigation at CRI and maximum tillering stages (40-45 DFS) up to field capacity, T_3 = Irrigation at CRI, maximum tillering, and booting and heading stages (60-65 DFS) up to field capacity and the sub plot treatment were as follows; N_0 = No Nitrogen (control), N_1 = 50 kg N ha^{-1}, N_2 = 100 kg N ha^{-1} and N_3 = 150 kg N ha^{-1}. The crop was harvested on 4 April, 2012. After harvest of wheat, the same plot and layout were used for the successive crop mungbean. The treatments were as follows: T_0 = No supplementary irrigation, T_1 = One irrigation at vegetative stage (15-20 DFS), T_2 = One irrigation at flowering stage (32-38 DFS), T_3 = One irrigation at vegetative stage and one irrigation at flowering stage. Seeds of mungbean (Binamoog-8) were sown on 7 April 2012. The treatments were followed are as follows: T_0 = No supplementary irrigation, T_1 = One irrigation at vegetative stage (25-30 DFS), T_2 = One irrigation at yield formation stage (50-60 DFS) and T_3 = One irrigation at vegetative stage and one irrigation at yield formation stage. For all the Rabi and Kharif-–I crops, soil moisture was recorded at sowing time, before and after irrigation, and at harvest time of crop using gravimetric method and neutron probe (Troxler). All the cultural practices were followed as and when necessary. Yield and yield attributes were recorded which were then statistically analyzed. The ^{15}N isotope could not be applied as it was not received from IAEA.

It is found that the rice variety BRRI dhan49 produced almost identical yield of 4.85 to 5.41 t ha^{-1} under rainfed condition (Table 113.) Profile soil moisture at sowing and its depletion pattern at different depths of wheat are shown in Fig. 46. At sowing time, the soil moisture at different depths (0-15, 15-30, 30-45 and 45-60 cm) was high, ranging from about 30 to 39% (by volume). Effects of irrigation and fertilizer practices on the yield and yield attributing characters of wheat are shown in Table 114. Irrigation showed significant effect on plant height and spike length. Amount of irrigation water requirement and water productivity of wheat are shown in Table 115. Irrigation water productivity was highest in T_0 treatment (control). Effects of irrigation and fertilizer practices on the yield and yield attributing characters of mungbean are shown in Table 116. Irrigation showed significant effect on plant height, pod length, number of seed pod^{-1} and 1000 seed weight. The highest yield (1698.45 kg ha^{-1}) was obtained in treatment T_3. Amount of irrigation water requirement and water productivity of wheat are shown in Table 117. It is observed that irrigation water productivity is highest in T_3 treatment.

Table 113. Yield and yield attributing characters of T. aman (BRRI dhan49) rice at Wheat Research Sub-station, Rajbari, Dinajpur under rainfed condition

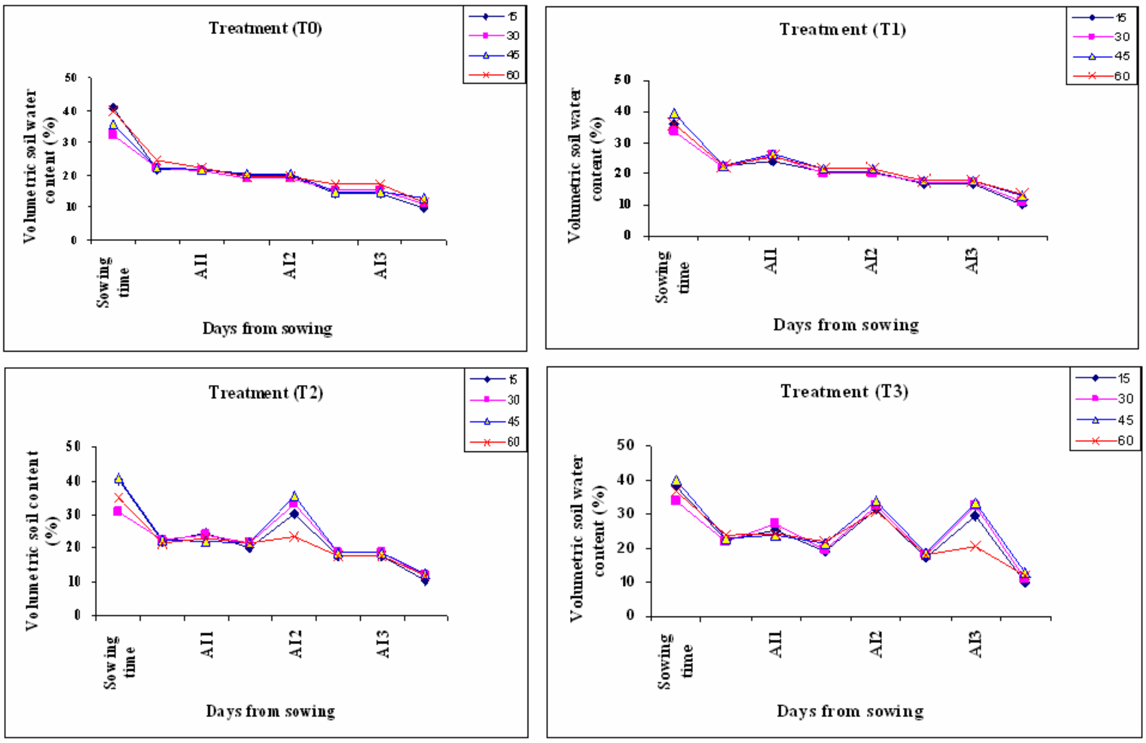
Treatments	Plant height (cm)	Tiller hill^{-1} (no.)	Panicle length (cm)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	92.60	10.10	24.10	26.20	5.41	5.75
T_1	103.00	17.17	24.60	25.90	5.27	6.00
T_2	95.00	12.20	23.40	24.85	4.85	5.30
T_3	97.10	11.20	24.20	24.95	5.10	5.82
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS

Table 114. Yield and yield attributing characters of Wheat (BARI Gom-26) at Wheat Research Sub-station, Rajbari, Dinajpur

Treatments	Plant height (cm)	Spike length (cm)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	88.70	8.67	3.70	5.49
T_1	92.87	8.93	4.06	5.72
T_2	93.28	9.17	4.04	5.86
T_3	94.02	8.84	4.03	5.62
$LSD_{(0.05)}$	3.96	0.26	NS	NS
N_0	83.10	7.50	2.58	4.30
N_1	92.51	9.02	3.81	5.48
N_2	96.86	9.22	4.70	6.33
N_3	96.86	9.86	4.75	6.58
$LSD_{(0.05)}$	2.32	0.44	0.24	0.51

Table 115. Water requirement and irrigation water productivity of Wheat (BARI gom26) at Wheat Research Sub-station, Rajbari farm, Dinajpur

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re + ΔS (cm)	Yield (kg ha^{-1})	Irrigation water productivity (kg ha^{-1}cm^{-1})
T_0	0	0	15.51	15.51	3700	238.55
T_1	3	0	14.67	17.67	4060	229.77
T_2	6	0	14.94	18.94	4040	213.30
T_3	9	0	15.44	24.44	4030	164.89



* BI1 = Before 1st irrigation, AI1 = After 1st irrigation, BI2 = Before 2nd irrigation and AI2 = After 2nd irrigation

Fig. 46 Volumetric soil water content (%) at various stages from sowing to harvest of wheat at Wheat Research Sub-station, Rajbari farm, Dinajpur

Table 116. Yield and yield attributing characters of mungbean at Wheat Research Sub-station, Rajbari, Dinajpur

Treatments	Plant height (cm)	Pod plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000 seed wt. (g)	Seed yield (t ha^{-1})
T_0	36.99	14.41	7.23	7.82	26.15	1413.48
T_1	48.32	15.57	8.97	9.59	28.76	1667.31
T_2	45.92	14.42	8.24	9.42	27.14	1463.04
T_3	55.40	15.34	9.02	10.12	28.93	1698.45
$LSD_{(0.05)}$	7.94	NS	0.56	1.04	0.78	NS
N_0	49.92	14.85	8.50	9.63	27.58	1500.04
N_1	46.64	15.67	8.48	9.25	27.66	1620.75
N_2	46.95	14.56	8.27	9.27	27.85	1586.37
N_3	43.12	14.65	8.20	8.80	27.87	1535.12
$LSD_{(0.05)}$	NS	NS	NS	Ns	NS	NS

Table 117. Water requirement and irrigation water productivity of Mungbean (Binamoog-8) at Wheat Research Sub-station, Rajbari farm, Dinajpur

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re+ ΔS+* (cm)	Yield ($t\ ha^{-1}$)	Irrigation water productivity ($kg\ ha^{-1}cm^{-1}$)
T_0	0	13.0	9.80	25.8	1413.48	54.78
T_1	3.0	13.0	1.25	20.25	1667.31	82.33
T_2	0	13.0	9.98	25.98	1463.04	56.31
T_3	3.0	13.0	1.23	17.23	1698.45	98.57

*Includes 3.0 cm post sowing irrigation

Rain water harvesting in ponds and its feasibility assessment for irrigation to non rice upland crops

The objective of this experiment was to determine the rain-water volume that could be stored and used for irrigation of non-rice low water-demanding upland crops during Kharif-I (July-November), Rabi (November-March) and Kharif-I (March-June) season. The experiment was conducted at farmer's field near Rajbari farm, Dinajpur district. A single cropping pattern e.g.; pattern I; T. aman (Binadhan-7)–Mustard (BARI Sarisha-14)–Mungbean (Binamoog-8) was followed. Thirty day old seedling of (Binadhan-7) T. aman rice was transplanted on 20 July, 2011. There was no irrigation treatment but the plots were made as per design of the next crops. The crop was grown under rainfed condition and normal cultural and management practices, and harvested on 21 October 2011 (110 days life cycle). After T. aman rice (Binadhan-7), the same plot and layout were used for the successive crop mustard. Seeds of mustard (BARI Sharisha-14) were sown in plots on 14 November 2011. The treatments were as follows: T_0 = No supplementary irrigation, T_1 = One irrigation at vegetative stage (20-25 DFS), T_2 = One irrigation at flowering stage (32-36 DFS) and T_3 = One irrigation at vegetative stage and one irrigation at flowering stage. The crop was harvested on 31 January, 2012. After harvest of mustard, the same plot and layout were used for the successive crop mungbean.

Seeds of mungbean (Binamoog-8) were sown in plots on 20 March 2012. The treatments were as follows: T_0 = No supplementary irrigation T_1 = One irrigation at vegetative stage (25-30 DFS), T_2 = One irrigation at pod formation stage (50-60 DFS) and T_3 = One irrigation at vegetative stage and one irrigation at pod formation stage. For all the robi and Kharif-I crops, soil moisture was recorded at sowing time, before and after irrigation, and at harvest time of crop using gravimetric method and neutron probe (Troxler). All the cultural practices were followed as and when necessary. Yield and yield attributes were recorded which were then statistically analyzed.

It is found that Binadhan-7 produced almost identical yield of 4.00 to 4.5 t ha^{-1} under rainfed condition (Table 118.) Profile soil moisture at sowing and its depletion pattern at different depths of mustard are shown in Fig. 47. Soil moisture at different depths (0-15, 15-30, 30-45 and 45-60 cm) was high ranging from about 30 to 38% (by volume). Effect of irrigation on the yield and yield attributing characters of mustard are shown in Table 119. Irrigation did not show any effect on the yield and its parameters except straw yield. The highest seed yield of 2.51 t ha^{-1} was obtained under the soil moisture regime T_3. Amount of irrigation water requirement and water productivity of mustard are shown in Table 120. It is observed that irrigation water productivity is highest in T_0 treatment (control). Effect of irrigation on the yield and yield attributing characters of mungbean are shown in Table 122. Irrigation showed significant effect only on the seed yield. The highest seed yield of 1308.33 kg ha^{-1} was obtained under the soil moisture regime T_3. Amount of irrigation water requirement and water productivity of mungbean are shown in Table 123. From table, it is observed that irrigation water productivity is highest in T_3 treatment.

Table 118. Yield and yield attributing characters of T. aman (Binadhan-7) rice at Vatpara, Dinajpur under rainfed condition

Treatments	Plant height (cm)	Tiller $hill^{-1}$ (no.)	Panicle length (cm)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	90.20	10.50	22.85	25.20	4.50	4.66
T_1	89.90	9.40	21.73	24.80	4.00	4.33
T_2	91.60	10.00	23.08	25.10	4.33	4.03
T_3	92.30	11.00	23.40	25.40	4.38	4.38
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS

Table 119. Yield and yield attributing characters of Mustard (BARI Sharisha-14) at Vatpara, Dinajpur

Treatments	Plant height (cm)	Branch $plant^{-1}$ (no.)	Pod $plant^{-1}$ (no.)	Pod length (cm)	Seed pod^{-1} (no.)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	88.40	7.00	63.00	4.30	36.27	3.67	2.20	3.25
T_1	96.00	7.20	52.13	3.97	35.00	3.90	2.31	4.06
T_2	90.47	6.47	51.67	4.43	32.93	3.88	2.34	3.63
T_3	91.13	7.47	61.73	4.23	33.27	3.95	2.51	3.54
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS	0.25

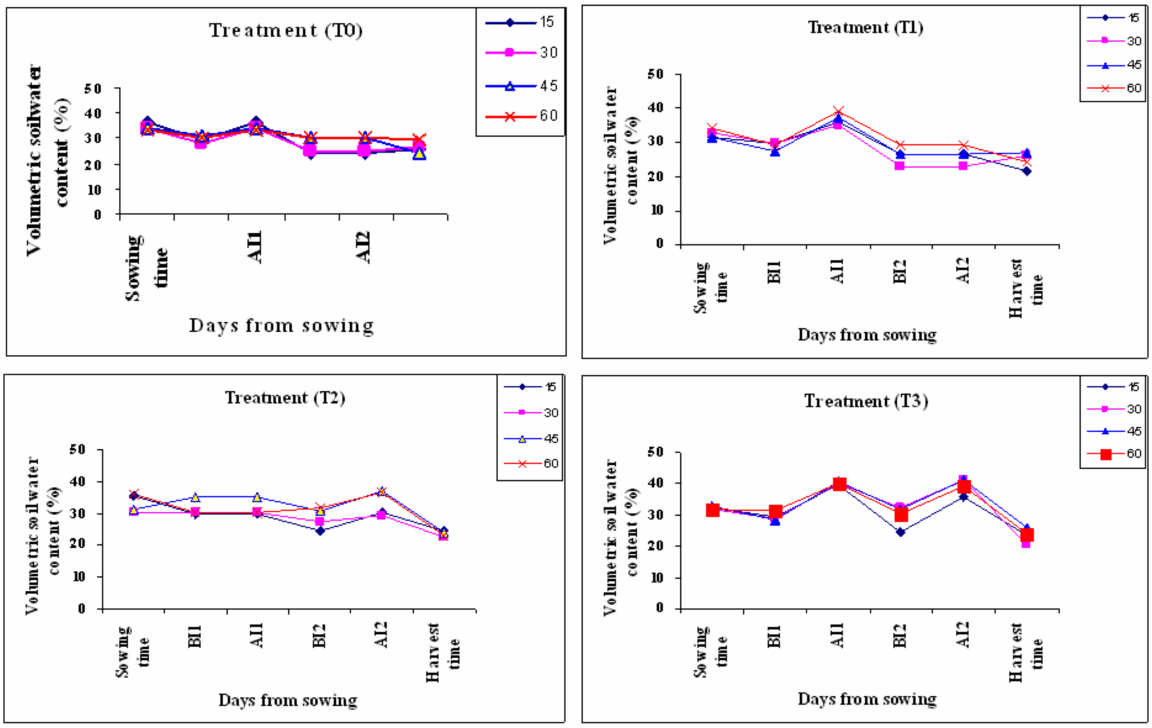
Table 120. Water requirement and irrigation water productivity of Mustard (BARI sharisha14) at Vatpara, Dinajpur

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re + ΔS (cm)	Yield (kg ha^{-1})	Irrigation water productivity (kg $ha^{-1}cm^{-1}$)
T_0	0	0	10.75	10.75	2200	204.65
T_1	3	0	11.00	14.00	2310	165.00
T_2	3	0	11.83	14.83	2340	157.78
T_3	6	0	9.28	15.28	2510	164.26

Table 121. Pond water depth in cropping season of Rice-Mustard-Mungbean

Date	Depth (m) of pond water and crop growth stages
28.07.2011	1.55 at transplanting time of rice
17.08.2011	1.73 at weeding time of rice
25.10.2011	1.25 at harvest time of rice
14.11.2011	1.13 at sowing time of mustard
15.12.2011	1.10 at vegetative stage of mustard
30.12.2011	0.95 at flowering stage of mustard
31.01.2012	0.60 at harvest time of mustard
18.04.2012	0.50 at sowing time of mungbean
08.05.2012	0.55 at vegetative stage of mungbean (depth increase due to rainfall)
26.05.2012	0.60 at harvest time of mungbean (depth increase due to rainfall)

Pond area: 410 square meter



* BI1 = Before 1st irrigation, AI1 = After 1st irrigation, BI2 = Before 2nd irrigation and AI2 = After 2nd irrigation

Fig. 47. Volumetric soil water content (%) at various stages from sowing to harvest of mustard at Vatpara farmers field, Dinajpur district

Table 122. Yield and yield attributing characters of mungbean at farmers' field, Dinajpur

Treatments	Plant height (cm)	Pod plant^{-1} (no.)	Pod length (cm)	Seed pod^{-1} (no.)	Seed yield (kg ha^{-1})
T_0	53.20	19.80	9.00	12.00	1033.33
T_1	50.80	15.20	9.10	12.46	1290.00
T_2	56.80	20.26	9.33	13.00	1265.00
T_3	54.33	17.73	8.93	12.27	1308.33
$LSD_{(0.05)}$	NS	NS	NS	NS	56.97

Table 123. Water requirement and irrigation water productivity of mungbean (Binamoog-8) at Vatpara farmer's field, Dinajpur district

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re + ΔS + * (cm)	Yield (t ha^{-1})	Irrigation water productivity (kg ha^{-1}cm^{-1})
T_0	0	13.0	8.65	24.65	1033.33	41.92
T_1	3.0	13.0	3.29	22.29	1290.00	57.87
T_2	0	13.0	7.58	23.58	1265.00	53.65
T_3	3.0	13.0	2.45	21.45	1308.33	60.99

* Includes 3.0 cm post-sowing irrigation

AGRONOMY DIVISION

RESEARCH HIGHLIGHTS

In boro season, aromatic fine grain rice varieties (Kalozira and Binadhan-9) produced highest grain yield in August 01 transplanting. The data recorded on crop duration from seed to seed revealed that Binadhan-9 required the least average of 119 days and Kalozira required 149 days. Delayed transplanting of both the varieties shortened the crop duration.

Three rice lines/variety were evaluated under four dates of transplanting starting from Dec. 31 with an interval of 15 days at saline area of Kaligonj, Shamnagar Upazila of Satkhira during boro season of 2011-12. The salt tolerant line PBRC-37 produced the maximum grain yield (4.03 t ha^{-1}) when transplanted on Feb. 15.

Two drought tolerant exotic rice varieties (Nerica-1 and Nerica-10) were evaluated compared to one check variety in dibbling method at the farmers' field of Godagari, Rajshahi district during Boro season, 2011-12. The results showed that highest grain yield (4.11 t ha^{-1}) was obtained from the variety Nerica-10 when transplanted with 15 cm × 15 cm spacing.

Three tomato mutants (TM-131, TM-134 and TM-219) with a check variety were assessed under three dates of transplanting started from Nov. 10 with an interval of ten days at the BINA sub-station, Magura during rabi season, 2011-2012. The mutant line-219 produced higher fruit yield in both Nov. 20 (116.19 t ha^{-1}) and Nov. 30 (107.06 t ha^{-1}).

In a soybean experiment with different spacings showed that the seed yield of the line, BAU-S/70 with row spacing of 20 cm was the highest (2.94 t ha^{-1}) followed by Binasoybean-1 (2.78 t ha^{-1}) with the same spacing.

Sesame trial with different row spacings showed that Binatil-1 and Binatil-2 produced the higher seed yield with 15 cm and 20 cm row spacing at Ishurdi and Magura. It meant that row spacings can be used for these varieties from 15 cm to 20 cm for maximizing seed yield.

In herbicide trail in boro season, the highest grain yield was obtained (5.50 t ha^{-1} and 5.44 t ha^{-1}) from two hands weeding at 30 and 50 DAT by Binadhan-5 and BRRI dhan29. The herbicide pre-chlor 500 EC with one hand weeding at 50 DAT produced also similar grain yield (5.42 t ha^{-1} and 5.27 t ha^{-1}).

Effect of date of transplanting on the yield performance of aromatic long slender fine grain advanced mutants of rice in T. aman season

Two fine rice varieties were evaluated under three different dates of transplanting starting from August 01, 2011 with an interval of 10 days at the experimental farm of Bangladesh Institute of Nuclear Agriculture, Mymensingh during aman season of 2011-12. The objective was to determine the yield performances of the varieties affected by different dates of transplanting. The three different dates of transplanting were Aug. 01 (D_1), Aug. 10 (D_2), and Aug. 20 (D_3). The advanced fine rice varieties were Kalozira (V_1) and Binadhan-9 (V_2). The experiment was laid out as factorial randomized complete block design with three replications. The unit plot size was 4 m × 3 m. Thirty days-old seedlings were transplanted @ 2-3 seedlings hill^{-1} with a planting spacing of 20 cm x 15 cm. The plots were fertilized with 105, 15, 60, 15 and1.5 kg ha^{-1} of N, P, K, S, Zn as urea, TSP, MOP, gypsum and zinc sulfate, respectively. All fertilizers except urea were applied at final land preparation in full doses. Urea was applied in three equal splits- at 7, 30 DAT and at before panicle initiation stage. The crop was harvested at different dates at maturity and data on yield and yield components were recorded at harvest and were statistically analyzed following the design used for the experiment and the means were compared with LSD.

The results revealed that mean grain yield of Aug. 01 transplanting was the highest (2.88 t ha^{-1}) and that of Aug. 10 was the second highest (2.29 t ha^{-1}, Table 1). The mean grain yield of Binadhan-9 irrespective of transplanting dates was 2.25 t ha^{-1} which did not differ statistically from Kalozira (2.26 t ha^{-1}). The interaction results showed that the variety, Kalozira when transplanted on Aug. 01 produced the maximum grain yield (2.90 t ha^{-1}) but its grain yield did not show statistical differences with Binadhan-9 (2.87 t ha^{-1}). Both the varieties showed decreased grain yield in late transplanting. The data recorded on crop duration from seed to seed revealed that Binadhan-9 required the least average maturity duration of 119 days and that of Kalozira required 149 days. Both the varieties with delayed transplanting shortened the crop duration.

Table 1. Dates of transplanting of fine rice in T. aman season in Mymensingh during 2011-12

Treatments	Plant height (cm)	Tillers hill^{-1} (no.)	Panicles hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Duration (days)
Transplant. date										
Aug.01(D_1)	106.03	8.65	7.52	24.30	75.80	29.03	17.28	2.88	3.70	136
Aug.10 (D_2)	107.24	7.17	5.88	23.43	79.56	30.33	17.52	2.29	4.49	134
Aug.20 (D_3)	99.27	7.38	6.26	22.60	76.76	36.06	15.03	1.56	3.15	132
$Lsd_{0.05}$	1.56	0.59	0.88	0.79	1.95	2.67	1.04	0.08	0.08	
Varieties										
Kalozira (V_1)	109.80	8.13	7.05	23.10	93.44	17.69	14.46	2.26	3.41	149
Binadhan-9 (V_2)	98.56	7.33	6.05	23.78	61.31	45.93	18.76	2.25	4.15	119
$LSD_{0.05}$	**	**	**	*	**	**	**	ns	**	
Date x Variety										
D_1V_1	110.20	9.70	8.37	24.23	98.86	9.46	15.04	2.90	3.90	151
D_1V_2	101.87	7.60	6.67	24.36	52.73	48.60	19.53	2.87	3.50	121
D_2V_1	110.60	6.73	6.06	22.60	91.46	19.80	14.47	2.15	3.56	149
D_2V_2	103.87	7.60	5.70	24.26	67.67	40.86	20.58	2.44	3.42	119
D_3V_1	108.60	7.96	6.73	22.46	90.00	23.80	13.89	1.68	2.77	147
D_3V_2	89.93	6.80	5.80	22.73	63.53	48.33	16.17	1.44	3.53	118
$LSD_{0.05}$	2.54	0.41	0.56	0.86	1.57	1.99	1.29	0.09	0.27	

Evaluation of Binadhan-8 with some salt tolerant advanced rice lines transplanting at different dates in boro season

Three rice lines/variety were evaluated under four dates of transplanting starting from Dec. 31 with an interval of 15 days at saline area of Kaligonj, Shamnagar upazila of Satkhira during boro season of 2012. The objective was to observe how the yield performances of these lines were affected by different dates of transplanting. The four dates of transplanting were Dec. 31 (D_1), Jan. 15 (D_2), Jan. 31 (D_3) and Feb. 15 (D_4). The salt tolerant advanced rice lines/variety was PBRC-37, PBSAL-655 and Binadhan-8. The experiment was laid out in RCBD with three replications. The unit plot size was 4 m × 3 m. Forty days-old seedlings were transplanted @ 3-4 seedlings hill^{-1} with a planting spacing of 20 cm × 15 cm. The plots were fertilized @ 75, 20, 40, 10 and 2 kg ha^{-1} of N, P, K, S, Zn as urea, triple super phosphate, muriate of potash, gypsum and zinc oxide. All fertilizers except urea were applied at final land preparation in full amount. Urea was applied in three splits: 30% at 7-10 days after transplanting (DAT), 30% at 25-30 DAT and 40% at panicle initiations (PI) stage. The crop was harvested at different dates at maturity and data on yield and yield components were recorded at harvest and were statistically analyzed following the design used for the experiment and the means were compared with LSD.

The mean grain yield due to date of transplanting was the highest (3.15 t ha^{-1}) in Feb. 15 transplanting followed by Jan.31 while Dec. 31 and Jan. 15 transplanting had produced the least (Table 2). The results of mean grain yields among the lines, PBRC-37 irrespective of transplanting dates was the highest (3.39 t ha^{-1}) followed by the rice line PBSAL-655. The interaction results showed that PBRC-37 when transplanted on Feb. 15 produced the maximum grain yield (4.03 t ha^{-1}) and when transplanted on Jan. 31 (3.96 t ha^{-1}).

Table 2. Date of transplanting of Salt tolerant rice lines in Boro season at Satkhira during 2011-12.

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-seed wt. (g)	Grain yield (t ha^{-1})
Transplant Date:								
Dec. 31 (D_1)	81.21	11.78	10.31	20.03	88.53	31.95	15.10	2.23
Jan. 15 (D_2)	79.58	10.88	9.40	19.51	88.91	32.04	15.09	2.23
Jan. 31 (D_3)	87.33	13.20	10.90	20.56	127.51	46.82	17.57	3.37
Feb. 15 (D_4)	86.69	13.04	11.20	20.56	131.55	45.86	17.76	3.51
$LSD_{0.05}$	2.73	1.27	0.99	0.77	4.03	1.57	0.29	0.13
Varieties:								
PBRC- 37 (V_1)	88.10	14.35	12.68	20.55	108.60	27.53	15.73	3.39
PBSAL- 655 (V_2)	83.29	10.60	8.95	20.24	121.96	56.43	18.71	2.61
Binadhan-8 (V_3)	79.72	11.73	9.73	19.70	96.81	33.55	14.70	2.51
$LSD_{0.05}$	2.36	1.10	0.85	0.67	3.34	1.36	0.25	0.11
Date × Variety:								
D_1V_1	86.73	12.60	11.33	21.50	97.46	16.20	15.23	2.80
D_1V_2	80.92	10.80	9.33	19.88	100.00	59.33	18.59	2.42
D_1V_3	76.00	11.93	10.26	18.73	68.13	20.33	11.48	1.47
D_2V_1	81.26	10.86	9.73	19.76	96.80	16.67	15.35	2.78
D_2V_2	83.20	11.00	9.53	19.83	102.53	58.40	18.33	2.47
D_2V_3	74.26	10.80	8.93	18.93	67.40	21.06	11.57	1.45
D_3V_1	92.86	17.13	14.66	20.66	119.00	38.67	16.14	3.96
D_3V_2	85.07	10.00	8.06	20.56	142.66	54.33	19.04	2.73
D_3V_3	84.07	12.46	10.00	20.43	120.86	47.46	17.53	3.43
D_4V_1	91.53	16.80	15.00	20.26	121.13	38.60	16.21	4.03
D_4V_2	84.00	10.60	8.86	20.70	142.66	53.67	18.87	2.83
D_4V_3	84.53	11.73	9.73	20.70	130.87	45.33	18.20	3.68
$LSD_{0.05}$	4.73	2.21	1.72	1.34	6.98	2.73	0.51	0.23

Effect of different spacing on dibbling method of sowing on the yield performance of Nerica rice in boro season

Two drought tolerant rice varieties were evaluated compared to one check variety at the farmer's field of godagari, Rajshahi district during Boro season, 2011-12. The objective was to evaluate the yield performances of these varieties in non-irrigated condition. The variety was Nerica-1 (V_1), Nerica-10 (V_2) and the check was Binadhan-8 (V_3). The three spacings were 15 cm x 15 cm (S_1), 20 cm × 15 cm (S_2) and 20 cm × 20 cm (S_3). Three to four seeds were sown in dibling method. The experiment was laid out in a RCB design with three replications. Data on yield and yield components were recorded at harvest and were statistically analyzed following the design used for the experiment and the means were compared with LSD. The results of the experiments are discussed below.

The results showed that the highest grain yield (3.76 t ha^{-1}) was obtained by Nerica-10 (Table 3) fallowed by Binadhan-8 which produced the second highest yield (2.99 t ha^{-1}). Nerica-1 produced the lowest yield (2.75 t ha^{-1}). Spacing showed significant effect on the grain yield. Highest grain yield (3.44 t ha^{-1}) was produced in closer spacing (15 cm x 15 cm) and the second highest yield (3.15 t ha^{-1}) in medium spacing (20 cm × 15 cm). Lowest yield was obtained in wider spacing (20 cm × 20 cm). Interaction between variety and spacing showed that the highest yield (4.11 t ha^{-1}) was obtained by the variety Nerica-10 when transplanted with 15 cm × 15 cm spacing. For genuine recommendation, further investigation is needed.

Table 3. Date of transplanting of Nerica rice in Boro season at Rajshahi during 2011-12

Treatments	Plant height (cm)	Total tillers $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Varieties:									
Nerica-1 (V_1)	90.21	16.04	15.60	21.75	74.97	21.15	25.61	2.75	11.40
Nerica-10 (V_2)	93.02	17.73	46.46	22.27	73.86	25.81	23.68	3.76	10.65
Binadhan-8 (V_3)	94.20	16.28	14.24	24.09	98.13	23.00	23.81	2.99	11.96
$LSD_{0.05}$	0.76	ns	ns	1.35	15.78	ns	0.63	0.56	ns
Spacings:									
15cm x 15cm (S_1)	92.54	14.66	13.80	22.05	73.17	22.80	24.32	3.44	12.57
20cm x 15cm (S_2)	93.05	16.97	15.69	22.81	83.35	23.84	24.30	3.15	11.37
20cm x 20cm (S_3)	91.93	18.42	16.82	23.26	90.43	23.32	24.48	2.90	10.07
$LSD_{0.05}$	0.76	2.56	1.88	ns	11.45	ns	ns	0.41	ns
Variety × spacing									
$V_1 S_1$	90.00	14.40	14.40	21.70	68.40	20.96	25.68	2.77	11.22
$V_1 S_2$	91.10	17.06	16.73	22.08	73.13	20.66	25.68	2.83	11.53
$V_1 S_3$	89.83	16.66	15.66	21.48	83.40	21.83	25.47	2.66	11.44
$V_2 S_1$	92.86	16.00	15.00	21.56	64.33	28.17	23.76	4.11	13.39
$V_2 S_2$	93.63	17.40	16.33	21.78	70.46	25.06	23.67	3.83	10.00
$V_2 S_3$	92.56	19.80	18.07	23.46	86.77	24.20	23.63	3.33	8.56
$V_3 S_1$	94.76	13.60	12.00	22.88	86.80	19.27	23.53	3.44	13.11
$V_3 S_2$	94.43	16.46	14.00	24.57	106.47	25.80	23.57	2.80	12.57
$V_3 S_3$	93.40	18.80	16.78	24.83	101.13	23.93	24.33	2.72	10.22
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns

Effect of different dates of transplanting on the growth and yield of tomato mutants

Three tomato mutants with a check variety were assessed under three dates of transplanting started from Nov. 10 with an interval of ten days at the BINA sub-station, Magura during rabi season, 2011-2012. The mutants were TM-131, TM-134, TM-219 and the check variety was Baritomato-5. The transplanting dates were Nov.10, Nov.20 and Nov.30. A unit plot size was 3 m x 4 m. The design used was RCBD with three replications. Data on yield and yield attributes were recorded at harvest. Yield and yield parameters did not show significant differences over transplanting dates (Table 4). The mean yield was highest 84.05 t ha^{-1} when transplanted on Nov. 20 followed by 80.1 t ha^{-1} when transplanted on Nov. 30. Among the mutant lines, highest fruit yield was obtained (102.66 t ha^{-1}) by TM-219. The results of interaction between transplanting date and varieties showed that the mutant line-219 produced higher fruit yield in both Nov. 20 (116.19 t ha^{-1}) and Nov. 30 (107.06 t ha^{-1}).

Table 4. Date of transplanting of Tomato at Magura during 2011-12

Treatments	Plant height (cm)	Branches $plant^{-1}$ (no.)	Fruits $plant^{-1}$ (no.)	Fruit yield (t ha^{-1})
Transplanting Date:				
Nov. 10 (D_1)	88.45	3.21	38.08	74.38
Nov. 20 (D_2)	86.28	3.53	39.55	84.05
Nov. 30 (D_3)	87.93	3.10	36.53	80.10
$LSD_{0.05}$	ns	ns	ns	ns
Varieties:				
TM-131 (V_1)	81.67	3.20	31.26	72.22
TM-134 (V_2)	77.78	2.93	35.04	69.06
TM-219 (V_3)	94.38	3.93	46.24	102.66
Binatomato-5 (V_4)	96.40	3.06	39.66	74.10
$LSD_{0.05}$	5.04	0.67	8.93	18.03
Date × Variety:				
D_1V_1	82.53	3.00	31.53	74.02
D_1V_2	77.93	3.00	29.26	53.43
D_1V_3	94.93	3.86	43.13	84.73
D_1V_4	98.40	3.00	48.40	85.36
D_2V_1	82.47	3.60	32.20	71.97
D_2V_2	76.40	2.93	39.60	79.02
D_2V_3	94.46	4.40	50.93	116.19
D_2V_4	91.80	3.20	35.46	69.02
D_3V_1	80.00	3.00	30.06	70.66
D_3V_2	79.00	2.86	36.27	74.73
D_3V_3	93.73	3.53	44.67	107.06
D_3V_4	99.00	3.00	35.13	67.93
$LSD_{0.05}$	ns	ns	ns	ns

Determination of optimum spacing and seed rate for growth and yield of soybean lines

The experiment was conducted at two locations viz., BINA HQ farm at Mymensingh and sub-station farm at Magura to evaluate the effect of three row spacings such as 20 cm (S_1), 25 cm (S_2) and 30 cm (S_3) on the yield and yield contributing characters of two advanced soybean lines viz., BAU-S/70 (V_1), AVRDC-78 (V_2) along with one check variety Binasoybean-1 (V_3). The experiment was laid out in RCBD with 3 replications. The unit plot size was 4 m × 3 m. Recommended doses of fertilizers were applied. The seeds were sown on 1 January 2011 at both the locations. The experiment was harvested on different dates according to the maturity of the mutant lines/varieties at two locations. The data on yield attributes were recorded from randomly selected 10 plants while the yield data were recorded from the harvest of the whole plot. All the recorded data were statistically analyzed using MSTAT Statistical Computer Package Programme according to the design used for the experiment. Least significant difference (LSD) was used to compare variations among treatments. Results are discussed below in Table 5.

The mean seed yield was highest (2.65 t ha^{-1}) in Mymensingh contributed by higher number of population, pods $plant^{-1}$, pod $length^{-1}$ and seeds pod^{-1}. Among different advance lines, BAU–S/70 produced highest seed yield (2.70 t ha^{-1}) and AVRDC–78 produced second highest seed yield (2.49 t ha^{-1}). The lowest seed yield was obtained by Binasoybean-1 (2.45 t ha^{-1}). The closer spacing (20 cm row) yielded higher (2.79 t ha^{-1}) than 25 cm and 30 cm row spacing. The interaction results presented in (Table 5) revealed that the seed yield of BAU-S/70 with row spacing of 20 cm was the highest (2.94 t ha^{-1}) followed by Binasoybean-1 (2.78 t ha^{-1}) with the same spacing. BAU-S/70 performs better in respect of yield in both 20 cm and 25 cm row spacing.

Table 5. Determination of optimum spacing for growth and yield of soybean lines

Treatment	Population stand (no. m^{-2})	Plant height (cm)	Pod $plant^{-1}$ (no.)	Pod length (cm)	Seed pod^{-1} (no.)	Seed yield (t ha^{-1})
Location:						
Mymensingh (L_1)	51.926	61.44	49.28	3.80	2.74	2.65
Magura (L_2)	40.889	67.05	44.03	3.69	2.58	2.44
T-Values	**	ns	ns	*	**	ns
Varities:						
BAU-S/70 (V_1)	45.05	82.48	48.86	3.72	2.54	2.70
AVRDC78 (V_2)	37.00	50.71	53.66	3.76	2.68	2.49
Bina soybean 1 (V_3)	57.16	59.54	37.43	3.74	2.76	2.45
$LSD_{0.05}$	11.26	20.45	9.71	ns	ns	ns
Row spacing:						
20 cm (S_1)	54.44	68.15	45.37	3.67	2.63	2.79
25 cm (S_2)	47.33	64.25	45.60	3.78	2.68	2.55
30 cm (S_3)	37.44	60.33	48.98	3.77	2.67	2.29
$LSD_{0.05}$	4.86	7.11	ns	ns	ns	0.33

Table 5 Contd.

Treatment	Population stand (no. m^{-2})	Plant height (cm)	Pod $plant^{-1}$ (no.)	Pod length (cm)	Seed pod^{-1} (no.)	Seed yield (t ha^{-1})
Interaction:						
Location × Variety:						
L_1V_1	54.22	80.91	49.24	3.76	2.57	2.80
L_1V_2	36.88	48.55	59.02	3.84	2.82	2.58
L_1V_3	64.66	54.86	39.57	3.78	2.84	2.58
L_2V_1	35.88	84.06	48.48	3.69	2.51	2.60
L_2V_2	37.11	52.86	48.31	3.67	2.55	2.40
L_2V_3	49.66	64.22	35.28	3.70	2.68	2.32
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns
Location × Spacing:						
L_1S_1	60.77	66.97	48.35	3.63	2.75	2.90
L_1S_2	53.77	60.24	49.33	3.82	2.68	2.76
L_1S_3	41.22	57.11	50.15	3.94	2.80	2.29
L_2S_1	48.11	69.33	42.40	3.72	2.51	2.69
L_2S_2	40.88	68.26	41.86	3.74	2.68	2.34
L_2S_3	33.66	63.55	47.82	3.60	2.55	2.28
$LSD_{0.05}$	ns	ns	ns	0.23	ns	ns
Variety × Spacing:						
$V_1 S_1$	54.66	84.00	49.73	3.67	2.46	2.94
$V_1 S_2$	45.33	85.13	43.96	3.76	2.60	2.70
$V_1 S_3$	35.16	78.33	52.90	3.74	2.56	2.45
$V_2 S_1$	41.83	56.80	56.06	3.71	2.66	2.67
$V_2 S_2$	38.83	49.43	53.53	3.77	2.66	2.55
$V_2 S_3$	30.33	45.90	51.40	3.81	2.73	2.25
$V_3 S_1$	66.83	63.66	30.33	3.65	2.76	2.78
$V_3 S_2$	57.83	58.20	39.30	3.82	2.80	2.41
$V_3 S_3$	46.83	56.76	42.66	3.76	2.73	2.16
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns
Location × Variety × Spacing:						
$L_1V_1 S_1$	65.00	84.66	49.73	3.53	2.53	3.15
$L_1V_1 S_2$	57.00	83.93	46.06	3.86	2.46	2.68
$L_1V_1 S_3$	40.66	74.13	51.93	3.90	2.73	2.56
$L_1V_2 S_1$	41.33	55.40	60.33	3.78	2.86	2.93
$L_1V_2 S_2$	39.33	46.33	59.00	3.80	2.80	2.70
$L_1V_2 S_3$	30.00	43.93	57.73	3.96	2.80	2.10
$L_1V_3 S_1$	76.00	60.86	35.00	3.60	2.86	2.61
$L_1V_3 S_2$	65.00	50.46	42.93	3.80	2.80	2.90
$L_1V_3 S_3$	53.00	53.26	40.80	3.96	2.86	2.22
$L_2V_1 S_1$	44.33	83.33	49.73	3.82	2.40	2.72
$L_2V_1 S_2$	33.66	86.33	41.86	3.66	2.73	2.72
$L_2V_1 S_3$	29.66	82.53	53.86	3.58	2.40	2.35
$L_2V_2 S_1$	42.33	58.20	51.80	3.64	2.46	2.41
$L_2V_2 S_2$	38.33	52.53	48.06	3.73	2.53	2.39
$L_2V_2 S_3$	30.66	47.86	45.06	3.66	2.66	2.40
$L_2V_3 S_1$	57.66	66.46	25.66	3.70	2.66	2.94
$L_2V_3 S_2$	50.66	65.93	35.66	3.83	2.80	1.92
$L_2V_3 S_3$	40.66	60.26	44.53	3.57	2.60	2.09
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns

Yield performance evaluation of sesame varieties with different row spacing

An experiment was conducted in the sub-station farms of BINA at Ishurdi and Magura to evaluate the effect of four row spacings viz., 15 cm, 20 cm, 25 cm and 30 cm on the yield and yield contributing characters of sesame varieties Binatil-1 and Binatil-2. The experiment was conducted following split-plot design with 3 replications. The unit plot size was 4.5 m × 2.5 m. Sesame varieties were placed in the main plot and row spacing in the sub plot. Fertilizers urea, TSP, MP, Gypsum, Zinc sulphate and borax were applied @ 125, 115, 75, 150, 2.5 and 2 kg ha^{-1}. Half of urea and all other fertilizers were applied at final land preparation and rest half of urea was top dressed at the commencement of flowers. Plants were thinned in the lines according to the treatments after 15 days of seedling immergence. Data on yield attributes were recorded from randomly selected 10 plants from the middle of each plot. Plant population seed and straw yields were taken from the harvest of 5 middle lines and then converting per plot basis. All recorded data were statistically analyzed using the MSTAT Statistical Computer Package Program. Least significant difference (LSD) was used to compare variations among treatments. Results are discussed below.

Table 6(a). Mean effect of mutant/variety, spacing and their interaction on the yield and yield attributes of sesame at sub-station farm of BINA at Ishurdi during 2011-2012

Treatments	Plant population m^{-2}	Plant height (cm)	Capsule $plant^{-1}$ (no.)	Length $capsule^{-1}$ (cm)	Seed $capsule^{-1}$ (no.)	1000 seed weight (g)	Seed yield (kg ha^{-1})
Varieties:							
Binatil-1 (V_1)	32.42	94.78	38.15	4.13	80.03	3.18	942.50
Binatil-2 (V_2)	29.66	89.17	70.52	2.52	63.83	2.95	1084.83
T-values	**	**	**	**	**	**	**
Spacings:							
15 cm (S_1)	41.17	90.57	50.63	3.26	71.87	3.09	1080.83
20 cm (S_2)	34.17	93.47	52.83	3.34	73.07	3.08	1150.67
25 cm (S_3)	27.33	93.50	57.40	3.31	72.53	3.08	1027.00
30 cm (S_4)	21.50	90.37	56.47	3.41	70.27	3.00	796.17
$LSD_{0.01}$	2.54	ns	3.84	ns	ns	ns	50.03
Interactions:							
$V_1 S_1$	41.67	94.27	36.00	4.05	80.67	3.22	1091.67
$V_1 S_2$	35.00	97.53	37.67	4.08	82.67	3.23	994.33
$V_1 S_3$	29.33	95.20	40.33	4.16	77.60	3.17	98.33
$V_1 S_4$	23.67	92.13	38.60	4.15	79.20	3.10	695.67
$V_2 S_1$	40.67	86.87	65.27	2.47	63.06	2.96	1209.67
$V_2 S_2$	33.33	89.40	68.00	2.49	63.47	2.94	1167.33
$V_2 S_3$	25.33	91.80	74.47	2.47	62.93	3.00	1065.67
$V_2 S_4$	19.33	88.60	74.33	2.66	65.87	2.90	896.67
$LSD_{0.01}$	ns	ns	ns	ns	ns	ns	50.98

Ishurdi:

Results of the experiment showed that none of the crop characters recorded at Ishurdi was significantly influenced by planting spacing except plant height. It was observed that the varieties produced mean seed yield of 1084 kg ha^{-1} which was higher than Binatil-1 and contributed by the higher number of capsule (Table 6.a). On the other hand, mean seed yield due to spacing was the highest 1150 kg ha^{-1} with the closest spacing (15 cm row) mostly contributed by higher number of plant population and 1000 seed weight. The interaction results showed that the varieties Binatil-2 produced the highest seed yield (1209 kg ha^{-1}) at 15 cm row spacing and the second highest (1167 kg ha^{-1}) yield at 20 cm row spacing. The another variety Binatil-1 yielded highest at 15 cm row spacing. It meant that row spacing can be used for these varieties from 15 cm to 20 cm.

Table 6(b). Mean effects of mutant/variety, spacing and their interactions on the yield and yield attributes of sesame at sub-station farm of BINA at Magura during 2011-2012

Treatments	Plant population m^{-2}	Plant height (cm)	Capsule plant^{-1} (no.)	Length capsule^{-1} (cm)	Seed capsule^{-1} (no.)	1000 seed weight (g)	Seed yield (kg ha^{-1})
Varieties:							
Binatil-1 (V_1)	41.36	102.80	37.91	4.37	80.18	3.30	930.17
Binatil-2 (V_2)	40.15	92.47	63.07	2.68	64.06	2.99	997.33
T -values	ns	**	**	**	**	**	**
Spacings:							
15 cm (S_1)	52.08	99.57	51.11	3.45	70.17	3.19	1038.33
20 cm (S_2)	45.95	100.83	52.01	3.56	72.57	3.17	1214.67
25 cm (S_3)	37.33	95.23	49.08	3.55	72.83	3.16	932.83
30 cm (S_4)	27.67	94.90	49.76	3.51	72.93	3.07	669.17
LSD $_{(0.01)}$	5.49	ns	ns	ns	ns	ns	75.15
Interactions:							
V_1 S_1	51.44	106.93	39.40	4.21	77.40	3.38	985.67
V_1 S_2	49.28	104.33	38.40	4.43	77.93	3.35	1199.67
V_1 S_3	36.83	101.13	37.67	4.56	83.80	3.28	874.00
V_1 S_4	27.89	98.80	36.20	4.22	81.60	3.21	661.33
V_2 S_1	52.67	92.20	60.50	2.68	62.93	3.00	1091.00
V_2 S_2	42.61	97.33	62.83	2.69	67.20	3.00	1229.67
V_2 S_3	37.83	89.33	65.63	2.54	61.87	3.05	991.67
V_2 S_4	27.50	91.00	63.33	2.80	64.27	2.93	677.00
LSD $_{(0.01)}$	ns	ns	ns	ns	ns	ns	ns

Magura:

The released variety Binatil-2 produced maximum mean seed yield (997 kg ha^{-1}) which was mainly due to higher number of capsule^{-1}. Among the row spacing, 20 cm produced the highest mean seed yield (1214 kg ha^{-1}) which was statistically significantly different. Higher number of capsule^{-1} contributed to their higher yields (Table 6.b). The interaction results depicted that Binatil-2 produced the highest seed yield (1229 kg ha^{-1}) with the row spacing of 20 cm × 5 cm. On the other hand, the variety Binatil-1 produced second highest seed yield (1199 kg ha^{-1}) with the spacing of 20 cm row. In closer spacing (15 cm) comparable yield was obtained by both variety (Table 6.b)

Effect of different herbicides on weed infestation and yield in boro rice

Two rice varieties were evaluated under six weed management comprising two herbicide. The experiment was conducted at the Bangladesh Institute of Nuclear Agriculture, farm Mymensingh during the Boro season of 2011-2012. The objective was to evaluate the effect of herbicides on weed attack and yield of boro rice. Six treatment combination are as follows; No weeding, two hand weeding at 30 DAT and 50 DAT, Pre-chlor 500 EC @ 1 Lha^{-1}, Emchlor 5G @ 20 kg ha^{-1}, Pre-chlor 500EC @ 1 L ha^{-1} + One hand weeding at 50 DAT, Emchlor 5G @ 20 kg ha^{-1} + One hand weeding at 50 DAT. In all cases herbicides were applied in 4-5 cm standing water in the plots. In case of manual weeding treatment it was included 2 weeding at 30 DAT and 50 DAT respectively whereas in weed free treatment weeding was done by hand when they were found. The experiment was laid in a Randomized Complete Block design with three replications. The size of the individual plot was 3 m × 3 m. Treatments were assigned in unit plots at random. Weed density was collected from each plot at vegetative stage at 30 DAT & 50 DAT of rice by using 0.5 m × 0.5 m quadrate. The weeds within the quadrate were counted species wise and converted to number m^{-2} multiplying by four. After counting the weed density the weeds inside each quadrate were uprooted, cleaned, separated species wise and dried first in the sun and then in an electric oven for 72 hours at a temperature of 80^0c. The dry weight of each species was taken with an electric balance and expressed in g m^{-2}. Data on crop yield were collected at proper maturity of the crop. All the recorded data were compiled and analyzed using Mstat programme of computer and the means were judged by LSD.

Table 7. Particulars of weed species in the weeded plots of the experiment at vegetative growth

Sl. no.	Local name	Scientific name	Family	Morphological type	Life cycle
01.	Khudey shama	*Echinochloa colomum*	Gramineae	Grass	Annual
02.	Angta	*Paspalum scrobiculatum*	Gramineae	Grass	Perennial
03.	Panikachu	*Monochoria vaginalis*	Pontederiaceae	Broad-leaved	perenial
04.	Jaina	*Fembristylis miliacea*	Cyperaceae	Sedge	Annual
05.	Arail	*Leersia hexandra L.*	Gramineae	Grass	Annual
06.	Chechra	*Scirpus mucronatus*L.	Cyperaceae	Sedge	Perennial
07.	Angule ghash	*Digitaria sanguinalis*	Gramineae	Grass	Annual
08.	Amrul shak	*Oxalis europaea*	Pontederiaceae	Broad leaved	Annual
09.	Chela ghash	*Parapholis incurva L.*	Gramineae	Grass	Perennial
10.	Keshuti	*Eclipta alba Hassk.*	Compositae	Broad leaved	perennial

Table 8. Effect of weed control treatments on weed density and weed dry weight at 30 and 50 DAT

Treatment	Weed density (no.) 30 DAT	Weed density (no.) 50 DAT	Weed dry weight ($g\ m^{-2}$) at 30 DAT	Weed dry weight ($g\ m^{-2}$) at 50 DAT
Varieties:				
Binadhan- 5(V_1)	10.33	8.4	4.64	10.5
BRRI dhan29 (V_2)	9.5	6.7	5.9	13.4
T -values	ns	ns	ns	0.05
Herbicide:				
No weeding (H_1)	17.33a	12.0a	11.4a	18.0a
Weeding at 30 and 50 DAT (H_2)	9.33b	7.1b	4.6b	10.8bcd
Pre-chlor (H_3)	8.83b	7.6b	3.5b	13.3b
Emchlor (H_4)	7.33b	5.8b	5.0b	8.7d
Pre-chlor + Weeding at 50 DAT (H_5)	8.33b	6.6b	3.5b	9.0cd
Emchlor + Weeding at 50 DAT (H_6)	8.33b	6.3b	3.3b	11.9bc
$LSD_{0.05}$	0.01	0.05	0.01	0.05
Interaction:				
V_1H_1	18.0	14.3	8.4	14.7bc
V_1H_2	11.0	7.3	3.9	11.5cde
V_1H_3	8.6	8.6	3.8	10.4def
V_1H_4	7.3	6.3	4.2	7.5f
V_1H_5	8.3	7.0	3.9	7.9ef
V_1H_6	8.6	7.0	3.4	10.9def
V_2H_1	16.6	9.6	14.5	21.4a
V_2H_2	7.6	7.0	5.3	10.0def
V_2H_3	9.0	6.6	3.3	16.2b
V_2H_4	7.3	5.3	5.9	9.8def
V_2H_5	8.3	6.3	3.0	10.2def
V_2H_6	8.0	5.6	3.2	12.9bcd
$LSD_{0.05}$	ns	ns	0.05	0.05
CV (%)	22.51	24.66	49.31	16.27

Ten weed species were infested the crop, which belong to five families. Among them three were broad- leaved, five were grasses and two were sedges. The particular of weeds is described in (Table 7). It was found that the density and dry weight of weeds varied considerably in different weed control treatments (Table 8). The highest weed dry weight 11.4 g m^{-2} and 18.0 gm^{-2} were observed in no weeding (control) treatment at 30 DAT and 50 DAT respectively. The lowest weed dry weight 3.3 g m^{-2} and 8.7 g m^{-2} were observed with Emchlor 5G @ 20 kg ha^{-1} + one hand weeding at 50 DAT and Emchlor 5G @ 20 kg ha^{-1} at 50 DAT weeding (Table 9). Among the weed control treatment highest grain yield (5.47 t ha^{-1}) was produced with the treatment of two hand weeding at 30 DAT and 50 DAT followed by Pre-chlor 500EC @ 1 Lha^{-1} + One hand weeding at 50 DAT On the other hand, the lowest grain yield was recorded in (3.6 t ha^{-1}) no weeding treatment. In most cases, the interaction effect between variety and herbicides management was significant. The highest grain yield produced (5.50 t ha^{-1} and 5.44 t ha^{-1}) by two hands weeding at 30 and 50 DAT by both the variety. The herbicide pre-chlor 500EC with one hand weeding at 50 DAT produced also similar grain yield (5.42 t ha^{-1} and 5.27 t ha^{-1}).

Table 9. Effect herbicide and weed management on the yield and yield contributing characters of Boro season

Treatment	Plant height (cm)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Varieties:							
Binadhan-5 (V_1)	103.11	7.1	1.1	112.8	14.6	4.9	7.02
BRRI dhan29 (V_2)	95.0	74	1.0	107.2	15.7	4.4	6.06
T-Values	0.05	ns	ns	0.01	ns	0.05	0.05
Herbicide:							
No weeding (H_1)	100.0a	4.9d	1.4ab	100.8d	22.2a	3.6c	5.96b
2 weeding (H_2)	97.2b	8.6ab	0.6b	117.2a	16.1b	5.47a	6.65ab
Pre-chlor 500EC (H_3)	99.5ab	6.5c	0.9b	104.9d	12.7b	4.61bc	7.2a
Emchlor 5G (H_4)	98.5ab	6.9c	2.1a	111.3bc	11.5b	4.55c	7.1a
Pre-chlor + Weeding at 50 DAT (H_5)	100.5a	8.9a	0.4b	115.4ab	14.8b	5.35ab	6.2b
Emchlor + Weeding at 50 DAT (H_6)	98.7sb	7.9b	0.8b	110.3c	13.6b	4.76abc	6.1b
$LSD_{0.05}$	0.05	0.01	0.01	0.01	0.01	0.05	0.01
Interaction:							
V_1H_1	120.4a	4.8	1.4	103.6f	22.1	3.67b	6.5b
V_1H_2	103.2a	8.4	0.7	119.7a	14.4	5.50a	6.6b
V_1H_3	104.4a	6.4	1.2	105.1ef	12.1	5.0ab	7.7a
V_1H_4	102.8a	6.9	2.1	114.8b	11.5	4.92ab	7.6a
V_1H_5	102.5a	8.8	0.4	120.5a	13.3	5.42a	6.8b
V_1H_6	103.1a	7.6	0.5	113.1bc	14.2	5.20ab	6.7b
V_2H_1	97.6a-c	5.0	1.4	98.0g	22.2	3.60c	5.3c
V_2H_2	91.2c	8.8	0.5	114.8b	17.8	5.44a	6.6b
V_2H_3	94.5bc	6.7	0.5	104.8b	13.3	4.22ab	6.6b
V_2H_4	94.2bc	7.0	2.2	107.8ef	11.5	4.18ab	6.5b
V_2H_5	98.4ab	9.0	0.4	110.3cd	16.4	5.27a	5.6c
V_2H_6	94.4bc	8.2	1.0	107.6de	13.1	4.23ab	5.4c
$LSD_{0.05}$	0.05	ns	ns	0.05	ns	0.05	0.05
CV (%)	1.37	6.04	46.6	2.01	14.05	5.66	5.03

TRAINING, COMMUNICATION AND PUBLICATION DIVISION

RESEARCH HIGHLIGHTS

During 2011-12, a total of 555 block demonstrations with BINA developed crop varieties were conducted at the farmers' field in collaboration with the Department of Agriculture Extension (DAE) and personnel of BINA sub-stations. Besides demonstrations farmers' training, field days, publications, man power development and other assigned activities were implemented by TCP division.

Thirtyfive block demonstrations with boro rice variety, Binadhan-5 were conducted in 7 districts. Binadhan-5 produced average grain yield of 5.92 t ha^{-1} and matured in 154 days. Some upazilas of Tangail, Pabna, Netrokona, Nawgaon and Mymensingh districts were identified for the large-scale extension of this variety. Eleven block demonstrations with boro rice variety, Binadhan-6 were conducted in 5 districts. Binadhan-6 produced average grain yield of 5.93 t ha^{-1} and matured in 158 days. Based on the better performance and farmers preference some upazilas of Jhalakathi, Barisal and Bhola districts were identified for the large-scale extension of this variety. Ninetythree block demonstrations with aman rice variety, Binadhan-7 were carried out in19 districts. It produced average grain yield of 4.26 t ha^{-1} and matured in 117 days, which was 2-3 weeks earlier than the existing cultivars of BR-11 and Sharna, respectively and around 10% higher yield as well. Popularity of Binadhan-7 is tremendously increasing in almost all areas demonstrated due to its better grain yield and earliness. It facilitates rabi crop cultivation timely after rice harvest. Adopting this variety an additional rabi crop can easily be cultivated. Fifty three block demonstrations with salt tolerant boro rice variety Binadhan-8 produced average grain yield of 5.54 t ha^{-1} and matured in 135 days. Based on the 12.09 percent higher yield and 10 days earlier than the salt tolerant check variety BRRI dhan47 Barisal, Cox's Bazar, Satkhira and Chittagong districts were found suitable for Binadhan-8 extension.

Twenty block demonstrations were carried out in Rabi season with mustard variety, Binasarisha-4 in four districts. Binasarisha-4 produced average seed yield of 1.40 t ha^{-1}, which was 37.71 percent higher than the check variety, Tori-7. Sirajgonj, Jhenaidah, Chuadanga and Narail were identified as suitable area for large-scale cultivation of Binasarisha-4. Thirty nine block demonstrations were conducted in Kharif-1 and Kharif-2 season with groundnut variety, Binachinabadam-4 in four districts. In kharif-2 season, Binachinabadam-4 produced average seed yield of 2.53 t ha^{-1}, which was 38.01 percent higher than the check variety, Dacca-1 (1.85 t ha^{-1}). On the other hand, in kharif-1 season, Binachinabadam-4 produced average seed yield of 2.23 t ha^{-1}, that was 38.96 percent higher than the check variety, Dacca-1 (1.62 t ha^{-1}). Farmers showed their interest to cultivate Binachinabadam-4 for its higher yield and attractive pod size and acceptable crop duration. Natore, Lalmonirhat, Jhenaidah and Jessore were identified as suitable area for large-scale cultivation of Binachinabadam-4. Twelve block demonstrations were carried out with sesame variety, Binatil-2 in three Districts. Binatil-2 produced average seed yield of 1.61 t ha^{-1}, which was 22.44 percent higher than the check variety, Atshira. Farmers showed their interest to cultivate Binatil-2 for its higher seed yield. Jessore, Chuadanga and Faridpur were identified as suitable area for its large-scale extension.

Sixteen demonstrations with chickpea variety, Binasola-4 were conducted in two districts. It produced average seed yield of 1.52 t ha^{-1}, which was 32.17% higher compared to local cultivar. Farmers of

Jessore and Magura district were found interested to continue this variety for its higher seed yield. Thirteen demonstrations with Binasola-6 were carried out in Jessore and Magura. It produced average seed yield of 1.13 t ha^{-1} that was 21.53 % higher over the check variety. Twenty demonstrations with lentil variety, Binamasur-2 were conducted in Magura, Kushtia and Natore. It produced average seed yield of 1.43 t ha^{-1} which was 20.28 % higher than the check variety. Another 13 demonstrations with Binamasur-4 were carried out in Kustia and Natore. It produced average seed yield of 1.14 t ha^{-1} that was 7.32% higher over the local check variety. Fifty seven demonstrations with Binamoog-5 were conducted in five districts. It produced average seed yield of 1.16 t ha^{-1} that was 12.93% higher compared to check. For Binamoog-6, six demonstrations were conducted at Dinazpur and Magura and it produced average seed yield of 1.45 t ha^{-1}, which was 37.24% higher than the check variety. Eight demonstrations with Binamoog-7 were carried out in Pabna, Barisal and Magura. Binamoog-7 produced average seed yield of 1.33 t ha^{-1}.

BINA technology villages, a approach to popularize BINA's developed technologies among the neighboring farmers of BINA headquarter and substations. Demonstrations and other rational activities were carried out in order to establish BINA technology villages around BINA Headquarter and it's five sub-stations. In sadar upazila of Mymensingh, established BINA technology villages are Paranganj and Sutiakhali, where Binadhan-5, Binadhan-7 and Binasarish-4 are adopted remarkably. Established BINA technology villages in Magura sadar are West Ramnagar, Khalimpur, Echhakhada and Alamkhali. About 15 promising varieties of different crops i.e. summar mungbean, mustard, sesame, aman and boro rice, lentil and chickpea are cultivating extensively in these villages. In Ishurdi, Pabna established BINA villages are Dulti, Auronkhola and Athaishimul. About 12 crop varieties have already been included in these villages. In Rangpur sadar upazila established BINA technology villages are Auvirampur and Parbotipur. Five crop varieties were adopted extensively in these villages. Two established BINA villages of Satkhira are Jhapaghat (Kalaroa upazila) and Daulatpur (sadar upazila). In these villages adopted crop varieties are Binadhan-7, Binadhan-8, Binamoog-5, Binamoog-7 and Binamoog-8, Binamasur-2 and Baisarisha-4. In Comilla sardar, promotional activities were carried out in Palpara and Rasulpur and BINA technology village establishment is in progess.

TCP Division made necessary arrangements for nominating 43 Scientists/Staff in different training courses or workshop organized by other organizations in home and abroad. In order to promotion of BINA generated crop varieties 10 training courses were organized. During this period 210 male and female farmers including 40 Sub-Assistant Agricultural Officers were also trained on cultivation techniques of BINA developed improved crop varieties across the country.

A total of 23 field days were also arranged in different areas of the country to motivate farmers and popularize the BINA developed crop varieties/technologies to the end users. For technology transfer through print media, publications were made on 6 types of leaflets total of 30,000 copies during this period. Besides these, five TV programmes were telecasted to popularize some promising BINA crop varieties.

TECHNOLOGY TRANSFER AND IMPACT ASSESMENT

Farmer's Observation Trials (FOTs)/Block Demonstration with rice varieties developed by BINA

Block dsemonstration with Binadhan-5 and Binadhan-6 compared to other popular HYV in different locations

During Boro season of 2011-12, 35 block demonstrations with Binadhan-5 and that of 11 with Binadhan-6 were conducted at the farmer's field in different agro-ecological zones in collaboration with the Department of Agricultural Extension (DAE). The main objectives were to demonstrate the yield performance of these varieties and widening their adoption by the farmers. Area of each demonstration plot was 1 acre. Spacings between line to line and plant to plant were 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 10 to 31 January, 2012 and age of seedlings was 40 to 50 days. The farmers used manage their own practices for the production. Based on the available reports, data of demonstration plots are presented in Table 1 and 2.

Table 1. Performance of Binadhan-5 compared to other popular cultivar in different locations during 2011-12

Districts	Upazila	No. of Demons.	Crop duration (days)		Seed yield (t ha^{-1})		Yield increased over check (%)
			Binadhan-5	Check*	Binadhan-5	Check	
Mymensingh	Sadar	1	153	145 V1	6.33	5.30	19.43
	Muktagacha	1	150	155 V2	6.74	6.20	08.70
	Fulbaria	1	148	143 V1	6.13	5.01	22.36
	Gouripur	1	153	146 V1	5.97	5.85	2.05
	Fulpur	1	157	158 V2	5.95	6.00	- 0.83
	BAUEC area	20	154	144 V1	6.10	5.30	15.09
Tangail	Mirzapur	1	156	145 V1	6.10	6.25	-2.40
Netrokona	Sadar	1	158	159 V2	6.55	6.98	-6.16
Nawgoan	Manda	1	151	141 V1	7.11	5.93	19.90
	Mahadebpur	2	155	145 V1	7.41	5.85	26.67
Jessore	Jhikorgasa	1	151	144 V1	6.50	6.20	4.84
Khagrachori	Sadar	1	148	145 V3	6.12	4.20	45.71
	Matiranga	1	160	147V3	6.44	4.11	56.69
Pabna	Ishurdi	2	155	146V1	7.02	5.50	27.64
	Total	35					
	Mean (Total)		154		6.46		
	V_1 Mean			144		5.69	13.35
	V_2 Mean			157		6.39	1.09
	V_3 Mean			145		4.16	27.59

*Note: V1 = BRRI dhan28, V2 = BRRI dhan29, V3 = BRRI dhan50

Data in Table1 reveal that Binadhan-5 produced average grain yield of 6.46 t ha^{-1}. The highest yield of 7.41 t ha^{-1} of Binadhan-5 was recorded at Mohadevpur upazila of Nawgoan district, while the lowest yield of 5.95 t ha^{-1} was recorded at Fulpur upazila of Mymensingh district. On the other hand Binadhan-5 matured in 154 days, which was similar to BRRI dhan29 and 10 days later than the BRRI dhan28 and BRRI dhan50. Farmers reported that Binadhan-5 is easy to thresh and required low input cost than the BRRI dhan29 that encouraged them to cultivate Binadhan-5. Farmers expressed their satisfaction as the grain yield of Binadhan-5 was higher with less diseases and insect infestation. Considering all the attributes, Binadhan-5 was more profitable compared to other existing cultivars. Tangail, Mymensingh, Pabna, Netrokona, and Nawgoan districts are suitable area for Binadhan-5 cultivation. However, Farmer's of Jessore and Khagrachori preferred short duration crop variety.

Table 2. Performance of Binadhan-6 compared to other popular cultivar in different locations during 2011-12

Districts	Upazila	No. of Demons.	Crop duration (days)		Seed yield (t ha^{-1})		Yield increase over check (%)
			Binadhan-6	*Check	Binadhan-6	Check	
Khulna	Fultola	01	160	-	4.25	-	-
Comilla	Borichang	02	158	163 V3	4.88	5.63	-15.37
Jhalakathi	Nalchiti	01	160	155 V2	7.41	6.85	7.56
	Sadar	01	160	150 V2	6.00	6.02	0.33
	Kathalia	01	160	-	7.00	-	-
Barisal	Sadar	01	160	148 V1	7.60	6.20	18.42
	Uzirpur	01	165	-	6.67	-	-
Bhola	Dowlatkhan	03	160	160 V2	6.64	5.60	15.66
	Total	11					
Mean (Total)			160		5.93		
	V_1 Mean			148		6.20	-4.55
	V_2 Mean			155		6.16	-3.87
	V_3 Mean			163		5.63	5.06

*Note: V_1 = BRRI dhan28, V_2 = Vozon, V_3 = BRRI dhan29

Binadhan-6 (Table-2) produced the highest grain yield of 7.60 t ha^{-1} at sadar upazila of Barisal district and the lowest yield of 4.25 t ha^{-1} at Fultola upazila of Khulna district with an average of 5.93 t ha^{-1}. Average crop duration of Binadhan-6 was 160 days that was 10 days longer than that of BRRI dhan28 and apparently similar to BRRI dhan29. Considering the higher grain yield and coarse grain, farmers showed interest to adopt Binadhan-6 in greater Barisal areas.

Blok demonstrations with Binadhan-7 compared to other popular cultivar in different locations

During Aman season of 2011-12, 93 block demonstrations with Binadhan-7 were conducted at the farmer's fields in 19 districts in collaboration with the Department of Agricultural Extension (DAE). The main objectives were to evaluate the performance of this variety at different sites and widening its adoption by the farmers. Area of each demonstration plot was one acre. Spacings between line to line and plant to plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 15 July to 05 September, 2011 and age of seedlings was 20 to 25 days. Based on the available reports, data of demonstration plots are presented in Table 3.

Table 3. Performance of Binadhan-7 compared to other popular cultivar in different locations during 2011-12

Districts	Upazila	No. of Demons.	Crop duration (days)		Seed yield (t ha^{-1})		Yield increased over Check (%)
			Binadhan-7	Check*	Binadhan-7	Check	
Mymensingh	Sadar	1	120	145 V2	4.54	3.90	14.10
	Muktagacha	1	119	-	3.45	-	-
	Fulbaria	1	115	143 V2	3.75	4.10	9.33
	Trisal	1	120	120 V4	3.55	3.50	1.41
	Bhaluka	1	120	-	3.45	-	-
	Gafargoan	1	120	143 V2	3.65	3.85	5.09
	Nandail	1	113	-	3.65	-	-
	Ishwargonj	1	113	-	4.44	-	-
	Gouripur	1	120	121 V4	3.65	3.95	-8.22
	Fulpur	1	120	120 V4	3.95	3.80	3.80
	Haluaghat	1	120	-	4.14	-	-
	Dhubaura	1	120	-	4.44	-	-
Jamalpur	Sadar	1	114	150 V6	4.44	4.80	-8.11
	Sarishabari	1	114	136 L	4.34	2.37	45.39
	Melando	1	115	130 V6	4.05	3.66	9.63
	Islampur	1	114	136 L	4.14	5.83	-40.82
	Deoangonj	1	115	125 L	4.14	2.40	42.02
	Madargonj	1	113	118 V4	4.24	3.46	18.40
	Bakshigonj	1	113	140 L	3.95	2.97	24.81
Netrokona	Sadar	1	117	145 V3	4.44	3.68	-
	Purbadhala	1	115	115 L	4.24	2.97	29.95
	Durgapur	1	120	122 L	4.24	3.75	11.56
	Kendua	1	120	120 L	3.45	2.97	13.91
	Atpara	1	120	120 L	4.94	3.46	29.96
Kishorgonj	Hoshenpur	1	120	149 L	3.46	2.96	14.45
	Pakundia	1	120	148 L	3.16	1.78	73.67
	Katiadi	1	118	120 V4	4.89	4.45	8.99
	Karimgonj	1	116	142 V3	4.45	4.20	5.62
	Kuliarchar	1	120	141 L	4.45	3.85	13.48
Sherpur	Sadar	1	118	164 V6	4.45	4.15	6.74
	Sribordi	1	115	119 L	3.65	2.47	32.33
	Jhenaigati	1	117	144 L	4.64	3.95	14.87
	Nalitabari	1	118	127 L	4.45	3.85	13.84
	Nakla	1	115	-	3.46	-	-
Tangail	Sakhipur	14	116	-	3.91	-	-
	Ghatail	4	118	-	4.50	-	-
Natore	Boraigram	1	118	135 L	4.94	4.74	4.05
	Singra	1	120	118 V5	4.74	4.45	6.12
Gopalgonj	Sadar	1	115	130 L	4.94	2.47	0.50
Nawgoan	Sadar	1	120	138 V1	3.85	4.00	-3.89
	Mohadebpur	1	110	141 V1	4.15	3.85	7.23
	Manda	1	120	136 V1	4.45	4.15	6.74
Patuakhali	Kalapara	1	116	130 V1	4.84	3.46	28.51
	Sadar	1	115	-	3.75	-	-

Table 3 Contd.

Districts	Upazila	No. of Demons.	Crop duration (days)		Seed yield (t ha^{-1})		Yield increased over Check (%)
			Binadhan-7	Check*	Binadhan-7	Check	
Panchagor	Sadar	1	120	-	4.15	-	-
	Tetulia	1	119	-	3.95	-	-
Jessore	Jhikorgacha	5	117	143 V2	4.45	3.46	22.25
	Sadar	1	111	145 V3	4.15	4.45	-7.23
	Monirampur	1	114	120 V5	4.34	4.25	2.07
Satkhira	Sadar	2	114	142 V3	5.19	4.19	11.56
	Kaloroa	2	109	118V4	4.15	3.95	4.82
Barisal	Sadar	2	108	-	4.60	-	-
	Babugonj	4	112	-	5.40	-	-
Barguna	Amtoli	1	115	140	4.00	3.50	12.50
	Sadar	1	120	145	4.90	2.47	49.59
Jhenaidah	Sadar	1	118	148	4.96	4.05	-21.88
	Soilokupa	1	116	136	5.03	4.44	11.73
	Kaligonj	1	118	147	5.92	6.14	-3.72
Faridpur	Sadar	1	120	128	3.95	3.75	5.06
	Bowalmari	6	115	140	5.43	4.44	18.23
Chittagoan	Puthia	2	120	-	4.90	-	-
Khagrachori	Sadar	2	114	-	4.01	-	-
	Total	95					
Mean (Total)			117		4.26		
	V1 Mean			136		3.87	9.15
	V2 Mean			132		3.83	10.09
	V3 Mean			129		4.13	3.05
	V4 Mean			121		3.85	9.62
	V5 Mean			119		4.35	-2.11
	V6 Mean			148		4.20	1.41
	Local Mean			131		3.36	21.13

*V1= Swarna, V2= BR-11, V3= BRRI dhan30, V4= BRRI dhan33, V5= BRRI dhan39 , V6= Hori, L= Local Mean

Data in Table 4 reveal that grain yields of Binadhan-7 ranged from 3.16 to 5.40 t ha^{-1} with an average of 4.26 t ha^{-1}. Average maturity period of this variety was 117 days. Based on the location specific popularity, six cultivars were used as check, which were: Swarna, BR-11, BRRI dhan30, BRRI dhan33, BRRI dhan39, Hori and local cultivar. Binadhan-7 demonstrated better performance in terms of yield and duration. It was harvested about 3-4 weeks earlier, which facilitated rabi crop cultivation timely after rice harvest. Adopting this variety an additional rabi crop can easily be cultivated. That means Binadhan-7 enables farmers getting higher aman production with an additional rabi crop which encouraged farmers massive adoption of this variety. That’s why almost in all the locations farmers were found very much keen to cultivate Binadhan-7 in the upcoming years. The results of Binadhan-7 reveal that this variety is suitable for massive extension in all the districts mentioned above. All over Bangladesh, especially moderately high land is suitable areas for cultivation of Binadhan-7. Northern region of Bangladesh including Barisal, Jessore, Satkhira, Jhenaidah, Faridpur, Khulna, Chittagoan, Jamalpur, Netrokona, Kishorgonj, Sherpur, Tangail and Mymensingh were most suitable for Binadhan-7 cultivation.

Block demonstrations with salt tolerant rice variety, Binadhan-8 compared to other popular cultivar in different locations

During Boro season of 2011-12, 53 block demonstration with Binadhan-8 were conducted at the farmer's fields in different agro-ecological zones in collaboration with the Department of Agricultural Extension (DAE). The main objectives were to demonstrate the performance of these varieties and widening their adoption by the farmers. Area of each demonstration plot was 1 acre. Spacings between line to line and plant to plant were 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 10 to 31 January, 2012 and age of seedlings was 40 to 50 days. The farmers used there own management practices for the production. Based on the available reports, data of demonstration plots are presented in Table 4.

Table 4. Performance with salt tolerant rice variety, Binadhan-8 compared to other popular cultivar in different locations during 2011-12

Districts	Upazila	No. of Demons.	Crop duration (days)		Seed yield (t ha^{-1})		Yield increase over check (%)
			Binadhan-8	Check*	Binadhan-8	Check	
Mymensingh	Sadar (BAUEC)	06	139	-	5.04	-	-
Satkhira	Sadar	02	144	145 V1	5.48	5.82	6.20
	Devhata	02	133	139 V1	5.82	6.03	-3.61
	Kaligonj	02	130	136 V1	6.00	6.07	-1.17
	Ashasuni	02	135	-	4.05	-	-
	Shamnagar	02	129	129 V1	5.93	4.95	16.53
Barisal	Sadar	02	134	162 V2	5.20	7.20	38.46
	Babuganj	03	145		7.30		-
	Gouronodi	02	134		6.80		-
Chittagoan	Bashkhali	10	134	137 V1	5.20	4.60	11.54
Cox's Bazar	Chokoria	10	138	-	6.35	-	-
Bagerhat	Sadar	01	130	145 V1	5.43	5.00	7.92
	Fakirhat	01	129	150 V4	5.90	4.90	16.95
	Mollarhat	02	130	135 V1	5.30	4.90	7.55
	Rampal	02	137	138 V1	6.30	4.90	22.22
	Kochua	01	139	131 V3	4.40	3.90	11.36
	Morolgonj	01	128	145 V4	4.41	4.40	0.23
	Soronkhola	01	144	148 V4	5.50	5.30	3.64
	Chitolmari	01	141	146 V3	4.90	4.70	4.08
Total		53					
Mean (Total)			135		5.54		
V_1 Mean				138		5.28	4.70
V_2 Mean				162		7.20	-29.96
V_3 Mean				139		4.30	22.38
V_4 Mean				148		4.87	12.09

*V1= BRRI dhan28, V2= BRRI dhan29, V3=Vozon, V4= BRRI dhan47

It is revealed that grain yields of Binadhan-8 ranged from 4.05 to 7.30 t ha^{-1} with an average of 5.54 t ha^{-1} (Table 4). Average maturity period of this variety was 135 days. Check varieties were BRRI dhan28, BRRI dhan29, Vozon and BRRI dhan47, which produced average grain yield of 5.28, 7.20, 4.30 and 4.87 t ha^{-1}, respectively. Of these only check variety, BRRI dhan29 produced higher grain yield (7.20 t ha^{-1}) though this was not recommended as a salt tolerant variety. Higher yield of BRRI dhan29 was due to cultivation in non saline plot. Farmers were found very much interested to cultivate

Binadhan-8 for its salinity tolerance and it's risk avoidence potentiality. They also requested BINA authority to conduct more demonstration at these localities for their better understanding about the variety. Bagerhat, Satkhira, Cox's Bazar and Chittagong were found the most suitable areas for cultivation of Binadhan-8. It needs more trials in different locations for identifying suitable areas of Binadhan-8 cultivation and thereby massive promotion.

Block Demonstration/Farmer's Observation Trials with oilseeds varieties developed by BINA

Block demonstrations with mustard variety, Binasarisha-4 compared to local cultivar

During the Rabi season of 2011-12, 20 block demonstrations were conducted with Binasarisha-4 in four different districts in collaboration with the DAE. The main objectives were to demonstrate the performance of Binasarisha-4 to evaluate their location specific suitability and widen adoption by the farmers. Unit plot size of block demonstrations was 1 bigha at all the locations. Seeds were sown during October to November, 2010 at the rate of 7.5 kg ha^{-1}. The local check varieties were Tori-7 and BARI Sarisha-9. All fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 5.

Table 5. Performance of Binasarisha-4 compared to local check variety at block demonstrations in different districts during 2011-2012

District	Upazila	No. of Farmers' Plot	Crop Duration (Seed to seed) in days		Seed yield (t ha^{-1})		Percent yield increased over check (%)
			Binasarisha-4	Check*	Binasarisha-4	Check*	
Sirajgonj	Sadar	1	85	80	1.63	1.18	38.14
		1	86	75	1.48	1.11	33.33
		1	85	77	1.53	1.10	39.09
		1	84	78	1.61	1.14	41.23
Narail	Sadar	1	85	78	1.58	1.04	51.92
		1	83	75	1.48	1.09	35.78
		1	82	77	1.47	0.99	48.48
		1	80	74	1.34	0.87	54.02
Chuadanga	Alamdanga	1	86	83	1.49	1.08	37.96
		1	88	78	1.37	1.03	33.01
		1	89	78	1.19	0.89	33.71
		1	86	70	1.49	0.98	52.04
		1	90	77	1.58	1.19	32.77
		1	89	78	1.18	0.91	29.67
Jhenaidah	Sadar	1	86	76	1.08	0.89	21.35
		1	87	79	1.50	0.95	57.89
		1	88	78	1.28	1.05	21.90
		1	89	79	1.33	1.02	30.39
		1	85	77	1.29	0.95	35.79
		1	87	78	1.17	0.93	25.81
Total Mean		20	86	77	1.40	1.02	37.71

* Tori-7 and BARI Sarisha-9

Binasarisha-4 produced average seed yield of 1.40 t ha^{-1}, which was 37.71 percent higher than the check varieties (1.02 t ha^{-1}). The highest yield of Binasarisha-4 was produced at Sirajgonj sadar (1.63 t ha^{-1}) while the lowest seed yield was at Alamdanga in Chuadanga (1.08 t ha^{-1}). Comments of farmers' and extension personnel on Binasarisha-4 were that it was a long durative high yielding variety, almost no pest infestations and most of the farmers' interested to cultivate this variety in next year. Therefore, to introduce the variety it is very important to timely sowing of Binasarisha-4 and previous aman variety should be short durative as well as high yielding like Binadhan-7.

Block demonstrations with groundnut variety, Binachinabadam-4 compared to local variety

During Kharif-2 and kharif-1 season of 2011-2012, 39 block demonstrations with Binachinabadam-4 were conducted at farmers' plots in four districts collaboration with the Demonstration of Agricultural Extension (DAE). The objectives were to demonstrate and evaluate the performance of Binachinabadam-4 for its dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next seasons. Unit plot size of individual block demonstrations was 1 bigha at all the locations. Seeds were sown during July to September, 2011 in kharif-2 and January to February, 2012 in kharif-1 seasons. The local check variety was Dacca-1 in both seasons. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and grain yield. The results are presented in Table 6 and 7.

Table 6. Performance of Binachinabadam-4 compared to local check variety at block demonstrations in different districts during Kharif-2 season of 2011-2012

District	Upazila	No. of Farmers' Plot	Crop Duration (days)		Grain yield (t ha^{-1})		Increased over check (%)
			Binachinabadam-4	Dacca-1	Binachinabadam-4	Dacca-1	
Jhenaidah	Moheshpur	1	125	124	2.66	1.76	51.14
		1	125	125	2.96	1.79	65.36
		1	120	121	3.16	2.05	54.15
		1	120	122	3.12	2.02	54.46
		1	120	123	3.15	2.07	52.17
Jessore	Sharsha	1	141	141	2.67	1.98	34.85
		1	138	138	2.56	2.37	8.02
		1	138	137	2.47	1.78	38.76
		1	137	141	2.57	1.87	37.43
		1	136	142	1.98	1.67	18.56
		1	139	139	2.37	1.75	35.43
Natore	Sadar	1	135	135	3.11	2.22	40.09
		1	136	135	2.67	2.12	25.94
		1	134	134	2.96	2.13	38.97
		1	133	132	2.65	2.21	19.91
almonirhat	Kaligonj	1	135	135	1.98	1.38	43.48
		1	135	135	2.17	1.49	45.64
		1	125	125	1.78	1.57	13.38
		1	124	124	1.78	1.28	39.06
	Aditmari	1	121	124	2.37	1.67	41.92
		1	120	121	2.39	1.72	38.95
		1	130	129	2.94	1.64	79.27
		1	122	122	2.27	1.58	43.67
		1	128	128	2.17	1.96	10.71
		1	121	121	2.46	2.07	18.84
Total Mean		25	130	130	2.53	1.85	38.01

Table 7. Performance of Binachinabadam-4 compared to local check variety at block demonstrations in different districts during Kharif-1 season of 2011-2012

District	Upazila	No. of Farmers' Plot	Crop Duration (days)		Grain yield (t ha^{-1})		Increased over check (%)
			Binachinabadam-4	Dacca-1	Binachinabadam-4	Dacca-1	
Jessore	Sharsha	1	136	130	2.39	1.63	46.63
		1	132	131	2.27	1.60	41.88
		1	135	134	2.32	1.77	31.07
Natore	Sadar	1	133	133	2.96	2.37	24.89
		1	136	136	1.78	1.48	20.27
		1	132	136	2.87	2.27	26.43
Lalmonirhat	Kaligonj	1	137	132	1.77	1.28	38.28
		1	132	127	1.88	1.27	48.03
		1	128	132	1.87	1.58	18.35
		1	129	127	1.86	1.57	18.47
		1	129	124	1.67	1.29	29.46
	Aditmari	1	140	138	2.44	1.51	61.59
		1	142	139	2.47	1.49	65.77
		1	145	142	2.72	1.56	74.36
Total Mean		14	135	133	2.23	1.62	38.96

In kharif-2 season, Binachinabadam-4 produced average seed yield of 2.53 t ha^{-1}, which was 38.01 percent higher than the check variety Dacca-1 (1.85 t ha^{-1}). Binachinabadam-4 produced the highest seed yield (3.16 t ha^{-1}) at Maheshpur in Jhenaidah while the lowest was at Kaligonj in Lalmonirhat (1.78 t ha^{-1}). In case of kharif-1 season, Binachinabadam-4 produced average seed yield of 2.23 t ha^{-1}, which was 38.96 percent higher than the check variety Dacca-1 (1.62 t ha^{-1}). Binachinabadam-4 produced the highest seed yield (2.96 t ha^{-1}) at Sadar in Natore while the lowest was at Kaligonj in Lalmonirhat (1.67 t ha^{-1}). Comments of farmers' and extension personnel on Binachinabadam-4 were that it was a high yielding and larger pod bearing variety, that's why market price was higher than local variety, almost no pest infestations observed and most of the farmer's interested to cultivate this variety in next year. In Aditmari upazila of Lalmonirhat, there were some unfilled grain observed may be due to the use of imbalanced doses of fertilizers. However, it is well known that Lalmonirhat, Natore and Jhenaidah were the popular seed growing as well as groundnut growing areas. Farmers of said districts were growing their groundnut seeds throughout the year for their own use and commercial purpose. Therefore, there was a great opportunity to disseminate Binachinabadam-4 in those districts. That's why farmers of other groundnut growing districts will be able to collect their seeds from Lalmonirhat, Natore and Jhenaidah.

Block demonstrations with Sesame variety, Binatil-2 compared to local check variety

During Kharif-1 season of 2011-2012, 12 block demonstrations with variety Binatil-2 were conducted at farmers' plots in 3 districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binatil-2 for their dissemination and encourage the farmers for adopting these varieties. Unit plot size of individual block demonstrations was 1 bigha at all the locations. Seeds were sown during February to March 2012. The local check variety was atshira. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 8.

Table 8. Performance of Binatil-2 compared to local check variety at block demonstrations in different districts during 2011-2012

District	Upazila	No. of Farmers' Plot	Crop duration (seed to seed) in days		Seed yield ($t\ ha^{-1}$)		Yield increased over check (%)
			Binatil-1	Atshira	Binatil-1	Atshira	
Chuadanga	Alamdanga	1	98	97	1.97	1.77	11.30
		1	97	95	1.77	1.68	5.36
		1	97	95	1.98	1.78	11.24
		1	98	96	1.87	1.67	11.98
Faridpur	Madhukhali	1	96	93	1.38	1.09	26.61
		1	89	88	1.38	0.99	39.39
		1	95	93	1.48	1.08	37.04
		1	94	92	1.38	0.98	40.82
Jessore	Bagharpara	1	95	93	1.45	1.32	9.85
		1	97	94	1.63	1.27	28.35
		1	94	92	1.47	1.24	18.55
		1	96	93	1.52	1.18	28.81
Total Mean		12	96	93	1.61	1.34	22.44

Binatil-2 produced average seed yield of 1.61 $t\ ha^{-1}$, which was 22.44 percent higher than the control variety Atshira (1.34 $t\ ha^{-1}$). Highest seed yield (1.98 $t\ ha^{-1}$) was found at Alamdanga in Chuadanga while the lowest (1.47 $t\ ha^{-1}$) was at Baghar para although the difference was not so remarkable. Comments of farmers' and extension personnel on Binatil-2 were that it was a high yielding as well as attractive seed coated variety. Farmers' of almost all locations were interested to cultivate the variety in the next year.

Farmers observation trials (FOTs)/block demonstration with pulse varieties developed by BINA

Block demonstrations of chickpea variety, Binasola-4 at different AEZ in collaboration with DAE

During the Rabi season of 2011-12, a total of 16 demonstrations on Binasola-4 were set up at the farmer's fields in three upazilas of two districts, Jessore and Magura. The main objectives were to demonstrate and evaluate the performance of Binasola-4 across the locations and encourage the farmers to continue the variety in their fields. The area for each of the demonstration plot was one acre where 5 decimal was allocated for local cultivar. Sowing time ranged from Mid November to Mid December, 2011. It is notable here that sowing dates within a month have been categorized into three intervals; first 10 days as early, middle 10 days as mid and last 10 days as late of the respective month. In all cases seeds were sown using broadcast method at the rate of 30 kg/ha. The fertilizers like urea, TSP, MoP, gypsum and zinc sulphate were applied at the rate of 35, 120, 70, 90 and 4 kg per hectare, respectively. All intercultural operations were managed by the farmers as and when required. Data on sowing time, crop duration, seed yield and insect and disease infestation were recorded. The results are presented in Table 9.

Table 9. Performance of Binasola-4 compared to popular cultivar in different locations during 2011-12

District	Upazila	Date of sowing (Binasola-4)	No. of demons.	Duration (days)		Yield ($kg\ ha^{-1}$)		Yield increased over check (%)
				Binasola-4	check	Binasola-4	check	
Magura	Sadar	25-30 Nov.	04	123	118	1.80	1.20	33.33
Jessore	Sadar	4-12 Dec.	09	111	111	1.20	1.00	16.67
	Jhikorgacha	15-17 Nov.	03	122	125	1.55	1.25	19.35
Total Mean			16	119	119	1.52	1.15	32.17

It is evident from the Table 9 that average duration of Binasola-4 was 119 days and there were no significant differences in crop duration between the check and demo variety. The average yield of Binasola-4 was 1.52 t ha^{-1} which was higher than the check. The highest yield (1.8 t ha^{-1}) was recorded at sadar upazila of Magura district. The lowest yield (1.2 t ha^{-1}) was recorded at sadar upazila of Jessore. Late sowing might be one of the vital reasons for low yield. Shiny seed coat of Binasola-4 was also marked by the farmers as an additional advantage, especially for higher market price. However, farmers shown their deep interest to cultivate Binasola-4 due to its more yields, shiny seed coat, less pest and disease infestation.

Block demonstration of chickpea variety Binasola-6 at different AEZ in collaboration with DAE

With the same objectives, during the *Rabi* season of 2011-12, a total of 13 block demonstrations on Binasola-6 were set up at the farmer's fields in three upazila of two districts, Jessore and Magura. In all cases seeds were sown using broadcast method at the rate of 30 kg ha^{-1}. The fertilizers like urea, TSP, MoP, gypsum and zinc sulphate were applied at the rate of 35, 120, 70, 90 and 4 kg per hectare, respectively. The farmers used their own management all intercultural operations as and when required. Data on sowing time, crop duration, seed yield, insect and disease infestation were recorded. The results are presented in Table 10.

Table 10. Performance of Binasola-6 compared to popular cultivar in different locations during 2011-12

District	Upazila	Date of sowing (Binasola-6)	No. of demons.	Duration (days)		Yield ($kg\ ha^{-1}$)		Yield increased over check (%)
				Binasola-6	check	Binasola-6	check	
Magura	Sadar	25-29 Nov.	04	129	122	1.50	1.20	20.00
Jessore	Sadar	3-7 Dec.	06	110	110	1.20	1.00	16.61
	Jhikorgacha	16-20 Nov.	03	124	126	1.63	1.20	26.38
Total Mean			13	121	119	1.44	1.13	21.53

The Table indicates the facts that the average duration of Binasola-6 was 121 days and there was no significant difference between the check and demo variety. But the average yield of Binasola-6 was 1.44 t ha^{-1} which was 21.53% higher than the check variety. The highest yield (1.63 t ha^{-1}) was recorded at Jhikargacha of Jessore district and the lowest yield was recorded at sadar upazila of Magura district. The yield data revealed the facts that more area of Jessore district could be brought under the cultivation of Binasola-6 through exhaustive extension campaign among the farmers.

Block demonstration of lentil variety, Binamasur-2 at different AEZ in collaboration with DAE

During the Rabi season of 2011-12, a total of 20 demonstrations with Binamasur-2 were set up at the farmers fields in three districts; Natore, Magura and Kustia. The main objectives were to demonstrate and evaluate the performance of Binamasur-2 across the locations and encourage the farmers to continue the variety in their fields. The area for each of the demonstration plots was one acre where, 5 decimal was allocated for check variety, seeds were sown in different dates of November, 2011 and using broadcast method at the rate of 25 kg ha^{-1}. The fertilizers like urea, TSP, MoP, gypsum and zinc sulphate were applied at the rate of 35, 120, 70, 90 and 4 kg per hectare, respectively. The farmers managed all intercultural operations like thinning, weeding, measures against insects and pests as and when required. Data on crop duration, insect and disease infestation and seed yield were recorded. The results are presented in the Table 11.

Table 11. Performance of Binamasur-2 compared to popular cultivar in different locations during 2011-12

District	Upazila	Date of sowing	No. of demons.	Duration (days)		Yield (kg ha^{-1})		Yield increased over check (%)
				Binamasur-2	check*	Binamusur-2	check	
Kustia	Sadar	5-7 Nov	06	98	96 V1	1.40	0.90	35.71
	Mirpur	7-9 Nov	03	106	112 V1	1.18	0.70	40.67
	Veramara	5-8 Nov	04	102	100 V1	1.50	1.10	26.67
Magura	Sadar	1-4 Nov	04	99	104 V2	1.80	1.60	11.11
Natore	Boraigram	14-18 Nov	03	110	115 V3	1.28	1.40	9.38
Total Mean			20	103		1.43	1.14	20.28

*V1= Local cultivar, V2 = BARI Masur-4, V2 = BARI Masur-6

Seed yields of Binamasur-2 varied from 1.18 to 1.80 t ha^{-1} across the locations. The highest yield (1.8 t ha^{-1}) was recorded at sadar of Magura district while the lowest yield (1.18 t ha^{-1}) was at Mirpur upazila of Khustia district. It could be seen from the Table that although in some cases check variety produced higher seed yield than the demo variety. The average performance of Binamasur-2 was 20.28% higher than the check variety. However, the comments of the farmers, on performance of Binamasur-2 at the farmers' field were less diseases and insect infestation and cultivate in rain fed condition.

Block demonstration of lentil variety, Binamasur-4 at different AEZ in Collaboration with DAE

A total of six block demonstrations with Binamasur-4 were set up at the farmer's fields in five Upazila under two districts; Natore and Jessore. The main objectives were to demonstrate and evaluate the performance of Binamasur-4 compared to check variety across the locations and encourage the farmers to continue the variety in their fields. The area for each of the demonstration plots was one acre where, 5 decimal were allocated for control variety, BARI Masur-6. Data on crop duration, insect and disease infestation and seed yield were recorded. The results are presented in the Table 12.

Table 12. Performance of Binamasur-4 compared to popular cultivar in different locations during 2011-12

District	Upazila	Date of sowing	No. of demons	Duration (days)		Yield (kg ha^{-1})		Yield increased over check (%)
				Binamasur-4	BARI Masur-6	Binamasur-4	BARI Masur-6	
Kustia	Sadar	4-7 Nov	03	123	113	1.42	1.11	21.83
	Mirpur	13 Nov	01	110	-	1.10		-
	Veramara	9-10 Nov	02	106	106	1.00	0.90	10.00
Natore	Boraigram	12 Nov	01	115	117	1.40	1.40	-
Total Mean			6	114		1.23	1.14	7.32

The Table indicates that no significance difference was observed in duration of Binamasur-4 and the check variety. But the average yield of Binamasur-4 was 7.32% higher than the check variety. The highest seed yield (1.42 t ha^{-1}) was recorded both at sadar upazila of Kustia district. No influence of sowing time was observed on yield of Binamasur-4.

Block demonstration of mungbean variety, Binamoog-5 at different AEZ in Collaboration with DAE

During the Kharif-1 season of 2011, a total of 57 block demonstrations with mungbean variety, Binamoog-5 were conducted at farmers' fields in five districts. The Department of Agricultural Extension (DAE) was the main collaborator in implementing the demonstrations programme. The main objectives were to demonstrate and evaluate the performance of Binamoog-5 for its dissemination and adoption among the farmers. The area of each of the demonstrations was one acre. The trials were conducted under farmers' own management. Farmers of the southern districts like Patuakhali and Barisal have started sowing in mid of February and continued up to end of February. On the other hand, sowing started in late of March and continued up to end of April in the north-western districts: Dinajpur, Jessore and Pabna. In all cases, seeds were sown using broadcast method at the rate of 30 kg ha^{-1}. The fertilizers like urea, TSP, MoP, gypsum and zinc sulphate were applied at the rate of 35, 120, 70, 90 and 4 kg per hectare, respectively. The available data on sowing time, crop duration and seed yield are presented in the Table 13.

Table 13. Performance of Binamoog-5 compared to popular cultivar in different locations during 2011-12

District	Upazila	Date of sowing	No. of demons.	Duration (days)		Yield (kg ha^{-1})		Yield increased over check (%)
				Binamoog-5	check	Binamoog-5	check	
Dinajpur	Birgonj	04 April	01	90	85	1.20	1.10	8.33
Pabna	Chatmohor	20-23 Mar.	08	74	79	1.59	1.15	27.67
	Atghoria	2-4 April	04	80	87	1.18	0.95	19.49
Barisal	Babugonj	1-7 Feb.	25	83	90	1.30	1.06	18.46
	Sadar	10-12 Feb.	03	63	88	1.20	0.99	17.50
Jessore	Sadar	3-5 Mar.	04	95	94	1.52	1.00	32.21
Patuakhali	Baufal	11-15 Feb	08	75	100	1.25	0.89	28.80
	Sadar	13-15 Feb.	04	75	110	1.00	0.97	3.00
Total Mean			57	79		1.16	1.01	12.93

It is revealed from the Table 13 that sowing started in the southern districts at least one month ahead of the northwestern districts. Binamoog-5 required an average of 79 days to maturity. The average yield of Binamoog-5 was 1.16 t ha^{-1} across the locations. However, the highest yield was recorded at Chatmohor of Pabna district and the lowest yield (1.10 t ha^{-1}) was at sadar under Patuakhali district. Drought tolerance and short duration characteristics of Binamoog-5 might have influenced the farmers in taking decision to continue this variety in their fields. Farmers showed their interest to cultivate this variety for its shiny seed coat, short duration and suitable for rice-wheat-mungbean pattern.

Block demonstration of mungbean variety, Binamoog-6 at different AEZ in Collaboration with DAE

A total of six block demonstrations with mungbean variety, Binamoog-6 were conducted at farmers' fields in two districts. The Department of Agricultural Extension (DAE) was the main collaborator in making the demonstrations successful. The objectives were to demonstrate and evaluate the performance of Binamoog-6 for its dissemination and adoption among the farmers. The area of each of the demonstrations was one acre. The seed rate and fertilizer dose were similar as of Binamoog-5. The trials were conducted under farmers' own management in rain-fed condition. Data on sowing time, crop duration and seed yield are presented in the Table 14.

Table 14. Performance of Binamoog-6 compared to popular cultivar in different locations during 2011-12

District	Upazila	Date of sowing	No. of demons.	Duration (days)		Yield (kg ha^{-1})		Yield increased over check (%)
				Binamoog-6	check	Binamoog-6	check	
Dinajpur	Birgonj	16-18 Mar.	02	74	68	1.60	1.02	36.25
Magura	Sadar	12-15 Feb.	04	70	63	1.30	0.80	38.46
Total Mean			6	72		1.45	0.91	37.24

The average seed yield of Binamoog-6 was 1.45 t ha^{-1}, which was 37.24% higher than the check variety. The highest yield was recorded at Birganj under Dinajpur district. Farmers shows their positive attitude to cultivate this variety.

Block demonstration of mungbean variety, Binamoog-7 in different AEZ in Collaboration with DAE

A total of eight block demonstrations with mungbean variety, Binamoog-7 were conducted at farmers' fields in three districts. The Department of Agricultural Extension (DAE) was the main collaborator in making the demonstrations successful. The objectives were to demonstrate and evaluate the performance of Binamoog-7 for its dissemination and adoption among the farmers. The area of each of the demonstrations was one acre. The seed rate and fertilizer dose were similar as of Binamoog-5. The trials were conducted under farmers' own management. Data on sowing time, crop duration and seed yield are presented in the Table 15.

The Table revealed that the duration of Binamoog-7 and the check variety was very much identical. Seed yield of Binamoog-7 was 21.05% higher than the check variety. The highest yield (1.7 t ha^{-1}) was recorded at sadar upazila under Magura district.

Table 15. Performance of Binamoog-7 compared to popular cultivar in different locations during 2011-12

District	Upazila	Date of sowing	No. of demons.	Duration (days)		Yield (kg/ha)		Yield increased over check (%)
				Binamoog-7	check	Binamoog-7	check	
Pabna	Atghoria	1-3 Feb.	04	76	82	1.18	1.03	12.71
Barisal	Babugonj	2 Feb.	01	80	88	1.20	1.00	16.67
	Banaripara	17 Feb.	01	95	79	1.45	0.95	34.48
Magura	Sadar	20-21 Mar.	02	70	80	1.50	1.20	20.00
Total Mean			8	80	82	1.33	1.05	21.05

Block demonstration of mungbean variety, Binamoog-8 at different AEZ in Collaboration with DAE

A total of thirty five block demonstrations with mungbean variety, Binamoog-8 were conducted at farmers' fields in five districts. The Department of Agricultural Extension (DAE) was the main collaborator in making the demonstrations successful. The objectives were to demonstrate and evaluate the performance of Binamoog-8 for its dissemination and adoption among the farmers. The area of each of the demonstrations was one acre. The trials were conducted under farmers' own management. Data on sowing time, crop duration and seed yield are presented in the Table 16.

Table 16. Performance of Binamoog-8 compared to popular cultivar in different locations during 2011-12

District	Upazila	Date of sowing	No. of demons	Duration (days)		Yield (kg ha^{-1})		Yield increased over check (%)
				Binamoog-8	check	Binamoog-8	check	
Natore	Singra	20-22 Mar.	02	67	80	1.42	0.92	35.21
Pabna	Chatmohor	21-22 Mar	03	74	-	1.62	-	-
	Atgharia	25-28 Mar	07	81	88	1.21	0.98	19.00
Dinajpur	Birgonj	2-4 April	03	90	78	1.20	1.05	12.50
Barisal	Babugonj	1-5Feb.	17	75	85	1.40	1.15	17.86
Jessore	Sadar	8-10 Mar.	03	100	96	1.60	1.00	31.25
Total Mean			35	81	85	1.41	1.02	27.66

The Table revealed that there was no significant difference between the duration of Binamoog-8 and the check variety. But the yield of Binamoog-8 was 27.66% higher than the check variety. The highest yield (1.62 t ha^{-1}) was recorded at Chatmohor upazila under Natore district.

Establishment of BINA-Technology Pilot Area (BINA-Village)

In order to establish BINA-Tech. village, block demonstrations and other extension work were done in collaboration with the Department of Agricultural Extension (DAE) and personnel of BINA-substations at the farmer's fields around BINA Head quarter and its sub-stations. Results of block demonstrations of different locations and status of BINA technology village establishment are presented below.

Block demonstration with different BINA developed crop varieties around BINA Headquarter

During 2011-12, a totla of 20 block demonstrations were conducted with BINA developed 03 crop varieties at Sutiakhali, Khagdahar and Porangonj villages under sadar upazila of Mymensingh district. Results of Demonstrations are presented in Table 17.

Table 17. Performance of BINA varieties in some areas of sadar upazila, Mymensingh district during 2011-12

Crops/Varieties	Total no. of demonstrations	Duration (days)	Yield (t ha^{-1}.)
Rice:			
Binadhan-5	5	154	6.72
Binadhan-7	9	118	4.58
Total	14		
Oilseeds:			
Binasarisha-4	6	85	1.52
Grand Total	20		

Mymensingh district is mostly suitable for rice cultivation and that of partly for mustard growing. Results in Table 17 depict that rice varieties of Binadhan-5 and Binadhan-7 produced remarkably higher grain yield. For boro season farmers' preferred Binadhan-5 for its higher yields and easy to thresh which help getting more straw. For Transplanted aman season, Binadhan-7 was highly preferable by the farmers for its higher yield, short crop duration and fine grain. Rabi crop especially mustard can be easily cultivated after harvesting Binadhan-7 without yield sacrifice. BINA developed mustard variety, Binasarisha-4 also produced remarkably higher yield than the local cultivar. An extra rabi crop could easily be cultivated adopting Binadhan-7 in aman season having higher yield of aman rice. A cropping pattern of "Binadhan-7-Binasarisha-4-Boro rice" has demonstrated very suitable and highly profitable in Porangonj of sadar upazila and this pattern are adopting extensively by the farmers. These BINA varieties following above cropping pattern are disseminating spontaneously among the farmers in other villages as well.

COMILLA SUB-STATION

Block demonstration with different BINA developed crop varieties around Comilla Sub-station

During 2011-12, 14 Block Demonstrations were conducted with BINA developed 03 crop varieties at Rasulpur and Palpara villages under Sadar upazila of Comilla district. Results of demonstrations are presented in Table 18.

Table 18. Performance of BINA varieties in some areas of sadar upazila, Comilla district during 2011-12

Crops/Varieties	Total no. of demonstrations	Duration (days)	Yield (t ha^{-1})
Rice:			
Binadhan-5	3	155	6.13
Binadhan-7	5	118	4.55
Total	**8**		
Oilseeds:			
Binasarisha-4	6	87	1.46
Grand Total	**14**		

Rasulpur village in Comilla district is mostly suitable for rice cultivation and partly that of vegetables and oilseeds. Results in Table 18 indicate that Binadhan-5 produced higher grain yield. Farmer's interest seemed to be most positive for Binadhan-7 in aman season. Mustard variety, Binasarisha-4 showed immense potentials in terms of yield and duration for cultivation in between aman and boro rice. However, it needs further trials for technical support and farmer's motivation. Establishment of BINA technology village is underway through promotional activities of mutant varieties in Rasulpur villlage.

ISHURDI SUB-STATION

Block demonstration with different BINA developed crop varieties around Ishurdi sub-station

During 2011-12, 23 block demonstrations were conducted with BINA developed promising 8 crop varieties at some villages under Ishurdi upazila of Pabna district around Ishurdi sub-station. Results of demonstrations are presented in Table 19.

Table 19. Performance of BINA varieties in some areas of Ishurdi upazila, Pabna district during 2011-12

Crops/Varieties	Total no. of demonstrations	Duration (days)	Yield (t ha^{-1}.)
Rice:			
Binadhan-5	03	155	6.35
Binadhan-7	05	117	4.16
Total	**08**		
Pulse:			
Binamoog-5	02	67	1.77
Binamoog-8	04	67	2.43
Binamusur-2	03	104	1.53
Total	**09**		
Oilseeds:			
Binasarisha-4	04	97	1.81
Binasarisha-7	01	108	2.37
Binasarisha-8	01	104	2.07
Total	**06**		
Grand Total	**23**		

Ishuardi under Pabna district is very suitable area for growing pulse, oilseeds and rice. Results in Table 23 showed the identical yield of Binadhan-5 with moderate crop duration. Farmers have been interested to cultivate BINA developed rice varieties in boro season for their good yield, moderate crop duration, easy harvesting and getting varietals diversification. Transplanted aman variety Binadhan-7 produced higher grain yield. It matured one month earlier than the local cultivar sharna, which created enough farmers' interest to adopt Binadhan-7. Mustard variety Binasarisha-4 showed immense yield potential over the local cultivar Tori-7 and preferred by the farmers. Another two newly released mustard varieties Binasarisha-7 and Binasarisha-8 produced maximum yield but crop duration of these mustard varieties was higher than the check variety. However, Binamoog-5 and Binamoog-8 produced remarkably higher yield compared to existing cultivars these two varieties are extending spontaneously in this area. Lentil variety, Binamasur-2 produced encouraging seed yield. However, in three villages established BINA technology villages namely, Dulty, Athysimul and Auronkhola.

RANGPUR SUB-STATION

Block Demonstration with different BINA developed crop varieties around Rangpur sub-station

During 2011-12, 22 block demonstrations were conducted with BINA developed promising 6 crop varieties at two villages under sadar upazila of Rangpur district. Results of demonstrations are presented in Table 20.

Table 20. Performance of BINA varieties in some areas of sadar upazila, Rangpur district during 2011-12

Variety	Total no. of Demonstration	Duration (days)	Yield (t ha^{-1})
Rice:			
Binadhan-5	4	154	6.10
Binadhan-7	10	114	5.10
Total	**14**		
Oil seeds:			
Binasarisha-4	04	92	1.61
Binasarisha-7	01	109	2.35
Binasarisha-8	01	105	2.02
Total	**6**		
Vegetable:			
Binatomato-5	2	91	70.00
Grand Total	**22**		

Rangpur district mainly is suitable for growing rice, potato, partly tomato and mustard. Results in Table 20 reveal that in boro season Binadhan-5 produced higher grain yield. Farmers were interested to adopt these varieties. However, Binadhan-7 proved as the miraculous transplanted aman variety for this area as it produced higher yield, matured earlier that facilitate earlier rabi crop cultivation and help in management of Manga problem effectively. Binatomato-5 also appreciated by the farmers for its higher yield, good taste, higher keeping quality and market demand. Binasarisha-4 also produced good seed yield of 1.61 t ha^{-1} which is suitable for cultivation in between aman and boro rice. Another two newly released mustard varieties Binasarisha-7 and Binasarisha-8 produced also high yield potentials but crop duration of those varieties was higher than check variety. In locality established BINA technology villages at Auvirampur and Parbotipur.

SATKHIRA SUB-STATION

Block Demonstration with different BINA developed crop varieties around Satkhira sub-station

During 2011-12, 19 block demonstrations were carried out with BINA developed promising 05 crop varieties at some villages in sadar and Tala upazilas of Satkhira district. Results of demonstrations are presented in Table 21.

Table 21. Performance of BINA varieties in some areas of sadar upazila, Satkhira district during 2011-12

Variety	Total no. of demonstrations	Duration (days)	Yield (t ha^{-1})
Rice:			
Binadhan-5	05	153	6.40
Binadhan-7	05	116	4.50
Binadhan-8	05	138	6.15
Total	**15**		
Oilseeds:			
Binasarisha-4	02	85	1.55
Binasarisha-5	02	86	1.18
Total	**4**		
Grand Total	**19**		

Satkhira district is suitable for cultivation of rice and that of partly mungbean, and oilseeds. Data in Table 21 indicate that Binadhan-5 produced remarkably higher yield. Farmers preferred this BINA variety for their higher yield and more economic return. Binadhan-6 exhibited similar yield performance. However, Binasarisha-4 and Binasarisha-5 produced encouraging yield and farmers showed positive response to those mutant varieties. Above performance of BINA developed mutant varieties depicted the good sign for establishing BINA technology village in this locality. However, BINA developed salt tolerant rice variety, Binadhan-8 demonstrated with encouraging performance. It was expected that this variety would be extended rapidly in this area. In this area established BINA technology villages at Jhapaghat (Kalaroa upazila) and Dulatpur (Sadar upazila)

MAGURA SUB-STATION

Block Demonstration with different BINA developed crop varieties around Magura sub-station

Reports of 44 block demonstrations were conducted during 2011-12 with BINA developed promising 9 crop varieties at West Ramnagar and Alamkhali villages under sadar upazila of Magura district. Results of Demonstrations are presented in Table 22.

Table. 22. Performance of BINA varieties in some areas of sadar upazila, Magura district during 2011-12

Variety	Total no. of demonstrations	Duration (days)	Yield (t ha^{-1})
Rice:			
Binadhan-5	4	152	6.42
Binadhan-7	5	117	4.56
Total	**9**		
Pulse:			
Binamoog-5	05	81	1.62
Binamoog-6	03	69	1.52
Binamoog-8	09	66	1.66
Binamusur-2	03	99	1.75
Binamusur-4	02	103	1.45
Binasola-4	08	120	1.79
Total	**30**		
Oilseeds:			
Binasarisha-4	5	88	1.68
Grand Total	**44**		

Magura district is suitable for growing almost all the crops. Some of the promising BINA developed pulses, oilseeds and rice varieties are demonstrating good yield and other better attributes. In this location demonstrations were conducted with 9 BINA varieties. Demonstrated varieties were Binasarisha-4, Binamoog-5, Binamoog-6, Binamoog-8, Binamasur-2, Binamasur-4, Binasola-4, Binadhan-5 and Binadhan-7 which produced remarkably higher yield. Farmers preferred all of the above BINA varieties and diffusing spontaneously among the farming community. However, established BINA technology villages at West Ram Nagar. Khalimpur, Ishakhada and Alamkhali.

Progress in BINA technology Village establishment

Sl. No.	Location	Working village	Establishment Status	Most suitable BINA variety
1.	Mymensingh sadar	Sutiakhali Poranganj	Established BINA Technology village.	Binadhan-5, Binadhan-7 and Binasarisha-4
		Khagdahar	Underway	do
2.	Magura	West Ramnagar, Khalimpur, Echakhada, Alamkhali	Established BINA Technology village.	Binamoog-5, Binamoog-6, Binamoog-8, Iratom-24, Binadhan-5, Binadhan-7, Binamasur-2, Binamasur-5, Binasola-4, Binasarisha-4, Binasarisha-7 and Binasarisha-8
		Shidhrampur	Underway	do
3.	Ishurdi	Dulti Aurankhola Athaishimul	Established BINA Technology village.	Binadhan-7, Binamasur-2, Binamoog-5, Binamoog-6, Binamoog-7, Binamoog-8, Binasarisha-4, 7, 8 and Binadhan-5
		Kalikapur	Underway	do
4.	Rangpur	Auviram, Parbotipur	Established BINA Technology village.	Binadhan-5, Binadhan-7 and Binasarisha-4, Binasarisha-7 and Binasarisha-8,
		Najirarhat	Underway	do
5.	Satkhira	Jhapaghat in Kolaroa, Daulatpur	Established BINA Technology village.	Binadhan-8, Binadhan-7, Binamasur-2 and Binamoog-7,8
		Brahmorajpur Shenergati in Tala	Underway	Binadhan-8, Binasarisha-7 and 8
6.	Comilla	Palpara	Underway	Binasarisha-7, Binadhan-5 and Binadhan-7.
		Rasulpur	do	Binadhan-5, Binadhan-7 and Binasarisha-4.

Training of scientists, farmers, extension personnel and workers

Under this project manpower development and technology transfer activities are usually done through nomination of BINA personnel for participation in different national and overseas training programme, arranging training and workshops for extension personnel, farmers and field days. Training related functions which were done during this period were as follows:

Manpower Development

Necessary arrangements were made to nominate 42 BINA personnel for participation in different in-country training courses/workshop/seminar organized by other national organizations. All process was also made to nominate 15 BINA personnel for participation in foreign training/workshop/seminar. Necessary arrangements were made for nomination of 7 BINA stuff for in country Training. Details of the nomination activities regarding national and overseas training courses are presented in Table 27, Table 28 and Table 29.

Table 27. Arrangement of nomination of BINA personnel for foreign training course/workshop/seminar during 2011-12

Sl. no.	Title of training/workshop	Trainee	Duration	Venue
01.	Ph.D Course	Md. Harun-or-Rashid SO	01-03-2011 to 01-02-2013	Germany
02.	Post Doctoral Fellowship	Dr. Md. Abdul Malek PSO	13-06-2011 to 12-06-2012	Malaysia
03.	Training	Dr. Md. Manjorul Alam Mondol SSO	4-8 July 2011	Malaysia
04.	Impact Assessment of Agricultural Research	Dr. M. Raisul Haider PSO	10-17 August 2011	Phillippine
05.	Using climate scenarios and analogues for designing adaptation strategies in agriculture	Dr. Md. Asgar Ali Sarker CSO	19-23 September 2011	Nepal
06.	Seminar on Hybrid rice for Bangladesh	Dr. Md. Monowar Karim Khan CSO	16 November to 05 Dec., 2011	China
07.	Seminar on Hybrid rice for Bangladesh	Dr. Mirza Mofazzal Islam PSO	16 November to 05 Dec., 2011	China
08.	Seminar on Hybrid rice for Bangladesh	Dr. Md. Rafiqual Islam SSO	16 November to 05 Dec., 2011	China
09.	RC First Technical Meeting	Dr. M. A. Salam Director (Research)	12-16 Dec., 2011	Vienna, Austria
10.	Scientific visit	Dr. Md. Asgar Ali Sarker CSO	16-25 December 2011	China
11.	Society for the advanced of breeding research in Asia ... (SABRAO)	Dr. Mirza Mofazzal Islam PSO	13-17 January 2012	Thailand
12.	Society for the advanced of breeding research in Asia ... (SABRAO)	Dr. Shamsun Nahar Begum SSO	13-17 January 2012	Thailand
13.	Study Visit	Dr. Reza Mohammad Emon SO	01 March to 30 April, 2012	China
14.	Ph. D Course	Md. Mahmudul Hasan SO	15-03-2012 to 30-09-2015	Malaysia
15.	Post Doctoral Fellowship	Dr. Md. Monjurul Alam Mandol SSO	01-05-2012 to 30-04-2013	University of Petra, Malaysia

Table 28. Arrangement made for nomination of BINA personnel for in-country training curse/workshop/ seminar during 2011-12

Sl. no.	Title of training/workshop/seminar	Trainee	Duration	Venue
01.	Adobe Illustrator and Adobe Photoshop software	Md. Sakawat Hossain Asst. Liberian	01-08-11 to 30-11-2011	Bhuiyan Computer Mymensingh
02.	Research Methodology	Dr. Md. Rafiqul Islam SSO	10-9-11 to 21-10-11	GTI
03.	Research Methodology	Md. Nurun Nobi Mazumder SO	10-9-11 to 21-10-11	GTI
04.	Research Methodology	Md. Faruk Hossain SO	10-9-11 to 21-10-11	GTI
05.	Research Methodology	Md. Md. Habibur Rahman SO	10-9-11 to 21-10-11	GTI
06.	Research Methodology	Khandaker Shamsul Arefin SSO	10-9-11 to 21-10-11	GTI
07.	Water security and climate change	Dr. Md. Tariqul Islam PSO	20-22 Sept. 2011	Dhaka
08.	Food security and climate change	Dr. Md. Monowar Karim Khan CSO (cc)	20-22 Sept. 2011	Dhaka
09.	Research Methodology	Md. Asadullah SO	22 Sept. to 06 Oct. 2011	GTI
10.	Research Methodology	Krishna Rani Das SO	08-20 Oct. 2011	GTI
11.	Biotechnology food security and economic development	Dr. Md. Monowar Karim Khan CSO (cc)	30-31 Oct. 2011	BARI
12.	Biotechnology food security and economic development	Dr. Mirza Mofazzal Islam PSO	30-31 Oct. 2011	BARI
13.	Biotechnology food security and economic development	Dr. Samsun Nahar Begum SSO	30-31 Oct. 2011	BARI
14.	Biotechnology food security and economic development	Dr. Md. Imtiaz Uddin SSO	30-31 Oct. 2011	BARI
15.	Biotechnology food security and economic development	Dr. Reaz Mohammad Emon SO	30-31 Oct. 2011	BARI
16.	Conduct and Discipline course	Kazi Rafiqul Alam PS (AO), DG s Office	13-24 Nov. 2011	Dhaka
17.	Excutive Management Seminar on Industrial Application of Gamma Radiation Bangladesh	Dr. Shariful Haque Bhuiyan, PSO Khondokar Shamsul Arafin SSO	11 Dec. 2011	Dhaka
18.	Food Safety and phytosanitary measures	Dr. Hosna Ara Begum PSO	13-14 Dec. 2011	Dhaka
19.	Post harvest management of fruits & vegetables	Dr. A F M Saiful Islam PSO	25-26 Jan. 2012	Dhaka
20.	Organic pollutants in food agricultural products and environment	Dr. Md. Jahangir Alam PSO	17-18 Jan. 2012	Dhaka University
21.	Organic pollutants in food agricultural products and environment	Dr. Md. Eqramul Haque PSO	17-18 Jan. 2012	Dhaka University
22.	Organic pollutants in food agricultural products and environment	Dr. Md. Azizul Haque SSO	17-18 Jan. 2012	Dhaka University

Table 28 Contd.

Sl. No.	Title of training/workshop/seminar	Trainee	Duration	Venue
23.	Training Course	Mohammad Maruf Hossain SO	5 Feb to 5 June, 2012	Comilla
24.	Training Course	Md Habibur Rahman SO	5 Feb to 5 June, 2012	Comilla
25.	Information	Md. Faruque Hossain	12-16 Feb. 12	Dhaka
26.	Sustainable alternative agriculture	Dr. Md. Monowar Karim Khan CSO (cc)	5 March 2012	Dhaka
27.	National workshop on research achievement of past ten years of pules & oilseeds and their future research straties to sustain crop production and food security	Dr. Md. Raisul Haider PSO	20-21 March 2012	Dhaka
28.	Crop production technologies under environmental strees condition fort NARS	Md. Siddiqur Rahman SSO	11-15 March	Dhaka
29.	Identification of major diseases and insect pests of important crops and their management for NARS scientists	Dr. Md. Abul Kashem SSO	4-8 March 2012	Gazipur
30.	Data Management and Report writing	Dr. Md Monjurul Islam SSO	1-5 April 2012	Dhaka
31.	Data Management and Report writing	Dr. Md Siddiqur Rahman SSO	8-12 April 2012	Dhaka
32.	Project Development & Management	Dr. Snigdha Roy SSO	8-12 April 2012	Dhaka
33.	Regional workshops 11-12 on outreach & information dissemination	Dr. Rafiqul Islam SSO	8 May 2012	Chittagong
34.	Regional workshops 11-12 on outreach & information dissemination	Dr. Rafiqul Islam SSO	10 May 2012	Comilla
35.	Seed quality management	Md. Ferdous Iqbal SO	21-23 May 2012	Dhaka
36.	Regional workshops 11-12 on outreach & Information Dissemination	Dr. Md. Asgar Ali Sarker CSO	28 May 2012	Rangpur
37.	Regional workshops 11-12 on outreach & information dissemination	Dr. Md. Raisul Haider PSO	20 May 2012	Mymensingh
38.	Plant Breeding & Plant Genetic training course	Dr. Reza Mohammed Emon SO	3-16 June 2012	Gazipur
39.	Plant Breeding & Plant Genetic training course	Mohammed Ferdous Iqbal SO	3-16 June 2012	Gazipur
40.	Review workshop on plant protection	Dr. Hosna Ara Begum PSO	13-14 June 2012	Dhaka
41.	Review workshop on crop improvement programme	Dr. M A Samad PSO	11-12 June 2012	Dhaka

Table 29. Arrangement made for in country training of BINA stuff during 2011-12

SL. No.	Title of training/workshop/seminar	Trainee	Duration	Venue
1.	Staff development course	Md. Sahadul Islam MLSS	07-11 August 2011	RPATC Dhaka
2.	Computer literacy and english language course	Md. Nasirul Haque Sharif Office Assistant-Cum-Computer Operator	09-27 October 2011	RPATC Dhaka
3.	Conduct and discipline course	Nilofa Begum MLSS	20-24 November 2011	RPATC Dhaka
4.	Staff development course	Md. Mojibor Rahman Bhoian Head Assistant	13-24 November 2011	RPATC Dhaka
5.	Computer literacy and english language course	Md. Sarwar Hossain Mollah UDA	04-22 December 2011	RPATC Dhaka
6.	Computer literacy and english language course	Md. Altab Masud Office Assistant-Cum-Computer Operator	04-22 March 2012	RPATC Dhaka
7.	Basic office management course	Ratan Kumar Talukder Office Assistant-Cum-Computer Operator	01-26 March 2012	RPATC Dhaka

Training on the use of BINA developed technologies

In order to technology promotion 5 training courses were organized during the period of 2011-12. A total of 170 female and male farmers including some Sub-assistant Agriculture Officers were trained on cultivation of BINA developed improved crop varieties. Details of the training programme are presented in Table 25.

Table 25. Farmers training on the use of BINA developed technologies during 2011-12

SL. No.	Topic	Place of training	Date of training	No. of participants	Source of fund
1.	Farmers training on “Cultivation & seed preservation method of BINA developed high yielding salt tolerant rice, Binadhan-8”	Bashkhali, Chittagoan	01-02-2012	50	IRRI, Bangladesh
2.	Sub-assistant Agriculture Officer(SAAO) training on “Cultivation & seed preservation method of BINA developed high yielding salt tolerant rice, Binadhan-8”	Bashkhali, Chittagoan	02-02-2012	40	IRRI, Bangladesh
3.	Farmers training on “Demonastration set up, cultivation metod and management of sesame and mustard”	Baghar para, Jessore	16-03-2012	25	YMMSP
4.	Farmers training on “Demonastration set up, cultivation method and management of sesame and mustard”	Madhukhali, Faridpur	17-03-2012	25	YMMSP
5.	Farmers training on “Demonastration set up, cultivation method and management of Binachinabadam-4”	Kaliganj, Lalmonirhut	29-02-2012	30	SRSD Project

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 23 field days/on-farm farmer's training on different crop varieties was organized across the country. Details of the field day activities are presented in Table 27.

Table 27. Field days arranged in the farmers fields on different crop varieties during 2010-11

Sl. No.	Crop	Variety	Locations	Participants	Remarks
1.	Rice	Binadhan-8	Shamnagar, Satkhira	650	Farmers were deeply impressed
		Binadhan-8	Sadar, Satkhira	200	Do
2.		Binadhan-8	Dagonbhuiya, Feni	200	Do
3.		Binadhan-8	Bashkhali, Chittagoan	200	Do
4.		Binadhan-8	Bashkhali, Chittagoan	200	Do
		Binadhan-8	Bashkhali, Chittagoan	200	Do
5.		Binadhan-8	Chokoria, Cox`s bazar	200	Do
6.	Participatory Variety Selection (PVS) on rice for short duration mutant line		Sadar, Barisal	200	Do
7.			Sadar, Rangpur	200	Do
8.			Sadar, Magura	200	Do
9.			Sadar, Mymensingh	200	Do
10.	Mustard	Binasarisha-4	Sadar, Mymensingh	200	Do
11.	Do	Binasarisha-7	Sadar, Rangpur	200	Do
12.	Do	Binasarisha-7	Ishurdi, Pabna	200	Do
13.	Do	Binamasur-4	Sadar, Magura	200	Do
14.	Do	Binasola-5	Sadar, Magura	200	Do
15.	Sunflower		Sadar, Satkhira	200	Do
16	Mustard	Binasarisha-4	Aditmari, Lalmonirhat	200	DO
17	Sesame	Binatil-1 and Binatil-2	Madhukhali, Faridpur	200	Do
18	Sesame	Binatil-1 and Binatil-2	Baghar para, Jessore	200	Do
19	Sesame	Binatil-1 and Binatil-2	Alamdanga, Chuadanga	200	Do
20	Mungbean	Binamoog-5	Ishwardi, Pabna	200	Do
21	Groundnut	Binachinabadam-4	Sadar, Natore	200	Do
22	Groundnut	Binachinabadam-4	Sharsha, Jessore	200	DO
23	Groundnut	Binachinabadam-4	Kaligonj, Lalmonirhat	200	Do

Publications and photographic enrichment

For technology transfer through printed media, publications were made on 6 types of leaflets total in 30,000 copies during this period. Besides these, three programmes were telecast to popularize some BINA crop varieties. Details of the publication activities are presented in Table 28.

Table 28. List of publications made on different crop varieties and electronic media exposure during 2011-12

Sl. No.	Name of crops/varieties	Name of publication	Language	Copies printed
01.	Binadhan-7	Leaflet	Bangla	5000
02.	Binadhan-8	Do	Do	5000
03.	Binasarisha-7 & 8	Do	Do	5000
04.	Binamasur-5 & 6	Do	Do	5000
05.	Binasoybean-1 & 2	Do	Do	5000
06.	Binasola-5 & 6	Do	Do	5000
			Total =	30,000

Electronic media exposure

Sl. no.	Name of crops/varieties	Name of the channel	Location	Remarks
01.	Binadhan-8	BTV, Chennel i, Bangla vision, Machranga, R-TV	Satkhira	It was very effective for Awareness creation
02.	Do	Chennel i, Bangla Vision, R-TV	Chittagoan	
03.	Do	Mati-O-Manus, BTV, Chennel i, Banglavision	Cox`s bazar	

BIOTECHNOLOGY DIVISION

RESEARCH HIGHLIGHTS

Three rice genotypes including PBRC-37 (Binadhan-10) were identified as salt tolerant with regard to RM 10772, RM 296 and RM 10701 markers.

In Binadhan-7 × FL-378, out of 32 BC_1F_1, 5 lines (BC_1F_1-30, BC_1F_1-40, BC_1F_1-2, BC_1F_1-16 and BC_1F_1-34) were identified as introgressed salt tolerant rice lines when RM585 and RM296 markers were used and lines BC_1F_1-1 and BC_1F_1-3 were identified as introgressed salt tolerant rice lines by useing 3 primers (RM585, RM296 and OSR30).

Foreground selection of Binadhan-7× FL-478 was performed and 32 BC_1F_1 population were selected with tightly linked salt tolerant markers RM585, RM10720 and RM310. Out of 32 BC_1F_1 populations, the marker RM585 identified 20 lines as salt tolerant, RM10720 identified 16 lines as salt tolerant and the marker RM310 identified 17 lines as salt tolerant.

Two salt tolerant rice genotypes (FL-378 & FL-478) were selected as parent for transferring salt tolerant genes to high yielding rice varieties Binadhan-5 and Binadhan-7. A total of 454 F_1 seeds were developed from this aman season 2011. For MAS, 800 BC_1F_1 populations were collected for genotyping.

Morpho-molecular characterization of 22 lentil genotypes, RAPD markers viz. OPC-05, OPB-08 and OPB-10 showed good resolution and sufficient variations among the genotypes. Three primers produced polymorphic bands in 24 polymorphic loci. OPC-05 produced maximum polymorphic bands in 100-850 bp compare to OPB-08 and OPB-10.

The proposed salt tolerant genotype, PBRC-37 exhibited 10 days earlier and higher yield (6.0 t ha^{-1}) (20%) than Binadhan-8 under 10-12 dS/m. This genotype has been applied to SCA for variety release. Note: PBRC-37 has already been released as Binadhan-10 on September 2012.

Line OMCS-2007 showed the earliest maturity (105 and 144 days in aman and boro, respectively), and higher yield among the tested entries.

Ciherang- *sub1* and Samba Mahsuri-*sub1* have been selected for submergence tolerant under 25 days of complete submergence and possess higher yield (4.2 and 3.4 t ha^{-1}) and early mature (110 and 120 days). SCA Team evaluated and reported to Technical Committee of NSB. Application has been made to SCA for variety release.

NERICA-1, NERICA-4 and NERICA-10 were irradiated with γ-rays and selected 111 M_5 generation which are being tested in drought and saline prone areas.

Development of salt tolerant rice varieties using induced mutation and biotechnological approaches

Screening of salt tolerant rice genotypes at the seedling stage using phenotypic and micro satellite markers

Twenty seven rice germplasms (Table 1) were used to evaluate salinity tolerance at the seedling stage and to identify salt tolerant rice lines using SSR markers. Salinity screening was done at the seedling stage using hydroponic system in glasshouse following IRRI standard protocol. Based on 1-9 scale SES, 4 tolerant, 8 moderately tolerant and 15 susceptible rice genotypes were identified.

These genotypes along with their check varieties (Binadhan-7 and Binadhan-8) were used with SSR markers for the identification of salt tolerant rice genotypes. Polymorphism survey was done with 8 SSR markers. Out of 8 markers, 3 polymorphic SSR markers viz., RM 10772, RM 296 and RM 10701 were selected to evaluate salt tolerant genotypes.

Table 1. Performance of the rice genotypes under salinized condition (EC 12 dS/m) grown in hydroponic system at the seedling stage

Genotypes	SES Scoring	Tolerance
Set 37 L-22 Set 37 L- 41 Set 37 L-29 PBRC-37 Binadhan-8 (Check)	3	T
Set 37 L-15 Set 37 L-16 Set 39 L-8 Set 39 L-33 PBRC-4 PBRC-30 PBSAL 730	5	MT
Set 10 SL-2 Set 10 SL-10 Set 10 SL-15 Set 37 L-23 Set 37 L-36 Set 39 L-1 Set 39 L-3 Set 39 L-10 Set 39 L-13 Set 39 L-22 Set 39 L-25 Set 39 L-28 Set 39 L-29 PBRC-5 Binadhan-7 (Check)	7	S

T = tolerant, MT = Moderately Tolerant, S = susceptible.
1-9 scale, where 1 = highly tolerant and 9 = highly susceptible

The marker RM 10772 identified 8 genotypes as salt tolerant, 3 genotypes as moderately tolerant and 16 genotypes as susceptible (Fig. 1). Marker RM 296 identified 7 genotypes as tolerant, 3 genotypes as moderately tolerant and 17 genotypes as susceptible in comparison with Binadhan-7 and Binadhan-8 (Fig. 2). Whereas marker RM 10701 was identified 7 genotypes as tolerant, 3 genotypes as moderately tolerant and rest of 17 genotypes as susceptible (Fig. 3). SET 37 L-29, SET 37 L-41 and PBRC-37 were identified as tolerant in comparison with Binadhan-8 (salt tolerant) when RM 10772, RM 296 and RM 10701 markers were used.

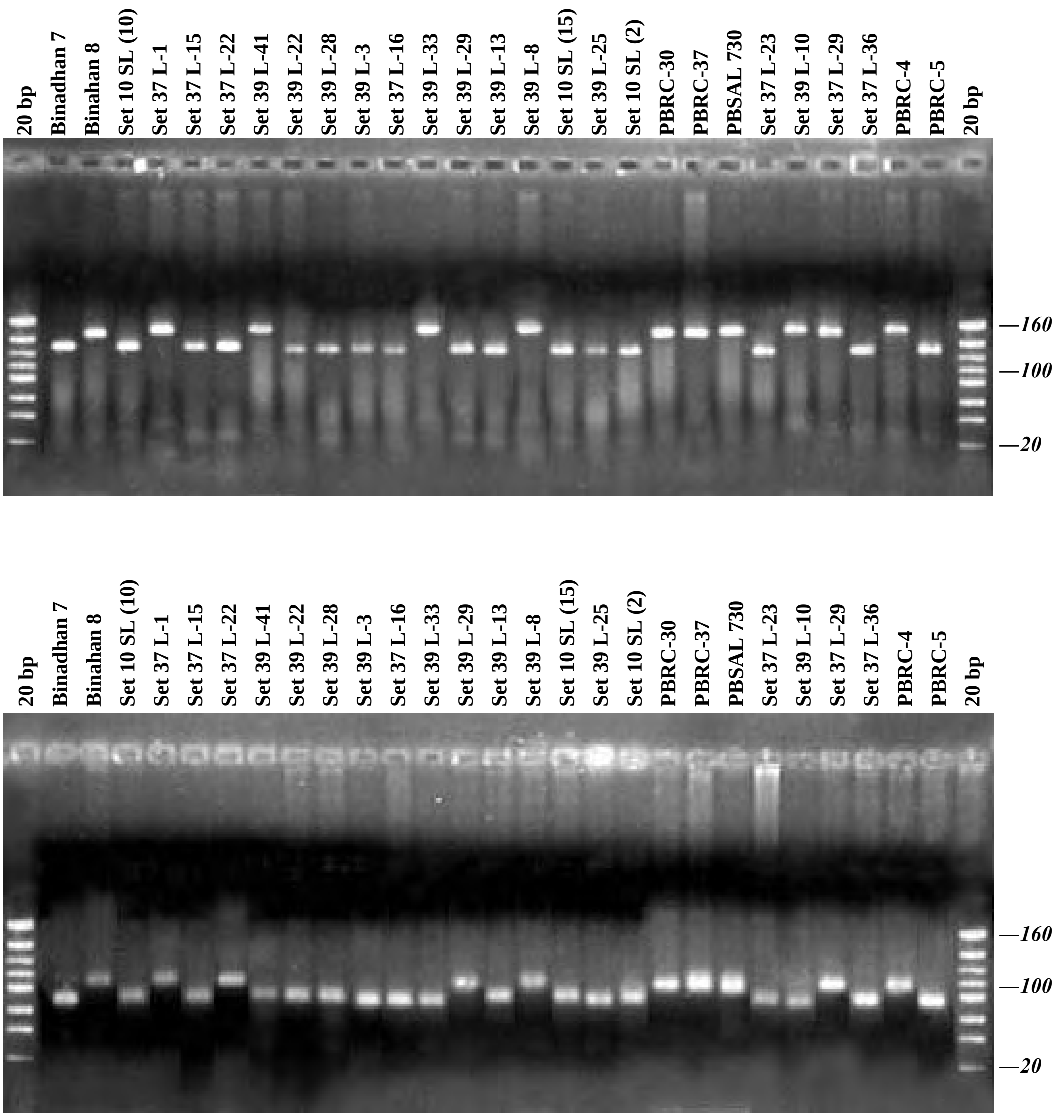


Fig. 1. RM10772 marker showing banding pattern of 27 rice genotypes

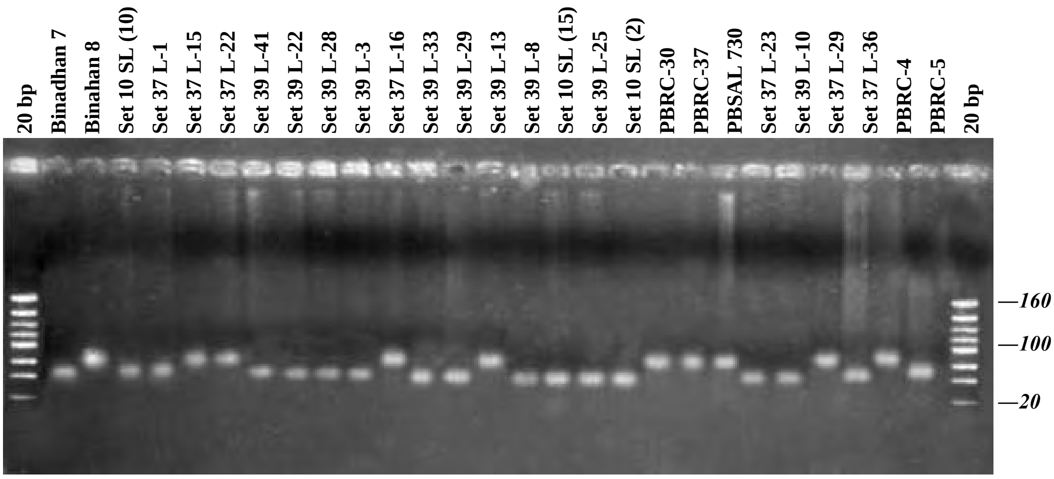


Fig. 3. RM10701 marker showing banding pattern of 27 rice genotypes

Identification of introgressed rice lines of Binadhan-7 × FL-378 under salt stress via SSR markers

Salt tolerant genotype, FL-378 was crossed with high yielding variety, Binadhan-7. Seeds of BC_1F_1 population of Binadhan-7/FL-378 was derived from backcross population of F_1 (Binadhan-7/FL-378). Thirty two rice lines of BC_1F_1 population (Binadhan-7/FL-378) were used to identify introgressed rice lines for salt tolerance using SSR markers. Randomly selected 32 BC_1F_1 progenies along with their two parents (Binadhan-7, FL-378) were genotyped with microsatellite or SSR markers for identification of introgressed rice lines. Parental polymorphism survey was assayed by 8 SSR markers and three polymorphic SSR markers viz., RM296, RM585 and OSR30 were selected to evaluate BC_1F_1 rice lines for salt tolerance.

In respect of primer RM585, 16 lines were found as introgressed salt tolerant and 16 lines were susceptible in comparison with salt tolerant parent FL-378 and salt susceptible parent Binadhan-7 (Fig. 4). Primer RM296 identified 13 introgressed salt tolerant and 19 susceptible lines (Fig. 5). Nine introgressed salt tolerant and 23 susceptible lines were identified when BC_1F_1 lines were evaluated with marker OSR30 (Fig. 6). Line BC_1F_1-30, BC_1F_1-40, BC_1F_1-2, BC_1F_1-16 and BC_1F_1-34 were identified as introgressed salt tolerant rice lines in comparison with parent FL-378 (salt tolerant) when RM585 and RM296 markers were used but line BC_1F_1-1 and BC_1F_1-3 were identified as salt tolerant lines in case of 3 primers (RM585, RM296 and OSR30). Again the lines BC_1F_1-5, BC_1F_1-24, BC_1F_1-26, BC_1F_1-27, BC_1F_{1}-29, BC_1F_1-31, BC_1F_1-37 and BC_1F_1-38 were found susceptible as compared with parent Binadhan-7 when marker RM585, RM296 and OSR30 were used. The average gene diversity over all SSR loci for the 32 BC_1F_1 rice lines along with two parents was 0.4614, ranging from 0.4152 to 0.4844. Positive correlations were found between the genetic diversity and the maximum number of repeats. The UPGMA cluster tree analysis led to the grouping of the 32 BC_1F_1 populations of Binadhan-7 × FL 378 along with their parents in two major cluster. 24 genotypes belonged to cluster 1 and these genotypes are separated from other 10 genotypes in cluster 2. (Fig. 7).

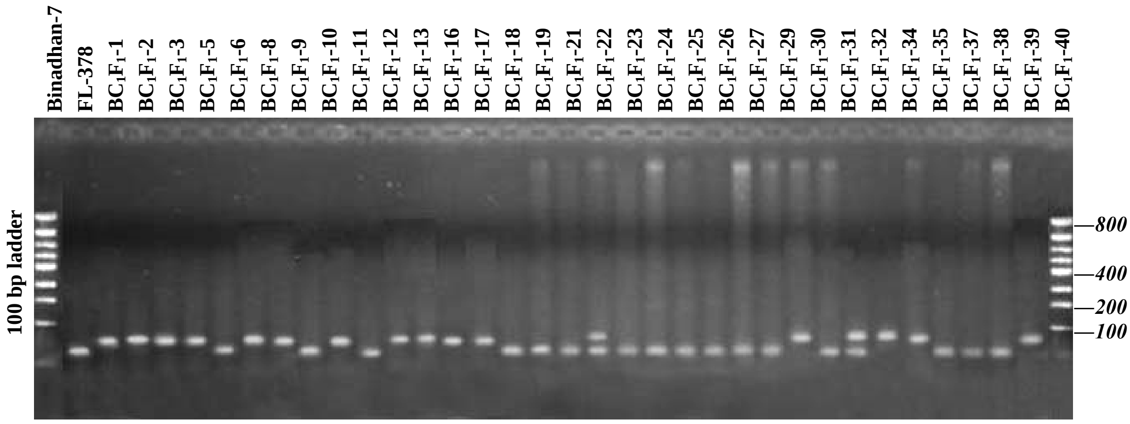


Fig. 4. RM585 marker showing a segment of rice genome from FL-378 (P1) into Binadhan-7 (P2)

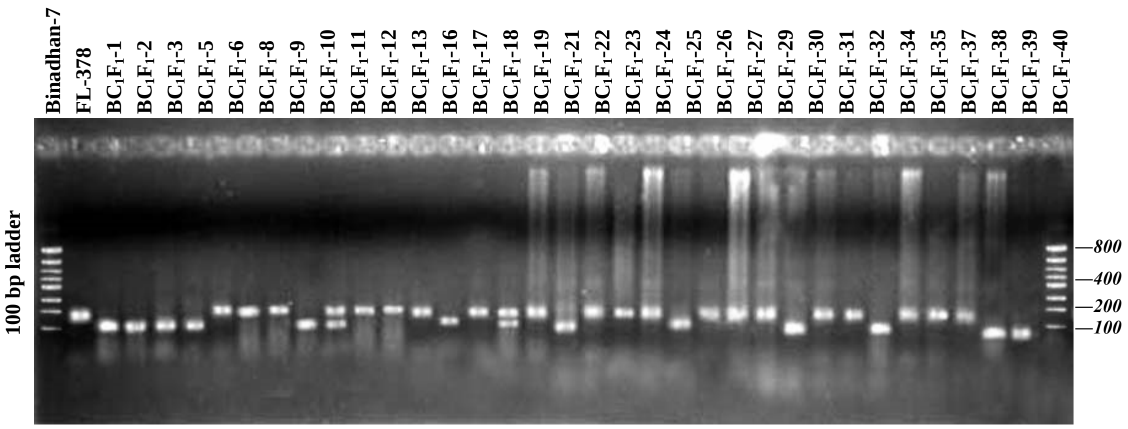


Fig. 5. RM296 marker showing a segment of rice genome from FL-378 (P1) into Binadhan-7 (P2)

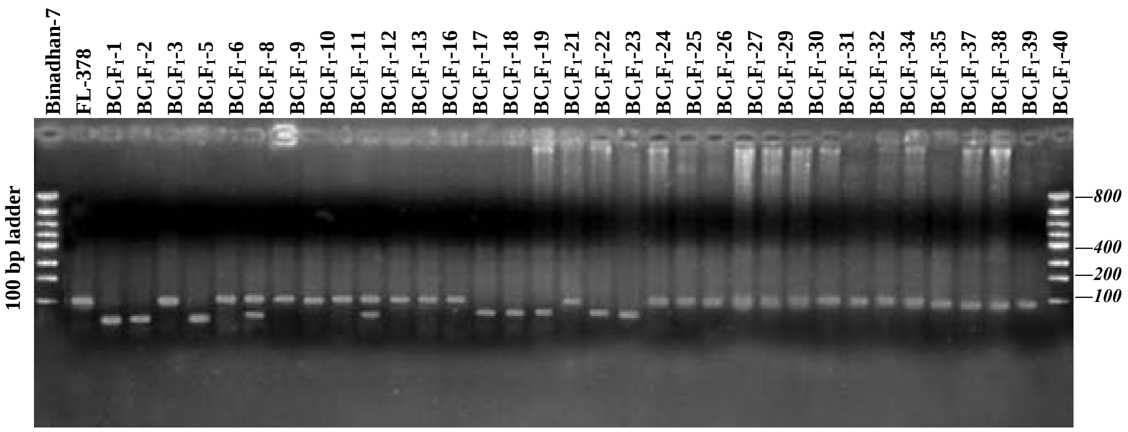


Fig 6. OSR30 marker showing a segment of rice genome from FL-378 (P1) into Binadhan-7 (P2)

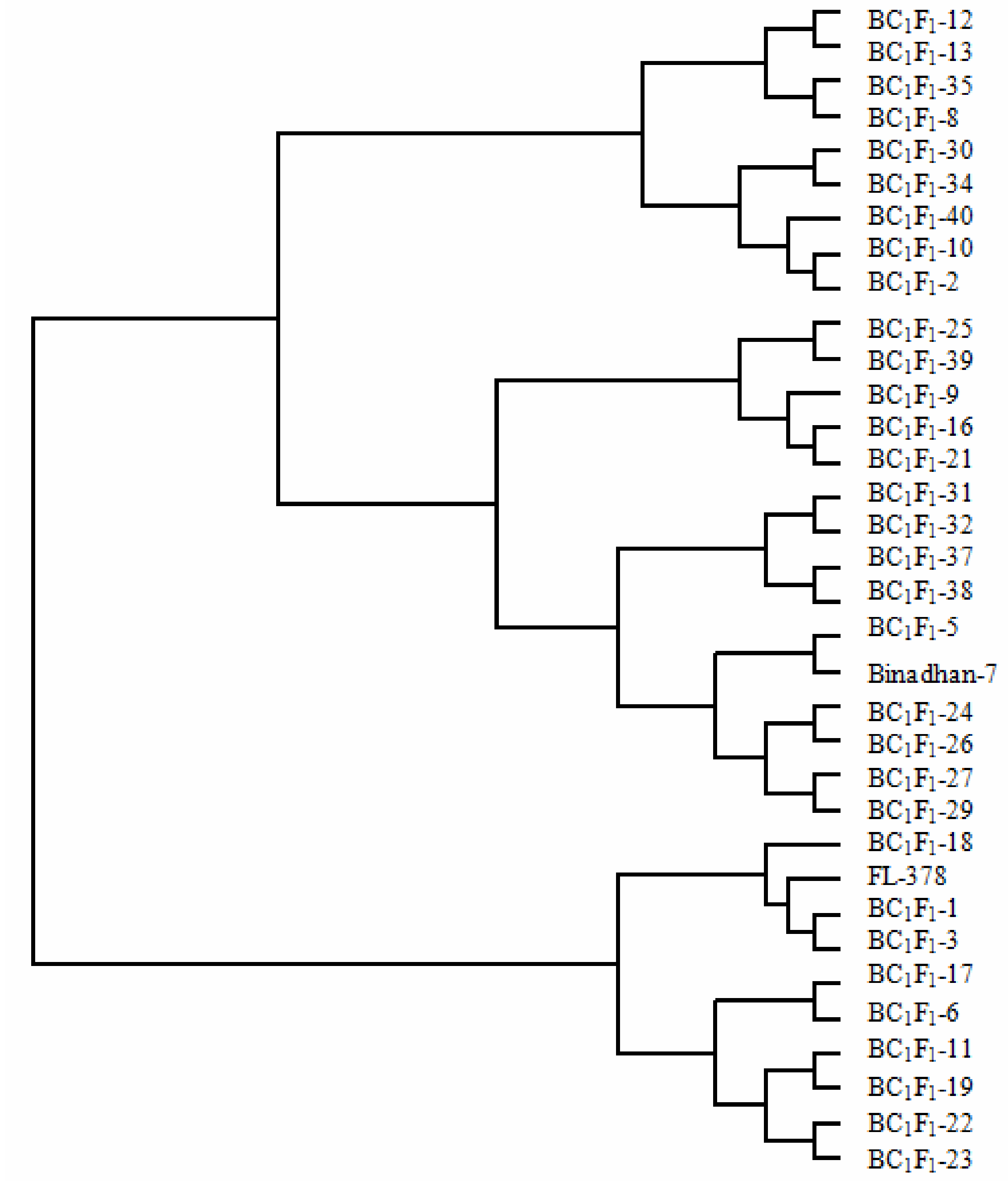


Fig. 7 Dendogram for 32 BC_1F_1 along with two parents derived from a UPGMA cluster analysis

Development of BC_2F_1 population from Binadhan-7 × FL-478 using phenotypic and marker assisted selection

Salt tolerant rice genotype (FL-478) was selected as parent for transferring salt tolerant genes to high yielding with short duration rice variety genotype Binadahan-7. Phenotypic performance of BC_1F_1 population of Binadhan-7 × FL-478 along with their parents was determined from a pot experiment. Backcrossing programme was conducted during aman season in 2011, where Binadhan-7 was the recurrent parent and FL-478 was the non-recurrent donor line. In BC_1F_1 population, average plant height was 85.5 cm. The average total number of tillers plant^{-1} was 39. The average number of productive tillers plant^{-1}, days to flowering and days to maturity were 34, 93 days and 125 days, respectively. BC_1F_1 population was backcrossed with the recurrent parent Binadhan-7 and produced 285 BC_2F_1 seeds.

Foreground selection was performed and 32 BC_1F_1 populations were selected with tightly linked salt tolerant markers RM585, RM10720 and RM310. Out of 32 BC_1F_1 populations, the marker RM585 identified 20 lines as salt tolerant (Fig. 8), RM10720 identified 16 lines as tolerant (Fig. 9), and the marker RM310 identified 17 tolerant (Fig. 10).

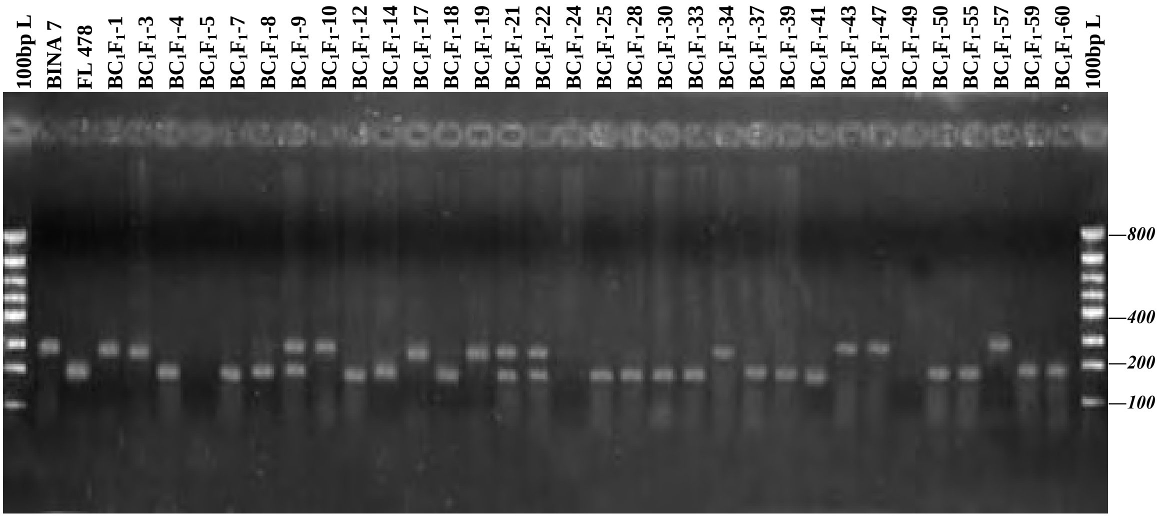


Fig. 8. RM585 marker showing a segment of rice genome from FL-478 (P1) into

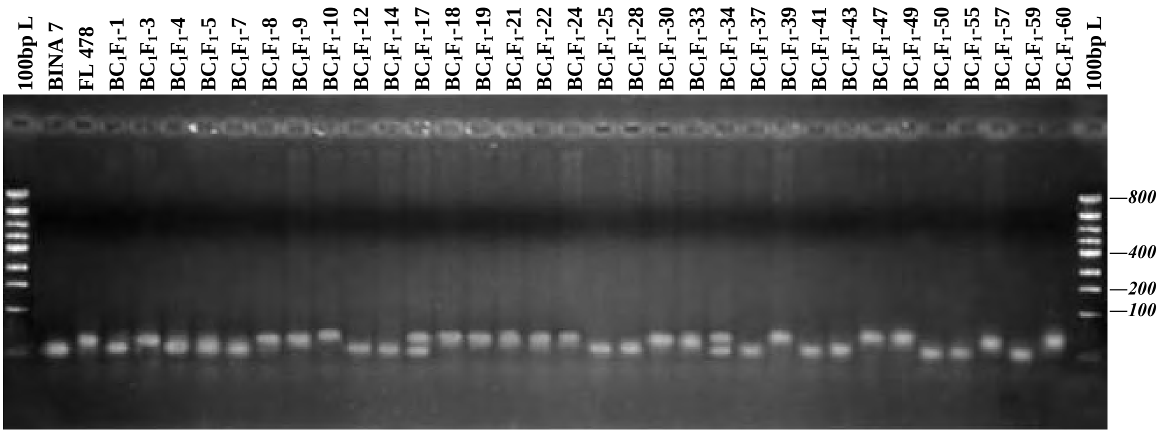


Fig. 9. RM10720 marker showing a segment of rice genome from FL-478 (P1) into Binadhan-7 (p2)

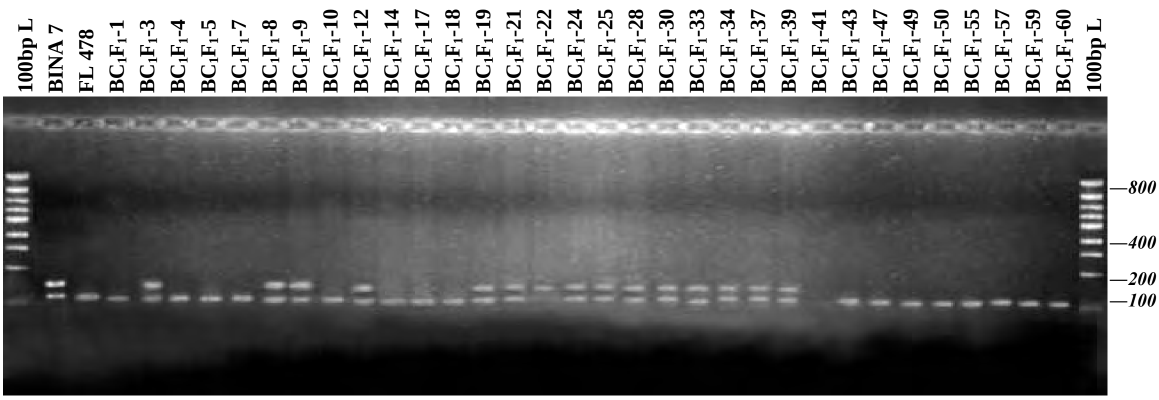


Fig. 10. RM310 marker showing a segment of rice genome from FL-478 (P1) into Binadhan-7 (P2)

A dendrogram was constructed based on the Nei's genetic distance calculated from the 32 BC_1F_1 population of Binadhan-7 × FL 478 along with their parents. All the BC_1F_1 populations of Binadhan-7 × FL 478 along with their parents were easily distinguished. The UPGMA cluster tree analysis led to the grouping of the 32 BC_1F_1 population of Binadhan-7 × FL 478 along with their parents in two major clusters (Fig. 11).

Cluster 1 comprised Binadhan-7 and 12 BC_1F_1 populations. In this main cluster Binadha-7 and BC_1F_1-5 were grouped in the same sub cluster, showed very close similarity. Cluster 2 comprised FL-378 and 22 BC_1F_1 populations. In this main cluster FL-378 was grouped with BC_1F_1- 18 and BC_1F_1- 21in the same sub cluster.

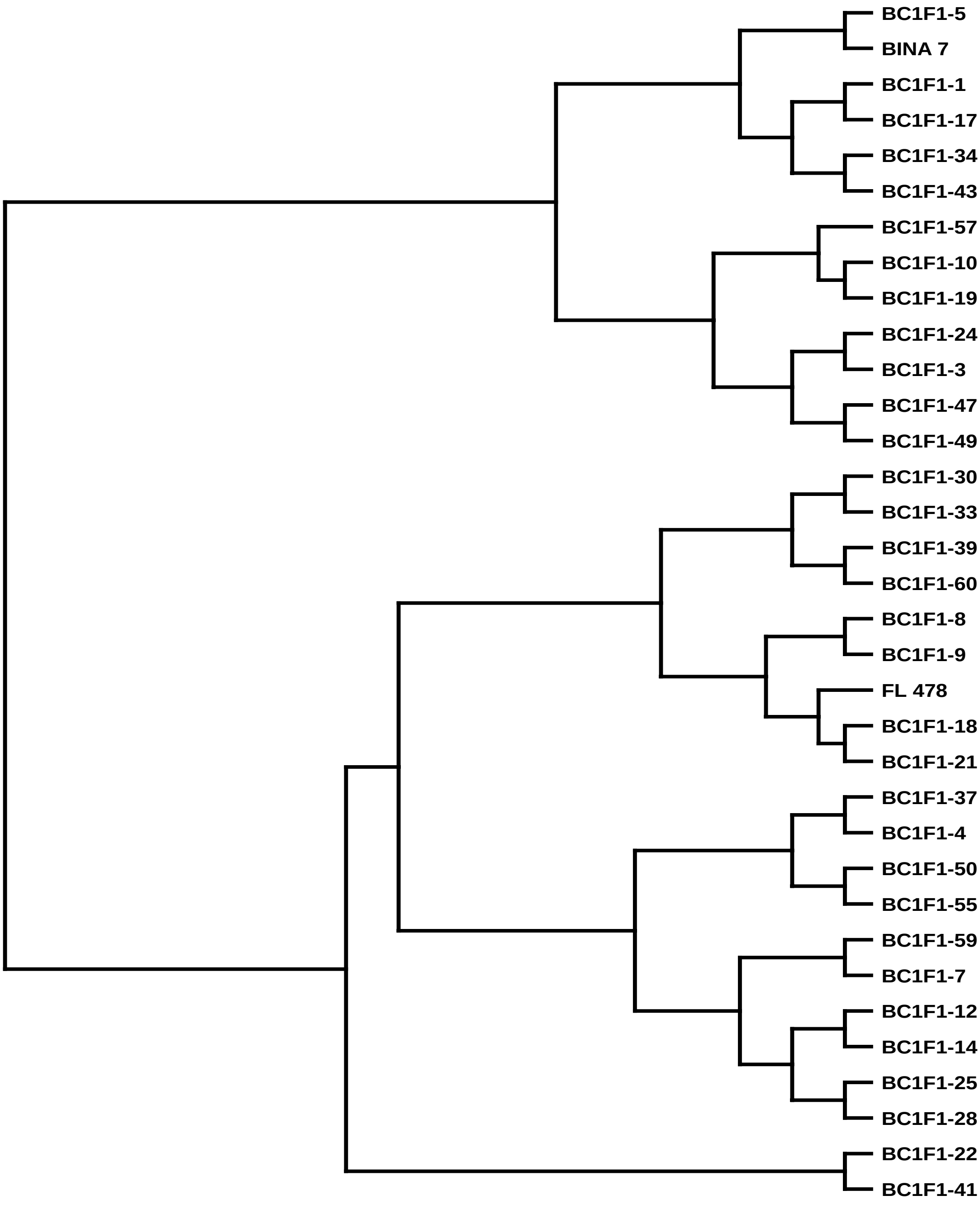


Fig. 11. Dendrogram for 34 germplasm derived from a UPGMA cluster analysis

Identification of salt tolerant rice lines of BC_1F_1 population (Binadhan-7 × FL-378) using SSR markers

Thirty two rice lines along with their parents were fingerprinted using 3 SSR primers. Eight SSR primers were tested for surveying of parental polymorphism. Among them 3 primers viz., RM585, RM296 and OSR30 were polymorphic and showed clear bands (Fig 12-14). PCR amplification were done and visualized by agarose gel electrophoresis.

Selected BC_1F_1 lines were genotyped and evaluated for salt tolerance with SSR primers compared with banding pattern of salt tolerant (FL-378) and salt susceptible parent (Binadhan-7). Genotypically, BC_1F_1 rice lines showed wide variation with the three primers; RM585, RM296 and OSR30. According to Nei's (1983), the highest level of gene diversity value (0.4567) was observed in loci RM296 and the lowest level of gene diversity value (0.3270) was observed in loci OSR30 with a mean diversity of 0.3996. The marker RM585 presented the smallest allele size range (31 bp); while OSR30 showed the largest allele size range (63 bp). As a measure of the informativeness of microsatellites, the PIC values ranged from a low of 0.2735 (OSR30) to a high of 0.3524 (RM296) and averaged 0.3183.

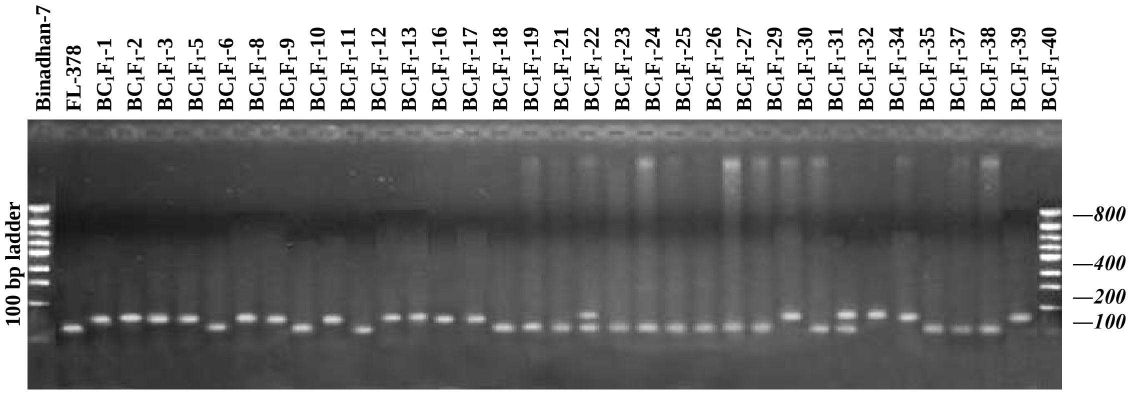


Fig 12. RM585 marker showing a segment of rice genome from FL-378 (P1) into Binadhan-7 (P2)

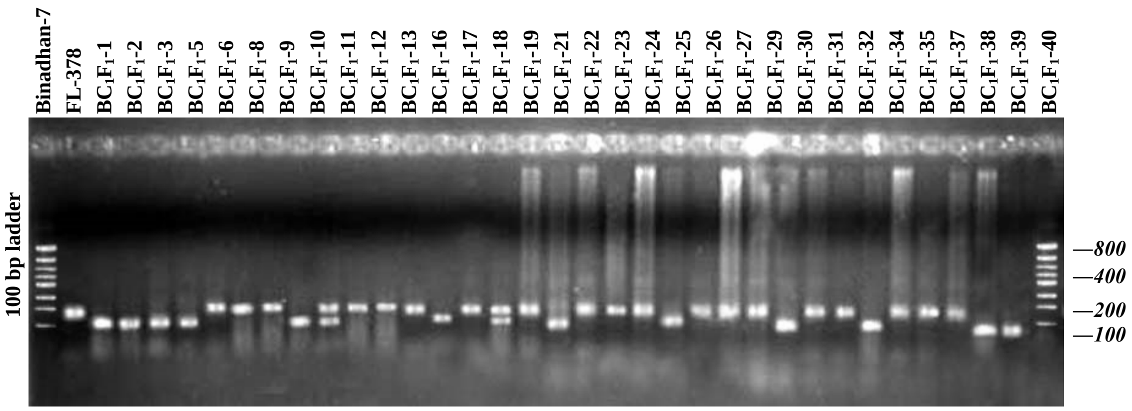


Fig 13. RM296 marker showing a segment of rice genome from FL-378 (P1) into Binadhan-7 (P2)

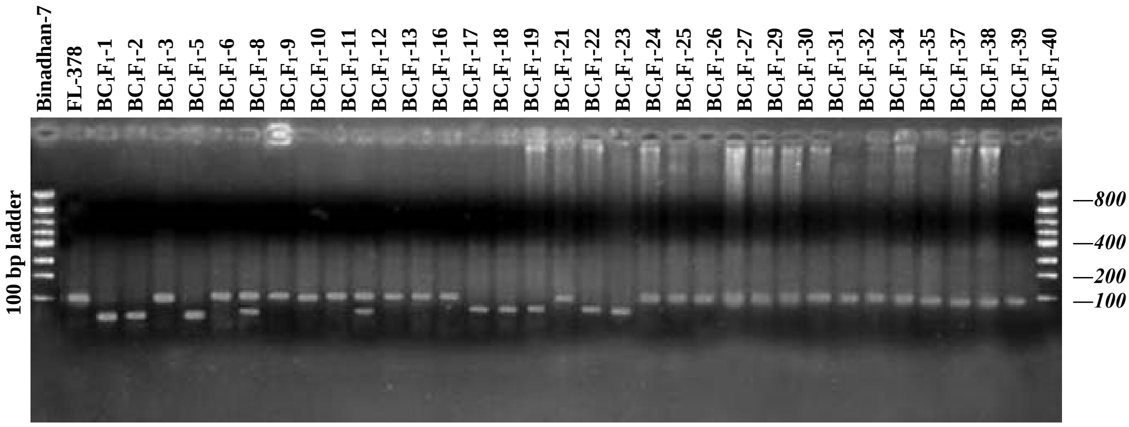


Fig 14. OSR30 marker showing a segment of rice genome from FL-378 (P1) into Binadhan-7 (P2)

The UPGMA cluster analysis of genetic similarity showed that 11 genotypes belonged to cluster 1 and this genotype is separated from other 23 genotypes. The tolerant germplasm were grouped in same cluster due to higher genetic distance. While, the susceptible germplasm were grouped in same cluster due to lower genetic distance (Fig. 15).

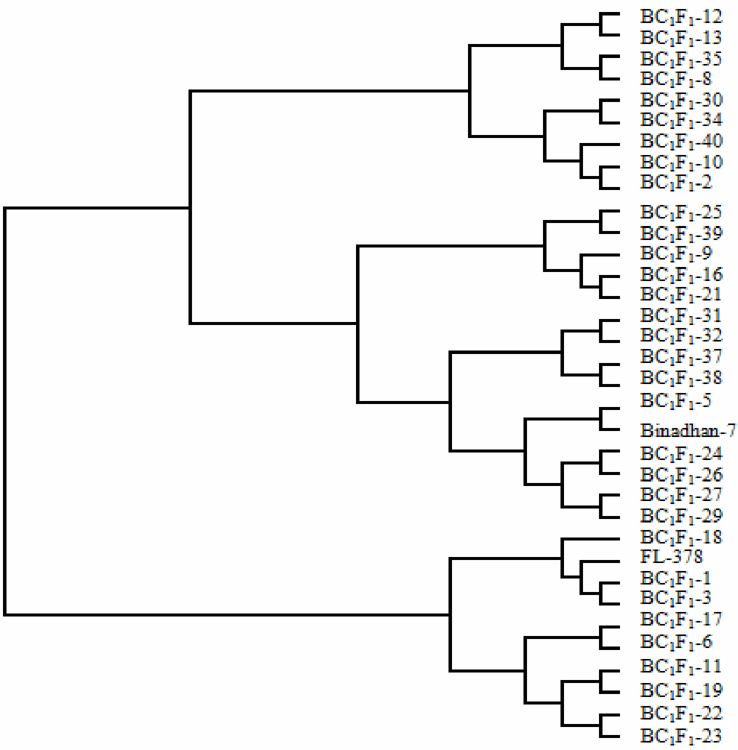


Fig 15. Dendrogram for 32 BC_1F_1 along with parents derived from a UPGMA cluster analysis

Introgression of salt tolerant genes into popular rice variety Binadhan-5 and Binadhan-7 from salt tolerant lines FL-378 & FL-478.

On the basis of previous phenotypic and genotypic evaluation for salt tolerance, two rice genotypes were selected as parents for transferring salt tolerant genes from tolerant lines to high yielding rice varieties. Two salt tolerant rice genotype (FL-378 and FL-478) were selected as parent for transferring salt tolerant genes to high yielding rice genotype Binadhan-5 and Binadhan-7. Crossing program was conducted during aman season in 2011, where Binadhan-5 and Binadhan-7 were the recurrent parents and FL-378 & FL-478 were the non recurrent donor lines. A total of 454 F_1 seeds were developed from this aman season. These seeds were collected and grown for producing BC_1F_1 seeds during boro season in 2012. F_1 populations were backcrossed with the recurrent parent Binadhan-5 and Binadhan-7 for the development of BC_1F_1 populations. Due to adverse environmental condition only 69 plants were survived. A total of 1029, BC1F1 seeds were developed from these 69 plants in Boro season. For MAS leaves from 800 BC_1F_1 populations were collected for genotyping. DNA extraction is going on. Foreground and recombinant selection of BC_1F_1 population will be carried out using 5 foreground markers (AP3206, AP3206f, RM8094, RM3412b, RM10748) and 4 flanking markers (RM1287, RM10694, RM493, RM10793). Further backcross will be done for genome conversion of the recipient parent with salinity tolerant gene.

Morpho-molecular characterization of lentil genotypes

Characterization of lentil germplasm through molecular markers

Twenty two lentil genotypes were characterized at molecular level through RAPD (Random Amplified Polymorphic DNA) markers. RAPD markers viz. OPC-05, OPB-08 and OPB-10 showed good resolution and sufficient variations among the genotypes (Fig. 16-18). Three primers produced polymorphic bands in 24 polymorphic loci. OPC-05 produced maximum polymorphic bands in 100-850 bp compare to OPB-08 and OPB-10. All the genotypes produced polymorphic bands with three tested RAPD markers suggesting that the genotypes were different from each other but genetic diversity were narrow among the genotypes.

Using Euclidean distance following Ward’s method, the genotypes were grouped into distinct clusters. Based on D^2-value, the genotypes were grouped into five clusters. Cluster I, III and V had same no. of genotypes i.e. four. The cluster II contained 8 genotypes which is the largest and the cluster IV contained only two genotypes which is the smallest. The average intra and inter cluster distances are presented in. It was observed that inter cluster distance were always higher than those of intra cluster distance. The intra cluster distance of cluster IV had 48091 which was the highest value.

However, cluster I contained only four genotypes but showed the second highest (16953) intra cluster distance.

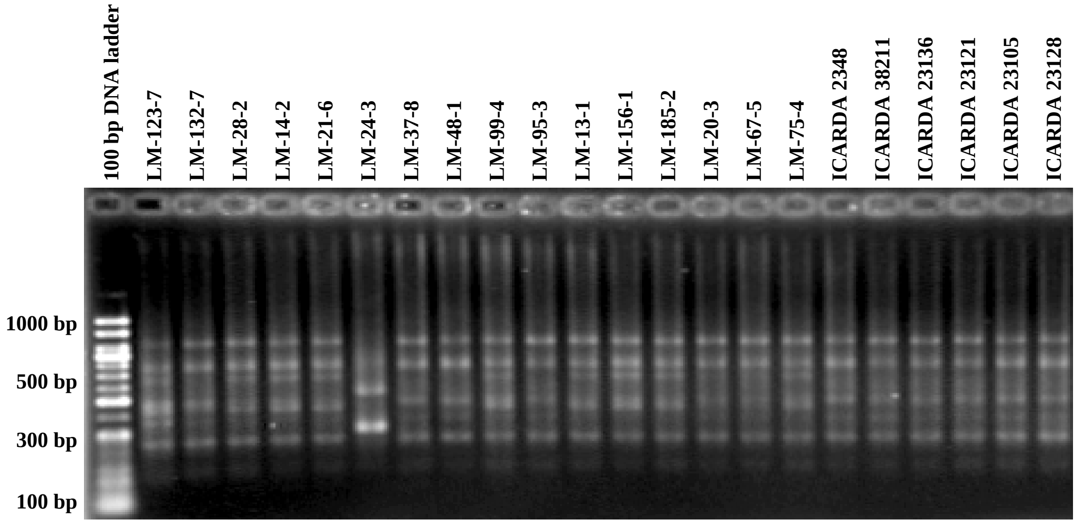


Fig. 16 RAPD profiles of different 22 lentil genotypes using primer OPC-5

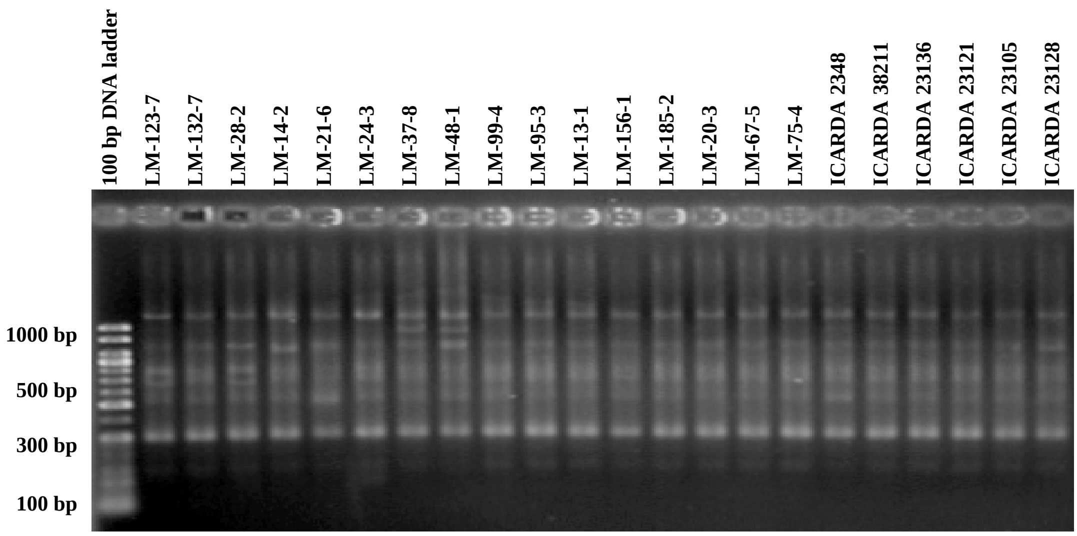


Fig 17. RAPD profiles of different 22 lentil genotypes using primer OPB-8

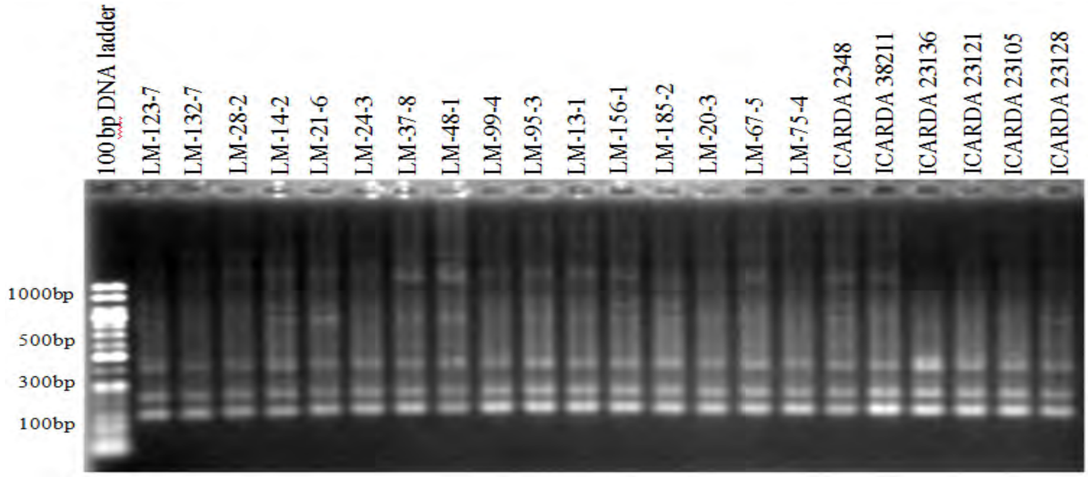


Fig. 18. RAPD profiles of different 22 lentil genotypes using primer OPB-10

Dendrogram based on Ward's method indicated grouping of 22 genotypes of lentil into five clusters (Fig. 19). LM-123-7, LM-132-7, LM-13-1 and LM-24-3 were grouped in cluster I with high genetic (130) distance, while LM-28-2, LM-14-2, LM-21-6, LM-37-8, LM-48-1, LM-99-4, LM-95-3 and LM-75-4 in cluster II with 113 and LM-156-1, LM-185-2, LM-20-3 and LM-67-5 in cluster III with 113. ICARDA 2348 and ICARDA 23128 were grouped in cluster IV with the highest genetic (219) distance. ICARDA 38211, ICARDA 23136, ICARDA 23121 and ICARDA 23105 were grouped in cluster V with the lowest genetic (103) distance.

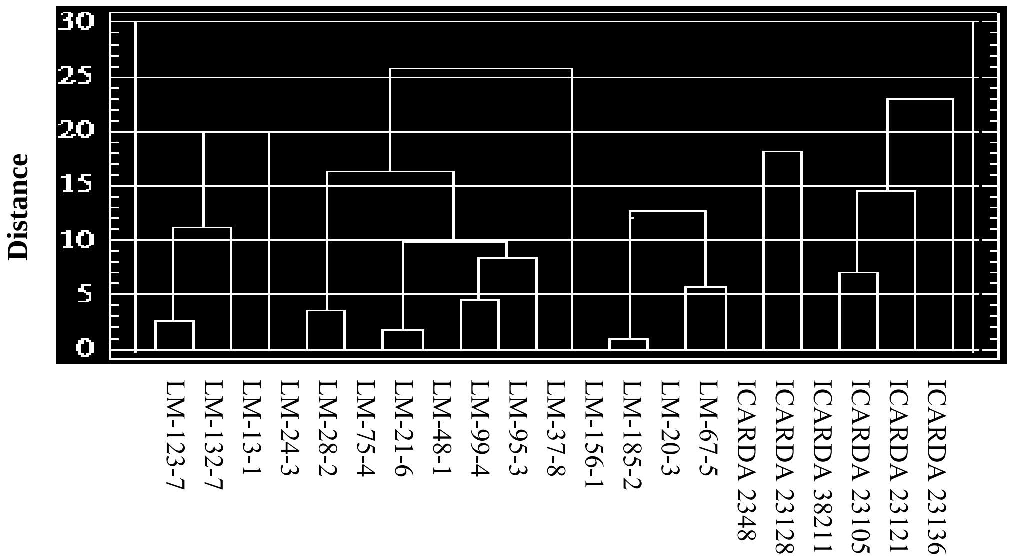


Fig. 19. Dendrogram based on summarized data on differentiation among 22 genotypes of lentil according to Ward's method

Evaluation of promising salt tolerant rice genotypes in saline areas

Performance of the proposed rice line PBRC-37 at on-farm trials under non saline and salt stress condition

Rice line PBRC 37 and salt tolerant check Binadhan-8 were evaluated for salt tolerance in farmer field at six location viz., Dumuria (Khulna); Gutodia (Khulna); Metro (Khulna); Fakirhat (Bagerhat); Sadar (Bagerhat); Bemorza (Bagerhat); Debhata (Satkhira); Shyamnagar (Satkhira) in Boro 2011-12. The unit plot size was 5 m × 5 m. Salinity level was 12-14 ds/m. Evaluation was done by SCA. Grain yield plant^{-1} in six locations range from 4.0 to 7.48 tons (Table 2). PBRC 37 recorded the highest yield at Metro (Khulna) followed by Debhata (Satkhira) and the lowest in Dumuria (Khulna). Proposed line PBRC-37 gave higher yield under high salt stress condition than Binadhan-8.

Table 2. Performance of the proposed lines at on-farm trials under salt stress condition (EC 12-14 dS/m) during boro 2011-12 (Evaluation was done by SCA)

Designation	Grain yield (t ha^{-1})								
	L1	L2	L3	L4	L5	L6	L7	L8	Mean
PBRC-37	4.2	5.01	7.48	6.85	4.81	5.92	7.37	6.0	5.96
Binadhan-8 (check)	4.0	4.28	7.40	6.30	4.71	5.63	6.43	5.5	5.53

L_1 = Dumuria (Khulna); L_2 = Gutodia (Khulna); L_3 = Metro (Khulna); L_4 = Fakirhat (Bagerhat);
L_5 = Sadar (Bagerhat); L_6 = Bemorta (Bagerhat); L_7 = Debhata (Satkhira); L_8 = Shyamnagar (Satkhira)

During boro season in 2010-11 a zonal yield trial was conducted in Satkhira and Khulna districts in 6 different locations where salinity level ranges between 5-12 dS/m. The unit plot size was 5 m × 5 m. Grain yield data showed that PBRC-37 gave the highest yield at Fakirhat, Bagerhat followed by Dumuria (Khulna) and the lowest in Kaligonj (Satkhira). Proposed line gave higher yield than Binadhan-8 (Table 3).

Table 3. Zonal yield trial of salt tolerant rice genotypes grown in saline (EC = 5-12 dS/m) areas at 6 locations in boro season during 2010-11

Designation	Grain yield (t ha^{-1})						
	L1	L2	L3	L4	L5	L6	Mean
PBRC-37	5.91	5.80	6.51	6.71	6.80	5.90	6.27
Binadhan-8 (check)	5.60	5.34	6.45	6.62	6.30	5.80	5.97

L_1 = Shyamnagar (Satkhira); L_2 =Kaligonj (Satkhira); L_3 = Sadar (Satkhira);
L_4 = Dumuria (Khulna); L_5 = Fakirhat (Bagerhat); L_6 = Mollarhat (Bagerhat)

Morphological and agronomical characters of the proposed line PBRC-37 was evaluated with Binadhan-8 (check) under salt stress condition of 12-14 dS/m in boro season, 2011-12. The proposed line PBRC-37 was shorter in plant height, 9 days earlier and yielded 0.5 t ha^{-1} more than Binadhan-8 (Table 4).

PBRC-37 was also evaluated for different morphological and agronomical characters with Binadhan-8 (check) in non-salinized condition in boro season, 2011-12. Proposed line perform better than Binadhan-8 for all the studied characters (Table 5).

Table 4. Morphological and agronomical characters of the proposed lines under salt stress condition (12-14 dS/m) in boro season, 2011-12.

Proposed line	Plant height (cm)	Days to maturity	1000 grain wt. (g)	Grain yield (t ha^{-1}) (at EC level 10-12 dS/m)
PBRC-37	95	121	24.3	5.5
Binadhan-8 (check)	97	130	26.5	5.0

Table 5. Morphological and agronomical characters of the proposed lines under normal condition (non-salinized) in boro season, 2011-12

Proposed line	Plant height (cm)	Days to maturity	1000 grain wt. (g)	Grain yield (t ha^{-1})
PBRC-37	97	125	24.9	8.5
Binadhan-8 (check)	99	130	26.7	8.0

Grain characteristics, viz., milling yield (%), chalkiness, whole grain length, dehulled grain length, breadth, L/B ratio, size shape and amylose were measured/estimated following SES for rice. Milling yield of was PBRC-37- 76%, chalkiness less than 10%, size of the dehuled grain is medium and slender in shape with 26% amylose content (Table 6).

Table 6. Grain characteristics of the proposed line PBRC-37.

Proposed lines with std. checks	Milling yield (%)	Chalkiness[a]	Whole grain length (mm)	Dehulled grain/kernel				Amylose (%)
				length (mm)	Breadth (mm)	L/B ratio	Size and shape	
PBRC-37	76	Wb1	8.5	6.7	2.6	2.58	Medium Slender	26.0
Binadhan-8 (check)	74	Wb1	8.2	6.2	3.0	2.06	Medium Medium	25.0

[a] Wb1 = Less than 10% chalkiness, Wb2 = Less than 20% chalkiness

The proposed line PBRC-37 has been applied to SCA for variety release.

On-farm trial of one salt tolerant rice line in aman season

Rice line PBRC-37, including two salt tolerance check varieties (Binadhan-8 and BRRI dhan53) were evaluated for salt tolerance in farmer's field at Kalikapoor Kaligong Satkira, Fakirhat Bagarhat and Paikgacha Khulna. The unit plot sige was 5 m × 5m. The average salinity level was 7 dS/m. Line PBRC-37 exhibited the highest number of tillers $plant^{-1}$ in most of the locations (Table 7). PBRC-37 was early maturing than the check varieties. Binadhan-8 produced the highest grain yield.

Table 7. Performance of salt tolerant rice line PBRC-37 in aman 2012

Location	Variety	Days to maturity	Plant height (cm)	Tillers hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Plot yield (kg)	Yield (t ha^{-1})
Kaligonj, Satkhira	PBRC-37	125	84.1	12	11	8.5	2.8
	Binadhan-8 (Chk.)	128	81.7	11	11	9.0	3.0
	BRRI dhan53 (Chk.)	130	97.4	10	9	5.6	1.8
	LSD (0.05)	0.00	2.00	1.36	1.78	1.42	0.80
Saymanagar, Satkhira	PBRC-37	125	79	18	16	6.1	2
	Binadhan-8 (Chk.)	128	87.5	14	14	6.3	2.2
	BRRI dhan53 (Chk.)	130	100.4	13	12	6.6	2.2
	LSD (0.05)	0.00	2.65	2.26	1.86	3.64	1.79
Lobonchora, Khulna	PBRC-37	126	102	11	10	10.5	3.5
	Binadhan-8 (Chk.)	129	94.9	11	11	10.6	3.5
	BRRI dhan53 (Chk.)	131	105.4	12	12	10.3	3.4
	LSD (0.05)	0.00	1.34	2.54	2.34	8.83	4.79
Fakirhat, Bagerhat	PBRC-37	125	98.1	10	9	11.6	3.8
	Binadhan-8 (Chk.)	128	98.1	12	12	14.3	4.7
	BRRI dhan53 (Chk.)	130	114.5	15	15	18.1	6
	LSD (0.05)	0.00	1.02	1.31	0.89	1.43	0.82
Paikgacha, Khulna	PBRC-37	126	93.1	16	15	15.6	5.2
	Binadhan-8 (Chk.)	129	95.2	13	13	16.6	5.5
	BRRI dhan53 (Chk.)	131	109.4	12	12	16	5.3
	LSD (0.05)	0.00	1.13	1.51	1.41	2.95	1.78
Combined	PBRC-37	125	91.2	13	12	10.4	3.4
	Binadhan-8 (Chk.)	128	91.5	12	12	11.5	3.8
	BRRI dhan53 (Chk.)	130	105.4	12	12	11.3	3.7
	CV (%)	0.00	4.50	14.40	15.11	15.19	15.20
	LSD (0.05)	0.00	2.15	3.53	0.00	3.12	1.75

Advanced yield trial of some selected early maturing rice lines

Eight rice genotypes along with one early check variety BRRI dhan28 were tested for early maturity during boro 2011-2012 in three locations, viz., BINA HQ (Mymensingh), BINA sub-stations Ishurdi and Magura. The experiment was laid out in RCBD with three replications. Unit plot size was 5 m × 4 m and spacing between hills and rows were 20 cm × 20 cm. Recommended fertilizer doses were applied. Data on plant height, no. of effective tillers hill^{-1}, days to flowering, days to maturity, no. of filled grains plant^{-1}, 1000 grain weight and grain yield plot^{-1} were recorded from five randomly selected plants from each plot. Plot yield was converted to t ha^{-1}.

The highest number of tillers hill^{-1} was found in ADT (R) 47 and the lowest in IR-71701-28-1-4 (58). The highest no. filled grains per panicle were found in CT-9882-16-4 and the lowest in ADT (R) 47 at Mymensingh and Ishurdi (Table 8). The lowest no. of filled grain was counted in BRRI dhan28 at Mymensingh and Ishurdi and the highest in CT-9882-16-4. For 1000 grain weight IR-71701-28-1-4(58) recorded the highest and the lowest in ADT (R) 47. Plot yield (t ha^{-1}) was the highest IR-71701-28-1-4(58) at Ishurdi and Magura and the lowest in OMCS-2007 and the lowest yield (t ha^{-1}) was recorded in OMCS 2007. OMCS 2007 was identified as the earliest maturing line. Based on different parameters three lines will be evaluated for zonal yield trial in the next season.

Table 8. Advanced yield trial of some selected early maturing rice lines in boro 2011-2012

Location	Variety	Days to maturity	Plant height (cm)	Tillers hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 grain weight (g)	Yield (t ha^{-1})
Mymensingh	ADT (R) 47	161.00	72.00	16.00	16.00	123.00	10.00	21.20	3.80
	OMCS-2007	152.00	82.50	12.00	1.00	146.00	16.00	26.80	3.30
	IR-71701-28-1-4 (58)	160.00	93.50	7.00	6.00	140.00	21.00	29.40	4.10
	IR-77734-93-2-3-2	161.00	87.50	16.00	15.00	144.00	23.00	24.10	3.90
	IR-7947867-3-3-2 (48)	154.00	85.10	11.00	9.00	118.00	15.00	27.30	3.80
	88023-RE	162.00	87.10	12.00	11.00	145.00	16.00	24.30	4.10
	CT-9882-16-4	158.00	76.60	11.00	11.00	160.00	21.00	24.80	4.10
	BRRI dhan28 (Chk.)	154.00	86.40	14.00	13.00	158.00	9.00	22.80	4.20
	LSD $_{0.05}$	0.00	1.40	1.59	1.24	6.84	2.67	0.00	1.19
Ishurdi	ADT (R) 47	143.00	77.40	27.00	22.00	121.00	11.00	21.20	5.10
	OMCS-2007	142.00	87.00	14.00	13.00	144.00	17.00	26.80	5.10
	IR-71701-28-1-4 (58)	145.00	100.70	14.00	13.00	138.00	22.00	29.40	5.80
	IR-77734-93-2-3-2	142.00	98.00	19.00	16.00	142.00	24.00	24.10	5.20
	IR-7947867-3-3-2 (48)	144.00	92.30	18.00	15.00	116.00	16.00	27.30	5.10
	88023-RE	147.00	97.30	16.00	15.00	143.00	17.00	24.30	4.80
	CT-9882-16-4	146.00	93.60	17.00	14.00	158.00	21.00	24.80	5.10
	BRRI dhan28 (Chk.)	143.00	96.00	22.00	17.00	156.00	10.00	22.80	5.50
	LSD $_{0.05}$	0.00	2.01	2.69	2.64	6.84	2.66	0.00	1.94
Magura	ADT (R) 47	140.00	70.80	16.00	16.00	93.00	9.00	21.20	6.10
	OMCS-2007	139.00	85.40	9.00	9.00	128.00	8.00	26.80	4.80
	IR-71701-28-1-4 (58)	147.00	97.70	9.00	9.00	108.00	14.00	29.40	7.60
	IR-77734-93-2-3-2	146.00	84.20	13.00	13.00	115.00	7.00	24.10	5.70
	IR-7947867-3-3-2 (48)	148.00	89.90	12.00	12.00	131.00	5.00	27.30	5.90
	88023-RE	147.00	92.10	12.00	12.00	111.00	13.00	24.30	5.90
	CT-9882-16-4	148.00	86.30	11.00	11.00	105.00	7.00	24.80	5.50
	BRRI dhan28 (Chk.)	143.00	92.10	12.00	12.00	100.00	7.00	22.80	6.70
	LSD $_{0.05}$	0.00	2.24	1.45	1.45	7.08	1.53	0.00	0.56
Combined	ADT (R) 47	148.00	73.40	19.00	18.00	112.00	10.00	21.20	4.90
	OMCS-2007	144.00	85.00	11.00	11.00	139.00	14.00	26.80	4.40
	IR-71701--28-1-4 (58)	150.00	97.30	10.00	9.00	129.00	19.00	29.40	5.60
	IR-77734-93-2-3-2	149.00	89.90	16.00	15.00	133.00	18.00	24.10	4.90
	IR-7947867-3-3-2 (48)	148.00	89.10	13.00	12.00	122.00	12.00	27.30	4.90
	88023-RE	152.00	92.20	13.00	13.00	133.00	16.00	24.30	4.90
	CT-9882-16-4	150.00	85.50	13.00	12.00	141.00	16.00	24.80	4.90
	BRRI dhan28 (Chk.)	146.00	91.50	16.00	14.00	138.00	9.00	22.80	5.50
	CV (%)	0.00	4.23	18.22	17.09	13.74	24.08	0.00	10.30
	LSD $_{0.05}$	0.00	1.98	2.17	1.95	8.16	2.59	0.00	1.19

Advanced yield trial of some selected early maturing rice lines

Eight rice genotypes along with one early check variety BRRI dhan28 were tested for early maturing ability in aman 2012 in three locations viz., BINA HQ (Mymensingh), BINA sub-stations Ishurdi and Magura. The experiment was laid out in RCBD with three replications. Unit plot size was 5m x 4m and spacing between hills and rows were 20 cm × 20 cm. Data on plant height, effective tillers hill^{-1}, days to flowering, days to maturity, filled grains plant^{-1}, 1000 grain weight and grain yield plot^{-1} were recorded from five randomly selected plants from each plot. Plot yield was converted in to t ha^{-1}.

CMCS-2007 was found to be the earliest in all locations, while IR-7947867-3-3-2(48) took longest time to mature. The highest numbers of tillers/plant and effective tillers were found in ADT (RT) 47. The longest panicle length was recorded in IR77734-93-2-3-2 and the smallest in CT-9882-16-4. IR-71701-28-1-4(58) gave highest 1000 seed weight. Yield was highest in IR-7947867-3-3-2 (48) and 88023-RE and the lowest in OMCS-2007 (Table 9).

Table 9. Advanced yield trial of some selected early maturing rice lines aman 2012

Location	Variety	Days to maturity	Plant height (cm)	Tillers hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 grain weight (g)	Yield (t ha^{-1})
Mymensingh	ADT (R) 47	109	86.1	15	14	20.3	90	19.5	3.3
	OMCS-2007	107	98.6	10	9	22.4	107	27.6	1.9
	IR-71701-28-1-4 (58)	110	107.1	9	8	22.2	106	27.9	2.7
	IR-77734-93-2-3-2	110	108	13	13	27.3	104	22.4	2.9
	IR-7947867-3-3-2 (48)	121	105.4	11	10	22.4	114	26.1	3
	88023-RE	115	113.8	8	8	23	107	24.3	3
	CT-9882-16-4	115	99.8	8	8	23.2	126	22.8	2.7
	Binadhan-7 (Chk.)	119	99.3	9	9	23.7	99	22.7	2.8
	LSD $_{0.05}$	1.38	1.31	1.94	1.87	1.32	1.20	1.31	1.56
Ishurdi	ADT (R) 47	109	86.1	15	14	20.3	90	19.5	3.3
	OMCS-2007	107	98.6	10	9	22.4	107	27.6	1.9
	IR-71701-28-1-4 (58)	110	107.1	9	8	22.2	106	27.9	2.7
	IR-77734-93-2-3-2	110	108	13	13	27.3	104	22.4	2.9
	IR-7947867-3-3-2 (48)	121	105.4	11	10	22.4	114	26.1	3
	88023-RE	115	113.8	8	8	23	107	24.3	3
	CT-9882-16-4	115	99.8	8	8	23.2	126	22.8	2.7
	Binadhan-7 (Chk.)	119	99.3	9	9	23.7	99	22.7	2.8
	LSD $_{0.05}$	1.36	1.29	2.12	2.12	1.32	1.20	1.61	2.04
Magura	ADT (R) 47	107	83.6	18	18	20.3	90	29.7	5.6
	OMCS-2007	103	92.1	15	15	22.4	107	27.1	6
	IR-71701-28-1-4 (58)	122	98.9	12	12	22.2	106	28.6	6
	IR-77734-93-2-3-2	114	106.1	15	15	27.3	104	31.7	4.3
	Binadhan-7	115	93.3	14	14	23.7	99	21.9	6
	IR-7947867-3-3-2 (48)	122	98.9	14	14	22.4	114	28.4	6.6
	88023-RE	122	106.5	12	12	23	107	26.3	6.6
	CT-9882-16-4	122	99.2	12	12	23.2	126	23.2	6.2
	Binadhan-7 (Chk.)	119	99.3	9	9	23.7	99	22.7	2.8
	LSD $_{0.05}$	1.33	1.31	1.63	1.58	1.32	1.20	1.41	1.15
Combined	ADT (R) 47	108	85.2	16	15	20.3	90	22.9	4.1
	OMCS-2007	105	96.4	11	11	22.4	107	27.4	3.2
	IR-71701--28-1-4 (58)	114	104.3	10	9	22.2	106	28.1	3.8
	IR-77734-93-2-3-2	111	107.4	14	13	27.3	104	25.5	3.4
	IR-7947867-3-3-2 (48)	121	103.2	12	11	22.4	114	26.8	4.2
	88023-RE	117	111.3	9	9	23	107	24.9	4.2
	CT-9882-16-4	117	99.6	9	9	23.2	126	22.9	3.9
	Binadhan-7 (Chk.)	117	97.3	11	11	23.7	99	22.4	3.8
	CV (%)	5.092	9.078	3.141	3.246	0.559	80.658	0.037	0.177
	LSD $_{0.05}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Zonal Yield Trial of some promising green super rice lines in boro 2011-2012

The zonal yield trial was carried out with 3 promising/selected green super rice (GSR) lines, namely WANXIAN 77, SACG 7 and HUA-565 during Boro season 2011-2012 in three locations viz., BINA HQ (Mymensingh), BINA sub-stations Ishurdi and Magura. The experiment was laid out in RCBD with three replications. Unit plot size was 5 m × 4 m and spacing between hills and rows were 20 cm × 20 cm. Data on plant height, effective tillers hill^{-1}, days to flowering, days to maturity, filled grains plant^{-1}, 1000 grain weight and grain yield plot^{-1} were recorded from five randomly selected plants from each plot (Table 10).

HUA 564 produced the highest number of filled grain plant and 1000 grain weight compared to other lines. WANXIAN77 was the earliest and HUA 564 was late maturing type. The highest yield was obtained in WANXIAN 77 and the lowest in HUA-564. 3ACG-7 had the lowest plant height and the highest effective tillers.

Table 10. Zonal Yield Trial of some promising green super rice lines in boro 2011-2012

Location	Variety	Days to maturity	Plant height (cm)	Tillers hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 grain weight (g)	Plot yield (kg)	Yield (t ha^{-1})
Mymensingh	WANXIAN 77	168.00	93.90	8.00	8.00	179.00	42.00	25.60	11.70	5.80
	SACG 7	174.00	78.20	8.00	8.00	136.00	33.00	21.60	11.10	5.50
	HUA 564	177.00	95.40	7.00	6.00	154.00	23.00	33.30	9.10	4.50
	BRRI dhan29	177.00	95.80	11.00	10.00	155.00	28.00	22.20	9.10	4.50
	$LSD_{0.05}$	0.00	1.12	1.47	1.38	3.59	1.52	0.00	1.02	0.72
Magura	WANXIAN 77	155.00	100.60	11.00	12.00	225.00	21.00	25.60	5.30	5.50
	SACG 7	161.00	91.30	14.00	15.00	218.00	17.00	21.60	5.90	6.20
	HUA 564	159.00	97.30	9.00	11.00	196.00	18.00	33.30	5.10	5.30
	BRRI dhan29	161.00	96.60	16.00	18.00	129.00	16.00	22.20	4.80	5.10
	$LSD_{0.05}$	0.00	0.98	2.08	1.61	4.46	1.09	0.00	1.00	1.02
Ishurdi	WANXIAN 77	158.00	94.60	6.00	6.00	177.00	44.00	25.60	10.50	5.20
	SACG 7	161.00	86.60	9.00	9.00	134.00	35.00	21.60	10.10	5.10
	HUA 564	158.00	92.60	6.00	6.00	152.00	29.00	33.30	10.30	5.10
	BRRI dhan29	162.00	97.60	11.00	11.00	153.00	34.00	22.20	9.20	4.60
	$LSD_{0.05}$	0.00	1.62	0.89	0.89	3.96	2.94	0.00	0.58	0.43
Combined	WANXIAN 77	160.00	96.40	8.00	9.00	193.00	35.00	25.60	9.20	5.50
	SACG 7	165.00	85.40	10.00	11.00	163.00	28.00	21.60	9.40	5.50
	HUA 564	164.00	95.10	7.00	8.00	167.00	23.00	33.30	8.20	5.10
	BRRI dhan29	166.00	96.70	12.00	13.00	145.00	26.00	22.20	7.70	4.70
	CV (%)	0.00	2.48	17.54	14.76	9.18	11.57	0.00	7.39	7.59
	$LSD_{0.05}$	0.00	1.41	1.66	1.46	4.89	2.08	0.00	0.99	0.91

Zonal Yield Trial of some promising green super Rice lines in Aman season 2012

The zonal yield trial was carried out with 3 promising/selected green super rice (GSR) lines, namely WANXIAN 77, SACG 7 and HUA-565 during aman season 2012 in three locations viz., BINA HQ (Mymensingh), BINA sub-station Ishurdi and Magura. The experiment was laid out in RCBD with three replications. Unit plot size was 5 m × 4 m and spacing between hills and rows were 20 cm × 20 cm. Data on plant height, effective tillers hill^{-1}, days to flowering, days to maturity, filled grains plant^{-1}, 1000 grain weight and grain yield plot^{-1} were recorded from five randomly selected plants from each plot.

The result shows that HUA-564 produced the highest number of filled grain plant and 1000 grain weight compared to other lines. WANXIAN77 was the earliest and HUA 564 was late maturing type. The highest yield was obtained in WANXIAN77 and the lowest in HUA-564. 3ACG-7 had the lowest plant height and the highest effective tillers (Table 11).

Table 11. Zonal Yield Trial of some promising green super Rice lines in aman season 2012

Location	Variety	Days to maturity	Plant height (cm)	Tillers hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	1000 grain weight (g)	Yield (t ha^{-1})
Mymensingh	WANXIAN 77	123	107.8	7	7	21.9	152	25	3.4
	SACG 7	124	90.2	7	7	22.2	151.3	20.7	3.2
	HUA 564	125	110.6	5	4	25.1	154.3	32.1	2.3
	BR-11	121	107.4	8	8	23.2	145.3	23.8	3.4
	LSD $_{0.05}$	1.68	0.97	2.13	1.67	0.78	6.30	0.00	1.35
Ishurdi	WANXIAN 77	123	107.8	7	7	21.9	152	25	3.4
	SACG 7	124	90.2	7	7	22.2	151.3	20.7	3.2
	HUA 564	125	110.6	5	4	25.1	154.3	32.1	2.3
	BR-11	121	107.4	8	8	23.2	145.3	23.8	3.4
	LSD $_{0.05}$	2.417	4.347	2.861	2.417	0.436	76.25	0	0.476
Magura	WANXIAN 77	123	107.8	7	7	21.9	152	25	3.4
	SACG 7	124	90.2	7	7	22.2	151.3	20.7	3.2
	HUA 564	125	110.6	5	4	25.1	154.3	32.1	2.3
	BR-11	121	107.4	8	8	23.2	145.3	23.8	3.4
	LSD $_{0.05}$	125	105.2	7	7	21.9	152	17.5	4.8
Combined	WANXIAN 77	127	90.00	9	8	22.2	151.3	14.5	4.5
	SACG 7	128	108.8	6	5	25.1	154.3	22.5	4.3
	HUA 564	126	107.9	9	8	23.2	145.3	16.7	4.5
	BR-11	123	107.8	7	7	21.9	152	25	3.4
	CV (%)	1.49	1.50	1.67	1.60	0.70	5.70	0.03	1.72
	LSD $_{0.05}$	0.95	3.05	17.91	17.41	17.41	2.58	5.24	12.05

Zonal Yield Trial of some selected aromatic rice lines in boro 2011-2012

Four promising high yielding aromatic rice lines namely: IR-50 (48), BINA Arom-5, BINA Arom-8 and BINA Aroma-9 were evaluated during boro season 2011-2012. The experiments were set at BINA HQ (Mymensingh), BINA sub-stations viz., Ishurdi, Magura and farmers field at Dinajpur. RCBD design was followed these experiments with three replications. Unit plot size was 5 m × 4 m and spacing was 20 cm × 20 cm. Normal cultural practices were done as and when necessary. Yield and yield components were analyzed and presented below (Table 12).

It was observed that most of the lines were comparatively better in the experimental field with respect to filled grain plant^{-1}, 1000 grain wt and yield. Crop duration of the entries ranged from 157-162 days. The earliest maturing line was IR 50, the highest number of tiller was produced by BINA aroma lines and the highest number of effective tiller was also found in these two lines. Though BINA Aroma-5 took longest period to mature but filled grain, 1000 seed weight and yield were found highest among all other lines/varieties.

Table 12. Zonal Yield Trial of some selected aromatic rice lines in boro 2011-2012

Location	Variety	Days to maturity	Plant height (cm)	Tillers $hill^{-1}$ (no.)	Effective tiller $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	1000 grain weight (g)	Yield ($t\ ha^{-1}$)
Mymensingh	IR-50 (48)	170.00	87.30	12.00	11.00	98.00	8.00	20.90	4.60
	BINA Arom-5	171.00	83.60	16.00	15.00	142.00	15.00	33.30	4.90
	BINA Arom-8	168.00	81.50	14.00	13.00	119.00	24.00	26.80	5.00
	BINA Arom-9	166.00	88.30	10.00	10.00	142.00	23.00	28.30	5.00
	BRRI dhan50 (Chk.)	170.00	79.70	12.00	11.00	82.00	19.00	19.40	4.00
	$LSD_{0.05}$	0.00	1.50	1.03	1.19	1.45	2.75	0.00	1.22
Ishurdi	IR-50 (48)	154.00	87.00	16.00	17.00	138.00	15.00	20.90	4.30
	BINA Arom-5	154.00	85.60	17.00	18.00	134.00	25.00	33.30	5.10
	BINA Arom-8	155.00	85.60	19.00	21.00	107.00	12.00	26.80	4.30
	BINA Arom-9	155.00	94.60	14.00	17.00	123.00	16.00	28.30	4.90
	BRRI dhan50 (Chk.)	154.00	82.00	19.00	21.00	101.00	15.00	19.40	4.30
	$LSD_{0.05}$	0.00	0.85	2.79	2.78	4.86	1.50	0.00	0.94
Magura	IR-50 (48)	147.00	84.00	10.00	11.00	96.00	10.00	20.90	5.30
	BINA Arom-5	160.00	78.60	11.00	11.00	140.00	17.00	33.30	5.10
	BINA Arom-8	158.00	82.60	13.00	13.00	117.00	26.00	26.80	4.80
	BINA Arom-9	158.00	94.60	10.00	10.00	140.00	25.00	28.30	4.80
	BRRI dhan50 (Chk.)	156.00	80.30	11.00	11.00	80.00	22.00	19.40	4.70
	$LSD_{0.05}$	0.00	3.56	1.44	1.52	1.45	2.71	0.00	1.23
Combined	IR-50 (48)	157.00	86.10	13.00	13.00	110.00	11.00	20.90	4.70
	BINA Arom-5	162.00	82.60	15.00	15.00	139.00	19.00	33.30	5.00
	BINA Arom-8	160.00	83.20	15.00	16.00	113.00	21.00	26.80	4.70
	BINA Arom-9	160.00	92.50	11.00	12.00	135.00	21.00	28.30	4.90
	BRRI dhan50 (Chk.)	160.00	80.60	14.00	14.00	87.00	19.00	19.40	4.30
	CV (%)	0.00	4.33	12.96	13.35	7.52	21.33	0.00	9.53
	$LSD_{0.05}$	0.00	2.83	1.97	2.15	2.71	2.75	0.00	1.25

Zonal Yield Trial of some selected aromatic rice lines in aman 2011-012

Four promising high yielding aromatic rice lines were evaluated during aman season of 2012. The experiments were set at BINA HQ (Mymensingh), BINA sub-stations Ishurdi, Magura and farmers field at Dinajpur. RCBD design was followed in this experiment with three replications. Unit plot size was 5 m × 4 m and spacing was 20 cm × 20 cm. Yield and yield component data were analyzed and presented in Table 13.

Results show that BINA Aroma-9 was the earliest and Kalizira took the longest time to mature. BINA Aroma-9 was the shortest and Kalizira was the tallest for plant height. The highest no. of tiller and effective tiller per plant were found in BINA Aroma-9. Panicle length was the height in Kalizira and lowest in BINA Aroma-8. The highest 1000 seed weight was found in BINA Aroma-9 and the lowest in Kalizira. Highest yield was found in IR-50 (48) and the lowest in Kalizira.

Table 13. Performance of aromatic rice lines grown in different locations in Aman season 2012

Location	Variety	Days to maturity	Plant height (cm)	Tillers hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	1000 grain weight (g)	Plot yield (kg)	Yield (t ha^{-1})
Mymensingh	IR-50 (48)	120	105.5	9	8	23.6	130	21	6.4	3.2
	BINA Arom-5	122	102.6	8	8	26.7	135	21.6	6.4	3.2
	BINA Arom-8	120	95.2	10	10	22.3	104	25.2	6.3	3.2
	BINA Arom-9	115	91.2	8	8	23.4	129	25.9	5.5	2.7
	Kalizira (Check)	128	160.1	10	10	28.5	165	15.2	4.5	2.2
	LSD $_{0.05}$	1.26	0.72	1.39	1.44	0.34	2.09	0.00	1.56	1.06
Ishurdi	IR-50 (48)	120	105.5	9	8	23.6	130	21	6.4	3.2
	BINA Arom-5	122	102.6	8	8	26.7	135	21.6	6.4	3.2
	BINA Arom-8	120	95.2	10	10	22.3	104	25.2	6.3	3.2
	BINA Arom-9	115	91.2	8	8	23.4	129	25.9	5.5	2.7
	Kalizira (Check)	128	160.1	10	10	28.5	165	15.2	4.5	2.2
	LSD $_{0.05}$	1.26	0.72	1.39	1.44	0.34	2.09	0.00	1.56	1.06
Magura	IR-50 (48)	124	104.8	13	13	23.6	130	21	13.3	6.6
	BINA Arom-5	122	101.1	13	13	26.7	135	21.6	13.3	6.5
	BINA Arom-8	119	101.6	13	13	22.3	104	25.2	10.9	5.4
	BINA Arom-9	120	100.5	11	11	23.4	129	25.9	12.4	6.2
	Kalizira (Check)	124	148.1	11	11	28.5	165	15.2	6.2	3.1
	LSD $_{0.05}$	0.00	0.86	1.52	1.52	0.34	2.09	0.00	0.52	0.37
Combined	IR-50 (48)	121	105.2	10	10	23.6	130	21	8.7	4.3
	BINA Arom-5	122	102.1	10	9	26.7	135	21.6	8.6	4.3
	BINA Arom-8	119	97.3	11	11	22.3	104	25.2	7.9	3.9
	BINA Arom-9	117	94.3	9	9	23.4	129	25.9	7.8	3.9
	Kalizira (Check)	126	156.3	10	10	28.5	165	15.2	5.1	2.5
	CV (%)	1.26	2.73	10.2	10.89	1.44	4.8	0	10.93	10.93
	LSD $_{0.05}$	1.22	0.85	1.82	1.74	0.32	1.94	0.00	0.98	0.69

Evaluation of submergence tolerant rice lines

Submergence tolerant rice lines, Ciherang-*sub1* and Samba Mahsuri-*sub1* along with 1 check variety BRRI dhan51 were evaluated with (check) in farmer field at 5 locations viz., Rangpur Sadar, Nalitabari (Sherpur), Nokla (Sherpur), Dhobaura (Mymensingh) and Dewangonj (Jamalpur) in aman 2011-12 . The unit plot sige was 5 m × 5 m. The tested entries were under complete submergence of 20-25 days. Ciherang-*sub1* was 5-8 days more submergence tolerant, 1 month earlier and high yield (20%) more compared to BRRI dhan51 (Table 14). Samba Mahsuri-*Sub1* was found to be 5 days more submergence tolerant, 10 days earlier and high yielder (Table 14).

Table 14. Morphological and agronomical characters of the proposed lines Ciherang-*Sub1* and Samba Mahsuri-*Sub1* in aman season at submerged condition

Proposed lines	Plant height (cm)	Days to flowering	Days to maturity	1000 grain wt. (gm)	Grain yield (t ha^{-1})
Ciherang-*Sub1*	92	110	135	28.1	4.1
Samba Mahsuri-*Sub1*	84	120	151	16.0	3.8
BRRI dhan51 (Check)	82	130	165	20.3	3.9

Ciherang-*Sub1* showed the highest yield (4.2 t ha^{-1}) at all location under 25 days complete submergence (Table 15).

Table 15. Performance of the proposed lines at different on-farm trial under submerged condition in aman season, 2010

Designation	Grain yield (t ha^{-1})					
	L_1	L_2	L_3	L_4	L_5	Mean
Ciherang-*Sub1*	4.0	3.9	4.1	4.4	4.8	4.2
Samba Mahsuri-*Sub1*	3.4	3.8	3.5	3.2	3.1	3.4
BRRI dhan51 (Check)	3.7	3.6	3.7	3.5	3.5	3.6

L_1 = Sadar (Rangpur), L_2 = Nalitabari (Sherpur), L_3 = Nokla (Sherpur)
L_4 = Dhobaura (Mymensingh), L_5 = Dewangonj (Jamalpur)

With respect to grain quality, milling yield of Ciherang-*Sub1* was 71%, chalkiness less than 10%, size of the dehuled grain is long and medium and 23.74 % amylose content (Table 16). Milling yield of Samba Masuri-*Sub1* was 72%, chalkiness less than 10%, size of the dehuled grain is short and medium and 24.36 % amylase.

Table 16. Grain characteristics of the proposed lines Ciherang-*Sub1* and Samba Mahsuri-*Sub1*

Proposed lines with std. checks	Milling Yield (%)	Head rice Yield (%)	Chalkiness[a]	Whole grain length (mm)	Dehulled grain/kernel				Amylose (%)
					length (mm)	Breadth (mm)	L/B ratio	Size and shape	
Ciherang-*Sub1*	71	90	Wb1	9.0	7.1	2.4	2.96	Long Medium	23.74
Samba Masuri-*Sub1*	72	90	Wb1	7.1	5.3	2.0	2.65	Short Medium	24.36
BRRI dhan51(Check)	71	90	Wb1	7.5	6.0	2.3	2.60	Medium bold	28.12

[a] Wb1 = Less than 10% chalkiness, Wb2 = Less than 20% chalkiness

Both the tested lines are intermediate amylose content which indicate higher consumer preferences because of tastiness of cooked rice. These two submergence tolarent rice lines have been applied to SCA for variety release.

Screening for drought tolerance of M_3 generation of NERICA-1, 4 and 10

New Rice for Africa (NERICA) was originated from progeny of *O. sativa* × *O. glaberrima.* NERICA is drought tolerant, growth duration ranges from 90-100 days and photo-insensitive which is suitable for cultivation in Aus, Aman and Boro season. Adaptability of NERICA lines in Bangladesh is being tested. Variability was created through gamma radiation (250, 300 and 350 Gy) in 2010 to develop drought tolerant rice varieties. Screening was done during aman-boro 2011-12 at BINA HQ Mymensingh, Godagari (Rajshahi), Nachole (Chapainawabgonj) and Kaliganj (Jhenaidah). Data were collected on plant height, effective tillers hill^{-1} and filled grains panicle^{-1}. On the basis of the studied characters, a total of desired 111 mutant population were selected from NERICA-1, 4 and 10. Selected populations are now in M_5 generation. This M_5 mutants are being tested in drought (barind) and saline prone areas to observe their tolerance and yield potentiality as well.

HORTICULTURE DIVISION

RESEARCH HIGHLIGHTS

Eggplant:

In the pot experiment at Head Quarter farm, the eggplant genotype FCI produced the highest yield (2055.0 g $plant^{-1}$) than other genotypes (Purple long = 1904 g $plant^{-1}$, Kansant local = 1896 g $plant^{-1}$ and Pahuja-2 = 1833.0 g $plant^{-1}$).

In the field experiment at Magura substation, the eggplant genotype FCI produced the highest yield (57.33 t ha^{-1}) over all of the genotypes and the other three genotypes Kansant local, Purple long and BARI Begun-5 showed yield 51.33 t ha^{-1}, 49.51, t ha^{-1} and 51.16 t ha^{-1}, respectively. The selected genotype will be tested in advanced yield trial in next season.

Okra:

Under the pot condition, at Head quarter farm, the Okra genotype Patel Aunamica produced the highest fruit yield (658.1 g $plant^{-1}$) which was similar to City Aunamica (613.7 g $plant^{-1}$). The other two genotypes Pankoj Aunamica and Paravani Kanti showed yield of 530.4 g $plant^{-1}$ and 562.2 g $plant^{-1}$, respectively.

In field experiment at Magura substation, Patel Aunamica produced also the highest yield (74.1 t ha^{-1}) of all the genotypes. The genotypes City Aunamica, Pankoj Aunamica and Bogra-1 produced yield 68.5 t ha^{-1}, 67.5 t ha^{-1} and 61.5 t ha^{-1}, respectively. The selected genotypes will be irradiated to create variability for desired types.

Eggplant

Evaluation of elite genotypes of eggplant

A pot experiment was conducted at the pot yard of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during 20th November, 2011 to 25th March, 2012 during rabi season to select parents for irradiation. Fourteen genotypes including one exotic germplasm were used. The experiment was laid out in a randomized complete block design with three replications. Seedling was planted during last week of November 2011. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such as plant height, number of branches per plant, flowers per plant, fruit number per plant and fruit weight per plant were recorded. Maturity period was counted starting from transplanting date till the leaves senesced. Fruit yield of each pot was recorded after harvest.

The mean values for different characters of the selected genotypes are presented in Table 1. Significant variations were observed among the genotypes for all the characters. BAUBegun-2 took shorter period (70 days) followed by Pahuja-1, BARI Begun-1, BAUBegun-1 (79 days) and BARI Begun-5 took longer period (95 days) for maturing. The maturity of other genotypes ranged between 81-90 days. Three genotypes BARI Begun-7, BARI Begun-8 and Pahuja-2 had taller plants (81-86) while the genotypes BAUBegun-2, BAUBegun-1 and FCI genotypes had shorter plants (58-62 cm). Number of branches per plant was the highest in FCI genotype (12 plant^{-1}) which was statistically similar to Kansant local (11 plant^{-1}) followed by BARIBegun-5, BARIBegun-7 and BAUBegun-1 (9 plant^{-1}). Flowers per plant were found highest in FCI genotype with statistically similar result of Pahuja-2, purple long and Pahuja-1. But fruits per plant were observed highest in BARI Begun-1 (19.33 plant^{-1}) followed by BARI Begun-4 (16.33 plant^{-1}), FCI (13 plant^{-1}). The genotype FCI produced

Table 1. Performance of eggplant genotypes under pot condition at BINA farm, Mymensingh grown during rabi season 2011-2012.

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Flowers plant^{-1} (no.)	Fruits plant^{-1} (no.)	Fruit wt plant^{-1} (g)	Duration (days)
BARI Begun-1	75.0 cd	8.00 c	42.67 c	19.33 a	1174.0 d	79 d
BARI Begun- 4	74.6 cd	8.00 cd	44.67 bc	16.33 b	1228.0 cd	90 b
BARI Begun-5	71.6 d	9.00 bc	50.33 b	11.00 cd	1329.0 c	95 a
BARI Begun-7	86.0 a	9.00 bc	34.33 d	7.00 e	653.0 g	90 b
BARI Begun-8	81.3 ab	5.33 f	30.67 d	7.33 e	873.3 f	85 c
BARI Begun-9	63.3 e	7.33 de	44.00 bc	9.66 d	1019.0 e	90 b
BARI Begun-10	79.3 bc	7.00 de	46.00 bc	7.00 e	607.9 g	81 cd
BAU Begun-1	62.0 e	9.00 bc	32.67 d	5.33 f	805.7 f	75 de
BAUBegun-2	58.0 e	6.00 ef	31.67 d	8.00 e	546.7 g	79 d
Pahuja-1	74.6 cd	5.33 f	61.00 a	6.66 ef	370.3 h	70 e
Pahuja-2	85.0 ab	7.66 cd	65.00 a	10.33 d	1833.0 b	79 d
Kansant local	75.0 cd	11.00 a	10.00 d	10.00 d	1896.0 b	85 c
Purple long	70.0 d	9.00 bc	62.00 a	10.00 d	1904.0 b	82 cd
FCI	59.0 e	12.00 a	65.00 a	13.00 c	2055.0 a	89 bc
CV (%)	5.68	7.25	6.58	5.98	7.25	3.25

The common letter(s) in a column did not differ at 5% level of probability as per DMRT

highest fruit yield (2055 g plant^{-1}) followed by Pahuja long (1904 g plant^{-1}), Kansant local (1896 g plant^{-1}) and Pahuja-2 (1833 g plant^{-1}). FCI produced highest flowers per plant though its number of fruits per plant was not found highest. But due to produce highest yield per plant it can be said that FCI produced highest yield for higher fruit size. Although BARI Begun-1 and BARI Begun-4 produced the highest fruits per plant (19.33 and 16.33 respectively) but they did not show higher yield because of their smaller fruit size. There was no disease infestation observed in FCI genotype. The selected genotypes will be tested in advanced yield trial in next season.

Fourteen genotypes of eggplant were also tested to evaluate for yield trial at Magura substation farm during rabi season (November 2011-May 2012) presented in Table 2. The experiment was laid out in RCBD with three replications. Unit plot size was 3 m × 2 m and spacing 75 cm × 60 cm. Seedling was planted during first week of November 2011. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such as plant height, number of branches per plant, flowers per plant, fruit number per plant, and fruit weight per plant were taken from three replicated plots. Fruit yield of each plot was recorded after harvest.

It was observed that among the tested genotypes, FCI had the shortest plant height of 62.67 cm while BARI Begun-7 and BARI Begum-8 had the tallest (92.00 cm and 90.67 cm, respectively). The genotype FCI produced the second highest number of fruits per plant (11.00 plant^{-1}) with average fruit weight of 1849.0 g plant^{-1} and finally produced the highest fruit yield 57.33 t ha^{-1}. Kansant local produced the second highest fruit yield (51.33 t ha^{-1}) having non- significant difference with BARI Begum-5, which produced fruit yield of 51.16 t ha^{-1}. The selected eggplant genotypes will be irradiated to create variability and to get desirable types (resistant to shoot and fruit borer, higher yield potential, early fruit bearing, photo insensitive characteristics) as well.

Table 2. Performance of egg plant genotypes under field condition at BINA farm, Magura grown during rabi season 2011-2012.

Genotypes	Plant height (cm)	Branch plant^{-1} (no.)	Flowers plant^{-1} (no.)	Fruits plant^{-1} (no.)	Fruit wt plant^{-1} (g)	Yield (t ha^{-1})	Duration dyes
BARI Begun-1	77.00 d-f	9.33 bc	47.67 d	21.33 a	986.3 de	32.63 e	70 ef
BARI Begun-4	74.93 ef	9.93 ab	51.33 d	20.67 a	1123.0 cd	42.13 d	85 bc
BARI Begun-5	70.00 gh	9.00 b-e	57.67 c	10.00 b	1243.0 c	51.16 b	93 a
BARI Begun-7	92.00 a	8.40 c-e	41.00 e	7.00 d-f	653.3 gh	46.70 c	86 b
BARI Begun-8	90.67 a	7.73 ef	36.33 e	7.33 de	873.3 ef	25.00 f	78 d
BARI Begun-9	64.67 ij	8.06 de	50.67 d	8.00 d	1052.0 d	32.16 e	83 c
BARI Begun-10	88.33 ab	7.80 d-f	51.00 d	7.00 d-f	608.0 h	20.40 g	72 e
BAUBegun-1	79.00 de	7.80 ef	39.33 e	5.33 f	805.7 fg	19.23 g	68 f
BAUBegun-2	67.33 hi	6.13 g	38.33 e	8.00 cd	546.7 h	15.13 h	69 f
Pahuja-1	81.33 cd	6.66 f g	64.67 b	6.66 d-f	370.3 i	06.76 i	64 g
Pahuja-2	84.67 bc	7.86 d-f	70.67 a	5.66 ef	1266.0 c	46.12 c	78 d
Kansant local	74.00 fg	8.00 de	58.33 bc	9.66 bc	1449.0 b	51.33 b	80 d
Purple long	69.67 gh	9.06 b-d	61.00 bc	8.00 d	1598.0 b	49.51 b	79 d
FCI	62.67 j	10.50 a	62.67 bc	11.00 b	1849.0 a	57.33 a	85 bc
CV (%)	6.50	4.52	5.92	8.25	10.36	9.98	2.52

The common letter(s) in a column did not differ at 5% level of probability as per DMRT

Lady's finger

Preliminary screening of elite genotypes of okra (Lady's finger)

A pot experiment was conducted at the pot yard of BINA, Mymensingh during the Kharif-1 season, 2012 to screen Okra genotypes for selecting parent(s) for irradiation. Twelve genotypes were used in this experiment. The experiment was laid out in a randomized complete block design with three replications. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such as plant height, number of branches per plant, flowers per plant, fruit number per plant, and fruit weight per plant were taken from three replicated pots containing one plant per pot. Maturity period was counted from date of planting till the leaves senesced. Fruit yield of each pot was recorded after harvest.

Results showed significant variations in all the characters (Table 3). It was observed from results that the plant height of all genotypes ranged from 84-155 cm. The days of maturity ranged from 45 to 56 days with a City Aunamica being the longest (56 days) with statistically similar result of Pankoj Aunamica and Patel Aunamica. Patel Aunamica produced higher number of fruits per plant (28.33 plant^{-1}) and also the highest fruit yield/plant (658.1 g plant^{-1}) having non significant difference with City Aunamica which produced fruit weight per plant of 613.7 g plant^{-1}. Paravani Kanti and Pankoj Aunamica also performed better in respect of fruit yield ranged 530.4-562.2 g plant^{-1}. The selected okra genotypes will be irradiated to create variability and to get desirable types (higher yield potential, early fruit bearing, resistant to YMV, longer harvesting duration, increase of softness, small size with good taste) as well.

Table 3. Performance of okra genotypes under pot condition at BINA farm, Mymensingh grown during rabi season 2011-2012.

Genotypes	Plant height (cm)	Branch plant^{-1} (no.)	Fruits plant^{-1} (no.)	Fruit wt plant^{-1} (g)	Duration (days)
Dev-403	84.6 g	2.6 a-c	26.00 ab	302.0 gh	48 d
Dev-407	135.0 c	2.6 a-c	22.66 cd	472.5 e	48 d
Dev-408	144.6 b	2.6 a-c	25.33 bc	486.7 de	53 b
Paravani Kanti	116.0 d	2.3 b-d	24.33 bc	530.4 cd	50 cd
City Aunamica	155.0 a	2.6 a-c	24.66 bc	613.7 ab	56 a
Ispahani Aunamica	107.3 e	2.6 a-c	22.66 cd	567.2 bc	53 b
Mollah Aunamica	153.0 a	2.0 cd	23.33 b-d	346.0 fg	45 e
Patel aunamica	135.0 c	3.3 a	28.33 a	658.1 a	54 ab
Sohid Ahunamica	120.0 d	1.6 d	23.66 bc	392.2 f	52 bc
Pankoj Aunamica	121.3 d	3.0 ab	23.00 cd	562.2 bc	56 a
Bogra-1	105.0 e	1.6 d	20.66 d	290.3 h	49 d
Ufshi Aunmica	94.6 f	2.3 b-d	23.00 cd	290.3 h	49 d
CV(%)	3.63	11.84	6.29	6.74	2.35
Level of Sig.	0.01	0.01	0.01	0.01	0.01
$LSD_{0.05}$	7.54	0.745	2.55	49.73	2.03

The common letter(s) did not differ at 5% level of probability as per DMRT

Twelve genotypes of okra were tested to identify the higher fruit yield at Magura substation during Kharif-1 season 2012 (Table 4). The experiment was laid out in RCBD with three replications. Unit plot size was 4 m × 3 m and spacing 50 cm × 40 cm. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such as plant height, number of branches per plant, flowers per plant, fruit number per plant and fruit weight per plant were taken from three randomly selected plants. Maturity period was counted starting from seedling planted till the plants turned into almost all the leaves dried. Fruit yield of each plot was recorded after harvest.

Results showed that the tallest plant height was found in City Aunamica (125 cm) which was statistically similar to Mollah Aunamica (123.0 cm). The genotype DEV-403 showed the shortest plant (54.60 cm) of all the genotypes. Days to maturity ranged from 29 to 53 days with City Aunamica being the longest 53 days. Patel Aunamica produced higher number of fruits per plant (27.33 plant^{-1}) and also the highest fruit yield plant^{-1} (74.10 t ha^{-1}) having non significant difference with City Aunamica and Pankoj Aunamica which produced fruit yield of 68.5 t ha^{-1} and 67.5 t ha^{-1}, respectively. Paravani Kanti and Ufshi Aunamica also performed better in respect of fruit yield ranged 55.8 -58.4 t ha^{-1}. The selected genotypes will be irradiated to create variability also having desired types.

Table 4. Performance of okra genotypes under field condition at BINA farm, Magura grown during Kharif-1 season 2012

Genotypes	Plant height (cm)	Branch plant^{-1} (no.)	Fruits plant^{-1} (no.)	Fruits wt plant^{-1} (g)	Yield (t ha^{-1})	Duration (days)
Dev-403	54.6 g	2.6 a	15.00 e	315.6 f	21.2 g	29 i
Dev-407	105.0 c	2.5 ab	25.33 bc	319.5 f	40.5 e	39 f
Dev-408	114.6 b	1.3 d	26.00 a	496.7 cd	47.0 de	44 e
Paravani Kanti	86.0 d	1.5 cd	24.33 bc	538.0 b-d	55.8 cd	32 h
City Aunamica	125.0 a	1.4 d	24.66 bc	623.3 ab	68.5 ab	53 a
Ispahani Aunamica	77.3 e	1.2 d	22.66 cd	577.5 a-c	60.5 bc	43 e
Mollah Aunamica	123.0 a	1.7 cd	23.33 bcd	353.9 f	30.83 f	46 d
Patel aunamica	105.0 c	1.5 cd	27.33 a	666.7 a	74.10 a	46 d
Sohid Ahunamica	90.0 d	1.5 cd	23.66 bcd	404.2 ef	28.9 fg	48 c
Pankoj Aunamica	91.3 d	2.5 a	25.00 bc	605.8 ab	67.5 ab	36 g
Bogra-1	75.0 e	2.0 bc	20.66 d	457.7 de	61.5 bc	50 b
Ufshi Aunmica	64.6 f	1.3 d	23.00 b-d	310.6 f	58.4 c	50 b
CV (%)	481	11.73	7.16	10.0	10.29	2.81

The common letter(s) in a column did not differ at 5% level of probability as per DMRT

AGRICULTURAL ECONOMICS DIVISION

RESEARCH HIGHLIGHTS

During 2011-12, technical and economic potential of Binadhan-7 experiments were conducted at different three locations. Besides these, Participatory Varietal Selection (PVS) for stress tolerant varieties studies were implemented by Agricultural Economics Division.

The technical and economic potential of Binadhan-7 study was undertaken in three major rice growing areas, namely Rangpur, Comilla and Mymensingh representing three agro-ecological zones of Bangladesh. The study was mainly based on a set of field level primary data collected from 300 sample farmers from three respective areas. The Stochastic Frontier production function analysis was used to determine the technical, allocative and economic efficiency of Binadhan-7 production. The farmers of all locations achieved 4.07 t ha^{-1} average yield of Binadhan-7. On an average, BCR (full cost basis) and BCR (cash cost basis) were 1.88 and 1.81, respectively. This means that Binadhan-7 growers benefited of Tk. 1.88 and 1.81 per taka for both full and cash cost investment. It shows that per hectare Net Returns were Tk.21, 749/- and 9371/- for full and cash cost basis, respectively. The coefficients of plot size, power tiller, MP, sulphur, pesticide cost and crop duration are found to be significantly positive whereas human labour is negatively significant for small farms in the stochastic frontier. In the technical inefficiency effect model for small farms, the coefficients of age, household size and extension contact are negative and significant which indicates that an increase in the magnitudes of these variables results in the corresponding decrease in the technical inefficiency effect.

The PVS study was conducted on the basis of these objectives; to identify the best variety/mutant line; to assess the acceptability of crop varieties/mutant lines; to identify the consumers preference (cooking quality, grain shape-size, aroma, tastiness etc); to determine the economic constraints of the worst varieties/mutant lines. In Labanchara of Khulna nine rice lines with one salt tolerant check variety (Binadhan-8), RCBD with 3 replications was considered for the study. Binadhan-8 provided the highest yield (4.53 t ha^{-1}), but the yield of line P19S8 was not satisfactory, though the farmers preference was high. At Kaligonj, check variety Binadhan-8 performed well with highest yield (2.08 t ha^{-1}) and its superior performance also exhibited at Shyamnagor.

Economic impact assessment study of mutant crop varieties/technologies developed at BINA

Technical and Economic Potential of Binadhan-7 production (a aman rice variety)

The study was undertaken in three major rice growing areas, namely Rangpur, Comilla and Mymensingh representing three agro-ecological zones of Bangladesh. The analysis was mainly based on a set of field level primary data collected from 300 sample farmers from three respective areas. Tabular, statistical and project appraisal technique were used for analyzing the collected data. In the study, costs and return analysis were done on both cash cost and full cost basis and students t-test was applied to test the observed difference between means. The Stochastic Frontier production function analysis was used to determine the technical, allocative and economic efficiency of Binadhan-7 production.

According to Table 1, the farmers of all locations achieved 4.07 t ha^{-1} average yield of Binadhan-7. On an average, the Benefit Cost Ratio (BCR-full cost basis) and BCR (cash cost basis) were 1.88 and 1.81, respectively. This means that Binadhan-7 growers benefited of Tk. 1.88 and 1.81 per taka for both full and cash cost investment. Table 1 shows that per hectare Net Returns (full cost basis) and Net return (cash cost basis) were Tk.21, 749/- and 9371/-, respectively.

Table 1. BCR, net return and per hectare yield of Binadhan-7 in different areas

Area	Farm category	Yield (kg/ha)	BCR		Net return	
			full cost basis	cash cost basis	full cost basis	cash cost basis
Comilla	Small	4705.63	1.88	1.42	24024.06	10378.57
	Medium	4700.43	1.88	1.35	23900.16	10377.27
	Large	4831.35	1.92	1.70	25037.30	10381.94
	Mean	4714.81	1.88	1.42	24064.45	10378.34
Mymensingh	Small	3483.14	1.75	2.54	17468.88	7967.68
	Medium	3657.10	1.87	2.06	20410.10	10109.88
	Large	3385.81	1.67	2.12	15849.88	8276.06
	Mean	3528.50	1.78	2.20	18244.94	9008.93
Rangpur	Small	3876.90	1.97	2.33	21884.40	29961.72
	Medium	4021.87	1.99	1.75	23317.68	8670.38
	Large	3997.62	1.99	1.53	23252.19	8752.44
	Mean	3977.87	1.98	1.83	22938.40	8724.91
All three areas	Small	4110.56	1.80	1.65	19013.42	9216.28
	Medium	4241.96	2.05	2.13	25105.38	9726.05
	Large	3728.79	1.78	1.65	19574.81	8957.16
	Mean	4073.73	1.88	1.81	21749.26	9370.73

Table 2 presents estimates of the area-specific Cobb-Douglas Stochastic Frontier production function for Binadhan-7. The coefficients of plot size, seed, MP and pesticides are found to be positive and significant in the Comilla area. The coefficients of urea and land rent are negative and significant which indicates that the output of Binadhan-7 decreases with the increase in the magnitude of these variables. The function coefficients show that in Comilla area the production technology is characterized

Table 2. Ordinary Least Squares (OLS) Estimates and Maximum Likelihood (ML) Estimates of Area-Specific Cobb-Douglas (C-D) Stochastic Production Frontier for Binadhan-7

Independent variables		Areas					
		Comilla		Mymensingh		Rangpur	
		OLS Estimates (SE)	ML Estimates (Asymptotic SE)	OLS Estimates (SE)	ML Estimates (Asymptotic SE)	OLS Estimates (SE)	ML Estimates (Asymptotic SE)
Stochastic Frontier:	symbols						
Intercept	β_0	0.006	0.013	-2.770	-1.541	16.755	18.400**
		(2.261)	(0.986)	(12.841)	(0.987)	(16.155)	(0.976)
Plot size	β_1	3.165**	3.162**	0.758	0.041	-0.052	-0.607**
		(1.105)	(0.625)	(0.666)	(0.236)	(0.288)	(0.025)
Human labour	β_2	0.044	0.044	-1.177**	-0.381**	-0.065*	0.049**
		(0.057)	(0.052)	(0.543)	(0.058)	(0.029)	(0.003)
Power tiller cost	β_3	-0.008	-0.008	0.128*	0.168	0.099*	0.022**
		(0.034)	(0.032)	(0.112)	(0.130)	(0.041)	(0.007)
Seed	β_4	0.021*	0.021*	0.357	0.165	0.044*	0.144**
		(0.009)	(0.008)	(0.247)	(0.143)	(0.023)	(0.004)
Urea	β_5	-0.079**	-0.079**	0.010*	0.067*	-0.045	0.264**
		(0.028)	(0.027)	(0.004)	(0.026)	(0.229)	(0.011)
TSP	β_6	-0.029	-0.029*	-0.166	-0.246**	-0.037	-0.006
		(0.016)	(0.014)	(0.262)	(0.029)	(0.085)	(0.004)
MP	β_7	0.048**	0.048*	0.118*	0.209**	0.061*	0.061**
		(0.024)	(0.024)	(0.058)	(0.060)	(0.028)	(0.001)
Sulphur	β_8	-0.024	-0.024	0.069	0.046*	0.053	-0.450**
		(0.054)	(0.048)	(0.067)	(0.023)	(0.389)	(0.012)
Manure	β_9	-0.001	-0.001	0.172	0.029	0.004	0.056**
		(0.054)	(0.049)	(0.174)	(0.076)	(0.149)	(0.010)
Pesticide cost	β_{10}	0.089**	0.089**	0.038*	-0.006	-0.008	0.002
		(0.035)	(0.031)	(0.016)	(0.021)	(0.054)	(0.003)
Land rent	β_{11}	-2.199*	-2.196**	-0.088	-0.001	0.007*	0.074**
		(1.341)	(0.627)	(0.133)	(0.061)	(0.003)	(0.003)
Seedling age	β_{12}	0.019	0.019	0.687*	0.143	0.388	0.053**
		(0.104)	(0.099)	(0.313)	(0.148)	(0.664)	(0.013)
Crop duration	β_{13}	2.076	2.074**	1.428	1.694**	-2.161	-1.950**
		(1.168)	(0.483)	(2.608)	(0.207)	(3.175)	(0.189)
Dummy for land type	β_{14}	-0.025	-0.025	-0.125	0.049	-0.138	-0.287**
(1 = MHL, 0 = otherwise)		(0.034)	(0.031)	(0.292)	(0.147)	(0.372)	(0.002)
Dummy for transplanting date	β_{15}	-0.026	-0.026	0.432	0.818**	-0.053	-0.276**
(1 = optimum, 0 = otherwise)		(0.042)	(0.038)	(0.289)	(0.056)	(0.278)	(0.012)
Dummy for variety	β_{16}	0.014	0.014	-0.433	-0.881**	-0.112	-0.158**
(1 = Binasail, 0 = otherwise)		(0.040)	(0.037)	(0.265)	(0.040)	(0.254)	(0.006)
Function Coefficient		1.01	1.03	0.99	1.01	0.93	0.94
F-statistic model		50.34*		45.22*		17.41*	
Adj. R^2		0.84		0.80		0.71	
Variance parameters							
Sigma squared	σ^2	0.207	0.406**	0.537	0.728**	0.602	0.944**
			(0.001)		(0.275)		(0.570)
Gamma	γ		0.390		0.989**		0.998**
			(0.227)		(0.0001)		(0.0002)
Log likelihood function		118.560	118.560	-101.485	-74.859	-107.241	-82.515

** and * indicate significant at 1 percent and 5 percent level of probability, respectively.
Figures in the parenthesis indicate standard error

by increasing return to scale for Binadhan-7. In Mymensingh area the coefficients of power tiller, urea, MP and seedling age are significantly positive whereas the coefficient of human labour is significantly negative. The function coefficients show constant return to scale. The coefficients of power tiller cost, seed, MP and land rent are significantly positive in Rangpur area whereas coefficient of pesticide cost, land type, transplanting date and variety dummy are found to be negative but not significant. The production technology in Rangpur area for Binadhan-7 is characterized by decreasing return to scale. There are significant inefficiency effects in all areas.

For Binadhan-7, the coefficient of plot size, seed, MP, pesticides and crop duration are found to be significant and positive in Comilla area in the Cobb-Douglas Stochastic Frontier production function (Table 3) while the coefficients of urea, TSP, land rent and land type (dummy) are significantly negative. In the inefficiency effect model, the coefficients of experience is found to be significant with positive signs and coefficients of farm size and extension contact are found to be significant with expected signs which means that the inefficiency effect in production decreases with the increase in farm size and extension contact. In Mymensingh area, the coefficients of power tiller, urea, MP, seedling age, crop duration and transplanting date (dummy) are found to be significant with positive signs whereas the coefficient of human labour, TSP and variety (dummy) is significantly negative in the stochastic frontier. The coefficients of education and occupation are significant with expected signs in the technical inefficiency effect model. The signs of the coefficients of experience, farm size, household size, extension contact and training (dummy) are also expected but these coefficients are not significant. In Rangpur area, the coefficient of power tiller, seed, MP and land rent are significant with positive sign but plot size, TSP, sulphur, crop duration, and land type (dummy) coefficient of variable are found to be negative and significant in the stochastic frontier. In the technical inefficiency effect model, the coefficient of occupation and experiences are negative and significant which means that the inefficiency effect decreases with the increase in the number of farmers with agriculture occupation and experience of farmers. The significantly large values of γ for all areas remind us that there are significant inefficiency effects in the production in all areas.

Table 3. Maximum Likelihood (ML) Estimates for Parameters of Area-Specific Cobb-Douglas Stochastic Frontier Production Functions and Technical Inefficiency Effect Model for Binadhan-7

Independent variables		Areas		
		Comilla	Mymensingh	Rangpur
Stochastic Frontier:	symbols			
Intercept	β_0	0.559	-1.294	17.622**
		(1.129)	(1.547)	(0.957)
Plot size	β_1	3.236**	0.208	-0.493*
		(0.565)	(0.123)	(0.212)
Human labour	β_2	-0.004	-0.430**	0.023
		(0.094)	(0.051)	(0.120)
Power tiller cost	β_3	0.020	0.135**	0.091*
		(0.051)	(0.031)	(0.044)
Seed	β_4	0.043*	0.052	0.080*
		(0.019)	(0.052)	(0.038)
Urea	β_5	-0.098**	0.065**	0.136
		(0.026)	(0.024)	(0.343)

Table 3 Cond.

Independent variables		Areas		
		Comilla	Mymensingh	Rangpur
Stochastic Frontier:	symbols			
TSP	β_6	-0.039**	-0.239**	-0.016*
		(0.014)	(0.033)	(0.045)
MP	β_7	0.053**	0.212*	0.079*
		(0.021)	(0.100)	(0.040)
Sulphur	β_8	0.055	0.041	-0.324*
		(0.065)	(0.043)	(0.176)
Manure	β_9	0.007	0.070	0.028
		(0.054)	(0.073)	(0.107)
Pesticide cost	β_{10}	0.102**	-0.003	-0.005
		(0.029)	(0.023)	(0.051)
Land rent	β_{11}	-2.383**	0.038	0.082**
		(0.569)	(0.029)	(0.013)
Seedling age	β_{12}	0.106	0.231*	-0.086
		(0.212)	(0.163)	(0.593)
Crop duration	β_{13}	2.171**	1.509**	-1.736**
		(0.467)	(0.432)	(0.531)
Dummy for land type	β_{14}	-0.189*	0.016	-0.339**
(1 = MHL, 0 = otherwise)		(0.078)	(0.064)	(0.067)
Dummy for transplanting date	β_{15}	-0.053	0.801**	-0.119
(1 = optimum, 0 = otherwise)		(0.036)	(0.073)	(0.375)
Dummy for variety	β_{16}	0.042	-0.925**	-0.215
(1 = Binasail, 0 = otherwise)		(0.035)	(0.030)	(0.317)
Technical Inefficiency model:				
Constant	δ_0	0.359	-1.278	0.525
		(0.311)	(1.467)	(0.978)
Farm size	δ_1	-0.003*	0.0001	0.000
		(0.001)	(0.002)	(0.001)
Farmers age	δ_2	-0.00001	0.017	0.040
		(0.005)	(0.028)	(0.031)
Farmers education	δ_3	-0.003	-0.101*	0.032
		(0.007)	(0.051)	(0.058)
Farmers occupation	δ_4	0.114	-1.414**	-0.655**
		(0.128)	(0.031)	(0.219)
Farmers experience	δ_5	0.006*	-0.036	-0.033*
		(0.003)	(0.033)	(0.014)
Household size	δ_6	-0.010	-0.053	-0.225
		(0.012)	(0.042)	(0.146)
Dummy for extension contact	δ_7	-0.155*	-0.722	-0.268
(1 = Yes, 0 = otherwise)		(0.062)	(0.956)	(0.858)
Dummy for rice training	δ_8	0.166	-0.926	0.033
(1 = Yes, 0 = otherwise)		(0.147)	(1.410)	(0.722)
Variance parameters:				
Sigma squared	σ^2	0.405**	0.987**	0.939**
		(0.001)	(0.148)	(0.274)
Gamma	γ	0.415*	0.899**	0.999**
		(0.202)	(0.0002)	(0.0003)
Log likelihood function		125.270	-73.714	-86.403

** and * indicate significant at 1 percent and 5 percent level of probability, respectively
Figures in the parenthesis indicate standard error

Table 4 shows OLS estimates and ML estimates of farm-size-specific Cobb-Douglas stochastic production frontiers for Binadhan-7. The coefficients of human labour, power tiller, TSP, MP, pesticide cost, crop duration and land type dummy are positive and significant for small farms. The coefficients of plot size, TSP and pesticides are positively significant for all farm size groups. The quasi-function coefficient in both the frontier and the OLS model is 1.06 which shows increasing return to scale.

For medium sized farms, the coefficient of plot size, human labour, seed, TSP and pesticides are found to be significantly positive whereas coefficients of urea are found to be significantly negative and all other coefficients of variables in the model are insignificant. The quasi-function coefficient which is the sum of all coefficients of all variables is about 1.01 for OLS model and 1.02 for the frontier model, which means increasing return to scale existed for medium farms.

For large farms, the coefficients of plot size, TSP and pesticides are positive and significant whereas the coefficients of human labour are found to be significantly negative. The quasi-function coefficient is 1.02 for OLS model and 1.03 for the frontier model which reveals increasing return to scale. The models are well fitted to the data for all farm groups. The inefficiency effect is significant only in large farm group. The significant values of γ show that there are significant inefficiency effects in large farm groups of Binadhan-7.

Table 4. Ordinary Least Squares (OLS) Estimates and Maximum Likelihood (ML) Estimates of Farm-Size-Specific Cobb-Douglas (C-D) Stochastic Production Frontiers for Binadhan-7

Independent variables	symbols	Farm groups: Small OLS Estimates (SE)	Small ML Estimates (Asymptotic SE)	Medium OLS Estimates (SE)	Medium ML Estimates (Asymptotic SE)	Large OLS Estimates (SE)	Large ML Estimates (Asymptotic SE)
Stochastic Frontier:							
Intercept	β_0	-1.238**	-1.218	2.743	2.756*	-1.236	1.316
		(1.926)	(0.990)	(2.202)	(1.228)	(2.936)	(2.278)
Plot size	β_1	0.934**	0.934**	0.841**	0.841**	0.966**	0.979**
		(0.093)	(0.086)	(0.084)	(0.077)	(0.077)	(0.067)
Human labour	β_2	0.229**	0.229**	0.109*	0.109*	-0.047*	-0.046*
		(0.067)	(0.061)	(0.050)	(0.047)	(0.023)	(0.023)
Power tiller cost	β_3	0.175*	-0.175**	-0.024	-0.024	0.037*	0.034
		(0.067)	(0.061)	(0.028)	(0.026)	(0.016)	(0.028)
Seed	β_4	0.0001	0.0001	0.132**	0.132**	-0.043	-0.033
		(0.058)	(0.054)	(0.040)	(0.036)	(0.038)	(0.031)
Urea	β_5	0.016	0.016	-0.052*	-0.052*	-0.013	-0.053
		(0.027)	(0.026)	(0.026)	(0.025)	(0.033)	(0.031)
TSP	β_6	0.041*	0.041*	0.028*	0.028**	0.034*	0.028*
		(0.021)	(0.019)	(0.012).	(0.011)	(0.022)	(0.014)
MP	β_7	0.087*	0.087*	0.001	0.001	0.010	0.008
		(0.040)	(0.038)	(0.017)	(0.016)	(0.024)	(0.020)
Sulphur	β_8	0.022*	0.022	-0.035	-0.035	-0.009	-0.003
		(0.012)	(0.026)	(0.022)	(0.020)	(0.027)	(0.024)
Manure	β_9	0.002	0.002	0.010	0.010	0.050	0.047
		(0.063)	(0.059)	(0.025)	(0.024)	(0.044)	(0.036)
Pesticide cost	β_{10}	0.034*	0.034**	0.023**	0.023**	0.045**	0.046**
		(0.011)	(0.010)	(0.008)	(0.007)	(0.011)	(0.009)
Land rent	β_{11}	-0.018	-0.018	-0.016*	-0.016	-0.042	-0.047
		(0.029)	(0.027)	(0.008)	(0.018)	(0.100)	(0.081)
Seedling age	β_{12}	-0.196	-0.194	0.054	0.053	0.058	-0.048
		(0.171)	(0.163)	(0.102)	(0.096)	(0.181)	(0.151)
Crop duration	β_{13}	1.048*	1.044**	0.044	0.043	0.840	0.472
		(0.383)	(0.228)	(0.427)	(0.215)	(0.534)	(0.425)
Dummy for land type	β_{14}	0.118*	0.118**	0.035	0.035	0.043	-0.007
(1 = MHL, 0 = otherwise)		(0.044)	(0.038)	(0.040)	(0.034)	(0.084)	(0.072)
Dummy for transplanting date	β_{15}	0.086	0.087	-0.042	-0.042	-0.022	0.044
(1 = optimum, 0 = otherwise)		(0.067)	(0.061)	(0.045)	(0.043)	(0.129)	(0.108)
Dummy for variety	β_{16}	-0.064	-0.064	0.015	0.015	-0.045	-0.112
(1 = Binadhan-7, 0 = otherwise)		(0.066)	(0.060)	(0.041)	(0.038)	(0.122)	(0.104)
Function Coefficient		1.06	1.062	1.01	1.022	1.02	1.031
F-statistic model		80.11*		35.34*		98.38*	
Adj. R^2		0.88		0.84		0.77	
Variance parameters							
Sigma squared	σ^2	0.124	0.320**	0.122	0.419**	0.147	0.388
			(0.005)		(0.007)		(0.204)
Gamma	γ		0.398		0.528		0.926**
			(0.216)		(0.442)		(0.083)
Log likelihood function		53.634	53.633	72.545	72.545	17.535	19.319

** and * indicate significant at 1 percent and 5 percent level of probability, respectively.
Figures in the parenthesis indicate standard error

To identify the factors which influence technical inefficiency effects according to farm groups, farm size-specific Cobb-Douglas stochastic production frontier and technical inefficiency effect models were estimated for Binadhan-7. Table 5 shows simultaneous estimation of farm-size-specific Cobb-Douglas stochastic frontiers and technical inefficiency effect models for Binadhan-7. The coefficients of plot size, power tiller, MP, sulphur, pesticide cost and crop duration are found to be significantly positive whereas human labour is negatively significant for small farms in the stochastic frontier. In the technical inefficiency effect model for small farms, the coefficients of age, household size and extension contact are negative and significant which indicates that an increase in the magnitudes of these variables results in the corresponding decrease in the technical inefficiency effect.

Table 5 reveals that the coefficients of human labour, seed and TSP are positive and significant whereas the coefficient of urea is significantly negative for medium farm size groups for Binadhan-7. In the technical inefficiency effect model for medium farms, the coefficient of extension contact is negative and significant which indicates that an increase in the magnitudes of extension contact variables results in the corresponding decrease in the technical inefficiency effect.

For large farms, the coefficients of plot size, power tiller, TSP and pesticide cost are found to be positive and significant whereas the coefficients of human labour and variety (dummy) are significantly negative for medium farm size groups for Binadhan-7. In the technical inefficiency effect model for large farms, the coefficient of extension contact is negative and significant. Decreasing return to scale prevails in all farm size groups. The models are well fitted to the data for all farm size groups. The significant value of γ indicates that there are significant inefficiency effects in the large and small farms (Table 5).

Table 5. Maximum Likelihood (ML) Estimates of Parameters of Farm-Size-Specific Cobb-Douglas Stochastic Production Frontiers Function and Technical Inefficiency Effect Model for Binadhan-7

Independent variables	Para-meters	Farm groups		
		Small	Medium	Large
Stochastic Frontier:				
Intercept	β_0	-2.457*	2.768**	2.392
		(1.140)	(1.000)	(3.267)
Plot size	β_1	1.110**	0.841	0.857**
		(0.182)	(0.990)	(0.069)
Human labour	β_2	-0.239*	0.109*	-0.053*
		(0.116)	(0.049)	(0.027)
Power tiller cost	β_3	0.256*	-0.024	0.028*
		(0.119)	(0.099)	(0.013)
Seed	β_4	-0.060	0.132*	-0.003
		(0.045)	(0.059)	(0.028)
Urea	β_5	0.019	-0.052*	-0.027
		(0.025)	(0.025)	(0.031)
TSP	β_6	0.020	0.027*	0.036*
		(0.018)	(0.013)	(0.019)
MP	β_7	0.071*	0.001	0.016
		(0.034)	(0.199)	(0.021)

Table 5 Contd.

Independent variables	Parameters	Farm groups		
		Small	Medium	Large
Sulphur	β_8	0.082*	-0.035	0.020
		(0.037)	(0.219)	(0.025)
Manure	β_9	0.008	0.010	0.041
		(0.056)	(0.197)	(0.034)
Pesticide cost	β_{10}	0.025*	0.023	0.027**
		(0.010)	(0.128)	(0.011)
Land rent	β_{11}	-0.027	-0.016*	0.078
		(0.027)	(0.008)	(0.089)
Seedling age	β_{12}	-0.162	0.054	0.036
		(0.181)	(0.113)	(0.153)
Crop duration	β_{13}	0.983**	0.044	0.118
		(0.244)	(0.775)	(0.547)
Dummy for land type	β_{14}	-0.136	0.035	-0.088
(1 = MHL, 0 = otherwise)		(0.105)	(0.539)	(0.101)
Dummy for transplanting date	β_{15}	0.008	-0.042	0.108
(1 = optimum, 0 = otherwise)		(0.058)	(0.678)	(0.100)
Dummy for variety	β_{16}	-0.030	0.015	-0.150*
(1 = Binadhan-7, 0 = otherwise)		(0.060)	(0.214)	(0.069)
Technical Inefficiency model:				
Constant	δ_0	0.333	-0.00000001	0.743**
		(0.240)	(0.00000001)	(0.279)
Farm size	δ_1	0.004	0.00000069	-0.000
		(0.003)	(0.0000007)	(0.000)
Farmers age	δ_2	-0.006*	-0.00000025	0.004
		(0.003)	(0.0000003)	(0.006)
Farmers education	δ_3	-0.010	0.00000072	-0.053
		(0.009)	(0.0000007)	(0.043)
Farmers occupation	δ_4	0.003	0.00000003	-0.187
		(0.049)	(0.00000003)	(0.172)
Farmers experience	δ_5	0.011*	0.00000117	-0.008
		(0.004)	(0.0000012)	(0.008)
Household size	δ_6	-0.047**	-0.000000055	-0.028
		(0.015)	(0.00000006)	(0.030)
Dummy for extension contact	δ_7	-0.197**	-0.00000046*	-0.865**
(1 = Yes, 0 = otherwise)		(0.046)	(0.00000024)	(0.329)
Dummy for rice training	δ_8	-0.028	-0.000000064	-0.052
(1 = Yes, 0 = otherwise)		(0.059)	(0.00000006)	(0.165)
Variance parameters				
Sigma squared	σ^2	0.311**	0.195	0.437**
		(0.002)	(0.099)	(0.008)
Gamma	γ	0.431**	0.180	0.724**
		(0.0001)	(0.099)	(0.080)
Log likelihood function		81.938	72.543	38.379

** and * indicate significant at 1 percent and 5 percent level of probability, respectively.
Figures in the parenthesis indicate standard error

The coefficients of output, human labour wage, power tiller price and sulphur price are significantly positive whereas the coefficients of seed price, land rent and land type (dummy) are found to be significantly negative in the cost frontier in Comilla area for Binadhan-7 (Table 6). In Mymensingh area, the coefficients output and human labour wage significantly positive but the coefficient of pesticide price is significantly negative. The coefficient of output and human labour price are positive and significant whereas power tiller and seed price are negatively significant in Rangpur area for Binadhan-7.

To identify factors which influence economic inefficiency for producing Binadhan-7 in all areas, area-specific Cobb-Douglas stochastic normalized cost frontiers and economic inefficiency effect models were estimated. Table-7 reveals that the coefficients of output and human labour are significantly positive in cost frontiers in all areas. In addition, the coefficients of seed, TSP, pesticide and land type (dummy) are found to be negative in the stochastic frontier in Comilla area for Binadhan-7. In the economic inefficiency effect model, the coefficient of farm size is significantly positive whereas the coefficients of training are significantly negative in Comilla area. In Mymensingh area, the coefficients of experience and extension contact are found to be significantly negative but in Rangpur area only the coefficient of experience, household size and extension contact (dummy) variable are significantly negative in the economic inefficiency effect model.

The coefficients of output are positive and significant in all farm size groups for Binadhan-7 (Table 8). It reveals that in small farms, the coefficients of MP price and land type (dummy) are positive and significant whereas the coefficient of pesticide price and transplanting date (dummy) are significantly negative. In medium farms, the coefficients of human labour and TSP price are positive and significant in the cost frontier whereas the coefficient of land type (dummy) is significantly negative. The coefficients of human labour and land rent are significantly positive in large farm. The significant value of γ shows that there are significant economic inefficiency effects in small farm groups for Binadhan-7.

Table 8 presents simultaneous estimation of farm-size-specific Cobb-Douglas stochastic normalized cost frontiers and economic inefficiency effect models for Binadhan-7. The coefficient of output is significantly positive in all farm groups in the cost frontiers. In addition, coefficients of TSP price and land type (dummy) are positively significant in small farms. The coefficients of human labour price and TSP price are significantly positive in medium farms whereas the coefficient of variety (dummy) is significantly positive in addition to other coefficients discussed earlier for large farms.

Table 9 shows that in the economic inefficiency effect model, the coefficient of age is significant with negative signs in small farms whereas education, occupation, experience, household size, extension contact (dummy) are negative but insignificant. In medium farms, the coefficients of age and extension contact are found to be significant with expected (negative) signs. The coefficients of extension contact (dummy) and training (dummy) are also significant with the expected negative signs in large farm in the economic inefficiency effect model which means that the economic inefficiency effect decreases with the increase in the magnitudes of these variables.

Table 6. Ordinary Least Square (OLS) and Maximum Likelihood (ML) Estimates for Parameters of Area-Specific Cobb-Douglas Stochastic Normalized Cost Frontiers for Binadhan-7

Independent variables	Parameters	Comilla OLS Estimates (SE)	Comilla ML Estimates (Asymptotic SE)	Mymensingh OLS Estimates (SE)	Mymensingh ML Estimates (Asymptotic SE)	Rangpur OLS Estimates (SE)	Rangpur ML Estimates (Asymptotic SE)
Stochastic Frontier:							
Intercept	β_0	-5.351**	-5.357**	-5.453**	-5.641**	-3.608**	-3.612**
		(0.492)	(0.408)	(0.789)	(0.997)	(0.909)	(0.970)
Output	β_1	0.890**	0.890**	0.931**	0.925	0.962**	0.962**
		(0.019)	(0.017)	(0.031)	(0.526)	(0.026)	(0.025)
Human labour price	β_2	0.980**	0.980**	0.803**	0.784*	0.814**	0.814**
		(0.027)	(0.025)	(0.148)	(0.328)	(0.121)	(0.117)
Power tiller price	β_3	0.112*	0.112*	-0.263	-0.248	-0.704**	-0.705**
		(0.061)	(0.057)	(0.163)	(0.912)	(0.263)	(0.264)
Seed price	β_4	-0.137*	-0.137*	-0.161	-0.149	-0.714**	-0.714**
		(0.068)	(0.063)	(0.123)	(0.760)	(0.252)	(0.248)
TSP price	β_5	-0.003	-0.003	-0.022	-0.029	0.002	0.002
		(0.003)	(0.003)	(0.020)	(0.506)	(0.012)	(0.011)
MP price	β_6	-0.005	-0.005	-0.029*	-0.029	-0.001	-0.001
		(0.003)	(0.003)	(0.015)	(0.361)	(0.009)	(0.009)
Sulphur price	β_7	0.021*	0.021*	-0.022	-0.038	0.018	0.018
		(0.009)	(0.009)	(0.024)	(0.506)	(0.025)	(0.023)
Manure price	β_8	0.013	0.013	-0.012	-0.010	0.015	0.015
		(0.008)	(0.008)	(0.021)	(0.203)	(0.031)	(0.030)
Pesticide price	β_9	-0.005	-0.005	-0.042*	-0.035*	0.007	0.008
		(0.008)	(0.008)	(0.020)	(0.018)	(0.029)	(0.028)
Land rent	β_{10}	-0.019*	-0.019*	0.005	0.038	0.001	0.001
		(0.009)	(0.008)	(0.024)	(0.541)	(0.025)	(0.024)
Dummy for land type	β_{11}	-0.099**	-0.099**	-0.201**	-0.042	-0.023	-0.023
(1 = MHL, 0 = otherwise)		(0.031)	(0.028)	(0.068)	(0.466)	(0.102)	(0.095)
Dummy for transplanting date	β_{12}	0.041	0.041	-0.058	-0.103	-0.013	-0.013
(1 = optimum, 0 = otherwise)		(0.039)	(0.036)	(0.079)	(0.987)	(0.064)	(0.065)
Dummy for variety	β_{13}	-0.020	-0.020	-5.453**	0.143	-0.045	-0.045
(1 = Binadhan-7, 0 = otherwise)		(0.038)	(0.036)	(0.789)	(0.998)	(0.062)	(0.059)
F-statistic model		156.23*		127.25*		29.30*	
Adj. R^2		0.91		0.89		0.74	
Variance parameters							
Sigma squared	σ^2	0.205	0.455**	0.140	0.479**	0.137	0.532**
			(0.001)		(0.127)		(0.009)
Gamma	γ		0.509		0.934*		0.408
			(0.303)		(0.410)		(0.299)
Log likelihood function		127.771	127.770	26.438	30.943	30.858	30.857

** and * indicate significant at 1 percent and 5 percent level of probability, respectively.
Figures in the parenthesis indicate standard error

Table 7. Maximum Likelihood Estimates of Area-Specific Cobb-Douglas Stochastic Normalized Cost Frontiers and Economic Inefficiency Effect Models for Binadhan-7

Independent variables	Parameters	Areas		
		Comilla	Mymensingh	Rangpur
Stochastic Frontier:				
Intercept	β_0	0.729	-6.098**	-4.246**
		(1.179)	(0.707)	(1.023)
Output	β_1	0.741**	0.975**	0.830**
		(0.037)	(0.035)	(0.045)
Human labour price	β_2	1.052**	0.826**	0.652**
		(0.038)	(0.129)	(0.145)
Power tiller price	β_3	-0.053	-0.163	-0.278
		(0.188)	(0.102)	(0.261)
Seed price	β_4	-0.910**	-0.143	-0.152
		(0.070)	(0.085)	(0.253)
TSP price	β_5	-0.012**	-0.056**	0.007
		(0.004)	(0.015)	(0.010)
MP price	β_6	0. 004	-0.044**	0.001
		(0.003)	(0.010)	(0.007)
Sulphur price	β_7	0.019	-0.004	0.013
		(0.028)	(0.013)	(0.020)
Manure price	β_8	0.009	-0.003	0.005
		(0.010)	(0.014)	(0.028)
Pesticide price	β_9	-0.008**	-0.025**	0.002
		(0.003)	(0.008)	(0.026)
Land rent	β_{10}	-0.017	0.019	-0.004
		(0.010)	(0.021)	(0.022)
Dummy for land type (1 = MHL, 0 = otherwise)	β_{11}	-0.394**	0.096	0.055
		(0.067)	(0.062)	(0.101)
Dummy for transplanting date (1 = optimum, 0 = otherwise)	β_{12}	0.040	-0.051	-0.025
		(0.119)	(0.056)	(0.052)
Dummy for variety (1 = Binadhan-7, 0 = otherwise)	β_{13}	-0.026	0.096	-0.022
		(0.103)	(0.051)	(0.051)
Inefficiency effect model:				
Constant	δ_0	0.642	0.132	0.733**
		(0.498)	(0.192)	(0.168)
Farm size	δ_1	0.002*	0.001	0.003
		(0.001)	(0.002)	(0.003)
Farmers age	δ_2	-0.006	0.005	0.004
		(0.007)	(0.007)	(0.003)
Farmers education	δ_3	0.003	-0.009	0.004
		(0.011)	(0.019)	(0.007)
Farmers occupation	δ_4	-0.069	-0.037	-0.026
		(0.104)	(0.143)	(0.047)
Farmers experience	δ_5	0.003	-0.013*	-0.005*
		(0.011)	(0.006)	(0.002)
Household size	δ_6	0.002	-0.050	-0.029*
		(0.028)	(0.034)	(0.013)
Dummy for extension contact (1 = Yes, 0 = otherwise)	δ_7	-0.094	-2.402*	-0.180**
		(0.093)	(1.285)	(0.030)
Dummy for rice training (1 = Yes, 0 = otherwise)	δ_8	-0.247**	-0.798	-0.033
		(0.048)	(0.597)	(0.049)
Variance parameters				
Sigma squared	σ^2	0.504**	0.504**	0.415**
		(0.001)	(0.031)	(0.002)
Gamma	γ	0.999**	0.993**	0.992**
		(0.013)	(0.013)	(0.149)
Log likelihood function		147.78	47.192	67.80

** and * indicate significant at 1 percent and 5 percent level of probability, respectively
Figures in the parenthesis indicate standard error

Table 8. Ordinary Least Square (OLS) and Maximum Likelihood (ML) Estimates for Parameters of Farm-Size-Specific Cobb-Douglas Stochastic Normalized Cost Frontiers for Binadhan-7

Independent variables	Parameters	Farm groups					
		Small		Medium		Large	
		OLS Estimates (SE)	ML Estimates (Asymptotic SE)	OLS Estimates (SE)	ML Estimates (Asymptotic SE)	OLS Estimates (SE)	ML Estimates (Asymptotic SE)
Stochastic Frontier:							
Intercept	β_0	-2.403*	-2.370*	-3.975**	-4.169**	-1.380	-1.670
		(1.100)	(0.858)	(0.871)	(0.580)	(1.380)	(1.330)
Output	β_1	0.854**	0.938**	0.619**	0.622**	0.865**	0.874**
		(0.227)	(0.080)	(0.060)	(0.039)	(0.065)	(0.067)
Human labour price	β_2	-1.240	-1.100**	0.747**	0.751**	0.496**	0.485**
		(1.210)	(0.142)	(0.073)	(0.048)	(0.171)	(0.157)
Power tiller price	β_3	-0.665	-0.459	-0.068	-0.028	0.362	0.358
		(1.340)	(0.477)	(0.145)	(0.105)	(0.410)	(0.388)
Seed price	β_4	0.369	0.214	0.118	0.146	0.066	0.078
		(0.831)	(0.375)	(0.139)	(0.098)	(0.247)	(0.236)
TSP price	β_5	0.601	0.497	0.027**	0.024**	0.011	0.009
		(1.000)	(0.721)	(0.012)	(0.008)	(0.019)	(0.019)
MP price	β_6	0.006*	0.003**	0.012	0.010	-0.007	-0.007
		(0.003)	(0.001)	(0.010)	(0.007)	(0.015)	(0.013)
Sulphur price	β_7	-0.001	0.012**	-0.011	-0.007	-0.023	-0.020
		(0.043)	(0.002)	(0.034)	(0.024)	(0.026)	(0.025)
Manure price	β_8	-0.006	0.439	-0.027	-0.022	-0.011	-0.010
		(0.055)	(0.710)	(0.033)	(0.023)	(0.026)	(0.024)
Pesticide price	β_9	-2.840**	-2.870**	0.347	0.453	-0.003	-0.002
		(0.960)	(0.587)	(0.800)	(0.662)	(0.027)	(0.024)
Land rent	β_{10}	-0.879	-0.430	-0.616	-0.523	0.020*	0.021*
		(0.551)	(0.705)	(3.400)	(0.750)	(0.010)	(0.010)
Dummy for land type	β_{11}	2.870**	2.810**	-0.302**	-0.302**	-0.252**	-0.244**
(1 = MHL, 0 = otherwise)		(0.954)	(0.578)	(0.060)	(0.041)	(0.087)	(0.087)
Dummy for transplanting date	B_{12}	-2.770**	-2.800**	0.017	0.018	0.026	0.007
(1 = optimum, 0 = otherwise)		(0.954)	(0.578)	(0.069)	(0.048)	(0.157)	(0.150)
Dummy for variety	β_{13}	-0.022	0.011	-0.016	-0.019	0.022	0.031
(1 = Binadhan-7, 0 = otherwise)		(0.085)	(0.042)	(0.066)	(0.045)	(0.140)	(0.128)
F-statistic model		158.71*		89.40*		108.71*	
Adj. R^2		0.85		0.84		0.90	
Variance parameters							
Sigma squared	σ^2	1.020	2.050**	0.155	0.560**	0.160	0.464**
			(0.392)		(0.104)		(0.081)
Gamma	γ		0.998**		0.718		0.460
			(0.00002)		(0.474)		(0.785)
Log likelihood function		-134.000	-12.500	11.933	53.382	6.740	6.740

** and * indicate significant at 1 percent and 5 percent level of probability, respectively.
Figures in the parenthesis indicate standard error

Table 9. Maximum Likelihood Estimates of Farm-Size-Specific Cobb-Douglas Stochastic Normalized Cost Frontiers and Economic Inefficiency Effect Models for Binadhan-7

Independent variables	symbols	Farm groups		
		Small	Medium	Large
Stochastic Frontier:				
Intercept	β_0	-1.399	-4.304**	-1.275
		(0.996)	(0.692)	(0.889)
Output	β_1	0.870**	0.622**	0.581**
		(0.206)	(0.061)	(0.073)
Human labour price	β_2	-0.950	0.844**	0.583**
		(0.767)	(0.046)	(0.142)
Power tiller price	β_3	-0.516	-0.011	-0.061
		(0.750)	(0.097)	(0.341)
Seed price	β_4	0.186	0.067	-0.062
		(0.764)	(0.089)	(0.218)
TSP price	β_5	0.532*	0.009*	-0.014
		(0.245)	(0.004)	(0.013)
MP price	β_6	0.004	0.001	-0.001
		(0.028)	(0.006)	(0.010)
Sulphur price	β_7	0.002	-0.056**	-0.002
		(0.012)	(0.020)	(0.011)
Manure price	β_8	0.461	-0.036	-0.090**
		(0.710)	(0.020)	(0.026)
Pesticide price	β_9	-2.842**	0.456	0.009
		(0.581)	(0.662)	(0.010)
Land rent	β_{10}	0.408	-0.520	0.012
		(0.705)	(0.750)	(0.022)
Dummy for land type (1 = MHL, 0 = otherwise)	β_{11}	2.821**	-0.270**	-0.261**
		(0.576)	(0.037)	(0.083)
Dummy for transplanting date (1 = optimum, 0 = otherwise)	β_{12}	-2.821**	-0.008	-0.236*
		(0.576)	(0.037)	(0.112)
Dummy for variety (1 = Binasail, 0 = otherwise)	β_{13}	-0.008**	0.019	0.278**
		(0.034)	(0.036)	(0.109)
Inefficiency effect model:				
Constant	δ_0	-0.094	0.040	0.542**
		(0.998)	(0.179)	(0.197)
Farm size	δ_1	0.231	0.002*	0.001
		(0.997)	(0.001)	(0.001)
Farmers age	δ_2	-0.383*	-0.002*	0.005
		(0.191)	(0.001)	(0.005)
Farmers education	δ_3	-0.374	0.001	-0.015
		(0.989)	(0.004)	(0.022)
Farmers occupation	δ_4	-0.003	-0.101	-0.162
		(0.030)	(0.057)	(0.146)
Farmers experience	δ_5	-0.032	0.004	-0.004
		(0.090)	(0.003)	(0.006)
Household size	δ_6	-0.513	-0.014	-0.019
		(0.887)	(0.008)	(0.020)
Dummy for extension contact (1=Yes, 0= otherwise)	δ_7	-0.350	-0.234**	-0.183*
		(0.997)	(0.053)	(0.089)
Dummy for rice training (1=Yes, 0= otherwise)	δ_8	0.076	0.048	-0.303*
		(0.116)	(0.046)	(0.125)
Variance parameters				
Sigma squared	σ^2	0.621	0.515**	0.520**
		(0.503)	(0.003)	(0.006)
Gamma	γ	0.986**	0.600	0.999**
		(0.006)	(0.366)	(0.013)
Log likelihood function		-10.937	92.395	44.445

** and * indicate significant at 1 percent and 5 percent level of probability, respectively.
Figures in the parenthesis indicate standard error

Conclusion:

It was found that the sampled farmers started Binadhan-7 cultivation during last two years as well as the areas under its cultivation increasing in the study areas.

Participatory Variety Selection (PVS) for Stress (salinity, submergence, drought etc.) Tolerant Crop Varieties/Mutant Lines (Collaboration with Plant Breeding & Biotechnology Divisions)

The study was conducted on the basis of these objectives; to identify the best variety/mutant line; to assess the acceptability of crop varieties/mutant lines; to identify the consumers preference (cooking quality, grain shape-size, aroma, tastiness etc); to determine the economic constraints of the worst varieties/mutant lines

Activity 1. Evaluation of Promising Salt-Tolerant germplasm in Multi-location Trials and with Farmers (Mother Trials)

In Labanchara of Khulna nine rice lines with one salt tolerant check variety (Binadhan-8), RCBD with 3 replications was considered for the study. From table 10, Binadhan-8 achieved the highest vote and line P19S8 scored the second highest vote. Binadhan-8 provided the highest yield (4.53 t ha^{-1}), but the yield of line P19S8 was not satisfactory, though the farmers preference was high. Farmer's preference was based on the characters of Good yield, salt tolerant, long panicle, more number of tillers in a hill, attractive color of grain, fine grain etc

Table 10. Preference analysis of Mother trial of salt tolerant lines/germplasms at, Labanchara, Khulna during T. aman, November 17, 2011, Stress: Salinity

Entry		Total farmers (n = 30)		Preference score	Yield (t ha^{-1})
Code	Name	Positive	Negative		
PVS1	P27S5	0	29	-0.242	1.99
PVS2	P36S5	0	26	-0.217	1.45
PVS3	P25S1	0	1	-0.008	2.54
PVS4	P1L3	0	3	-0.025	2.72
PVS5	P29S7	0	1	-0.008	3.08
PVS6	P1L2	0	0	0.000	3.63
PVS7	P24L2	3	0	0.025	3.99
PVS8	P1L3	0	0	0.000	1.27
PVS9	Binadhan-8	29	0	0.242	4.53
PVS10	P19S8	28	0	0.233	2.72

Male (n = 19), Female (n = 11) and Researcher (n = 2)

Table 11. Correlation analysis of Mother trial of salt tolerant lines/germplasms at, Labanchara, Khulna during T. Aman, 2011

Variables	Correlation	Significance level of probability
Male and female farmers	r = 0.99 ***	significant at 1%
Farmers and researchers	r = 0.95 ***	significant at 1%
Farmers and yields	r = 0.62 *	significant at 10%

Table 12 shows that Check variety Binadhan-8 performed well with highest yield (2.08 t ha^{-1}) and got all 30 positive votes from farmers. Two lines P25S1 and P24L2 drew almost similar number of farmer's attention at Kaligonj

Table 12. Preference analysis of Mother trial of salt tolerant lines/germplasms at Kaligonj, Satkhira during T. aman November 13, 2011, Stress: Salinity

Entry		Total Farmers (n = 30)		Preference score	Yield (t ha^{-1})
Code	Name	Positive	Negative		
PVS1	P27S5	0	21	-0.175	0.33
PVS11	Binadhan-8	30	0	0.250	2.08

Table 13. Correlation analysis of Mother trial of salt tolerant lines/germplasm at Kaligonj, Satkhira, Bangladesh during T. aman, 2011

Variables	Correlation	Significance level of probability
Male and female farmers	r = 0.79 ***	Significant at 1%
Farmers and researchers	r = 0.71 **	Significant at 5%
Farmers and yields	r = 0.68 **	Significant at 5%

It was observed from table-14 that Check variety Binadhan-8 exhibited its superior performance also at Shyamnagor. Got all 30 positive votes along with the highest 5.0 t ha^{-1} yield. In terms of farmer's preference, line P24L2 was the 2nd best among the tested entries.

Table 14. Preference analysis of mother trial of salt tolerant lines/germplasms at, Shyamnagar, Satkhira during T. aman 2011, November 10, 2011, Stress: Salinity

Entry		Total farmers (n = 30)		Preference score	Yield (t ha^{-1})
Code	Name	Positive	Negative		
PVS1	P27S5	0	22	-0.183	0.48
PVS11	Binadhan-8	30	0	0.250	5.00

Male (n = 20), Female (n = 10) and Researcher (n = 1)

Table 15. Correlation analysis of Mother trial of salt tolerant lines/germplasms at Shyamnagar, Satkhira during during T. aman, 2011

Variables	Correlation	Significance level of probability
Male and female farmers	r = 0.87 ***	Significant at 1%
Farmers and researchers	r = 0.80 ***	Significant at 1%
Farmers and yields	r = 0.77***	Significant at 1%

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