BRRI ANNUAL REPORT
2011-2012

Bangladesh Rice Research Institute

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Plant Breeding Division

SUMMARY

Out of 360 crosses 272 were confirmed. In total 5,724 plants were selected from F_2 populations. From segregating generations 15,709 progenies and 855 fixed lines were selected. A total of 662 advanced lines were selected from observational and yield trials. The genotype OM1490 was selected for proposed variety trial from ALART in upland Aus rice. National seed board (NSB) approved the technical committee recommendation to release BRRI dhan29-SC3-28-16-4-HR2 as BRRI dhan58 for Boro season. In farmer's field condition, this variety yielded 7.5 t/ha with growth duration of 150-155 days in Boro season. BRRI dhan58 showed grain yield similar to that of BRRI dhan29, but it matured three to six days earlier. Field evaluation technical committee evaluated two promising salt tolerant lines in six locations and genotype BR7105-4R-2 produced the highest yield (6.3 t/ha) followed by BRRI dhan47 (6.2 t/ha), IR72579-B-3-2-3-3 (5.0 t/ha) and BRRI dhan28 (4.6 t/ha). The grain type of BR7105-4R-2 was slender and IR72579-B-3-2-3-3 was medium bold and both were non-shattering type. These two genotypes were moved to variety release system as salt tolerant variety for Boro season. Field evaluations of BR7323-4B-1 and BW328 have been completed during Boro 2011-12 in PVT trials at seven locations of Bangladesh. BR7323-4B-1 yielded 0.8 t/ha and BW328 yielded 0.6 t/ha higher than BRRI dhan28 but none of them exceeded BRRI dhan29. However, both the lines matured one week later than BRRI dhan28. In Boro season, BR7840-54-1-2-5 showing 6.4 t/ha and 149 days growth duration was recommended for evaluation in proposed variety trial as Zn enriched line. Field evaluation of BR7517-2R-27-3 has been completed during T. Aman 2011-12 in PVT trials at seven locations of Bangladesh. BR7517-2R-27-3 yielded (3.6 t/ha) similar to BRRI dhan33 (3.7 t//ha) but matured 11 days earlier. BINA dhan7 yielded 0.4 t/ha higher than BR7517-2R-27-3 but matured 18 days later. Also, it has long slender grain with intermediate Zn content (20 ppm) in polished grain. Through marker assisted breeding introgression of *Sub1* QTL into BRRI dhan33, BRRI dhan44 and BRRI dhan49 have been advanced up to BC_4F_1 generation. Four Bangladeshi landraces viz Kalojoma, DG1-349, Putidepa, and Damshi were identified as new sources of submergence tolerances having other than *Sub1* QTLs and development of mapping population has been initiated. Developments of rice varieties with abiotic and biotic stress tolerance along with nutritional quality were emphasized.

VARIETAL DEVELOPMENT

Upland Aus rice. Thrust has been given to develop varieties in combination of multiple traits viz quick seedling emergence; tolerance to lodging and drought; medium-bold to long slender grains and good grain quality suitable for direct dry seeded Aus areas of Bangladesh. In total, 10 crosses were confirmed and 172 progenies were selected from F_3 to F_5 generations. Forty-seven advanced lines were selected from OT, PYT, SYT and RYT. OM1490 were selected for proposed variety trial from ALART.

Transplant Aus rice. The main objective of the project was to develop short duration and high yield potential genotypes in combination with tolerance to lodging, high temperature and pre-harvest sprouting along with good grain quality. A total of 12 crosses were made, 13 crosses were confirmed and 566 progenies were selected from F_2 generation. The genotype BR7718-55-1-3 (4.51 t/ha) and BR7708-24-2-1 (4.35 t/ha) were selected for further yield evaluation.

Shallow flood tolerant rice. This project was aimed to develop genotypes in combination with slow elongation, high yield and submergence tolerance for shallow deepwater sub ecosystem (0.5-1.0 m water depth). Four crosses were made, 8 F_2, 6 BC_1F_4, 4 F_5 crosses were bulked for further generation advancement. One F_7 and 9 F_8 populations were bulked for observational yield trial. In SYT, IR64077-R-3-B-R-17-2-2 produced the highest yield (3.3 t/ha), which was around one ton higher than the check varieties.

Rainfed lowland rice (RLR). Development of varieties for rainfed lowland environments with emphasis on earliness, good grain quality and yield potential was the main objective of the project. Fifteen crosses were made, four crosses were confirmed, 279 plants from F_2 populations, 2,175 progenies and 111 fixed lines from F_3-F_6 generations, 12 genotypes from OT, 17 genotypes from two PYT, nine entries from SYT were selected.

Non-saline tidal submergence tolerance rice. Efforts have been made to develop high yielding varieties adaptable to non-saline tidal submergence condition in southern districts. A total of 12 crosses were made, 397 progenies and 22 fixed lines were selected from F_4 and F_5 generations. From 186 entries grown in OT, plants were selected from each entry due to lack of homogeneity. Nineteen entries with tall seedling height were tested, out of six were selected for further evaluation.

Salt tolerant rice. This programme emphasizes on the development of salt tolerant varieties suitable for the saline prone areas of coastal districts in Aman and Boro season. A total of 22 crosses in T. Aman and 33 crosses in Boro were made. Fifty-one F_1s in T. Aman and 29 in Boro season were confirmed. Thirty bulk progenies in T. Aman and 107 progenies in Boro were selected from F_2 populations. A total of 435 progenies and 5 genetically fixed lines in T. Aman season while 545 progenies and 18 fixed lines in Boro were selected from pedigree nurseries. Ten advanced lines from T. Aman and 12 from Boro season were selected from OT and eight entries were selected from PYTs. Three entries (BR7100-R-6-6, IR78794-B-Sat 29-1 and IR59418-7B-21-3) from RYT were selected in Boro season. In participatory variety selection (PVS) trials farmers preferred three lines BR7216-2B-26-2, IR84649-120-8-1-B and BRRI dhan54 in T. Aman season and the average yield advantage was 0.5 t/ha. Four genotypes viz BR7100-R-6-6, IR78794-B-Sat 29-1, BRRI dhan28-Saltol and IR59418-7B-21-3 were selected by the farmers in Boro season, which showed consistency with the yield performance. In addition, varietal trials were conducted during T. Aman season at three polders sites (Polder 3, Polder 30 and Polder 43/F/2), with different degree of salinity levels. Polder 3 represents high saline zone, polder 30 is the medium and Polder 43/2/F has low level of salinity. Farmers did not cultivated modern rice varieties in these areas due to lack of adaptable rice varieties in T. Aman having stagnation tolerance, non-photoperiod and photoperiod sensitivity and short duration (Polder 30 and 43/2/F), and for bold grain (Polder 43/2/F). Introduction of adaptable modern varieties like BRRI dhan53 and BRRI dhan54 in polder 43/2/F was the first adoption of HYVs in this area. Well adapted suitable varieties (BRRI dhan41 and BRRI dhan54) for polder 3 were selected which will fit best into rice-shrimp system. Information disseminating about varietal performance and acceptability through farmer participatory varietal selection (PVS) is also helpful for rapid varietal diffusion and popularization.

The technical committee of the NSB team evaluated three promising lines in six locations and genotype BR7105-4R-2 produced highest yield (6.3 t/ha) followed by BRRI dhan47 (6.2 t/ha), IR72579-B-3-2-3-3 (5.0 t/ha) and BRRI dhan28 (4.6 t/ha) (Table 1). The grain type of BR7105-4R-2 was slender and IR72579-B-3-2-3-3 was medium bold while both are non-shattering type. The previous salt tolerant Boro variety, BRRI dhan47 had bold type of grain with some shattering tendency, which were the causes of limited adoption. However, these two promising lines will be adopted by farmers quickly specially in Khulna and Satkhira region. These two genotypes were moved to variety release system as salt tolerant variety for Boro season.

Premium quality rice. This project was aimed to develop fine quality rice varieties with or without aroma for national consumption and export. Out of 49 crosses, 27 were confirmed. In total 1,079 and 363 progenies from F_2 populations were selected and 3,413 progenies plus 227 fixed lines and 1,163 progenies plus 100 fixed lines were selected from pedigree nursery in T. Aman and Boro seasons respectively. Five entries from OT, five genotypes from PYT, five genotypes were selected from SYT in T. Aman and 52 genotypes from OT, five from PYT, three from SYT and four from RYT were selected in Boro season.

Rice varieties for favourable Boro environment. Efforts have been made to improve genotypes with high yield potential, earliness and

Table 1. Performance of PVT genotypes at different locations, Boro 2010-11.

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)						
			Debhata	Ashasuni*	Paikgacha*	Tarabunia, Nazirpur	Chalitabaria, Nazirpur	Sonagazi	Mean
IR72579-B-3-2-3-3	102	152	5.7	2.5	1.6	5.7	6.5	7.9	5.0
BR7105-4R-2	96	152	6.6	4.9	3.8	6.3	7.1	8.4	6.3
BRRI dhan28	111	148	5.8	1.5	0.0	6.5	6.0	7.6	4.6
BRRI dhan47	102	152	6.2	4.6	3.2	7.3	8.1	7.9	6.2

*Level of salinity >15 dS/m during transplanting at Ashasuni and Paikgacha.

acceptable grain quality for irrigated areas of Bangladesh. Out of 22 crosses 19 were confirmed. Three hundred fifty-five plants were selected from F_2 populations. Also 1,108 progenies and 21 fixed lines were selected from pedigree generations. Considering growth duration less than or similar to check varieties coupled with at least 0.5 t/ha yield advantage 25 uniformed advanced lines were selected from OT. The genotypes BR7988-3-1-4 and BR7988-10-4-1 showing 0.5 t/ha yield advantage over BRRI dhan55 with similar growth duration were selected for further evaluation in PYT.

NSB approved the technical committee recommendation to release BRRI dhan29-SC3-28-16-4-HR2 as BRRI dhan58 for Boro season. BRRI dhan58 showed grain yield similar to that of BRRI dhan29, but it matured six days earlier. Table 2 show the performances of the variety.

Field evaluations of BR7323-4B-1 and BW328 have been completed during Boro 2011-12 in PVT trials at seven locations of Bangladesh. BR7323-4B-1 yielded 0.8 t/ha and BW328 yielded 0.6 t/ha higher than BRRI dhan28. However, both the lines matured five to seven days later than BRRI dhan28. Table 3 presents the agronomic performances of these lines.

Cold tolerant rice. The aim of this project is to develop high yielding rice varieties tolerant to cold injury by introducing cold tolerant genes**.** Twenty-six crosses were made using Korean Tongil type rice as donor for cold tolerance. One cross was confirmed out of three confirmed as true F_1. A total of 304 individual plants were selected from 10 crosses of F_2 population subject to natural cold temperature following standard protocol for screening against cold under natural chilling temperature. Also, 356 individual plants from different generations were selected for advancing generation. Considering growth duration, plant height and yield advantage over check varieties, five superior lines yielding 5.6 to 8.6 t/ha were selected for further evaluation. A set of materials viz Pungsan, Namcheon, Madlai, Dholi Boro and Khaia Boro have been identified as promising cold tolerant genotypes considering different selection criteria such as seedling emergence, leaf discolouration score at both seedbed and main field, heading date difference between Rangpur and Gazipur, culm length, panicle exertion, spikelet sterility and grain yield through BRRI-KOICA collaborative research. A screening protocol for cold tolerance at seedling stage has been developed and standardized through this research. Rice genotypes can be effectively discriminated by leaf discolouration with 13°C cold water treatment for six days. BR18, BR26 and BRRI dhan27 have been identified as tolerant and BR1 as most susceptible BRRI varieties at 13°C cold stress at seedling stage. BR18 was found very stable in cold stress in this study. Two BRRI varieties (BR5, BR18) and 24 genotypes from IRTON were found tolerant to

Table 2. Yield Performance of the BRRI dhan58 in the different locations of Bangladesh, Boro 2010-11.

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)								
			Gazipur	Comilla	Mymensingh	Habiganj	Jessore	Bhanga	Rangpur	Rajshahi	Mean
BRRI dhan58	108	161	7.17	8.22	8.54	8.07	8.94	7.11	6.76	7.38	7.8
BRRI dhan28 (ck)	112	153	7.32	6.11	6.71	7.6	7.11	5.83	6.46	5.74	6.6
BRRI dhan29 (ck)	116	167	7.27	8.43	6.70	8.6	9.56	7.70	7.51	5.80	7.7

Table 3. Performance of PVT genotypes at different locations, Boro 2010-11.

Designation	Plant ht cm)	Growth duration (day)	Yield (t/ha)							
			Gazipur	Bhanga	Kushtia	Rangpur	Comilla	Habiganj	Rajshahi	Mean
BR7323-4B-1	98	151	6.4	8.3	6.9	8.3	6.2	8.2	6.7	7.3
BW328	83	153	6.3	7.4	7.0	7.5	7.3	8.4	6.0	7.1
BRRI dhan28 (ck)	102	146	5.7	6.5	6.6	6.8	5.9	7.2	6.6	6.5
BRRI dhan 29 (ck)	101	164	6.9	9.1	7.4	7.9	8.3	10.4	8.0	8.3

cold stress at seedling stage in the mass scale screening of 240 genotypes. IRTON materials are mostly temperate japonica type, thus these genotypes are not suitable for direct use but as the donor they can be included in the breeding programme for cold tolerance. Another 27 BRRI varieties/lines particularly the advanced breeding lines and nine Korean varieties showing 4-5 score (moderately tolerant) were selected for direct use after necessary agronomic evaluation.

Low amylose rice. Development of high yielding indica rice variety with low amylose content for domestic use particularly for ethnic people and export is the main thrust of this project. A total of 333 individual progenies comprising 26 from F_3, 79 from F_4 and 228 from F_5 generation were selected.

Micronutrient enriched rice. Efforts have been made to develop high yielding rice varieties with high iron and zinc content to improve nutritional quality of rice. Thirty-one single crosses, 24 backcrosses were made in T. Aman season and nine crosses were made in Boro season. Thirty-seven crosses in T. Aman and four crosses in Boro were confirmed as true F_1. Six hundred forty-six superior progenies were selected from 27 F_2 populations. Also, 2,791 individual plants were selected from F_3 and advanced generations based on phenotypic performance in T. Aman and Boro seasons. Additionally, bulk selection was performed from 19 F_2 and F_3 populations due to small population size. Four hundred ninety-two uniform progeny rows were bulked from F_5-advanced generations. In T. Aman season, 30 uniform genotypes having Zn content more than 24 ppm (target amount) and another 28 uniform genotypes having intermediate Zn content (20-<24 ppm) in brown rice were selected based on initial performance over the check varieties. One hundred nineteen uniform genotypes producing at least 0.5 t/ha higher yield coupled with growth duration similar or less than the check varieties were selected for XRF analysis for Zn content followed by evaluation in PYT. From PYT, 11 entries in T. Aman and 10 entries in Boro season showing significant yield advantage over the check varieties were selected. Four entries from SYT and three entries from RYT were selected for evaluation in Boro season. BR7840-54-1-2-5 showing 6.4 t/ha and 149 days growth duration was recommended for evaluation in proposed variety trial. Field evaluation of BR7517-2R-27-3 has been completed during T. Aman 2011-12 in PVT trials at seven locations of Bangladesh. BR7517-2R-27-3 yielded (3.6 t/ha) similar to BRRI dhan33 (3.7 t//ha) but matured 11 days earlier. BINA dhan7 yielded 0.4 t/ha higher than BR7517-2R-27-3 but matured 18 days later. Also, it has long slender grain with intermediate Zn content (20 ppm) in polished grain. In the T. Aman-Potato-Boro or T. Aman-Mustard-Boro cropping pattern short duration material like BR7517-2R-27-3 (100 days) would be best fitted for increasing total farm productivity. Table 4 presents the agronomic performances of these lines.

Disease resistant rice. The objectives of the project were to develop varieties for resistance to BB, blast, RTV and ufra diseases. Eleven crosses for BB and three crosses for blast in T. Aman and two backcrosses for BB in Boro season were made. Two crosses for BB, four for blast, three for RTV and one for bakane in T. Aman and two crosses in Boro season were confirmed as true F_1. One hundred seven and 272 superior progenies were selected from F_2 population in T. Aman and Boro season respectively. Five hundred twenty-five superior progenies from three F_3-F_7 generations were selected for BB, Blast and RTV. A total of 24 uniform lines showing better agronomic performance over the check varieties were selected from OT. Two

Table 4. Agronomic performance of the materials evaluated in PVT, micronutrient enriched rice, T. Aman 2011-12.

Designation	Gazipur	Rangpur	Lalmonirhat	Dinajpur	Jessore	Rajshahi	Bogra	Mean
			Growth duration (day)					
BR7517-2R-27-3	110	101	98	96	104	106	101	102
BRRI dhan33(ck)	115	112	110	109	114	122	111	113
BINA dhan7 (ck)	120	-	-	-		-	-	120
			Plant height (cm)					
BR7517-2R-27-3	98.2	103	107	103	-	-	102	102.6
BRRI dhan33 (ck)	109.6	114	117	115	-	-	112	112.7
BINA dhan7 (ck)	112.1	-	-	-	-	-	-	112.1
			Yield (t/ha)					
BR7517-2R-27-3	4.17	3.92	3.68	3.48	3.7	3.4	2.86	3.6
BRRI dhan33 (ck)	3.42	3.79	4.10	3.73	4.0	4.1	3.49	3.7
BINA dhan7 (ck)	4.03	-	-				-	4.0

DS: 7-10 July 2011. DT: 30 July-18 Aug 2011.

genotypes, BR7965-2-1-2 and BR7965-19-3-1 showing significantly higher yield coupled with two weeks shorter in growth duration than check variety BR11 were selected from PYT. Two breeding lines for BB and one for RTV were selected from SYT for evaluation in RYT.

Insect resistant rice. Development of varieties resistant to BPH, WBPH and GM were the objectives of this project. Sixteen crosses for T. Aman and 10 crosses for Boro season were made. Four crosses in T. Aman and seven crosses in Boro were confirmed. Five hundred sixty-four (258 in T. Aman and 306 in Boro) progenies from F_2 populations, 824 (692 for BPH and GM in T. Aman season and 132 for BPH and WBPH in Boro season) progenies were selected from F_3-F_5 generation and 40 fixed lines (BPH) were selected in Boro season. Twelve lines from OT and 21 from PYT, five lines from SYT and two from RYT were selected showing resistance to BPH and GM in T. Aman season. Twenty-one lines from OT and 15 from PYT, three lines from SYT and three from RYT were selected showing resistance to BPH in Boro season.

Submergence and water stagnation tolerant rice. The thrust of the project was to develop rice varieties tolerant to submergence (flash flood of 14-21 days) and stagnant flood (SFT-water stagnation from 25-50 cm) in collaboration with IRRI as flash flooding and water stagnation are becoming major constraints in the rainfed lowland rice ecosystem in Bangladesh. In total, 39 crosses were made, 14 were confirmed, and 662 tolerant progenies were selected from F_2 to F_7 and backcross generations, which were grown under controlled submergence and medium stagnant condition. Introgression of *Sub1* QTL into BRRI dhan33, BRRI dhan44 and BRRI dhan49 have been advanced up to BC_4F_1 generation. Importantly, four Bangladeshi landraces viz Kalojoma, DG1-349, Putidepa, and Damshi were identified as new sources of submergence tolerance having other than *Sub1* QTLs and development of mapping population has been initiated.

Drought tolerant rice. In total 27 crosses were made and five were confirmed. Two hundred sixty-four progenies were selected from F_2 populations, 60 lines were selected from OYT and 27 lines were selected from AYT in T. Aman season. Three IR64 (NILS) genotypes were also selected and three donors were isolated as drought tolerant. In Boro season five crosses were confirmed, 43 genotypes were selected from pedigree nursery and 29 genotypes were selected from AYTs based on yield under reproductive stage stress condition.

INGER (International network for genetic evaluation of rice). This programme focuses on evaluation of germplasm from diverse origin into the local growing conditions for direct use as variety and/or use as parents in the breeding programme. A total of 76 germplasms from ten nursery sets were selected for using in the breeding programme.

Rice varieties/breeding lines for low water availability in South and South-east Asia (IRRI-UKM-BRRI). Development and identification of genotypes/varieties of irrigated ecosystem by utilizing minimum water with maximum output was the main objective of the project. A total of 76 progenies were selected from F_7 generations and eight genotypes were selected from RYT and AYT.

Green super rice (GSR). The aim of this project is to develop high yield potential rice varieties (inbred and hybrid) with less input. Eight genotypes from OT, 11 from SYT and four from RYT were selected in T. Aman season, while 14 genotypes from OT and 10 from SYT were selected in Boro season. Almost all the tested entries were found short duration. IR83140-B-11-B, IR83142-B-7-B-B, HUA565, ZHONGZU14 along with weed tolerant rice (WTR) were selected for further evaluation in SYT. The genotypes IR83142-B-19-B (3.4 t/ha), IR83140-B-28-B (3.7 t/ha), HHZ11-Y11-Y3-DT1 (3.5 t/ha) and ZX117 (3.4 t/ha) were selected for further yield evaluation.

Evaluation of exotic NERICA genotypes. Evaluation of yield and other agronomic characters of the genotypes were carried under field condition in T. Aman and Boro season. In T. Aman 2011, 13 genotypes were selected from 18 genotypes and in Boro all the genotypes were selected for further evaluation. NERICA genotypes were found as more or less homogeneous.

Pyramiding bacterial blight resistant genes into the genetic background of BR11-derived submergence tolerant rice lines (NATP, ID-179). Development of rice varieties with tolerance to submergence and resistance to bacterial blight through introgression of two bacterial blight resistant genes (*Xa21 and Xa13*) into BRRI dhan52 is the thrust of this project. Totally 307 primers were surveyed and 71 primers were found polymorphic between BRRI dhan52 and IRBB60. Seven plants were selected containing *Xa21* gene using the marker Xa21. A total of 938 BC_3F_1 seeds were produced. In BC_3F_1 generation, only one plant was obtained with heterozygous alleles for both Xa21, gene-based marker for *Xa21* and ART5, gene-based marker for *Sub1* QTL (promoter region of *Sub1*C) markers and the plant possessed 15 heterozygous background markers. Hundred BC_4F_1 seeds were produced from the best plant. In another approach two best plants from BC_1F_1 generation were selected with 26 (Plant no. 78 and 90) heterozygous alleles. Total number of BC_2F_1 seeds produced was 95 and 55 respectively, from the plant numbers 78 and 90.

Rice varieties with enhanced submergence tolerance through marker assisted breeding (BAS submergence project). Development of rice varieties with tolerance to submergence through introgression of *Sub1* QTL into BRRI dhan33. Totally 47 BC_5F_1 seeds were produced from selected BC_4F_1 plants where *Sub1* QTL was found in heterozygous state. Again around 1,200 BC_4F_2 seeds were produced from a BC_4F_1 plant where *Sub1* QTL was in homozygous condition. In another effort totally 323 BC_1F_1 seeds of BRRI dhan33/Ciherang-*Sub1* and BRRI dhan33/IR64-*Sub1* cross combinations were produced**.**

Varieties for tidal salinity and submergence prone areas. To develop a variety having tolerance to salinity and submergence for salt affected tidal areas of Bangladesh is the aim of this project. A total of 24 crosses and all crosses were confirmed. Six hundred seventy progenies were selected from F_2 populations. Ten BC_2F_1 crosses had been made and two crosses were used for marker assisted selection. Six fixed lines were selected from OT. The genotypes IR84645-312-11-1-B and IR84645-311-5-1-1-B were selected based on their yield performance and intermediate tall plant height for their adaptation in tidal flooding conditions.

Arsenic (As) tolerant rice. Efforts have been made to develop high yielding rice varieties tolerant to arsenic/reduced uptake in grain. Fourteen crosses using BRRI dhan47, BRRI dhan54 and weed tolerant rice (WTR1) as donor for arsenic tolerance were made. Seven crosses were confirmed in Boro season. Genotypic response to high arsenic level in soil and irrigation water based on significant threshold level of difference in performance among different agronomic traits over the arsenic prone and arsenic free site showed that BRRI dhan47 and JEFERSON had potential to provide stable performance in highly arsenic contaminated soils. JEFERSON and JING185-7 along with previously reported BRRI dhan47 showed tolerance to 60 ppm soil arsenic. On the other hand, BRRI dhan29, HUA564 and HUA565 were found as most susceptible genotypes to increased level of arsenic in soil.

Biotechnology Division

SUMMARY

The broad objectives of the BRRI Biotechnology Division are development of modern rice varieties through different biotechnological techniques, molecular characterization of important rice genotypes and carry out basic or upstream research pertinent to the development of improved variety. This division conducted 13 experiments under four projects. Twenty-seven plantlets were regenerated from BRRI dhan29 after transformed with *GlyI* and *GlyII*. Five putative transformants were confirmed by GUS test. In gene pyramiding of bacterial blight study, molecular screening was done on 20 BC_5F_1 progenies of BRRI dhan28*6/IRBB60 and three plants were selected having two BB resistant genes (*xa13* and *Xa21*). One plant showed resistance compared to resistant check. Three plants were also selected from BRRI dhan29*6/IRBB60 cross having only *Xa21* genes and one of them showed resistance compared to susceptible checks. Twenty-eight molecular markers were used to determine the inheritance pattern of yield enhancing QTLs in 238 individuals of BRRI dhan28/*Oryza rufipogon* (Ac. no.105890). Thirty-five molecular markers were used in F_2 population of BRRI dhan29/IR4630-22-2-5-1-3 to identify QTLs for salinity tolerance at both seedling and reproductive stages. A total of 127 Bangladeshi Aus genotypes (12 BRRI released and 115 landraces) were screened against 76 SSR markers and grouped into six clusters. All the BRRI developed modern Aus varieties were grouped in the same cluster. In *Sub-1* gene introgression into BRRI dhan44, background selection was carried out in BC_4F_1 generation of BRRI dhan44/BRRI dhan52 with 31 SSR markers. Out of 31 markers tested, 24 were homozygous for recipient parent. Twelve plants were regenerated from anther culture of BRRI dhan29/FL378 cross combination. A total of 189 plants were regenerated from seed culture of BRRI dhan47. Among them seeds were harvested from 20 plants. In T. Aman 2011, 204 plants were selected. In Boro 2011-12, 94 plants were selected and 70 homozygous lines were bulked. All the selected materials will be evaluated in the following season under respective trials. Twelve apparently superior genotypes were selected from observational trial for further evaluation.

DEVELOPMENT OF RICE VARIETY THROUGH TISSUE CULTURE

Thirteen F_1 populations (Table 1) were grown in the net house for developing salt tolerant line through anther culture. For callus induction, anthers were incubated into two different media (KA and M10) media. The highest number (16) of calli was obtained from hybrid anthers of BRRI dhan29 × FL378. Calli obtained from all F_1 populations were transferred to regeneration medium and only 12 green plants were regenerated (Table 1).

To generate somaclonal variants for reducing shattering loss of BRRI dhan47, seeds of BRRI dhan47 were sterilized and placed into callus induction medium (CIM) containing MS basal salts (Murashige and Skoog) with 2.0 mgl^{-1} of 2,4-dichlorophenoxy acetic acid (2,4-D) and sucrose (30 gl^{-1}). The percentage of callus induction was found 71% (Table 2). Calli were transferred into different regeneration media (T_1: 2 mg/L BAP, 1 mg/L NAA and 1 mg/L Kinetin; T_2: 1 mg BAP and 0.5 mg/L NAA; T_3: 5 mg/L BAP and 1 mg/L NAA and T_4: 1 mg/L NAA and 1 mg/L Kinetin). The highest number of plants was obtained from T_1 regeneration medium followed by T_2, T_3 and T_4 (Table 3). Among the 189 regenerated plantlets 50 plants were survived and seeds were collected from 20 plants. Rest of the plants did not produce any seeds. These seed will be used for further evaluation.

FIELD PERFORMANCE OF TISSUE CULTURE DERIVED LINES

Progeny selection was carried out to select the best progenies having high yield and salinity tolerance. A total of 208 lines were grown in T. Aman 2011 and 146 lines were grown in Boro 2011-12. In T. Aman 2011, 204 plants were selected. From Boro 2011-12, 94 plants were selected and 70 homozygous lines were bulked from pedigree lines.

Table 1. Callus induction and regeneration of hybrid anther of 12 crosses.

Cross	Anthers plated (no.)	Calli obtained (no.)	Regenerated plantlet (no.)	
			Green plantlet	Albino plantlet
BRRI dhan28 × FL478	3510	3	-	-
BRRI dhan49 × FL378	1640	-	-	-
BRRI dhan28 × BRRI dhan47	1920	-	-	-
BRRI dhan29 × FL478	3850	3	-	-
BRRI dhan29 × FL378	4680	16	12	-
BR11 × FL378	1380	-	-	-
BRRI dhan49× IR4630	1565	-	-	-
BR3 × IR4630	1490	-	-	-
BRRI dhan52 × FL478	1200	4	-	-
BRRI dhan52 × FL378	1680	1	-	-
BR3 × FL378	900	-	-	-
BRRI dhan50 × FL478	1500	-	-	-
Total	25315	25	12	-

Table 2. Percent callus induction of BRRI dhan47.

BRRI dhan47 (400 seeds/each batch)	Callus (no.)	% callus
Batch 1	245	61
Batch 2	261	65
Batch 3	282	70
Batch 4	278	69
Batch 5	277	69
Batch 6	322	81
Average	278	70

All the selected materials will be evaluated in the following season under respective trials.

Observational trials were carried out to select agronomically desirable and high yield potential tissue culture derived materials. A total of seven advanced breeding materials were grown in T. Aman 2011 season with three standard checks viz BRRI dhan40, BRRI dhan41 and BRRI dhan49. Thirty-three selected breeding materials from Boro 2010-11 were grown in Boro 2011-12 for observational trials in three replications with different standard checks. In T. Aman 2011, seven advanced breeding materials were grown with three standard checks. Two materials (Table 4) were selected depending on the growth duration and comparable yield with checks. In Boro 2011-12, ten materials were selected from 41 advanced breeding materials depending on the growth duration and comparable yield with checks (Tables 5, 6 and 7).

APPLICATION OF DNA MARKERS

In pyramiding of two BB resistant genes (*xa13* and *Xa21*) in two BRRI developed popular Boro varieties, IRBB60 was used as donor plant and BRRI dhan28 and BRRI dhan29 were used as a recurrent parent. The rice plants were inoculated with BB causal agent at booting stage using clipping method. In T. Aman 2011, molecular screening was done on BC_4F_1 progenies of BRRI dhan28*5/IRBB60 and four plant were selected

Table 3. Regeneration of BRRI dhan47.

Batch no.	T_1		T_2		T_3		T_4	
	Calli (no.)	Regenerated plant (no.)	Calli (no.)	Regenerated plant (no.)	Calli (no.)	Regenerated plant (no.)	Calli (no.)	Regenerated plant (no.)
Batch 1	35	14	35	13	35	9	35	4
Batch 2	35	13	35	12	35	5	35	6
Batch 3	35	19	35	16	35	8	35	4
Batch 4	35	11	35	10	-	-	-	-
Batch 5	35	12	35	11	-	-	-	-
Batch 6	35	10	35	12	-	-	-	-
Total	210	79	210	74	105	22	105	14
% regeneration		38%		35%		21%		13%

Table 4. Agronomic characteristics of selected anther culture derived materials tested as observation trial, T. Aman 2011.

Designation	Plant ht (cm)	Duration (day)	Yield (t/ha)
BR7784-2B-3	119	134	4.77*
BR7784-2B- 6	115	133	4.69*
BR8083-2B-30	118	134	4.45
BR8021-4-2-1-1	125	134	4.33
BR8033-2-2-1-2	122	132	4.50
BR8033-2-2-1-3	131	131	4.03
BR8009-1B-15-1-3	121	131	4.13
BRRI dhan40 (ck)	110	143	4.89
BRRI dhan41 (ck)	115	145	4.56
BRRI dhan54 (ck)	115	138	4.68

*Selected.

Table 5. Agronomic characteristics of selected anther culture derived materials tested as observation trial, Boro 2011-12.

Designation	Observation trial 1		
	Plant ht (cm)	Duration (day)	Yield (t/ha)
BR7783-AC12-3	96	160	5.63*
BR7783-AC13-5	94	162	5.37*
BR7783-AC12-5	94	162	5.43*
BR7783-AC14-5	92	161	5.32*
BR7783-AC15-1	92	161	5.46*
BR4828-54-4-1-4-9-AC3-8-5-64-1-3	104	164	4.48
BR4828-54-4-1-4-9-AC3-8-5-64-3-2	103	164	4.72
BR7783-AC6-3-2-1-5	93	156	5.23
BR7783-AC6-3-2-2-1	95	156	5.34
BR7783-AC6-3-4-3-3-3	105	163	5.16
BR7784-AC22-6-5-2-4	96	161	4.60
BR7784-AC28-6-2-2-3	103	164	4.94
BR7784-AC28-6-2-5-2	103	164	4.97
BR9782-AC	107	156	5.07
BR9783-AC	108	155	4.69
BRRI dhan28 (ck)	97	142	5.25
BRRI dhan29 (ck)	101	164	5.52
BRRI dhan55 (ck)	89	148	6.18

*Selected.

Table 6. Agronomic characteristics of selected anther culture derived materials tested as observation trial, Boro 2011-12.

Designation	Observation trial 2		
	Plant ht (cm)	Duration (day)	Yield (t/ha)
BR9784AC1	62	123	4.41
BR9784AC2	65	122	4.84
BR9784AC3	62	121	4.82
BR9784AC4	62	123	4.67
BR1 (ck)	81	121	5.55
BRRI dhan29 (ck)	101	164	5.91

(Fig. 1). In Boro 2011-12, molecular screening was done on 20 BC_5F_1 progenies of BRRI dhan28*6/IRBB60 and three plants were selected. One plant out of three showed resistance after bacterial inoculation although these three plants having both *xa13* and *Xa21* genes. On the other hand three plants were selected from BRRI dhan29*5/IRBB60 cross having both *xa13* and *Xa21* gene (Fig. 2). Finally 121 BC_5F_1 and 62 BC_6F_1 seeds were harvested and stored from both the crosses for further use.

To identify and introgress high yield QTLs for enhancing grain yield of elite Bangladeshi rice variety, BRRI dhan28 and BRRI dhan29 were used as recurrent parent and *Oryza rufipogon* (Ac. number 103404 and 105890) were used as donor

Table 7. Agronomic characteristics of selected anther culture derived materials tested as observation trial, Boro 2011-12.

Designation	Observation trial 3		
	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BR7783-AC6-3-2-1-6-1	102	151	4.88
BR7783-AC6-3-2-1-6-2	101	156	5.64*
BR7783-AC6-3-2-1-6-3	102	131	5.74*
BR7783-AC6-4-3-1-1-4-1	105	152	4.92
BR7783-AC6-4-3-2-1-1	105	162	4.47
BR7783-AC6-4-3-2-1-2	104	164	4.50
BR7783-AC6-4-3-3-1-1	105	164	4.91
BR7783-AC6-4-3-3-1-2	103	163	4.71
BR7784-AC22-6-1-3-1-1	101	164	4.88
BR7784-AC22-6-1-3-1-2	100	162	4.75
BR7784-AC22-6-1-3-2-1	101	162	2.89
BR7784-AC22-6-1-3-2-2	101	162	4.74
BR7784-AC22-6-1-3-3-1	102	162	4.85
BR7784-AC22-6-1-3-3-2	101	157	5.02
BR7784-AC28-6-2-2-2-1	104	164	5.29
BR7784-AC28-6-2-2-2-2	103	164	5.23
BR7784-AC28-6-2-5-4-1	104	164	5.22
BR7786-1B-2-1-3-3-3	106	156	5.65*
BR7786-1B-2-3-3-1-1	104	164	5.02
BR7786-1B-2-3-3-2	105	160	5.10
BR7786-1B-9-2-2-4-1	111	160	5.47*
BR7786-1B-9-2-3-1-1	103	160	5.55*
BRRI dhan28 (ck)	99	142	5.35
BRRI dhan29(ck)	105	164	5.91
BRRI dhan55(ck)	93	148	6.34

*Selected.

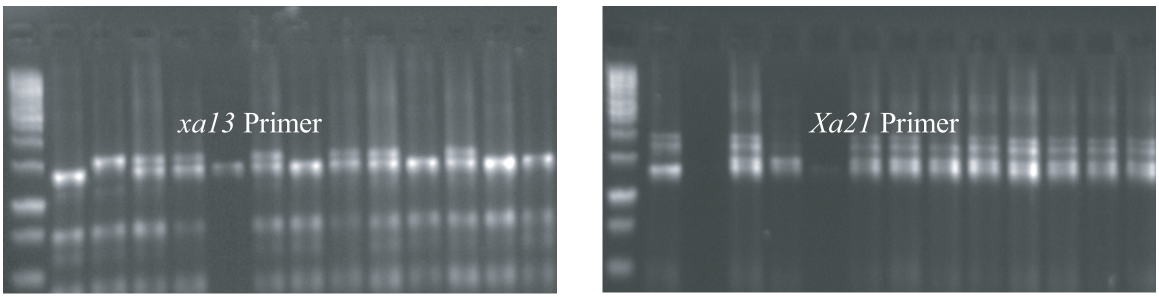


Fig. 1. DNA profile of selected BC_4F_1 progenies of BRRI dhan28*5/IRBB60 crosses.

Legend : 1=BRRI dhan28, 2=IRBB60; **3, 6, 9, 11**=Selected BC_4F_1 progenies of BRRI dhan28*5/IRBB60 cross having *xa13* and *Xa21* genes.

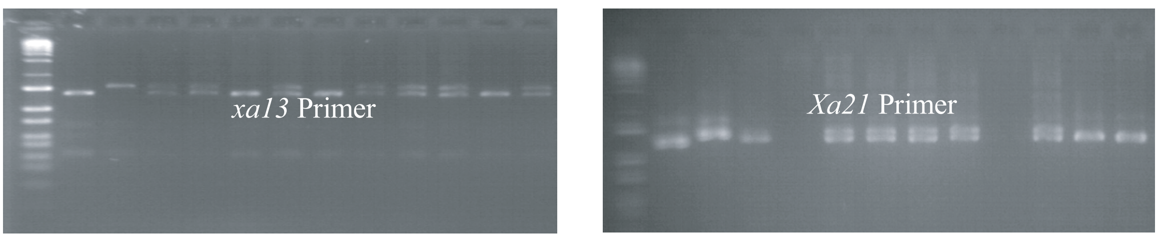


Fig. 2. DNA profile of selected BC_4F_1 progenies of BRRI dhan29*5/IRBB60 crosses.

Legend : 1=BRRI dhan29, 2=IRBB60; **6, 8, 10**=Selected BC_4F_1 progenies of BRRI dhan28*5/IRBB60 cross having *xa13* and *Xa21* genes.

parents. DNA were isolated from two populations consisted of 238 individuals derived from BRRI dhan28/*Oryza rufipogon* (Ac. number 105890) and 210 individuals generated from BRRI dhan28/*Oryza rufipogon* (Ac. number 103404) and their parents. One hundred and eight polymorphic markers were identified. Out of them, 28 molecular markers were used in BRRI dhan28/*Oryza rufipogon* (Ac. number 105890) to get molecular data to see the inheritance pattern of yield enhancing QTLs (Fig. 3). Collection of phenotypic data on yield and other agronomic characters is in progress.

To identify QTLs for salt tolerance at seedling and reproductive stages, 250 F_2 individuals developed from the cross between BRRI dhan29 and IR4630-22-2-5-1-3 were used for phenotyping at reproductive stages. Additionally, 121 F_2 derived F_3 progenies were used to screen against salt tolerance at seedling stage. A total of 250 SSR markers were screened for polymorphic survey between IR4630 and BRRI dhan29 parents and among them 60 were found polymorphic. Out of these, 35 molecular markers were used in BRRI dhan29/IR4630-22-2-5-1-3 to see genetics of QTLs conferring tolerance to salinity at seedling and reproductive stages (Fig. 4). Salinity screening at reproductive and seedling stage were carried out and data on plant height, tiller number, panicle length, spikelet fertility grain yield and biomass (individual plant basis) and overall phenotypic performance were collected. However, this data need to be linked with genotypic data to identify QTL for salt tolerance in the following year.

To make BRRI dhan44 tolerant to submergence for about two weeks through marker assisted backcross breeding, BRRI dhan52 was used as the donor parent for *Sub1* gene and the BRRI dhan44 was used as the recurrent parent. Best plants within the BC_1F_1 population were selected phenotypically. In this way BC_3F_1 population was generated. Seventy-five polymorphic markers were identified between parents. Out of them, 31 SSR markers were used in BC_4F_1 generation for background selection of BRRI dhan44 (Fig. 5). Among 31 markers, four were amplified both alleles of donor and recipient parents and four were amplified allele like donor allele.

A total of 127 (12 BRRI released and 115 landraces) Aus genotypes were screened against 76

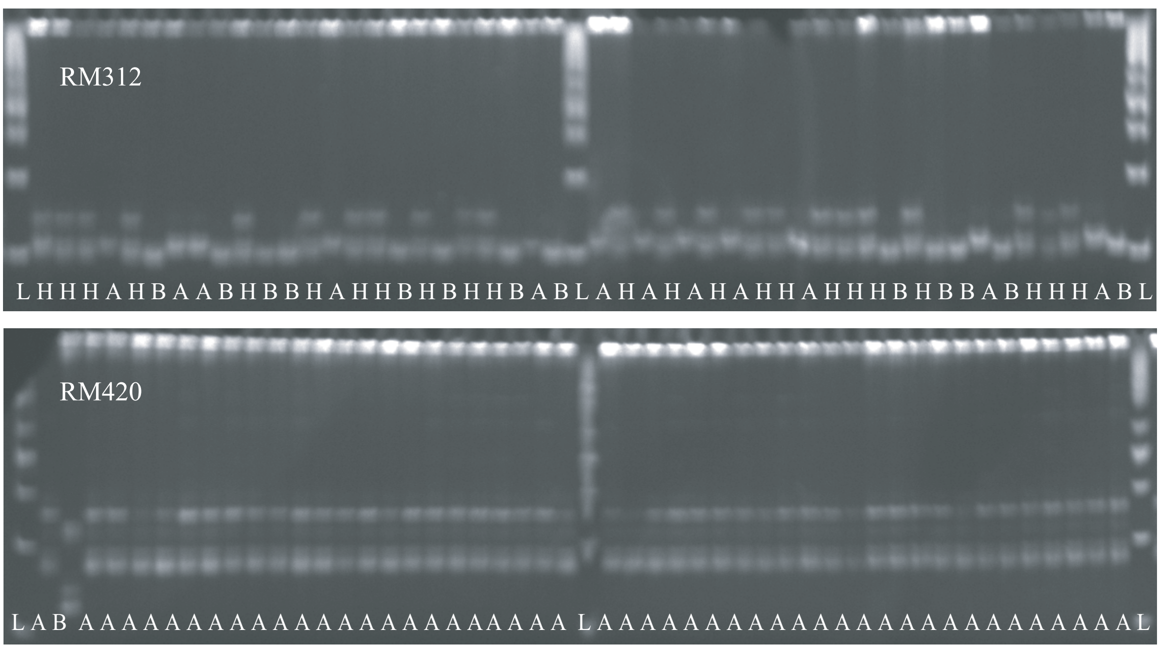


Fig. 3. Partial view of gel picture showing segregation pattern of BC_2F_2 mapping population.
Legend : A=BRRI dhan28, B=*Oryza rufipogon* (Ac. no.105890), H=Heterozygote , L=Ladder.

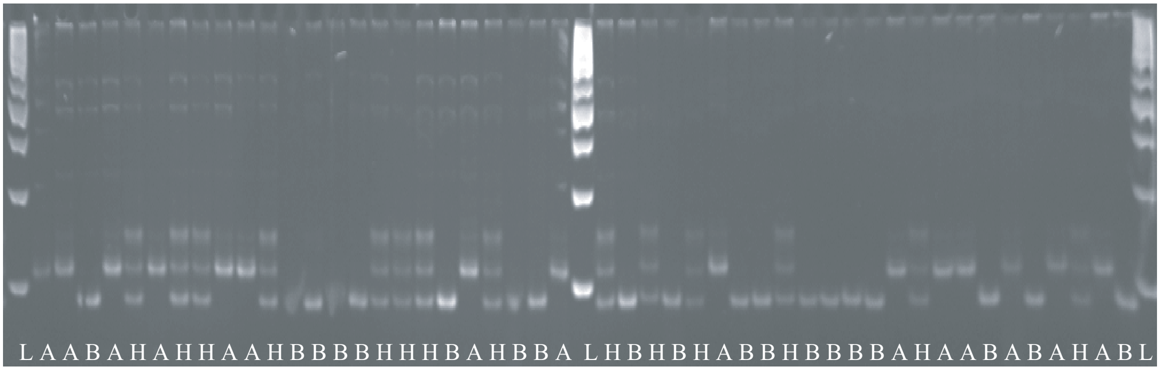


Fig. 4. Partial view of gel picture showing segregation pattern of F_2 mapping population using RM490.

Legend : A=BRRI dhan29, B=IR4630-22-2-5-1-3, H=Heterozygote , L=Ladder.

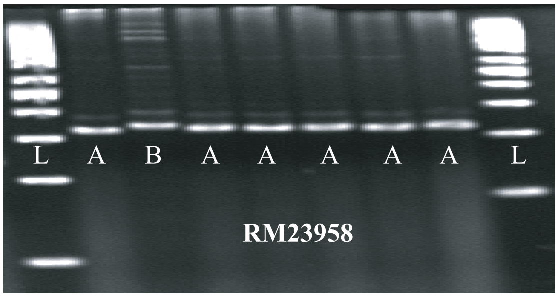


Fig. 5. Background selection of BRRI dhan44 in BC_4F_1 generation.

Legend : A=BRRI dhan44, B=BRRI dhan52.

SSR markers for DNA fingerprinting to assess extent of genetic variation and relationship in traditional and improved varities. Among 76 SSR markers, 54% were found polymorphic possessing 205 alleles. The number of alleles per locus for the polymorphic primers ranged from five (RM237 and RM536) to 25 (RM286), where average allele number was 13. The polymorphism information contents (PIC) lied between 0.510 (RM536) to 0.926 (RM286). Most robust marker was found RM286 (Fig. 6) since it provided the highest PIC value (0.926) (Table 9). Genetic dissimilarity co-efficient was recognized between every two genotypes based on DNA profile (Table 10). The highest genetic dissimilarity (1.000) was found among the Aus genotypes of Benaful, Manik Jor, Moush doll, Holae, Parija, Darial, BR319-1-HR-12, Ranga Moni, Barmulka, Soda, Sail bogi, IR19746-28-2-2, Tapa Sail, Udobali, Zamir Saita, Jamri Saity, BR6, Mi-mandi, Baisamugur, Lakhi lata, Beni-muri, Nordi, BR319-1-HR-12, Koi juri, Noroi, Bar Pa, Balion, Bil Kalae, Balam, Haji sail, Padha Moidu and Malshira. Whereas the lowest genetic dissimilarity was between Kala and Kalo hizli (0.1707) followed by Porangi 7 and Porangi (0.2927) (Table 8). The genetic distance- based results seen in the unrooted neighbour-joining tree (Fig. 7) revealed six clustering groups in the 127 genotypes. The highest number of genotypes grouped in cluster III and the lowest in cluster VI. All the BRRI developed modern Aus variety grouped in cluster VI.

DEVELOPMENT OF TRANSGENIC RICE

BRRI dhan29 and BRRI dhan28 were used for developing salt tolerant rice line through transformation. Calli were infected with *Agrobacterium* containing *GlyI* and *GlyII* gene. Twenty-seven plantlets were regenerated (Fig. 8) from BRRI dhan29 and five putative transformants showed GUS positive through GUS test (Fig. 9). Further confirmation will be done by PCR amplification.

Another study was conducted for developing salt tolerant rice line through transformation using a mangrove gene *AcMDHAR*. In this study BRRI dhan29 and BRRI dhan28 were used. *Agrobacterium* infected calli were under different stages of selection medium for getting putative transformed calli.

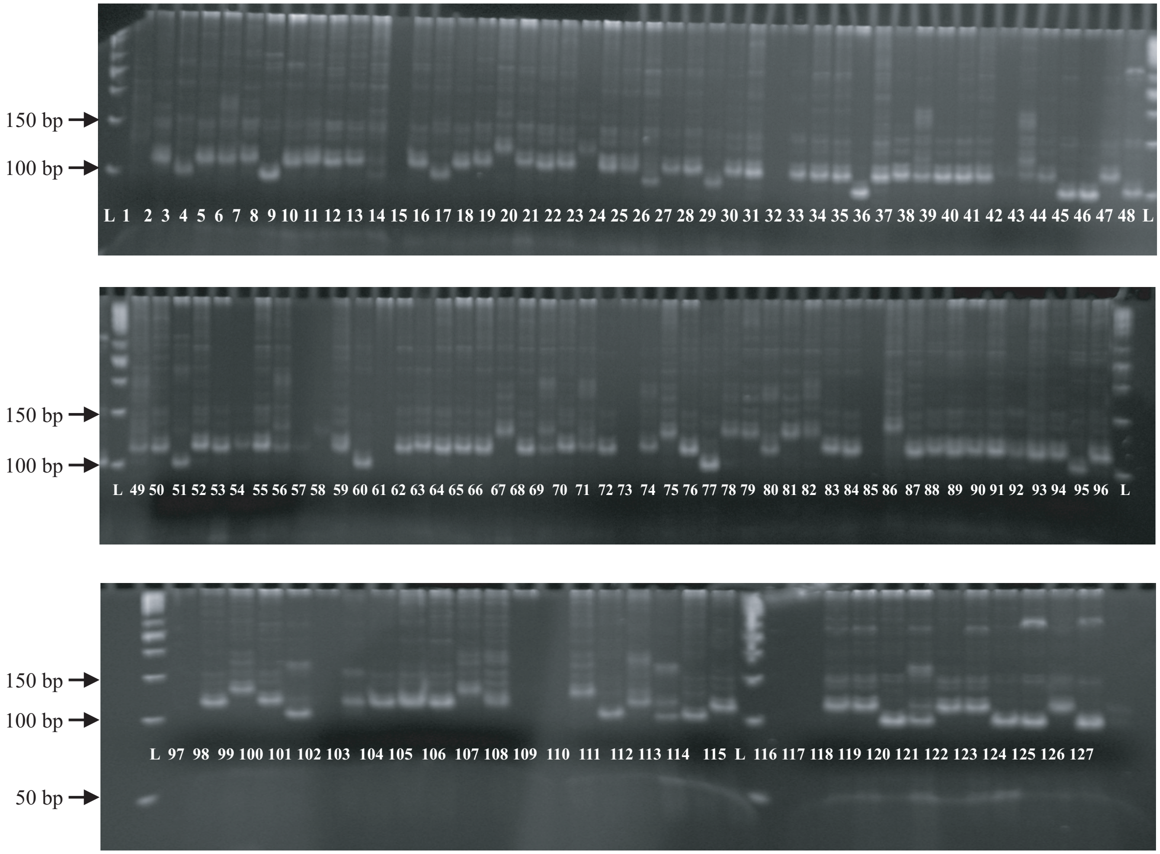


Fig. 6. DNA profile of 127 Aus genotypes (12 BRRI released and 115 Aus landraces) with the SSR marker RM286.

Legend : 1=Ajab Bett, 2=Agun Ban, 3=Atithi dhan, 4=Aalo Sate, 5=Begun Bahar, 6=Boilum, 7=Bailum-3, 8=Barmulka-2, 9=Benaful, 10=Benaful ,11=Bathuri, 12=Ausaloi, 13=Baismuguria, 14=Bador jota,15=Bawoi, 16=Beri, 17=Beni muri, 18=BR319-1-HR-12, 19=Bora dhan, 20=Baisha Muri, 21=Bar Pa, 22=Balion, 23=Bil Kalae, 24=Balam, 25=Bhatkarari, 26=Boailla, 27=Borga Dhan, 28=Bali Bokri, 29=Chenri, 30=Chamka, 31=Chiknal, 32=Chitri, 33=Chapila, 34=Chakulya, 35=Dhula Biz, 36=Darial, 37=Goreswar, 38=Gutle, 39=Hidi 2, 40=Holat, 41=Holae, 42=Haita saita, 43=Honuman jota, 44=Hijoli Aus, 45=Haji Sail, 46=Hati Bajor, 47=IR19746-28-2-2, 48=Jhora, 49=Jamri saity 50=Jamurus, 51=Jagli, 52=Japanese #7, 53=Japanese #3, 54=Joba, 55=Korcha Muri, 56=Katar, 57=Kali Bori, 58=Kali Boro, 59=Kamani sail, 60=Koi juri,61=Koblerash, 62=Khusni, 63=Korcha,64=Kala,65=Kalo Hizli, 66=Kheri Jamri, 67=Khamar Mundu, 68=Kaika, 69=Kadar Chap, 70=Laksmi lofa, 71=Lada Moni, 72=Lagi jota, 73=Lakhi Lata, 74=Manik Modu, 75=Malshira, 76=Mary satia 77=Manik Mondal, 78=Manik Mondol, 79=Mazra, 80=Modhu mala, 81=Manik Jor, 82=Magi Sarsa, 83=Moush Doll, 84=Morich Boti, 85=Mi-Mandi, 86=Mi-mandisarang, 87=Matia, 88=Nayan Tara, 89=Noroi, 90=Nusha Ratoi, 91=Nordi, 92=Porangi 7, 93=Parangi, and 94=Paik Juta, 95=Pankliiras, 96=Pipre Sail, 97=Panburi, 98=Padma Moni, 99=Padha Moidu, 100=Panchash, 101=Parija, 102=Ranga Moni, 103=Ranga Moni, 104=Rathail, 105=Sribalium, 106=Saribail, 107=Soloi, 108=Sodai Soru, 109=Soda, 110=Sail bogi, 111=Tarabali, 112=Tapa sail, 113=Tusha, 114=Udobali, 115=Zamir Saita, 116= BR1(Chandina), 117= BR2 (Mala), 118= BR3(Biplob), 119= BR6, 120=BR7 (Brri Balam), 121=BR8 (Aasa), 122=BR9 (Sufala), 123=BR12 (Mayana), 124=BR15 (Mohinye), 125=BR16 (Sahya Balam), 126=BR20 (Nizamy) and 127=BR21(Niamat).

Table 8. Seeds obtained from back crossing progenies for pyramiding of BB resistant genes.

Back cross	Generation	No. of seeds harvested
	T. Aman (2011)	
BRRI dhan28*5/IRBB60	BC_5F_1	50
BRRI dhan29*5/IRBB60	BC_5F_1	71
	Boro (2011-12)	
BRRI dhan28*6/IRBB60	BC_6F_1	30
BRRI dhan29*6/IRBB60	BC_6F_1	32

Table 9. Data summary for 41 SSR markers across 127 Aus genotypes.

Marker	Chr. no.	Position (bp)	Allele no.	Major allele frequency	PIC value
RM1	1	4.63	19	0.1890	0.8977
RM283	1	4.88	13	0.3386	0.8065
RM237	1	33.29	5	0.3701	0.6988
RM259	1	7.44	16	0.2362	0.8660
RM431	1	39.22	18	0.1339	0.9134
RM452	2	9.50	12	0.1654	0.8779
RM154	2	1.08	26	0.1417	0.9172
RM327	2	19.49	14	0.1417	0.8917
RM514	3	35.22	8	0.1890	0.8458
RM489	3	4.31	18	0.2047	0.8707
RM85	3	66.76	8	0.3780	0.6914
RM307	4	0.00	17	0.2362	0.8834
RM252	4	45.21	16	0.2126	0.8826
RM119	4	21.22	10	0.1890	0.8490
RM178	5	25.08	9	0.3150	0.7685
RM413	5	2.19	14	0.1811	0.8740
RM169	5	7.47	19	0.1260	0.9215
RM122	5	0.29	8	0.2835	0.8035
RM161	5	27.89	8	0.4567	0.6877
RM541	6	2.72	6	0.2992	0.7639
RM204	6	3.17	16	0.2205	0.8611
RM11	7	19.25	8	0.4724	0.6251
RM18	7	25.65	10	0.3071	0.7835
RM25	8	52.2	14	0.3150	0.8377
RM44	8	2.88	15	0.1339	0.8923
RM 105	9	9.28	13	0.1969	0.8553
RM215	9	21.18	11	0.2598	0.8068
RM219	9	3.38	14	0.1654	0.8880
RM171	10	18.79	18	0.1496	0.8909
RM147	10	20.68	7	0.3622	0.6843
RM484	10	20.80	6	0.4803	0.6224
RM216	10	5.10	13	0.3701	0.7227
RM536	11	8.96	5	0.6220	0.5103
RM209	11	17.77	16	0.1969	0.8755
RM167	11	4.07	10	0.2598	0.8160
RM206	11	21.97	14	0.2441	0.8504
RM286	11	0.38	25	0.1339	0.9260
RM287	11	16.73	15	0.2677	0.8524
RM20	12	0.97	10	0.2520	0.8070
RM519	12	19.90	20	0.1417	0.9205
RM277	12	16.53	6	0.3937	0.6438
Mean			13	0.2618	0.8142

Table 10. Pair-wise genetic dissimilarity co-efficient of Aus genotypes.

Gen. Sl	10	101	102	109	11	110	112	114	115	119	12	17	18	21	22	23	24	45	64	92
6	0.6829	0.8537	0.8537	0.9024	0.9268	0.6829	0.9024	0.8780	0.9268	0.9268	**1.0000**	0.8049	0.7073	0.6829	0.7317	0.7561	0.7561	0.8293	0.8780	0.8780
8	0.6585	0.9268	0.9268	**1.0000**	0.6585	0.9024	0.8780	0.9268	0.9268	0.9024	0.5610	0.8049	0.7561	0.7561	0.7073	0.8049	0.7317	0.9024	0.9024	0.9024
18	0.6829	0.9756	**1.0000**	0.9756	0.7317	0.9268	0.8293	0.9024	0.9512	0.9268	0.6585	0.3659	0.0000	0.4878	0.6341	0.7073	0.6829	0.8780	0.8537	0.9268
36	0.8780	**1.0000**	0.9512	0.9268	0.8780	0.9756	0.9756	0.9268	0.9512	0.9268	0.8293	0.7805	0.7317	0.8293	0.7805	0.6585	0.6829	0.8293	0.9268	0.8537
41	0.9268	**1.0000**	0.9756	0.9268	0.9268	**1.0000**	0.9268	0.9024	0.9512	0.8780	0.8780	0.7805	0.8049	0.9024	0.8780	0.8293	0.8537	0.8537	0.9024	0.9024
47	0.8780	0.7561	0.8780	0.9024	0.8537	0.9512	**1.0000**	**1.0000**	**1.0000**	0.8293	0.8780	0.8780	0.8537	0.9024	0.9024	0.7805	0.8537	0.5610	0.9024	0.9024
49	0.9024	0.9024	0.9024	0.9268	0.9024	0.9024	0.9268	0.8780	0.9756	**1.0000**	0.9268	0.8537	0.9024	0.9024	0.8780	0.8537	0.9268	0.8780	0.8293	0.8537
60	0.9024	0.8780	0.8537	0.9268	0.8780	0.8780	0.9268	0.9268	0.9268	0.9512	0.8780	0.9512	**1.0000**	0.9268	0.9268	0.8780	0.9268	0.9024	0.5854	0.8780
73	0.9268	0.8780	0.8780	0.9512	0.9268	0.9512	0.8537	0.8537	0.8780	0.9268	0.8780	**1.0000**	0.9512	0.9268	0.8780	0.9268	0.9024	0.9024	0.6829	0.7805
75	0.9268	0.9268	0.9268	0.8780	0.9268	0.9268	0.7561	0.8780	0.8049	0.8293	0.9024	0.9268	0.9268	0.9512	0.8780	0.9512	0.9268	**1.0000**	0.7317	0.8049
81	**1.0000**	0.8780	0.8537	0.9024	**1.0000**	0.9024	0.8049	0.8780	0.8537	0.9024	0.9024	0.9024	0.9024	0.9268	0.9024	0.9268	0.9268	0.8780	0.7317	0.6585
83	**1.0000**	0.9024	0.8537	0.9512	0.9756	0.7805	0.8293	0.8537	0.8780	0.9024	0.8293	0.9024	0.9268	0.9268	0.9024	0.9024	0.9512	0.9268	0.8049	0.7805
85	0.9756	0.9268	0.8780	0.8537	0.9756	0.9512	0.8537	0.8537	0.8049	0.8780	**1.0000**	0.9268	0.9756	0.9756	0.9024	0.9512	0.8780	0.9024	0.8537	0.6341
89	0.9512	0.8293	0.8293	0.8293	0.9512	0.8049	0.7317	0.7805	0.8293	0.8049	0.9268	0.8537	0.9268	**1.0000**	0.9512	0.9756	**1.0000**	0.8049	0.8049	0.6341
91	0.9512	0.8049	0.8293	0.8293	0.9512	0.8537	0.7317	0.8293	0.7805	0.7805	0.9512	0.9512	**1.0000**	0.9268	0.9024	0.9024	0.9512	0.8537	0.7317	0.5610
99	0.9512	0.7561	0.8049	0.8049	0.9024	0.7805	0.7805	0.8293	0.8537	0.9268	0.8780	0.9268	0.9268	0.9512	**1.0000**	**1.0000**	**1.0000**	0.9268	0.8049	0.7317
65	0.9268	0.8293	0.8537	0.8293	0.9268	0.9024	0.8049	0.8049	0.9024	0.9268	0.9512	0.8049	0.8537	0.8293	0.8780	0.8293	0.8780	0.9268	0.171	0.7073
93	0.8537	0.9756	0.8780	0.8293	0.8537	0.9756	0.9024	0.8049	0.8293	0.8049	0.9512	0.9268	0.9268	0.9512	0.9024	0.9512	0.9512	0.8049	0.7561	0.2927

Legend : 6=Boilum, 8=Barmulka-2, 10=Benaful,11=Bathuri, 18=BR319-1-HR-12, 36=Darial, 41=Holae, 47=IR19746-28-2-2, 49=Jamri saity, 60=Koi juri, 73=Lakhi Lata, 75=Malshira, 81=Manik Jor, 83=Moush Doll, 85=Mi-Mandi, 89=Noroi, 91=Nordi, 99=Padha Moidu, 101=Parija, 102=Ranga Moni, 109=Soda, 110=Sail bogi, 112=Tapa sail, 114=Udobali, 115=Zamir Saita, 119=BR6 , 12=Baisamugur, 17=Beni muri, 18=BR319-1-HR-12, 21=Bar Pa , 22=Balion, 23=Bil Kalae, 24=Balam, 45=Haji Sail, 64=Kala, 65=Kalo Hizli, 92=Porangi 7 and 93=Parangi.

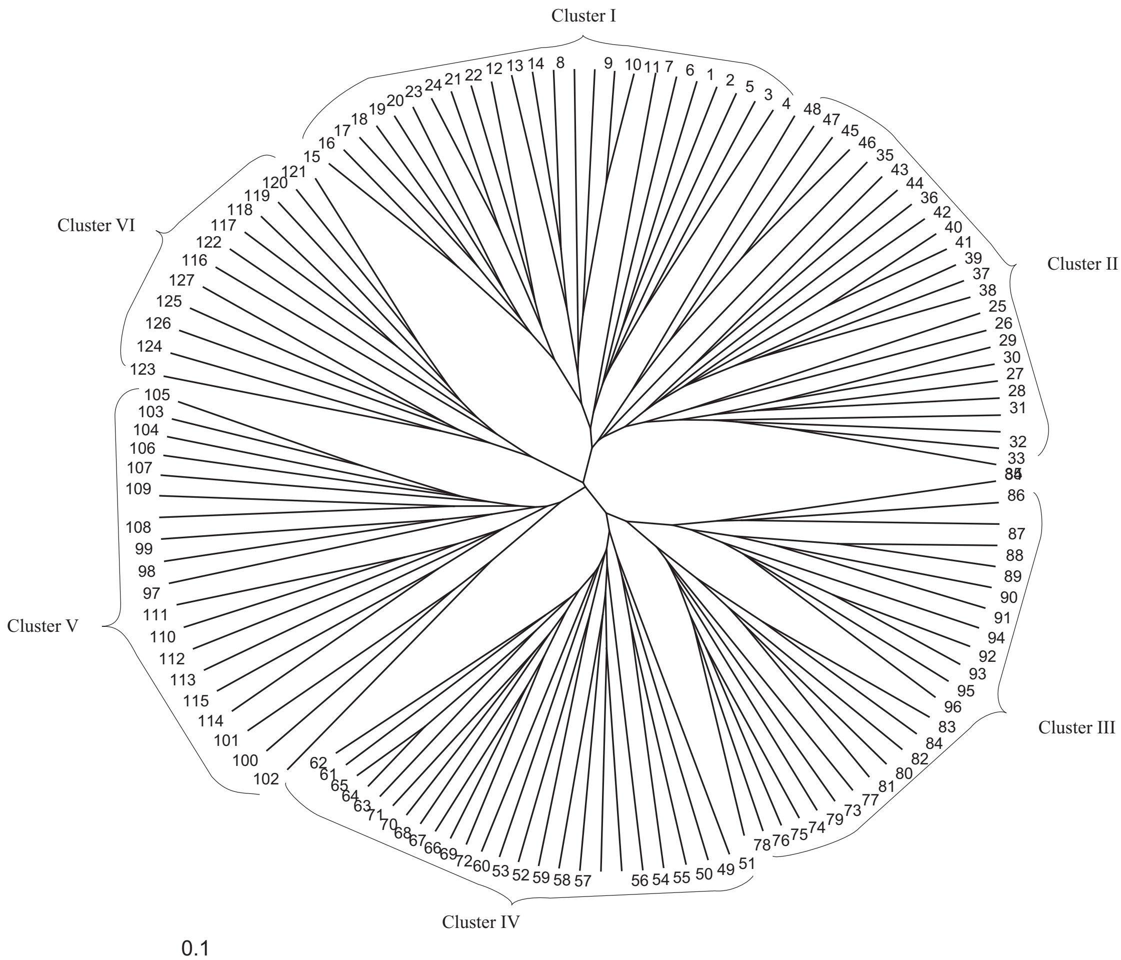


Fig. 7. An unrooted neighbour-joining tree showing the genetic relationships among 127 Aus genotypes (12 BRRI developed and 115 Aus landraces) based on the alleles detected by 41 microsatellite markers.

Legend : 1=Ajab Bett, 2=Agun Ban, 3=Atithi dhan, 4=Aalo Sate, 5=Begun Bahar, 6=Boilum, 7=Bailum-3, 8=Barmulka-2, 9=Benaful, 10=Benaful ,11=Bathuri, 12=Ausaloi, 13=Baismuguria, 14=Bador jota,15=Bawoi, 16=Beri, 17=Beni muri, 18=BR319-1-HR-12, 19=Bora dhan, 20=Baisha Muri, 21=Bar Pa, 22=Balion, 23=Bil Kalae, 24=Balam, 25=Bhatkarari, 26=Boailla, 27=Borga Dhan, 28=Bali Bokri, 29=Chenri, 30=Chamka, 31 Chiknal, 32=Chitri, 33=Chapila, 34=Chakulya, 35=Dhula Biz, 36=Darial, 37=Goreswar, 38=Gutle, 39=Hidi 2, 40=Holat, 41=Holae, 42=Haita saita,43= Honuman jota, 44= Hijoli Aus, 45= Haji Sail, 46= Hati Bajor, 47= IR19746-28-2-2, 48= Jhora, 49= Jamri saity 50= Jamurus, 51=Jagli, 52=Japanese #7, 53=Japanese #3, 54=Joba, 55=Korcha Muri, 56=Katar, 57=Kali Bori, 58=Kali Boro, 59=Kamani sail, 60=Koi juri, 61=Koblerash, 62=Khusni, 63=Korcha,64=Kala,65=Kalo Hizli, 66=Kheri Jamri, 67=Khamar Mundu, 68=Kaika, 69=Kadar Chap, 70=Laksmi lofa, 71=Lada Moni, 72=Lagi jota, 73=Lakhi Lata, 74=Manik Modu, 75=Malshira, 76=Mary satia 77=Manik Mondal, 78=Manik Mondol, 79=Mazra, 80=Modhu mala, 81=Manik Jor, 82=Magi Sarsa, 83=Moush Doll, 84=Morich Boti, 85=Mi-Mandi, 86=Mi-mandisarang, 87=Matia, 88=Nayan Tara, 89=Noroi, 90=Nusha Ratoi, 91=Nordi, 92=Porangi 7, 93=Parangi, and 94=Paik Juta, 95=Pankliiras, 96=Pipre Sail, 97=Panburi, 98=Padma Moni, 99=Padha Moidu, 100=Panchash, 101=Parija, 102=Ranga Moni, 103=Ranga Moni, 104=Rathail, 105=Sribalium, 106=Saribail, 107=Soloi, 108=Sodai Soru, 109=Soda, 110=Sail bogi, 111=Tarabali, 112=Tapa sail, 113=Tusha, 114=Udobali, 115=Zamir Saita, 116=BR1(chandina), 117=BR2 (Mala), 118=BR3(Biplob), 119=BR6, 120=BR7 (Brri Balam), 121=BR8 (Aasa), 122=BR9 (Sufala), 123=BR12 (Mayana), 124=BR15 (Mohinye), 125=BR16 (Sahya Balam), 126=BR20 (Nizamy) and 127=BR21(Niamat).

Fig. 8. Regenerated putative plantlet.

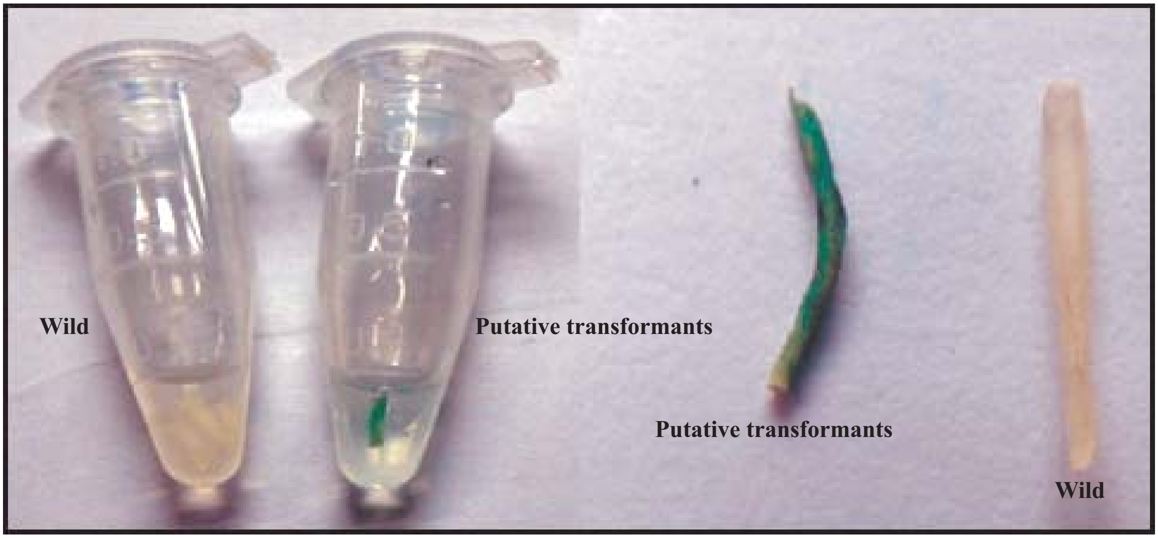


Fig. 9. Putative transformants confirmed by GUS test.

Genetic Resources and Seed Division

SUMMARY

Thirty Aus/Jhum, 264 Aman and 39 Boro germplasm were collected from different districts including hilly areas of Bangladesh during 2011-12. A total of 429 germplasm were characterized with 51 morpho-agronomic characters during T. Aman and Boro seasons. Besides, 1,607 germplasm accessions including 109 new collections were rejuvenated during the reporting year. Apart from this, 82 new collections were registered as accession. Genebank database preparation is going on and about 100 accessions have been entered into the database with available information during the reporting year. Genetic diversity was pronounced in 38 traditional hilly rice germplasm and the varieties were grouped into five clusters. Three germplasm *viz* Joli, Rangpuri (Sada) and Mi-Chocho out of 10, have allelopathic potentials and more inhibitory character to suppress weeds in laboratory condition. Fifty-three germplasm were screened against gall midge and none was not found resistant to gall midge. Among the tested 398 landraces, 67 genotypes found highly resistant against bacterial blight. Among the tested 98 genotypes for submergence tolerance, nine genotypes were found with very good recovery status, having survivability score 3. Twenty-eight genotypes were found with good recovery status having survivability score 5. Thirty-five genotypes were found with fair recovery status having survivability score 7 and 26 genotypes were found with poor recovery status having survivability score 9. In another study, among the tested 100 genotypes, 25 genotypes were found moderately tolerant having 92-100% survivability and its score was 3.

A total of 52 BRRI developed and recommended varieties were maintained as nucleus stock. A total of 115.90 tons of breeder seed of which 37.19 tons from 28 varieties in T. Aman and 78.71 tons from 10 varieties in Boro seasons were produced during 2011-12. About 29.39 tons from 23 varieties in T. Aman, 69.76 tons from 10 varieties in Boro and 2.86 tons from nine varieties in Aus seasons were distributed during 2011-12. Around 1.95 tons truthfully labelled seeds (TLS) from 22 varieties of T. Aman and 7.5 tons truthfully labelled seeds from nine varieties of Boro were available for distribution. Around 1.22 tons seeds from 20 varieties of T. Aman, 7.5 tons seeds from nine varieties of Boro and 168 kg from two varieties of Aus were distributed as quality seed (TLS) during 2011-12. Besides, two training programmes entitled 'Breeder seed production and preservation techniques of rice' were organized under breeder seed project for the BRRI scientists and scientific assistants. Four training programmes entitled 'Quality seed production and preservation techniques of rice' were organized under breeder seed project for the farmers during 2011-12.

RICE GERMPLASM CONSERVATION AND MANAGEMENT

Collection and acquisition. Thirty Aus/Jhum, 264 Aman and 39 Boro rice germplasm were collected from different districts including hilly areas of Bangladesh (Table 1). Many collected varieties were found to be duplicate, which were discarded from the list and remaining new ones are under process for registration (Table 1).

Rejuvenation and conservation. To increase the seed for rejuvenate and storage (in T. Aman), the accession, which possessed less than 80% germination and stored on or before 2006 were grown in T. Aman 2009 and Boro 2011-12 seasons under transplanted conditions in line sowing using single row of 5.4 m long per entry and single seedling per hill with a spacing of 25- × 20-cm between rows and plants respectively. Fertilizers were applied @ 60-60-40 kg NPK/ha in T. Aman and Aus and @ 80-60-40 kg NPK/ha in Boro season. Proper control measures were taken for pests, diseases and weeds when necessary. A total of 1607 germplasm accessions including 109 new collections were grown for rejuvenation in three rice growing seasons. The newly collected 11 Aus varieties did not flower and they will be transplanted in Aman 2012 season. Newly collected germplasm were registered as accession after sorting out the duplicates.

Characterization and documentation. To characterize and evaluate the stored as well as new collection of rice germplasm, 429 accessions were

Table 1. List of rice germplasms collected/received in 2011-12.

Variety	Upazila	District	Season
Tepu	Kalapara	Patuakhali	Boro
Minikit	Magura sadar	Magura	,,
Unknown	,,	Comilla	,,
Double rice	Birampur	Dinajpur	T. Aman
Pidi	Ruma	Bandaban	Jhum
Mongthu	,,	,,	,,
Galang	,,	,,	,,
Lal binni	,,	,,	,,
Ulukho	,,	,,	,,
Mongthong	,,	,,	,,
Kring	,,	,,	,,
Lakkhibinni sada	,,	,,	,,
Kakar 2	,,	,,	
Galang	,,	,,	,,
Binni	,,	,,	,,
Mongthong	,,	,,	,,
Binni	,,	,,	,,
Binni	,,	,,	,,
Binni			,,
Dilong	,,	,,	,,
Shray	,,	,,	,,
Kakar	,,	,,	,,
Binni	,,	,,	,,
Mongthong	,,	,,	,,
Mayathong	,,	,,	,,
Saitong	,,	,,	,,
Binni dhan			,,
Mukhchur dhan1	Rowanchhari	,,	,,
Momingcha dhan	,,	,,	,,
Mukhchur dhan2	,,	,,	,,
Horina binni	Khagrachhari sadar	Khagrachhari	,,
Maiowasa	Khagrachhari sadar	Khagrachhari	Jhum
Subal lata	Jhenaidah sadar	Jhenaidah	Boro
SKS-05	Jhenaidah sadar	Jhenaidah	Aman
SKS-06	,,	,,	,,
SKS-07	,,	,,	,,
SKS-09	,,	,,	,,
SKS-10	,,	,,	,,
SKS-11	,,	,,	,,
SKS-12	,,	,,	,,
SKS-16	,,	,,	,,
SKS-17	,,	,,	,,
SKS-22	,,	,,	,,
SKS-23	,,	,,	,,
SKS-24	,,	,,	,,
SKS-26	,,	,,	,,
SKS-27	,,	,,	,,
SKS-31	,,	,,	,,
SKS-35	,,	,,	,,
SKS-36	,,	,,	,,
SKS-37	,,	,,	,,
SKS-39	,,	,,	,,
SKS-40	,,	,,	,,
SKS-41	,,	,,	,,
SKS-42	,,	,,	,,
SKS-45	,,	,,	,,
SKS-46	,,	,,	,,
SKS-47	,,	,,	,,

Table 1. Continued.

Variety	Upazila	District	Season
SKS-48	Jhenaidah sadar	Jhenaidah	Aman
SKS-49	,,	,,	,,
SKS-50	,,	,,	,,
SKS-52	,,	,,	,,
SKS-53	,,	,,	,,
SKS-54	,,	,,	,,
SKS-56	,,	,,	,,
SKS-57	,,	,,	,,
SKS-58	,,	,,	,,
SKS-60	,,	,,	,,
SKS-62	,,	,,	,,
SKS-63	,,	,,	,,
SKS-65	,,	,,	,,
SKS-66	,,	,,	,,
SKS-68	,,	,,	,,
SKS-69	,,	,,	,,
SKS-71	,,	,,	,,
SKS-74	,,	,,	,,
SKS-75	,,	,,	,,
SKS-78	,,	,,	,,
SKS-80	,,	,,	,,
SKS-82	,,	,,	,,
SKS-84	,,	,,	,,
SKS-87	,,	,,	,,
SKS-90	,,	,,	,,
SKS-91	,,	,,	,,
SKS-92	,,	,,	,,
SKS-93	,,	,,	,,
SKS-94	,,	,,	,,
SKS-98	,,	,,	,,
SKS-99	,,	,,	,,
SKS-107	,,	,,	,,
SKS-109	,,	,,	,,
Kotrabari	,,	,,	,,
Mala iri	,,	,,	,,
Laili moznu	,,	,,	,,
Chinikanai	,,	,,	,,
Benapole	,,	,,	,,
Jotai	,,	,,	,,
Nunia	,,	,,	,,
Rupershor	,,	,,	,,
Pankhiraj	,,	,,	,,
Sadamota	,,	,,	,,
Kachkolom	,,	,,	,,
Gorekajol	,,	,,	,,
Shishumoti	,,	,,	,,
Bhojon	,,	,,	,,
Bilkajal	,,	,,	,,
Kathbirali	,,	,,	,,
Kalozira	,,	,,	,,
Lalsira	,,	,,	,,
Kalojira sorting	,,	,,	,,
Biroi	,,	,,	,,
Biroi Sorting-1	,,	,,	,,
Biroi Sorting-2	,,	,,	,,
Biroi Sorting-3	,,	,,	,,
Chinishail	,,	,,	,,
Chinishail Sorting	,,	,,	,,

Table 1. Continued.

Variety	Upazila	District	Season
Lalbinni	Jhenaidah sadar	Jhenaidah	Aman
Aijang	,,	,,	,,
Tulshi mala	,,	,,	,,
Badshabhog	,,	,,	,,
Moulota	,,	,,	,,
Chinigura	,,	,,	,,
Thakurbhog	,,	,,	,,
Malsira	,,	,,	,,
Begunbichi	,,	,,	,,
Lal Sakhorkora	,,	,,	,,
Sakhorkora	,,	,,	,,
Murkimala Sorting	,,	,,	,,
Kala mocha Sorting	,,	,,	,,
Kattaribhog	,,	,,	,,
Darshail	,,	,,	,,
Lalkartikshail	,,	,,	,,
Kartik balam	,,	,,	,,
Minikit	Jessore sadar	Jessore	Boro
Jati dhan	Khulna sadar	Khulna	Aman
Chinikanai	,,	,,	,,
Pajam dhan	,,	,,	,,
Lalbalam	Rampal	Bagerhat	
Chapshil	,,	,,	,,
Shakorkors	,,	,,	,,
Basfulbalam	,,	,,	,,
Moynamoti	,,	,,	,,
Dudbalam	,,	,,	,,
Kaligira	Noakhali sadar	Noakhali	,,
Kachamota	,,	,,	,,
Kachamota			,,
Gheecoach	,,	,,	,,
Shakkorkhana	,,	,,	,,
Shakorkhana (Screened)	,,	,,	,,
Bajal dhan	,,	,,	,,
Beti chikon	,,	,,	,,
Kaligira	,,	,,	,,
Shail dhan	,,	,,	,,
Kajalsail	,,	,,	,,
Kaligira	,,	,,	,,
Haidda Dhan	,,	,,	,,
Boilam	,,	,,	,,
Kalijira	Laxmipur sadar	Laxmipur	,,
Shakkorkhana	,,	,,	,,
Motapanchoach	,,	,,	,,
Haidda dhan	,,	,,	,,
Lal mota	,,	,,	,,
Lalchikon	Barguna sadar	Barguna	,,
Sadamota	,,	,,	,,
Kaligira	,,	,,	,,
Kaloshail	,,	,,	,,
Kachamota	,,	,,	,,
Kachamota(screened)	,,	,,	,,
Chotiagini dhan	,,	,,	,,
Betichikon	,,	,,	,,
Hailgirmi	Amtoli	,,	,,
Kalokhaia	,,	,,	,,
Shakorkhana	Pathorghata	,,	,,
Choiagini dhan	,,	,,	,,

Table 1. Continued.

Variety	Upazila	District	Season
Rupessoor dhan	Pathorgata	Barguna	Aman
Bogaibalam	,,	,,	,,
Koladema dhan	,,	,,	,,
Moina moti	,,	,,	,,
Fokirmota	,,	,,	,,
Chokamu dhan	,,	,,	,,
Moti dhan	,,	,,	T. Aman
Bamunkhich	,,	,,	,,
Sadachikon	,,	,,	,,
Buribota	,,	,,	,,
Rajashail	,,	,,	,,
Barshail	,,	,,	,,
Najirshail	,,	,,	,,
Jolkochuri dhan	,,	,,	,,
Kasradhan	,,	,,	,,
Kabdulhan	,,	,,	,,
Kerenjalmota	,,	,,	,,
Shaeb kochi	,,	,,	,,
Chaboli dhan	,,	,,	,,
Jamanimota	,,	,,	,,
Borai dhan	,,	,,	,,
Jamai naru	,,	,,	,,
Sylhet balam	,,	,,	,,
Mohini	,,	,,	,,
Kalomota	,,	,,	,,
Shordar dhan	,,	,,	,,
Patnidhan	,,	,,	,,
Golok khaia	,,	,,	,,
Holdia mota	,,	,,	,,
Pangas dhan	,,	,,	,,
Tulshi dhan	,,	,,	,,
Tulsidhan (Screened)	,,	,,	,,
Desibalam	,,	,,	,,
Saiod	,,	,,	,,
Chorkalam	,,	,,	,,
Pancoach	,,	,,	,,
Chinigura	,,	,,	,,
Kachamota	,,	,,	,,
Basful	,,	,,	,,
Betichikon	,,	,,	,,
Irridhan	,,	,,	,,
Sadamota	Kolapara	Patuakhali	,,
Shakorkana	Pathurgata	Barguna	,,
Binni dhan	,,	,,	,,
Binni dhan	,,	,,	,,
Kaligira	,,	,,	,,
Tepudhan	,,	,,	,,
Mothamota	,,	,,	,,
Keranjal	Kolapara	Patuakhali	,,
Shakorkhana	,,	,,	,,
Bohorimota	,,	,,	,,
Kalijira	,,	,,	,,
Swarnamosuri	,,	,,	,,
Tepadhan	,,	,,	,,
Swarna mosuri	,,	,,	,,
Khaia dhan	,,	,,	,,
Mothamota	Kolapara	Patuakhali	,,
Sadamota	,,	,,	,,

Table 1. Continued.

Variety	Upazila	District	Season
Chinigura	Kolapara	Patuakhali	T. Aman
Lalmota dhan	,,	,,	,,
Tepudhan	,,	,,	,,
Swarnamosuri	,,	,,	,,
Chinikanai	Paikgasa	Khulna	,,
Asfoldhan	,,	,,	,,
Horkoach	,,	,,	,,
Moris shail	,,	,,	,,
Moris shail	,,	,,	,,
Khaiguri dhan	,,	,,	,,
Chinikanai	,,	,,	,,
Kasradhan	,,	,,	,,
Jatibalam	,,	,,	,,
Kumrohor	,,	,,	,,
Chanshail	,,	,,	,,
Hogladhan	,,	,,	,,
Vutasalu	,,	,,	,,
Ghunchi	,,	,,	,,
Dakshail	,,	,,	,,
Dakshail	,,	,,	,,
Basfulbalam	,,	,,	,,
Asfulbalam	Dakop	,,	,,
Kalmilota	,,	,,	,,
Hogladhan	,,	,,	,,
Moris Shail	,,	,,	,,
Kaijuri dhan	,,	,,	,,
Kalijira	,,	,,	,,
Aus dhan	,,	,,	,,
Sadamota	,,	,,	,,
Jatibalam	,,	,,	,,
Sadamota	,,	,,	,,
Jatabalam	,,	,,	,,
Hogla dhan	,,	,,	,,
Asful balam	,,	,,	,,
Khetkumra	,,	,,	,,
Chunsi dhan	,,	,,	,,
Khetkumra	,,	,,	,,
Ghunsi dhan	,,	,,	,,
Bauranimota	,,	,,	,,
Kachamota	Kolapara	Patuakhali	,,
Binnidhan	,,	,,	,,
Swarnomosuri	,,	,,	,,
Kerenjal	,,	,,	,,
Shakorkhana	,,	,,	,,
Hogla dhan	,,	,,	,,
Kajolshail	,,	,,	,,
Kalijira	,,	,,	,,
Gopalbhog	,,	,,	,,
Kajol shail	,,	,,	,,
Haidda dhan	,,	,,	,,
Korenjal mota	,,	,,	,,
Sadamota	,,	,,	,,
Kaligira	,,	,,	,,
Kalorajshail	,,	,,	,,
Sadamota	,,	,,	,,
Binnidhan	,,	,,	,,
Swarnomosuri	,,	,,	,,
Dingamoni	,,	,,	,,

Table 1. Continued.

Variety	Upazila	District	Season
Kaligira	Kolapara	Patuakhali	T. Aman
Kachamota	,,	,,	,,
Moulata	Amtoli	Borguna	,,
Nerica 1		BADC	Boro
Nerica 10		,,	,,
Rateil	Barisal sadar	Barisal	Aus
Chikondhan	,,	,,	Boro
Kalodhan	,,	,,	B. Aman
Unknown	Kotalipara	Gopalganj	Boro
Unknown	,,	,,	,,
Achin	Nalsiti	Jhalakati	T. Aman
Susomai	Sadar	Patuakhali	Aus
HB-9R	Salna	BSMRAU	Boro
Shakti-R	,,	,,	,,
BHD-1R	,,	,,	,,
BHD-2R	,,	,,	,,
BHD-3R	,,	,,	,,
Hera-2R	,,	,,	,,
Hera-5R	Salna	BSMRAU	Boro
Hera-10R	,,	,,	,,
Mutali	,,	,,	,,
ACI-1R	,,	,,	,,
LP-70R	,,	,,	,,
LP-106	,,	,,	,,
LP-108R	,,	,,	,,
GoldR	,,	,,	,,
DoyelR	,,	,,	,,
MoynaR	,,	,,	,,
SL-8R	,,	,,	,,
BU-1R	,,	,,	,,
BU-7R	,,	,,	,,
HB-8R	,,	,,	,,
BU-3R	,,	,,	,,
BU-HR	,,	,,	,,
Jina-2R	,,	,,	,,
Jina-1R	,,	,,	,,
IR509R	,,	,,	,,
BU-521R	,,	,,	,,
BU-507R	,,	,,	,,
BU-329R	,,	,,	,,
Basmati (India R line)	,,	,,	T. Aman
IR58052 (B line)	,,	,,	,,
BRRI 1 (B line)	,,	,,	,,

grown in T. Aman and Boro seasons for characterization using the rice germplasm descriptor and evaluation form. Single seedling per hill with a spacing of 25- × 20-cm between rows and plants respectively were grown using single row of 5.4 m long per entry. Fertilizers were applied @ 80-10-60 kg NPK/ha in T. Aman and @ 100-10-60 kg NPK/ha in Boro seasons respectively. Appropriate control measures were taken for pests, diseases and weeds when necessary.

Among 429 germplasm, 207 accessions in T. Aman 2011 and 222 in Boro 2011-12 were characterized on the bases of 51 morpho-agronomic traits (Table 2). In T. Aman 2011, 48 germplasm/accessions have short growth duration type (<125 days), 68 have medium (125-135 days) and 91 have long (>135 days) growth duration. Forty-one germplasm were found with short (<110 cm), 52 were moderate (110-130 cm) and the rest (130) were with long (>130 cm) plant height. Fifty-six germplasm were found with long (>25 cm), 138

Table 2. Some important features of characterized germplasm during Aus, T. Aman 2011 and Boro 2011-12.

Growth duration		Plant height (cm)		Panicle length (cm)		Tiller (no.)		Effective tiller (no.)		Grain L/B ratio		1000-grain wt (g)		Yield/Hill	
Range (days)	Entries (no.)	Range (cm)	Entries (no.)	Range (cm)	Entries (no.)	Range (cm)	Entries (no.)	Range (cm)	Entries (no.)	Range (cm)	Entries (no.)	Range (cm)	Entries (no.)	Range (cm)	Entries (no.)
T. Aman															
<125 days	48	<110	41	<20	10	<10	32	<10	92	<3	0	<15	88	<5	38
125-135 days	68	110-130	52	20-25	138	10-15	153	10-15	106	3.5	176	15-25	110	5-15	141
>135 days	91	>130	111	>25	56	>15	22	>15	9	>5	31	>25	9	>15	28
Shortest (97 days)	Acc. 6243 (IR-61608-3B-20-2-2-1-1)	Shortest (59)	Acc. 6312 (SXO832)	Shortest (12)	Acc. 6275 (Pavlovsky)	Lowest (6)	Acc. 6337 (Dholi Khama)	Lowest (4)	Acc. 6265, 6275 (HG544-324-1, Pavlovsky)	Lowest (3.21)	Acc. 6683 (Jaldub)	Lowest (6)	Acc. 6677 (Chikan Sarna)	Lowest (1.55)	Acc. 6660 (Maita Vangor)
Longest (155 days)	Acc. 6650, 6651, 6652	Longest (186)	Acc.6341 (Kali Aman)	Longest (34.0)	Acc. 6636 (Dulai Aman)	Highest (45)	Acc.6293 (Kongou)	Highest (43)	Acc.6293 (Kongou)	Highest (6.41)	Acc. 6718 (Jira Sail)	Highest (31.90)	Acc. 6666 (Pakri dhan)	Highest (76.81)	Acc. 6288 (Milyang 80)
Boro															
<140 days	15	<80	38	<20	12	<10	93	<10	113	<3	1	<20	40	<10	25
140-160 days	176	80-120	144	20-25	153	10-15	111	10-15	101	3-5	175	20-25	125	10-20	152
>160days	34	>120	43	>25	72	>15	21	>15	11	>5	49	>25	60	>20	48
Shortest (129 days)	Acc. 6940 (Unknown 469467)	Shortest (60)	Acc.6941 (Unknown 469468)	Shortest (17)	Acc. 6856, 6940	Lowest (3)	Acc. 6987 (Unknown 474580)	Lowest (3)	Acc. 6893, 6894, 6987	Lowest (2.99)	Acc. 6949 (Unknown 469523)	Lowest (15.9)	Acc.7013 (Unknown 505360)	Lowest (3.94)	Acc. 6903 (Unknown 469324)
Longest (171 days)	7 Varieties	Longest (162)	Acc. 6902 (Unknown 469323)	Longest (32)	Acc. 6884 (Unknown 12090)	Highest (31)	Acc. 6856 (Khaiyely Boro)	Highest (27)	Acc. 6856 (Khaiyely Boro)	Highest (6.61)	Acc. 6930 (Unknown 469425)	Highest (31.1)	Acc. 6842 (Pokkali 28609)	Highest (33.38)	Acc. 6851 (Khato Mala)

were moderate (20-25 cm) and the rest (10) were with short (<20 cm) panicle length. Maximum (153) germplasm possessed moderate (10-15) number of tiller and nine had higher (>15) number of effective tillers respectively. Maximum (176) varieties showed medium (3-5), 31 were with higher (>5) grain length breadth ratio. Besides, nine had high (>25), 110 had moderate (15-25 g) and the rest (88) had low (<25 g) 1000-grain weight (TGW). The highest yield per hill (76.81 g) was observed in Milyang 80 (acc. no. 6288) and the lowest (1.55 g) was observed in Maita Vangor (acc. no. 6660) in respective season.

Among 207 accessions in Boro season, 15 accessions were short (<140 days), 176 were medium (140-160 days) and 34 were long (>160 days) growth duration type varieties. Thirty-eight germplasm were found with shorter (<80 cm), 144 were moderate (80-120 cm) and the rest (43) were with long (>120 cm) plant height. Seventy-two germplasm were found with higher (>25 cm) panicle length and the rest were moderate to small panicle length. Maximum (111) germplasm possessed medium (10-15) number of tiller and 101 varieties possessed moderate number of effective tiller respectively. Forty-nine varieties showed high (>5) and 175 showed medium (3-5) grain length breadth ratio. Sixty accessions were found to be higher (>25 g), 125 were medium (20-25 g) and the remaining 40 were with low (<20 g) TGW, in which the variety IR70181-3-PMI-1-1-6-1 (acc. no. 6543) has the lowest (14.5 g) and Pokkali 28609 (acc. no. 6842) has the highest (31.10 g). The highest yield per hill (33.38 g) was obtained in the variety Khato Mala (acc. no. 6851) and the lowest (3.94 g) was observed in unknown 469324 (acc. 6903). The variety having higher yield would be used in crossing programme if other characters are found satisfactory. The grain weight of rice is believed to be a maternally inherited character. Therefore, the accessions having higher TGW would be used as a parent for rice hybrid development. The rest accessions would be used as parental sources for breeding programme with respective objective.

Processing, registration and storage. To keep the rice germplasm with respective accession number in the long, medium and short-term storages of Genebank after duplicate sorting, 2,036 germplasm, including 109 new collections were grown for seed increase and rejuvenation and characterization during Aus, T. Aman 2011 and Boro 2011-12. The new collections with more than 80% germination were registered as accession after crosschecking with the seed and card catalogues to avoid duplication and seed mixture. Then at least 150 g seed of each variety was kept in the glass jar containing fresh silica gel in short term storage and another at least 150 g seed of each variety kept in aluminium foil and stored in airtight glass jar for medium and long term storages respectively.

A total of 2036 accessions of which 342 in Aus, 1714 in T. Aman and 577 in Boro seasons were processed and stored in short and medium term and long term storages. The seed of the old accessions were stored in their respective places. Among the above mentioned accessions, 99 have been stored in long term Genebank and 712 accessions have been stored in medium term Genebank during the reporting year. A total of 273 germplasm were registered as new accession stored both in short and medium term storages. Among 273 accessions, seven in Aus, 243 in T. Aman 2011 and 23 in Boro 2011-12 were processed and stored in Genebank (Tables 3, 4 and 5).

Viability testing, periodic evaluation and routine monitoring of stored germplasm. To check and monitor the germination percent of the stored germplasm in the short, medium and long term storages, 200 accessions in Aus season, 207 in T. Aman and 187 in Boro season were checked randomly for viability test during 2011-12 in short term storage. Seed viability was monitored by testing germination percentage of the stored germplasm in short term storage as well as tester in the medium and long-term storages. Five tester varieties *viz* Dharial, Hashikalmi, Nizersail, Patnai 23 and Purbachi possessing a seed viability range from very high to very low were used as tester in the medium and long term storages and viability was measured on every six month interval usually on October and March every year for prediction of the viability of mid-term and long term storage germplasm. Seed viability also monitored of the germplasm just before storage in the Genebank.

Table 3. List of newly registered rice germplasm during Aus 2011.

Variety/Designation	Accession (no.)	Thana	District	Origin
Laxmi Digha	7300	Kotalipara	Gopalganj	Bangladesh
Mosair Aus	7301	,,	,,	,,
Aus Dhan	7302	Nalsiti	Jhalakati	,,
Minikit	7303	Monirampur	Jessore	,,
Lal Aus	7304	Atghoria	Pabna	,,
Kalo Aus	7305	,,	,,	,,
Sada Aus	7306	,,	,,	,,

Table 4. List of newly registered rice germplasm during T. Aman 2011.

Accession (no.)	Designation	Thana	District	Origin
7307	Dakhana Lal Dhan	Kotalipara	Gopalganj	Bangladesh
7308	Sada Gabura	,,	,,	,,
7309	Kalo Dhan	Gopalganj Sadar	,,	,,
7310	Natpasha	,,	,,	,,
7311	Urichedra	,,	,,	,,
7312	Goura Kajol	,,	,,	,,
7313	Kalo Kathi Jaina	,,	,,	,,
7314	Balam	,,	,,	,,
7315	Birpala	,,	,,	,,
7316	Sakkarkhana	Nalsiti	Jalakati	,,
7317	Kala Mota	,,	,,	,,
7318	BR11	BRRI	Gazipur	,,
7319	BRRI dhan51	,,	,,	,,
7320	BRRI dhan52	,,	,,	,,
7321	BRRI dhan53	,,	,,	,,
7322	BRRI dhan54	,,	,,	,,
7323	BRRI dhan55	,,	,,	,,
7324	BRRI dhan56	,,	,,	,,
7325	BRRI dhan57	,,	,,	,,
7326	BR7870-5(Nils)-10-H-R3	PB Division	BRRI, Gazipur	,,
7327	BR7155-20-1-3	,,	,,	,,
7328	Guti Swarna	,,	,,	,,
7329	BPT5204	,,	,,	,,
7330	Kutari Para	,,	,,	,,
7331	Sugandhi dhan	,,	,,	,,
7332	Rajshahi-1042	,,	,,	,,
7333	Prova-7	,,	,,	,,
7334	Fajla (Nawgon)	,,	,,	,,
7335	Kajal (Nawgon)	,,	,,	,,
7336	BR6818-31-4-3-1	,,	,,	,,
7337	BR6817-5-4-5-2-HR-19	,,	,,	,,
7338	BR7878-5(Nils)72-HR-6	,,	,,	,,
7339	BR6926-1-1-1-1-2(PQR)	,,	,,	,,
7340	BR7878-5(Nils)72-HR-6	,,	,,	,,
7341	BR6922-4-4-4	,,	,,	,,
7342	Tulshi Mala	,,	Sherpur	,,
7343	Chini Sail	,,	,,	,,
7344	Rasmala	,,	,,	,,
7345	Chini Sagar	,,	,,	,,
7346	Kalojira	,,	,,	,,
7347	Malsira	,,	,,	,,
7348	Indur Sail	,,	,,	,,
7349	Rong-er-gura	,,	Bhola	,,
7350	Chini Kanai	,,	,,	,,
7351	Pabbat Jira	,,	Habiganj	,,
7352	Modhu Madab	,,	,,	,,

Table 4. Continued.

Accession (no.)	Designation	Thana	District	Origin
7353	Lotma	PB Division	Habiganj	Bangladesh
7354	Jhoria	,,	Sylhet	,,
7355	Tall Biruin(Talla)	,,	,,	,,
7356	Moyna Sail	,,	,,	,,
7357	Biruin	,,	,,	,,

Table 5. List of newly registered rice germplasm during Boro 2011-12.

Accession (no.)	Designation	Thana	District	Origin
7358	Begunbitchi	Manikganj sadar	Manikganj	Bangladesh
7359	Nerica-10	Khulna sadar	Khulna	,,
7360	Minikit	Jessore sadar	Jessore	,,
7361	Nerika-10(awned)	,,	,,	,,
7362	Jhora dhan(1)	Dinajpur sadar	Dinajpur	,,
7363	Jhora dhan(2)	,,	,,	,,
7364	Minikit	Rangpur sadar	Rangpur	,,
7365	Nerika-10	Dinajpur sadar	Dinajpur	,,
7366	Borodhan	,,	,,	,,
7367	Laljamaibabu	Tala	Satkhira	,,
7368	Sadajamaibabu	,,	,,	,,
7369	Kajollata	,,	,,	,,
7370	Superminikit	,,	,,	,,
7371	Hottopuri	,,	,,	,,
7372	Pankoj	Khulna sadar	Khulna	,,
7373	Chandrone	,,	,,	,,
7374	Khaily	,,	,,	,,
7375	Lalswarna	Nilphamari sadar	Nilphamari	,,
7376	Pajam Boro	,,	,,	,,
7377	Lal pajam	Nilphamari sadar	Nilphamari	Bangladesh
7378	Sungwala dhan	,,	,,	,,
7379	Sada boro	Patuakhali sadar	Patuakhali	,,
7380	Nerika-4	,,	,,	,,
7381	Jirasail	Comilla sadar	Comilla	,,

Silica gel was used to maintain the optimum moisture/relative humidity in the seed container. When the colour of silica gel had been changed from blue to pinkish, then the silica gel were taken out and replaced by the fresh blue silica gel. The containers used for seed storage in medium and long term storages are hermetically sealed.

The viability of the stored germplasm was monitored from randomly selected germplasm in three seasons those were stored for three years and most of the tested germplasm possessed more than 90% germination (Table 6). The germplasm accessions, rejuvenated and stored during 2011-12 for short term were found with more than 80% germination (Table 7).

Tables 8 and 9 present the germination percentages of the five test samples (testers) in the medium and long term storages. It is apparent from the table that the initial germination percent of the test varieties were 84-98% when stored in October 2011 and March 2012. Germination precent ranges from 82 to 96% in mid term and 80 to 96% in long term during March 2012.

Rice germplasm exchange. To supply rice germplasm to different researchers at home and abroad as per their demand and to exchange germplasm with national/international organizations, 1,956 sample of rice germplasm /BRRI developed rice varieties in Aus, Aman and Boro seasons were supplied to different users (Table 10). Among the samples, 1,050 germplasm were supplied for research purpose and only 906 samples from BRRI developed rice varieties were supplied for other purposes.

Screening for potential allelopathic effect of some rice cultivars on *Echinochloa crusgalli*. To evaluate potential allelopathic effect of rice cultivars on *Echinochloa crusgalli,* a study was

Table 6. Viability (germination %) monitoring in short term storage during 2011-12.

Season	No. of varieties with three different germination (%) catagories			
	<80	80-90	91-100	Total
Aus	09	31	160	200
T. Aman	10	46	151	207
Boro	14	34	139	187
Total	33	111	450	594

Table 7. The germination (%) of the stored germplasm in short term just before storage during 2011-12.

Season	No. of varieties with three different germination (%) catagories			
	<80	80-90	91-100	Total
Aus	22	53	125	200
T. Aman	20	41	89	150
Boro	15	66	129	210
Total	57	160	343	560

Table 8. Germination percentage of five test samples stored at different times in medium term storage of Gene Bank.

Variety (Acc. no.)	Storage date	Germination (%) (Initial) at storage time	Germination (%) October 2011	Germination (%) March 2012
Dharial (649)	12 Dec 2005	98	95	94
Hashikalmi (3575)	19 Aug 2006	98	96	96
Purbachi (6207)	24 Oct 2011	84	84	82
Nizersail (1229)	12 Dec 2005	96	92	90
Patnai-23 (52)	12 Dec 2005	98	96	94

Table 9. Germination percentage of five test samples stored at different times in long term storage of Gene Bank.

Variety (Acc. no.)	Storage date	Germination (%) (Initial) at storage time	Germination (%) October 2011	Germination (%) March 2012
Dharial (649)	11 Mar 2008	97	95	95
Hashi Kalmi (3575)	11 Mar 2008	97	96	94
Purbachi (6207)	24 Oct 2011	84	84	82
Nizersail (1229)	11 Mar 2008	99	95	93
Patnai-23 (52)	11 Mar 2008	99	97	96

Table 10. Number of germplasm/samples supplied during 2011-12.

Recepient	Number of recepient	No. of varieties/samples supplied	Type
Researcher	35	6495	Germplasm
	17	137	BRRI variety
DAE personnel	15	500	BRRI variety
Student	02	100	BRRI variety
Total	69	7232	

carried out in nutrient solution of urea, TSP and MP were prepared and poured in petridishes. Iron meshes were placed into each petridishes by a sterile forceps. The pregerminated rice seed of nine varieties were placed on iron mesh and allowed for root growth. The weed seeds were placed on another petridish for germination. Then the root exudates of rice cultivars were applied regularlly on petridishes containing weed seeds and allowed for 14 days for weed seedling growth. Then the weed seedlings were removed gently. Their root length, shoot length and dry matter (oven dried at 90°C for three days) was measured. The percentage reduction of root and shoot length were determined by using the formula as percent reduction=100 (LC - LT)/LC, where LC is the length of root or shoot of the control treatment (untreated weeds) and LT is the length of root or shoot of the treated weeds.

Significant reduction of root length of weeds was observed due to allelopathic effect of rice varieties (Table 11). Significantly the highest root length reduction of *Echinichloa crusgalli* was observed due to root exudates of Rajashail (78.63%), which is statistically similar with Joli (76.67%), Rangpuri (Sada) (77.39%), Mi-Chocho (76.62%). On the other hand the lowest root length reduction was found in Mati-Char (16.28%). The highest shoot length reduction of *Echinochloa crusgalli* was found due to the root exudates of Rajashail (77.32a%), which is statistically similar with Joli (74.18%), Rangpuri (Sada) (76.73%), Mi-chocho (71.43%). However, the lowest shoot length reduction was found in case of Kasia panja (37.07%). The highest dry matter reduction was observed in Rajashail (71.78%), which is statistically similar with joli (69.83%), Rangpuri (sada) (69.80%), Mi-chocho (70.39%) and the lowest dry matter reduction was found in Mati-char, which is 53.90%. Among the tested germplasm, three germplasm *viz* Joli, Rangpuri (sada) and Mi-chocho have allelopathic potentials and more inhibitory character to suppress weeds in laboratory condition.

Screening of rice genotypes against gall midge. A total of 53 genotypes (51 test germplasm and 2 check varieties) were screened against gall midge under net house condition. BRRI dhan44 was used as susceptible check, whereas BRRI dhan33 as the resistant check. The experiment was conducted in randomized complete block (RCB) design with three replications. Each genotypes was

Table 11. Allelopathic effect of rice varieties/lines on reduction of root, shoot length and dry weight of *E. crusgalli,* Aman 2011, BRRI Gazipur.

Variety	% reduction		
	Root length	Shoot length	Dry wt (g)
Shoni	44.90b	45.22b	54b
Joli	76.67a	74.18a	69.83a
Rangpuri(Sada)	77.39a	76.73a	69.80a
Kasia Panja	31.48c	37.07c	46.67bc
Boilam	26.80c	37.56c	47.83bc
Boteswar(2)	24.26c	38.39c	44.56c
Mati-Char	16.28d	37.95c	44.50c
Begum Bahar	49.69b	50.03b	48.56bc
Mi-Chocho	76.62a	71.43a	70.39a
Rajashail	78.63a	77.32a	71.78a
CV(%)	8.49	6.87	7.96

Small letters in a column means at the 5% level by DMRT.

sown in 6.1- × 0.9-m plot in 90 cm long line randomly in every work. At 20 DAT, 200 mated females were released in the net house and allowed to lay eggs on the test genotypes. During the experiment 27-32°C temperature and 80-90% RH situation was maintained in the net house. Onion shoots formed on the test materials were recorded and percent onion shoot developed on each line was calculated.

The susceptible check BRRI dhan44 shows 21.8±4.6% onion shoot development. No entries have onion shoot percentage greater than the percentage of susceptible check (Table 12). BRRI dhan33, which was used as the resistant check, exhibited zero percent onion shoot development. Therefore, the experiment needs to repeat for confirmation.

Screening landraces against bacterial blight (BB). To identify new resistant source against the bacterial blight disease for developing durable BB resistant rice variety in Bangladesh, 398 landraces from Genebank of BRRI were screened against bacterial blight (*Xanthomonas oryzae* pv. *oryzae*) pathogens. The experiment was conducted at greenhouse/nethouse condition. Plants were inoculated at 21-day-old seedlings.

Most virulent and representative isolate of major race (BXO9) in Bangladesh was used for inoculation and inoculated by leaf clipping method. Data of lesion length, relative lesion length and leaf damaged area were collected 14 days after inoculation. Mean data of each character were subjected to multivariate analysis *viz* principal coordinate analysis (PCO), principal component analysis (PCA), cluster analysis and canonical variate analysis using genestat 5.5 [Release 4.1 (PC/Windows NT)]

Among the tested materials, 67 were found highly resistant against Bacterial blight belong to cluster X (Table 13). The cluster means of the studied characters such as lesion length, relative lesion length and leaf damaged area were minimum 1.19 cm, 5.80 and 2.53% respectively in cluster X (Table 14). For more confirmation, the experiment needs to be repeated with molecular characterization.

Identification of new sources of submergence tolerance germplasm. To observe

Table 12. Reaction of 53 materials against gall midge under net house condition.

Variety Sl. no.	Accession (no.)	Mean no. of tillers	Mean no. of onion shoots	Mean of onion shoot (%)	% tiller infestation (Mean OS% ± SE)
1	52	14.3	1.7	11.9	11.9 ± 2.4
2	54	78.0	3.0	3.9	3.9 ± 0.9
3	57	32.3	2.3	7.6	7.6 ± 0.8
4	59	33.3	3.7	12.5	12.5± 3.9
5	61	30.7	0.3	1.0	1.0±1.0
6	66	33.0	5.3	16.4	16.4±2.6
7	69	55.7	11.3	21.6	21.6 ±3.1
8	70	77.3	7.3	9.5	9.5 ±1.6
9	71	75.0	7.0	10.2	10.2 ±2.8
10	73	80.3	9.7	12.0	12.0 ±0.9
11	74	113.3	7.0	6.2	6.2± 0.6
12	75	81.3	8.0	9.9	9.9 ±1.5
13	76	87.0	6.3	7.4	7.4 ±1.3
14	77	83.0	6.7	8.1	8.1 ±1.2
15	78	76.7	5.0	6.6	6.6 ±1.3
16	79	96.0	11.3	11.6	11.6 ±2.4
17	80	88.7	9.3	10.4	10.4 ±4.6
18	81	75.0	3.7	5.1	5.1 ±1.6
19	82	67.3	3.0	4.4	4.4 ±0.3
20	83	98.3	4.0	4.0	4.0 ±0.8
21	84	78.7	1.7	2.1	2.1 ±0.5
22	85	62.7	6.7	10.0	10.0 ±2.3
23	86	64.3	6.3	9.8	9.8 ±1.6
24	88	68.3	2.3	3.4	3.4 ±0.4
25	89	75.0	2.0	2.7	2.7 ± 0.8
26	91	89.3	6.7	7.2	7.2 ±1.7
27	92	79.7	5.7	7.1	7.1 ± 0.7
28	93	62.0	8.7	14.0	14.0 ± 0.3
29	94	32.3	2.0	6.7	6.7 ±2.6
30	95	96.3	10.3	10.7	10.7 ±0.5
31	96	83.0	3.7	4.4	4.4 ±0.3
32	97	106.7	4.7	4.4	4.4 ±1.1
33	98	50.0	4.7	10.4	10.4 ±3.7
34	99	41.0	3.7	9.5	9.5 ±2.8
35	100	49.7	0.3	0.7	0.7 ± 0.7
36	101	68.3	2.7	3.7	3.7 ±1.0
37	102	84.7	6.7	7.9	7.9 ± 0.9
38	104	77.3	3.3	4.4	4.4 ±0.7
39	106	74.7	3.3	4.7	4.7±1.6
40	107	63.0	3.0	4.5	4.5 ±1.4
41	108	70.7	3.0	3.8	3.8 ±1.2
42	110	62.7	4.0	5.6	5.6 ±2.0
43	112	71.7	12.0	16.8	16.8 ±0.1
44	113	106.3	2.7	2.5	2.5 ±0.8
45	114	81.3	10.3	12.9	12.9 ±1.2
46	115	79.3	1.7	1.7	1.7 ±1.2
47	116	99.7	8.7	8.7	8.7 ±0.5
48	117	56.3	0.3	0.8	0.8 ±0.8
49	122	55.0	1.0	1.6	1.6 ±0.9
50	123	99.3	2.0	2.0	2.0 ±1.0
51	125	91.3	12.3	13.5	13.5 ±1.0
52	BRRI dhan44	58.0	12.3	21.8	21.8 ±4.6
53	BRRI dhan33	81.7	0.0	0.0	0.0

Table 13. Distribution of 398 test entries in 10 different clusters.

Cluster (no.)	Genotypes (no.)	Genotypes (Acc. no.)
1	32	449, 450, 453, 468, 495, 507, 522, 529, 532, 539, 559, 1524, 1528, 1534, 1675, 1700, 1770, 1773, 1774, 1890, 1892, 1900, 1905, 1906, 1917, 1918, 1921, 1943, 1949, 2292, 2384.
2	8	456, 457, 466, 488, 499, 525, 531, 1765.
3	30	421, 432, 433, 438, 444, 473, 475, 480, 492, 494, 496, 549, 811, 1851, 1853, 1874, 1914, 2020, 2021, 2034, 2051, 2059, 2280, 2286, 2287, 2297, 2322, 2323, 2324, 2382.
4	55	417, 418, 419, 424, 425, 426, 435, 442, 465, 502, 516, 649, 654, 812, 945, 1203, 1205, 1210, 1289, 1525, 1550, 1551, 1626, 1656, 1671, 1680, 1681, 1687, 1688, 1692, 1695, 1701, 1723, 1882, 1898, 1903, 1908, 1912, 1913, 1923, 1929, 1937, 1950, 1957, 1958, 1986, 1991, 1999, 2003, 2006, 2013, 2024, 2050, 2276, 2325.
5	41	427, 430, 443, 459, 463, 464, 469, 470, 472, 498, 504, 952, 1052, 1212, 1662, 1666, 1696, 1699, 1738, 1746, 1762, 1767, 1883, 1897, 1915, 1927, 1938, 1939, 1947, 1953, 1973, 1974, 1978, 1982, 1998, 2044, 2294, 2298, 2366, 2375, 2385.
6	40	420, 422 , 434, 436, 445, 455, 486, 487, 489, 490, 493, 513, 518, 519, 520, 521, 536, 537, 574, 1216, 1286, 1633, 1641, 1728, 1750, 1751, 1871, 1873, 1895, 1920, 1936, 1954, 2016, 2031, 2043, 2047, 2279, 2281, 2288, 2293.
7	28	451, 454, 458, 462, 467, 479, 500, 1645, 1691, 1729, 1730, 1732, 1733, 1756, 1761, 1768, 1772, 1894, 1902, 1907, 1916, 1922, 1926, 1928, 1955, 1987, 2364, 2379.
8	50	431, 447, 448, 460, 461, 477, 485, 508, 953, 1211, 1213, 1317, 1532, 1546, 1643, 1655, 1682, 1683, 1684, 1707, 1725, 1737, 1752, 1755, 1782, 1872, 1878, 1884, 1901, 1904, 1910, 1911, 1924, 1925, 1945, 1975, 1976, 1994, 2029, 2033, 2042, 2057, 2365, 2369, 2370, 2373, 2374, 2376, 2378, 2383.
9	48	423, 429, 437, 440, 446, 471, 491, 501, 503, 514, 515, 651, 942, 948, 951, 1215, 1323, 1521, 1529, 1549, 1629, 1718, 1740, 1869, 1909, 1930, 1931, 1932, 1934, 1940, 1942, 1944, 1946, 1948, 1951, 1977, 1980, 1981, 1990, 1992, 2004, 2009, 2011, 2012, 2056, 2296, 2367, 2368.
10	67	428, 439, 523, 808, 1202, 1630, 1632, 1642, 1689, 1716, 1717, 1720, 1721, 1739, 1867, 1868, 1876, 1877, 1879, 1880, 1881, 1885, 1886, 1887, 1889, 1891, 1896, 1919, 1933, 1941, 19 52, 1956, 1984, 1995, 1996, 1997, 2000, 2001, 2002, 2014, 2017, 2018, 2019, 2022, 2023, 2025, 2026, 2027, 2028, 2030, 2032, 2035, 2036, 2037, 2038, 2039, 2040, 2046, 2048, 2277, 2278, 2282, 2285, 2290, 2291, 2295, 2371.

Table 14. Cluster means for 398 test entries.

Cluster (no.)	Cluster means of studied characters		
	Lesion length (cm)	Relative lesion length	Leaf damaged area (%)
1	6.89	29.14	17.51
2	13.21	49.93	38.83
3	3.45	15.33	6.08
4	4.18	15.89	12.31
5	6.27	26.06	23.05
6	5.47	21.77	11.16
7	7.38	34.24	2967
8	5.11	21.75	18.05
9	2.68	10.81	7.96
10	1.19	5.80	2.53

visual score and survivability of rice germplasm at the seedling stage under complete submergence condition, a total 98 genotypes and two checks namely FR13A and BR5 were evaluated in this experiment. Regarding this, direct seeded 25-day-old seedling was submerged in the Plant Physiology Division submergence tank. Uniformly sprouted 14 seeds of each genotype were seeded using one seed/hill and 20- × 20-cm spacing and two rows were maintained for each genotype. At 25 days after seeding, the crop was allowed to complete submergence maintaining 70 cm water depth for 14 days. During submergence period, the water of the tank was made turbid twice daily and the light intensity in upper level (normal), mid level (30 cm below the water surface) and lower level (70 cm below the water surface) of the tank water were measured through light meter (LI-250) (Table 15). The water pH and temperature were also measured (Table 15). At 14 days after submergence, the water drained out from the submergence tank. The survival data was taken at 5 days after de-submergence. Survival scoring was done by standard evaluation system (SES).

Table 15. Light intensity, water pH and water temperature during submergence period.

Water level	Light intensity (µ mole)		Water pH	Water temperature (°C)
	Before turbidity	After turbidity		
Upper level	1090-1120	-	7.5-8	27-30
Mid level	520-555	100-118		
Lower level	95-114	0-0.57		

Recovery status was also evaluated 30 days of de-submergence.

Tolerant check FR13A survived and the survival rate was 100% but susceptible check BR5 did not survive and its survival rate was only 21%. The rates of percent elongation and percent dry matter increase ranged from 12.8 to 65.4 and 31.3 to 81.8 respectively. Among the genotypes, nine were found with very good recovery status, with survivability score 3. Twenty-eight genotypes were found with good recovery status having survivability score 5. Thirty-five genotypes were found with fair recovery status having survivability score 7, and 26 genotypes were found with poor recovery status having survivability score 9 (Table 16 and Fig. 1). From the results, 37 genotypes may be taken for further study that has a very good and good recovery status.

Characterization of rice germplasm for identifying new sources of submergence tolerance. To observe visual score and survivability of rice germplasm at the seedling stage under complete submergence condition, 100 genotypes and two checks namely FR13A and BR5 were evaluated in this experiment. Regarding this, direct seeded 25-day-old seedling was submerged in the Plant Physiology Division submergence tank. Uniformly sprouted 24 seeds of each genotype were seeded using one seed/hill and with 20- × 20-cm spacing and two rows were maintained for each genotype. At 25 days after seeding, the crop was allowed to complete submergence maintaining 70 cm water depth for 14 days. During submergence period, the water of the tank was made turbid twice daily and the light intensity in upper level (normal), mid level (30 cm below the water surface) and lower level (70 cm below the water surface) of the tank water were measured through light meter (LI-250) (Table 17). The water pH and temperature were also measured (Table 17). At 14 days after submergence, the water drained out from the submergence tank. The survival data were taken at 5 days after de-submergence. Survival scoring was done by SES. Recovery status was not evaluated because all plants had died due to lodging and low temperature after 15 days of de-submergence.

Tolerant check FR13A survived with 100% success rate but susceptible check BR5 very poorly survived and its success rate was only 42%. The percent elongation ranged from 17.5 to 55.1. Among the genotypes, 25 were found moderately tolerant having survivability ranged from 92-100% and survivability score was 3 (Table 18). Further study will be needed for confirmation due to damage before recovery.

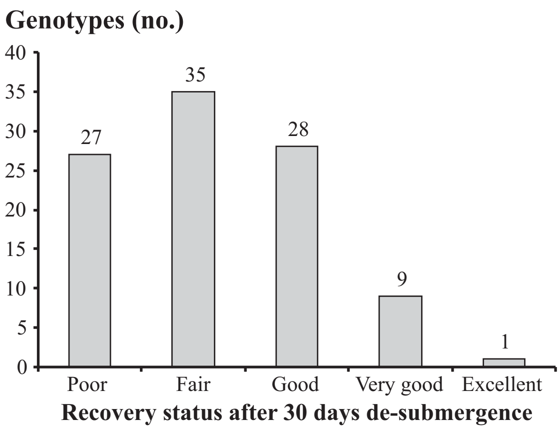


Fig. 1. Frequency distribution of rice germplasm under submergence condition.

QUALITY SEED PRODUCTION AND MAINTENANCE OF NUCLEUS STOCK

To maintain the nucleus seed stock, production and supply of breeder seed (BS) as per national demand with the expected output of varietal purity (both genetic and physical) and supply of BS and as well as limited quantity of quality seed (TLS) to GO,

Table 16. Submergence tolerance and survivability of the tested genotypes.

Acc. (no.)	Designation	% elongation	% survibility 5 days after de-submergence	% survibility 30 days after de-submergence	Score	% dry matter increased	Recovery status
3	Badsha Bhog	45.1	100	57	7	79.3	Fair
24	Gabura	44.4	100	100	3	81.8	Very good
46	Malia Bhangor	39.6	100	21	9	70.7	Poor
77	Kartik Sail	44.8	100	64	7	77.1	Fair
78	Kartik Jhul	40.6	100	64	7	57.6	Fair
79	Lotha	47.1	100	21	9	64.9	Poor
82	Holid Jaran	37.9	100	79	5	67.1	Good
83	Apchasa	43.6	100	79	5	69.8	Good
84	Apchasa	41.1	86	86	5	77.0	Good
86	Jamal Bhog	55.7	93	93	5	76.2	Good
87	Aricha Diga	46.0	100	71	7	42.9	Fair
88	Jhol Diga	39.7	100	86	5	74.7	Good
89	Dhalkatia	42.0	93	86	5	75.8	Good
90	Boron	48.9	100	93	5	79.2	Good
91	Boron	45.5	100	100	3	80.0	Very good
92	Dhaldata	42.0	100	100	3	80.5	Very good
93	Sechi	42.4	100	100	3	79.6	Very good
94	Sechi Aman	52.4	100	71	7	71.1	Fair
95	Soider Boron	58.8	93	79	5	75.6	Good
96	Lani khama	53.8	93	71	7	59.4	Fair
97	Hashfal Boron	39.1	100	100	3	80.2	Very good
98	Kaksmi Diga	49.7	100	71	7	51.7	Fair
99	Dal katra	38.5	100	100	3	64.8	Very good
100	Chota Bhawalia	56.5	100	57	7	45.0	Fair
101	Bhoka Bhawalia	58.8	100	71	7	60.0	Fair
102	Apchasa	59.1	100	79	5	76.2	Good
103	Diga	60.3	100	86	5	69.0	Good
104	Manik Diga	48.3	100	57	7	61.2	Fair
105	Manik Diga	59.1	100	57	7	71.0	Fair
106	Bhanal Diga	63.2	100	71	7	70.7	Fair
107	Jatra Motor	51.4	100	71	7	54.4	Fair
108	Bora Diga	51.4	100	93	5	74.1	Good
109	Rangi Khama	53.1	100	86	5	80.0	Good
110	Dudh Bhawalia	47.8	100	93	5	69.2	Good
111	Goirol	49.7	93	71	7	70.0	Fair
112	Bhawalia Amon	42.9	93	71	7	72.4	Fair
113	Hashful	40.9	100	100	3	69.2	Very good
114	Raj mondal	46.7	100	100	3	80.2	Very good
115	Gonakray	45.9	100	64	7	56.4	Fair
116	Kala Mona	43.5	100	21	9	52.9	Poor
117	Belon Dhan	45.5	100	50	7	61.3	Fair
119	Gorcha	45.5	100	86	5	69.0	Good
120	Luta	50.7	93	79	5	71.4	Good
121	Luta	47.9	100	100	3	67.7	Very good
122	Suna Diga	57.0	93	64	7	60.0	Fair
123	Gabura	49.3	100	79	5	62.0	Good
125	Khoia Motor	49.0	86	71	7	80.2	Fair
126	Suna Digha	36.1	93	71	7	37.3	Fair
127	Bhawalia Diga	46.8	86	86	5	76.9	Good
128	Diga -2	46.8	93	79	5	73.3	Good
129	Diga	57.3	86	43	9	79.2	Poor
130	Raj bhawalia	43.1	93	86	5	77.8	Good
131	Raj bhawalia	41.2	100	93	5	60.5	Good
132	Molla Diga	29.2	100	71	7	50.0	Fair
133	Molla Diga	41.9	100	64	7	71.2	Fair

Table 16. Continued.

Acc. (no.)	Designation	% elongation	% survibility 5 days after de-submergence	% survibility 30 days after de-submergence	Score	% dry matter increased	Recovery status
134	Bhawalia	65.4	100	64	7	68.9	Fair
135	Bhawalia	31.1	100	86	5	68.3	Good
136	Bhawalia	46.4	100	86	5	68.3	Good
137	Bhawalia	58.3	100	50	7	68.9	Fair
138	Net pasha	51.1	86	43	9	69.4	Poor
139	Net pasha	45.7	100	50	7	70.7	Fair
141	Ijol diga-2	48.9	93	50	7	65.8	Fair
142	Ijol Diga-3	44.0	64	64	7	61.3	Fair
143	Bawoi Jhak-3	45.7	100	79	5	63.9	Good
144	Bawoi Jhak-4	42.9	100	57	7	62.3	Fair
146	Bawoi Jhak-6	42.3	100	79	5	58.2	Good
147	Bawoi Jhak-2	47.3	100	57	7	56.1	Fair
157	Chini Sagar	34.0	100	50	7	58.8	Fair
158	Banshapor	33.9	100	43	9	31.3	Poor
159	Roshonbok	34.9	100	36	9	58.8	Poor
160	Dhoilush	40.3	100	36	9	31.3	Poor
161	Ashmber	40.2	100	71	7	59.3	Fair
162	Malsiraz	42.0	100	71	7	58.5	Fair
163	Khirsha moti	35.5	100	50	7	40.5	Fair
164	Laksmi Bilash	42.0	100	50	7	47.6	Fair
165	Bazail	25.8	100	86	5	72.3	Good
166	Ashini	45.3	100	79	5	62.5	Good
167	Buchi	34.5	93	0	9	67.1	Poor
168	Kaika	43.6	100	36	9	72.7	Poor
169	Maloti	37.9	79	7	9	80.4	Poor
170	Katisail	43.9	100	50	7	69.7	Fair
171	Bazail	43.6	93	79	5	67.4	Good
172	Madhu Sail	32.3	79	29	9	81.8	Poor
173	Shuli dhan	32.8	86	86	5	62.5	Good
174	Alad kumar	44.1	86	29	9	73.7	Poor
175	Kumri Amon	20.9	79	0	9	64.5	Poor
176	Lal chamara	52.6	79	43	9	73.9	Poor
177	Moriom	37.3	93	29	9	67.2	Poor
195	Subul Kua	45.6	71	14	9	72.8	Poor
197	Saror	43.9	50	0	9	76.5	Poor
198	Fulgainda	41.7	100	7	9	49.1	Poor
199	Baish Binni	12.8	93	0	9	61.9	Poor
201	Kumri	38.3	57	7	9	62.5	Poor
202	Kumarilal	30.5	71	21	9	76.9	Poor
203	Kumri	40.2	79	14	9	70.3	Poor
204	Kaisha Binni	40.0	57	0	9	57.1	Poor
206	Kaisha Binni	39.3	79	7	9	66.2	Poor
207	Kaisha Binni	39.1	79	0	9	65.9	Poor
	FR13A (ck)	16.2	100	100	1	76.4	Excellent
	BR5 (ck)	32.4	21	7	9	64.7	Poor

Score: 1- plant erect, green, none or slight elongation; 3- plant erect, green, elongated considerably; 5- plants elongated, bent at the middle and pale in colour; 7- plants very much elongated and lodged and 9- plants very much elongated and apparently dead.

Table 17. Light intensity, water pH and water temperature during submergence period.

Water level	Light intensity (µ mole)		Water pH	Water temperature (°C)
	Before turbidity	After turbidity		
Upper level	622-650	-	7.6-8	26-28
Mid level	320-340	60-65		
Lower level	75-80	0-2		

Table 18. Submergence tolerance and survivability of the tested genotypes.

Acc. (no.)	Designation	% elongation	% survibility 5 days after de-submergence	Score	Seedling wt (gm) before submergence
208	Koha Binni	44.9	92	5	0.12
209	Lal binni	40.0	100	5	0.12
210	LAL BINNI	41.2	100	5	0.12
211	Laksmi Bilash	45.9	100	5	0.12
212	Neel Kumari	40.0	100	5	0.12
213	Rotisail	42.7	100	5	0.12
214	Gabal Sail (Blam)	47.3	96	5	0.20
215	Dushor	47.4	63	7	0.24
217	Lao Bhug	31.1	100	3	0.20
218	Luha Garaa	43.4	100	5	0.20
220	Raimihi	41.3	79	7	0.28
221	Sham Rash	42.5	100	5	0.20
222	Gopal Bhog	47.1	92	5	0.20
223	Gohul sail	45.1	88	5	0.20
224	Depa Dhan	41.3	100	5	0.20
225	Dud sar	44.2	100	5	0.12
226	Dhulaiti	35.7	96	5	0.20
227	ABC HOYA	37.5	92	5	0.20
228	Kolom	42.3	75	5	0.20
229	Sagar dhana	42.1	83	5	0.20
230	Khirloni	31.8	100	3	0.12
232	Kataru Bhog	41.3	96	5	0.20
233	Nuria	40.1	100	5	0.20
235	Khorma	33.3	100	5	0.20
236	Kala Binni	46.6	96	5	0.20
337	Dudrat	30.8	92	3	0.20
238	Indra Sail	38.0	96	5	0.20
239	Lal Kumari	39.2	96	5	0.20
240	Kabra Balam	50.0	96	5	0.20
241	Birol (5)	49.1	96	5	0.20
242	Pura Binni (3)	49.6	92	5	0.20
243	Kashia Binni(2)	43.3	92	5	0.20
244	Kashia Binni(2)	43.8	96	5	0.20
246	Gurdoi (2)	49.3	92	5	0.20
247	Kali jura (3)	41.6	83	5	0.20
248	Telot	22.8	100	3	0.12
249	Bazail	35.1	96	5	0.12
250	Joli Amon	22.4	100	3	0.12
251	Bazail	35.6	100	5	0.12
252	Bazail	28.5	100	3	0.12
275	Naria Bochi	38.9	100	5	0.12
401	Mukta Har (L)	39.2	96	5	0.20
402	Boira Amon	42.5	92	5	0.20
403	Lal Pcuria	44.3	100	5	0.12
404	pan zra	38.0	100	5	0.12
405	Bashi	42.4	96	5	0.20
406	Bata	38.5	100	5	0.20
407	panalli	36.8	100	5	0.20
408	Muta Ganje	37.6	96	5	0.12
409	Lcha Dang	46.3	96	5	0.20
411	Moha Rani	36.4	100	5	0.12
412	Chcmgul	29.9	96	3	0.20
413	Shaheb Guta	36.5	88	5	0.20
414	Raga Sail (6)	33.9	96	5	0.20
415	Jingh Sail (1)	33.9	100	5	0.12
416	Jingh Sail (2)	28.9	96	3	0.20
417	Gorti (2)	40.9	100	5	0.20

Table 18. Continued.

Acc. (no.)	Designation	% elongation	% survibility 5 days after de-submergence	Score	Seedling wt (gm) before submergence
418	Suna Mulhi	36.2	92	5	0.20
419	Suna Sail (4)	55.1	96	5	0.20
420	Dhola Depa	34.8	100	5	0.12
422	Bakul Sail	37.3	92	5	0.20
423	Pajre	40.7	96	5	0.20
424	Binna phul	40.1	96	5	0.20
425	Khomon dhan	35.9	96	5	0.20
427	Harma Sail (1)	43.8	96	5	0.20
428	Harma Sail (2)	45.6	100	5	0.12
429	Kali Ray	44.5	96	5	0.20
430	Nagra dhan	35.9	100	5	0.20
431	Gainja	33.8	100	5	0.20
432	Bada dhan	37.3	100	5	0.20
433	Buchi	47.4	88	5	0.20
434	Bowal dah	39.1	88	5	0.20
436	Neel Kanthi	36.8	96	5	0.20
437	Kati Sail	46.8	100	5	0.20
438	Katik Sail	32.1	100	5	0.20
439	Horma	36.9	100	5	0.20
440	Raisa phul	31.9	100	3	0.20
441	Kon Koehur	33.3	96	5	0.20
443	Jola	37.6	100	5	0.20
444	Tangul	30.0	96	3	0.20
445	Bansh phul (1)	37.0	100	5	0.20
447	Tapa Khula	36.7	100	5	0.20
448	Kasia phul (2)	37.9	100	5	0.20
449	Bawai jhaki	30.2	100	3	0.12
450	Bas Kolom	21.9	96	3	0.20
451	Dola Goeha	26.9	100	3	0.12
453	Kali Bunni	30.9	100	3	0.12
454	Kolom Depa	23.5	100	3	0.12
455	Salla	36.1	100	5	0.12
456	Kolom	31.8	100	3	0.12
457	Babu Sail	28.6	92	3	0.20
458	Buta Sail	25.4	96	3	0.20
459	Mohon Bhog	23.0	96	3	0.20
460	Pengun	31.3	96	3	0.20
462	Beto	18.4	100	3	0.20
463	Ronjoy	25.0	96	3	0.20
464	Nedan Sail	35.3	100	5	0.12
465	Hash Raj	29.3	100	3	0.12
466	Bash phul	27.8	100	3	0.12
467	Guta Balam	29.6	100	3	0.12
	FRI3A (ck)	17.5	100	1	0.12
	BR5 (ck)	45.0	42	9	0.14

Score: 1- plant erect, green, none or slight elongation; 3- plant erect, green, elongated considerably; 5- plants elongated, bent at the middle and pale in colour; 7- plants very much elongated and lodged and 9- plants very much elongated and apparently dead.

NGOs and private sector seed producing organizations and to other divisions/regional stations of BRRI and farmers through DAE, respectively, the following experiments were conducted:

Breeder seed production. Eight BRRI RS (Barisal, Bhanga, Comilla, Habiganj, Rajshahi, Rangpur, Satkhira and Sonagazi) are now also engaged in Breeder seed production and were visited to monitor the varietal purity and performances of breeder seed plots. After harvest, the seed of each variety were threshed, dried, cleaned separately and stored in polythene coated gunny bag in the seed store room with controlled temperature (20°C with 30 % RH) at BRRI HQ, Gazipur. Under this condition, the seed remain viable at least for one year. The harvested seed then finally offered as lot for getting the laboratory certificate along with 'Breeder seed tag' from SCA.

A total of 115.90 tons of breeder seed of which 37.19 tons from 28 varieties in T. Aman and 78.71 tons from 10 varieties in Boro seasons were produced during 2011-12 (Table 19). On the other hand, a total of 102.01 tons breeder seed of which 29.39 tons from 23 varieties in T. Aman and 69.76 tons from 10 varieties in Boro and 2.86 tons from nine varieties in Aus seasons were distributed during 2011-12 (Tables 20, 21 and 22) from previous years stock (distribution target was 100 tons). Besides, 1.95 tons truthfully labeled seeds (TLS) from 22 varieties of T. Aman (Table 23) and 7.5 tons truthfully labelled seeds from nine

Table 19. Production of breeder seed during 2011-12.

Variety	Production (kg)										
	GRS Division	Farm Division	BRRI RS, Rangpur	BRRI RS, Rajshahi	BRRI RS, Habiganj	BRRI RS, Comilla	BRRI RS, Bhanga	BRRI RS, Sonagazi	BRRI RS, Barisal	BRRI RS, Satkhira	Total
						T. Aman					
BR10	120			2260							2380
BR11	300			7620				1320			9240
BR21	70										70
BR22	360										360
BR23	240								450		690
BR24	30										30
BR25	120										120
BRRI dhan30	540										540
BRRI dhan31	120										120
BRRI dhan32	200										200
BRRI dhan33	170		960			840					1970
BRRI dhan34	90										1830
BRRI dhan37	150										150
BRRI dhan38	120										120
BRRI dhan39	240		1140	1970							3350
BRRI dhan40	180							660			840
BRRI dhan41	420								1150		1570
BRRI dhan42	160										160
BRRI dhan43	100										100
BRRI dhan44	140								1510		1650
BRRI dhan46									850		850
BRRI dhan48	350										350
BRRI dhan49	840	3600				780		1980			7200
BRRI dhan51	640										640
BRRI dhan52	360								1660		2020
BRRI dhan53	100										100
BRRI dhan54	420										420
Nizersail	120										120
Sub total	6700	3600	2100	11850	-	1620	-	3960	5620	1740	37190
						Boro					
BR3	290										290
BR14	170			840							1010
BR16	170				1850			1900			3920
BR26	550									1500	2050
BRRI dhan28	2800	1600		7200	8320	10,500	3700	1550	6470	5220	47360
BRRI dhan29	2800	2080					4840				9720
BRRI dhan36	380										380
BRRI dhan45	350		2150								2500
BRRI dhan47	-								3350		3350
BRRI dhan50	2680					850	4600				8130
Sub total	10190	3680	2150	8040	10170	11350	13140	3450	9820	6720	78710
Grand total											115,900

Table 20. Distribution of Breeder Seed during T. Aman 2011-12.

Organization	Organizations (no.)	Variety (in kg)																						Total
		BR10	BR11	BR22	BR23	BR25	BRRI dhan30	BRRI dhan31	BRRI dhan32	BRRI dhan33	BRRI dhan34	BRRI dhan37	BRRI dhan38	BRRI dhan39	BRRI dhan40	BRRI dhan41	BRRI dhan44	BRRI dhan46	BRRI dhan49	BRRI dhan51	BRRI dhan52	BRRI dhan53	BRRI dhan54	Nizersail	
GO	2	1300	1440	200	250	-	500	-	200	1200	200	50	100	1220	800	420	1500	-	2580	260	610	100	350	110	13390
NGO	6	10	290	10	20	-	10	-	-	30	-	-	-	50	-	70	20	50	220	10	30	-	10	-	830
PS	210	270	5530	140	220	50	20	36	0	410	420	10	20	934	20	900	140	250	4180	390	1210	0	10	10	15170
Total	218	1580	7260	350	490	50	530	36	200	1640	620	60	120	2204	820	1390	1660	300	6980	660	1850	100	370	120	29390

Table 21. Distribution of beeder seed during Boro 2011-12.

Organization	Organizations (no.)	Variety (in kg)										Total
		BR3	BR14	BR16	BR26	BRRI dhan28	BRRI dhan29	BRRI dhan36	BRRI dhan45	BRRI dhan47	BRRI dhan50	
GO	3	100	200	200	1360	9230	3100	250	50	760	730	15980
NGO	8	-	60	20	-	1460	180	-	20	20	250	2010
PS	661	80	420	2290	590	37060	6530	130	620	520	3130	51370
Total	672	180	680	2510	2310	47786	9820	380	690	1300	4110	69,766

Table 22. Distribution of breeder seed during Aus 2011-12.

Client (s)	Variety (in kg)									Total
	BR3	BR14	BR16	BR21	BR24	BR26	BRRI dhan42	BRRI dhan43	BRRI dhan48	
					GO					
BADC, Dhaka	70	1000	630	70	30	350	160	100	340	2,750
EnergyPac Agro			110							110
Total	70	1000	740	70	30	350	160	100	340	2860

varieties of Boro (previous year's unsold breeder seeds and small graded portion of current year's breeder seed) were available for distribution, while 1.22 tons seeds from 20 varieties of T. Aman, 7.5 tons from nine varieties of Boro and 168 kg from two varieties of Aus were distributed as quality seed (TLS) during 2011-12, (Table 24) respectively.

BRRI has been supplying breeder seed (BS) through the BRRI's Rice Seed Network to the partner organizations for producing foundation seed (FS) and subsequently certified seed (CS)/truthfully labelled seed (TLS), which could partly satisfy the increasing national demand of quality seed. Moreover, now BADC produces

Table 23. Production of quality seed (TLS) in different seasons during 2011-12*.

Variety	Quantity (kg)
T. Aman	
BR10	40
BR11	32
BR22	19
BR23	34
BRRI dhan27	160
BRRI dhan30	03
BRRI dhan33	31
BRRI dhan34	111
BRRI dhan37	41
BRRI dhan40	13
BRRI dhan41	01
BRRI dhan44	12
BRRI dhan46	15
BRRI dhan48	10

Table 23. Continued.

Variety	Quantity (kg)
BRRI dhan49	299
BRRI dhan51	314
BRRI dhan52	40
BRRI dhan53	05
BRRI dhan54	16
BRRI dhan56	55
BRRI dhan57	700
Nizersail	03
Sub total	1954
Boro	
BR14	20
BR16	42
BR26	136
BRRI dhan28	2320
BRRI dhan29	4218
BRRI dhan36	33
BRRI dhan45	102
BRRI dhan47	277
BRRI dhan50	362
Sub total	7510
Grand total	9464

*Produced as from previous year's undistributed breeder seed and small graded portion of current year's breeder seed.

Table 24. Distribution of quality seed (TLS) during 2011-12.

Variety	Quantity (kg)
T. Aman	
BR10	40
BR11	32
BR22	19
BR23	34
BRRI dhan30	03
BRRI dhan33	31
BRRI dhan34	111
BRRI dhan37	41
BRRI dhan40	13
BRRI dhan41	01
BRRI dhan44	12
BRRI dhan46	15
BRRI dhan49	299
BRRI dhan51	314
BRRI dhan52	40
BRRI dhan53	05
BRRI dhan54	16
BRRI dhan56	55
BRRI dhan57	144
Nizersail	03
Sub total	1,228
Boro	
BR14	20
BR16	42
BR26	136
BRRI dhan28	2320
BRRI dhan29	4218

Table 24. Continued.

Variety	Quantity (kg)
BRRI dhan36	33
BRRI dhan45	101
BRRI dhan47	277
BRRI dhan50	362
Sub total	7,509
Aus	
BRRI dhan27	158
BRRI dhan48	10
Sub total	168
Grand total	8,905

foundation seed in one stage instead of two stages (foundation stage 1 and foundation stage 2). Therefore, BRRI will need to produce more quantity of breeder seed every year.

Nucleus seed production. To maintain genetic purity and homogeneity of morphological characteristics of BRRI developed rice varieties and source of breeder seed, 52 varieties (as mentioned below) of which 30 in T. Aman and 22 in Boro seasons were maintained as nucleus stock. 'Panicle to row' method was used for maintaining nucleus stocks those were maintained as a part of breeder seed production. According to panicle to row method, intact panicles were sown in seed bed and the seedling of a panicle was transplanted in a single row. In this method required number of healthy panicles, representing a typical variety was selected and checked individually for panicle and grain characteristics. Seedlings were transplanted into panicle to row in the main field for variety maintenance as well as breeder seed production. Individual row was carefully observed throughout the growing season for varietal characteristics. Off-type plants and rows were identified and rogued out at least three different growth stages. At maturity, required numbers of typical true to type and healthy intact panicles were selected for BRRI HQ, Gazipur along with threshed seeds for BRRI RSs as nucleus stock for next cycle of variety maintenance and the rest of the plot was harvested as breeder seed. However, in panicle to row method, intact panicles were sown instead of threshed seeds and seedlings from a panicle were then transplanted in to a single line for easy identification of off-type.

The following materials were grown for variety maintenance.

Season	No.	Variety
T. Aman	30	BR4, BR5, BR10, BR11, BR21, BR22, BR23, BR24, BR25, BRRI dhan27, BRRI dhan30, BRRI dhan31, BRRI dhan32, BRRI dhan33, BRRI dhan34, BRRI dhan37, BRRI dhan38, BRRI dhan39, BRRI dhan40, BRRI dhan41, BRRI dhan42, BRRI dhan43, BRRI dhan44, BRRI dhan46, BRRI dhan48, BRRI dhan49, BRRI dhan51, BRRI dhan52, BRRI dhan53, BRRI dhan54
Boro	22	BR1, BR2, BR3, BR6, BR7, BR8, BR9, BR12, BR14, BR15, BR16, BR17, BR18, BR19, BR26, BRRI dhan28, BRRI dhan29, BRRI dhan35, BRRI dhan36, BRRI dhan45, BRRI dhan47, BRRI dhan50

Monitoring breeder and foundation seed production farms. To observe foundation seed plots at flowering and maturity stages of seed producing agencies and to provide advises for confirmation of quality seed production by seed growers, foundation seed production farms of City Seed, Rangpur; Sonali Seed, Unique Seed Co. Ltd., Bogra; Janata Seed Store, Khandokar Agro, Grameen Bangla, Rupok Seed, Gaibandha; Chowdhury Seed, Sojeeb Seed, Asha Agro, Nilphamari; Modern Agro, J.C. Seed, Jafor Seed, Chuadanga; NAICOL, Mousumi Seed, Thakurgaon; Global Agro Farming, Dinajpur; MK Seed, Padma Seed Farm, Jerin Seed Farm, Utshab Seed, Green Agro, Ali Seed Farm, Silver Seed Farm, Mollah Seed, Rupali Seed Farm, Jessore; Uzirpur Organic Bahumukhi Samobai Sommittee, RD Traders, Norail were visited. We have had to do that specially to monitor the varietal purity and performances of foundation seed. During the visit, no major insect-pest damage was noticed in the visited plots. Varietal purity (%) was observed which were on average more than 99% in all the varieties and the crops were almost weed free. In maximum cases isolation distance was properly maintained. Overall crop conditions and management was satisfactory. We advised the seed producer for thorough roguing by themselves one more time before harvesting.

Exploratory and genetic studies. To estimate genetic variability, character associations and genetic relationships of T. Aman rice germplasm, 38 rice genotypes of hilly areas were grown under rainfed condition with three replications using one row of 5.4 m long each per entry. The seedlings were transplanted in single seedling per hill with 25- × 20-cm spacing between rows and plants respectively. Fertilizers were applied @ 80-10-60 kg NPK/ha. Control measures for pests, diseases and weed were taken whenever necessary. Thirteen morpho-agronomic and yield contributing characters were recorded to study the genetic diversity. Mahalonobis' D^2 and Canonical Vector Analysis methods were used to group the varieties based on their yield contributing and ancillaries characters.

Based on D^2 analysis the varieties/germplasm were grouped into five clusters (Table 25). Maximum 12 entries were grouped into the cluster V followed by eight in cluster II and IV, and five in cluster I and III.

Table 26 presents intra- and inter-cluster distance and Table 27 presents cluster means for studied characters. All the inter-cluster distances were larger than the intra-cluster distance indicating presence of wider diversity among genotypes of distance groups. The highest intra-cluster value was 1.099 and the highest inter-cluster value was 12.222, which clearly indicated variability in the germplasm of different clusters. The intra-cluster distances were low for all the five clusters with the range of 0.6254 in cluster I to 1.099 in cluster III which indicated homogeneous nature of the genotypes within the clusters. The inter-cluster distances ranged from 3.828 to 12.222 and PCA scores also indicated a high degree of genetic diversity among the genotypes. Cluster III showed maximum genetic distance (12.222) from cluster I followed by cluster II (10.060) from cluster III, Cluster III (8.789) from cluster IV. It is obvious that in all the cases cluster III showed the highest inter-cluster distances with other clusters suggesting wide diversity of the genotypes within cluster III with the genotypes of other clusters and the genotypes in these clusters could be used as parents in hybridization programme for getting transgressive segregants. Moderate distance was observed between cluster I and IV (7.235) followed by cluster I and V (6.704), cluster III and V (6.242). The minimum diversity was observed between

Table 25. Distribution of 38 rice genotypes in different clusters.

Cluster (no.)	Genotypes (no.)	BRRI collection no. of genotypes (New collection under KGF project)	Genotypes
I	5	85, 88, 111, 184, 109	Kamarang, Plokapora binni, Baijja, Silongma (Suli), Suri dhan
II	8	82, 90, 92, 146, 154, 165, 173, 107	Noli, Lal binni, Ranga binni, Patri, Rengui dhan, Gurli, Abdullah, Ranga binni,
III	5	99, 112, 114, 166, 182	Gul galong, Kiron lal, Magumai malok (Gura sada), Chorui, Rangun jhuri
IV	8	80, 81, 86, 117, 124, 138, 174, 175	Company, Kaborok, Bandarnok binni, Napidi, Maiosa, Bandarnok beni, Khulua, Iakedi,
V	12	83, 84, 89, 94, 98, 100, 118, 140, 144, 155, 177, 101	Guri dhan, Galon, Maloti, Chorui lal, Lankapura, Tomlong, Kanoktara, Uttrasha beni, 33 no. dhan, Narikel chhari, Guligh dhan, Maloti

Table 26. Intra (bold) and inter-cluster distances (D2) for 40 T. Aman rice genotypes.

Cluster	I	II	III	IV	V
I	**0.6254**	5.300	12.222	7.235	6.704
II		**0.7059**	10.060	3.828	4.272
III			**1.0998**	8.789	6.242
IV				**0.7113**	3.867
V					**0.7570**

Table 27. Cluster means for thirteen characters of 38 Jhum rice genotypes.

Character	Cluster (no.)				
	I	**II**	**III**	**IV**	**V**
Flag leaf length (cm)	38.26	38.57	38.01	34.60	36.58
Flag leaf width (cm)	1.72	1.49	1.60	1.55	1.52
Plant height (cm)	88.09	83.85	99.03	84.27	92.71
Days to 50% flowering	131.40	131.18	125.91	124.00	127.80
Days to maturity	159.53	159.59	154.58	149.95	156.33
Panicle length (cm)	24.17	23.35	24.58	21.77	24.61
Filled grains/panicle (no.)	39.59	50.33	85.86	46.78	60.23
Unfilled grains/panicle (no.)	35.95	14.92	17.01	13.46	16.63
Grain length (mm)	10.06	9.22	6.66	8.44	7.79
Grain breadth (mm)	2.00	2.00	1.85	2.12	1.93
Length-breath ratio	5.03	4.65	3.58	4.01	4.03
1000-grain weight (g)	22.92	23.21	18.95	23.83	19.98
Yield/hill (g)	3.03	4.50	7.37	5.15	6.64

cluster II and IV (3.828), cluster IV and V (3.867), cluster II and V (4.272) and cluster I and II (5.300) indicating that the genotypes of these clusters were genetically closed.

The highest cluster means for plant height, grains panicle^{-1} and yield were obtained from cluster III. The highest flag leaf width, days to 50% flowering, unfilled grain panicle^{-1}, grain length, grain breadth and grain length breadth ratio while the lowest mean value for yield were found in cluster I. The lowest days to 50% flowering and maturity, and the highest mean value for 1000-grain weight were found in cluster IV. Mean performance of different clusters for the characters revealed that dwarf stature, short growth duration, lower panicle length and moderate yielding varieties were clubbed into cluster IV whereas the highest panicle length and other second highest yield contributing characters (tall plant height, filled grains panicle^{-1}) and yield were obtained from cluster V.

Maximum good characters were accumulated in cluster III and as a result higher yield (7.37 g/hill) was obtained in this cluster. But it was interesting that in the entire cases cluster III produced the highest inter cluster-value with all other clusters. Therefore, the genotypes of cluster III can be used in hybridization programme to produce higher yielding genotypes with all other clusters.

Documentation of technology. To enter the available data of Genebank accessions for retrieving the information whenever necessary, computer based documentation system called Bangladesh Rice Information System (BanglaRIS) was prepared by Genetic Resources Centre of IRRI with the help of BRRI. In the software BRRI developed descriptor and evaluation form were used as the parameters/characters, which contain 73 physio-morphological data and special traits etc. This documentation is necessary for variety identification to establish intellectual property rights.

A total of 3,304 accessions were entered into the database with collected available information of the accession. Among them 100 accessions were recorded within the reporting year. The information, which entered into the database, can be retrieved any time if necessary.

Grain Quality and Nutrition Division

SUMMARY

Four breeding lines of Boro and five lines for T. Aman were analyzed for physicio-chemical and cooking properties of grain. All the lines had satisfactory milling outturn, good to very good appearance, acceptable amylose content was found in two lines and other lines contain intermediate amylose content. For all the lines, protein content was in satisfactory level. Cooking properties of all the lines were in acceptable level.

In total 62 local and high yielding cultivars were analyzed for physico-chemical properties. Among the varieties, 35 showed more than 70 percent milling yield. But head rice yield was unaccepted level. A wide range of cooking time was observed. Cooking properties were good for all the cultivars. Amylose content of all the varieties was low to intermediate level. Protein content of five cultivars was undesirable.

BR3 rice samples of Boro 2011-12 season collected from five different BRRI stations were analyzed for amylose and protein content. The range of protein content was 7.7 to 9 percent and the range of amylose content was found 21.1 to 25.7 percent. The experiment will be continued for the Aus and Aman seasons accordingly.

Physico-chemical and cooking properties of local varieties (12) of hill tract area were analyzed. Milling outturn was satisfactory but the range of head rice yield varied from 16.3-69.0 percent. Cooking time of the varieties was higher than high yielding varieties. Other cooking properties were desirable level. Among the varieties, four contain low amylose content which can be selected for further breeding programme. Protein content was found more than 7.0 percent for all varieties.

Puffed, popped and flattened rice were produced from five modern varieties to evaluate the quality products. Comparing few parameters with BR16, none of the varieties produce better quality puffed rice, whereas these varieties might be used for production of popped rice. Among the varieties, BRRI dhan41, BRRI dhan42 and BRRI dhan45 produce similar/better quality flattened rice comparing with BR16.

GRAIN QUALITY CHARACTERISTICS FOR VARIETY DEVELOPMENT

Physico-chemical and cooking properties of the proposed lines for standard Boro and salinity

The study was conducted to determine physico-chemical and cooking qualities of the proposed breeding lines of standard Boro and salinity for identifying lines with superior grain quality.

These standard Boro and salinity breeding lines were analyzed for milling performances (milling outtrun and head rice yield), physicochemical properties of milled rice (length, breadth, L/B ratio, size and shape, amylose and protein content) and cooking properties (cooking time, elongation ratio and imbibition ratio) by using GQN laboratory methods.

Rice grains of four Boro lines along with three check varieties had the range of milling outturn from 66.4 to 73.4 percent. Two lines had milling outturn less than 70 percent and the rest of the lines including check variety had milling outturn more than 70 percent. All the lines had good to very good appearance. Out of four lines three had medium grain size and the other named BR7323-4B-1 had extra long size with length of 7.0 mm (Table 1).

Three lines had cooking time less than 20 minutes, but the line IR72579-B-3-2-3-3 had cooking time more than 20 minutes. Cooked rice elongation ratio (ER) was in between 1.2 and 1.4. All the lines and varieties had acceptable range of imbibitions ratio except BR7105-4R-2. The line BR7105-4R-2 had imbibitions ratio (IR) 2.7 (Table 1). Of the four breeding lines only IR72579-B-3-2-3-3 had more than 25% amylose content. The other three had amylose content ranged from 21.8 to 24.6 percent. All the lines and check varieties, as they had protein content more than 7 percent are acceptable.

Physico-chemical and cooking properties of the proposed breeding lines for T. Aman.

The study was conducted to determine physico-chemical and cooking properties of the proposed breeding lines of T. Aman to screen out for varietal development.

Table 1. Physico-chemical and cooking properties of the proposed lines for standard Boro and salinity.

Variety/line	Milling outturn (%)	Head rice yield (%)	Length (L) mm	Breadth (B) mm	L/B ratio	Size and shape	Amylose (%)	Protein (%)	Cooking time (min)	ER	IR
BR7323-4B-1	70.3	53.3	7.0	2.0	3.5	Extra long, slender	22.2	7.8	18.30	1.3	4.0
BW328	73.4	55.6	5.7	2.4	2.3	Medium, bold	24.6	7.5	18.0	1.3	3.2
BRRI dhan28 (ck)	71.6	61.0	6.3	2.0	3.1	Long, slender	26.4	8.4	16.30	1.2	4.3
BRRI dhan29 (ck)	68.5	61.4	6.3	1.7	3.7	Long, slender	27.2	7.9	13.0	1.2	3.7
IR72579-B-3-2-3-3	66.4	54.8	5.3	2.3	2.3	Medium, bold	26.8	6.5	20.30	1.3	4.6
BR7105-4R-2	72.7	62.4	5.9	2.2	2.6	Medium, bold	21.8	8.8	16.30	1.3	2.7
BRRI dhan47 (ck)	71.9	57.4	5.5	2.8	2.0	Medium, bold	26.3	8.2	17.0	1.4	3.6

ER=Elongation ratio, IR=Imbibition ratio.

Proposed T. Aman breeding lines were analyzed for milling performances (milling outtrun and head rice yield), physico-chemical properties of milled rice (appearance, chalkiness, length, breadth, L/B ratio, size and shape, amylose and protein content) and cooking properties (cooking time, elongation ratio and imbibition ratio).

Milling outturn was found to be more than 70 percent for all the breeding lines including check varieties except the line BR7875-*5 (NIL)-52-HR1. The line BR7875-*5 (NIL)-52-HR1 had 68.3 percent milling outturn (Table 2). Lower head rice yield value was also found for the line BR7875-*5 (NIL)-52-HR1 (62.8%) in comparison with other lines including check varieties (the range is 86.2 to 98.6 percent).

All the assessed lines and varieties had good to very good appearance. While chalkiness was determined, then it was found that all the lines were of translucent grain type, but one check variety had grain type with white center (Wc) and two check varieties had white belly (Wb). The length all the lines and check varieties was ranged from 5.3 to 6.5, so all had size of short to medium category. Only one line namely BR7878-*5 (NIL)-72-HR6 and two other check varieties had the slender shape, but all the other lines and varieties had the medium shape. Cooking time of all the lines and varieties was 15.0-21.0 minutes. Cooking time of more than 20 minutes produces hard cooked rice. So, except the line BR7474-60-5-3, all the lines and varieties had acceptable range of cooking time. There is an acceptable range of cooked rice elongation ratio, which was in between 1.2 and 1.4. The imbibitions ratio was also under acceptable range. Of the breeding lines only one and two check varieties had amylose content more than 25 percent and all other lines and varieties had the amylose content 20.6 to 24.9 percent. The range of protein content of all lines and varieties was 7.1 to 10.1 percent (Table 2).

CHARACTERIZATION OF LOCAL GERMPLASM CULTIVARS FOR PHYSICO-CHEMICAL AND COOKING PROPERTIES

Physico-chemical and cooking properties of local aromatic rice varieties

The study was conducted to determine the physico-chemical and cooking qualities of local aromatic rice varieties collected from GRS Division for identifying superiority in specific grain quality characteristic.

Local aromatic rice varieties were analyzed for the determination of milling performances (milling outtrun and head rice yield), physico-chemical properties of milled rice (length, breadth, L/B ratio, size and shape, amylose content and protein content) and cooking properties (cooking time, elongation ratio and imbibition ratio) by using GQN laboratory methods.

Milling outturn of analyzed 62 aromatic varieties (57 were local and five were high yielding check varieties) varied between 62.1 to 74.2% (Table 3). Thirty-five rice varieties showed the milling outtrun more than 70 percent. In the study, all the rice varieties showed head rice yield ranged from 12.2 to 69.1 percent, of which Begun bitchi (12.2%), Khazar (21.7%), and Basmati sufaid 106 (29.5%) had shown very low head rice yield. Head rice yield less than 70% is undesirable. So all the varieties showed undesirable head rice yield.

Table 2. Physico-chemical and cooking properties of the proposed breeding lines of T. Aman 2011-12.

Variety/line	Milling outturn (%)	Head rice yield (%)	Appearance	Chalkiness	Length (L) mm	Breadth (B) mm	L/B ratio	Size and shape	Amylose (%)	Protein (%)	Cooking time (min)	ER	IR
BR7465-1-2-4	70.0	96.7	Very good	Translucent	6.5	2.2	2.9	Medium, medium	25.4	8.7	17.0	1.2	3.2
BR7474-60-5-3	70.8	88.1	Very good	Translucent	5.5	2.4	2.3	Short, medium	24.1	10.1	21.0	1.4	3.2
BR11 (ck)	72.3	86.2	Very good	Translucent	5.4	2.5	2.1	Short, medium	25.0	8.2	18.30	1.4	3.5
BRRI dhan49 (ck)	72.0	98.0	Good	White center	5.5	2.1	2.6	Short, medium	24.4	8.2	16.0	1.4	4.6
BR7465-1-4-1	70.0	91.6	Good	Translucent	5.5	1.8	3.0	Short, medium	24.5	7.9	16.0	1.3	3.7
BR7875-*5 (NIL)-52-HR1	68.3	62.8	Very good	Translucent	5.8	1.9	3.0	Medium, medium	22.9	9.9	17.0	1.4	3.5
BR7878-*5 (NIL)-72-HR6	70.7	96.5	Very good	Translucent	6.2	1.8	3.4	Medium, slender	24.9	7.8	16.0	1.3	4.3
Kataribhog (ck)	70.0	98.6	Very good	Translucent	5.3	1.7	3.1	Short, slender	20.6	7.1	15.0	1.2	4.6
Dadkhani (ck)	67.8	92.5	Very good	Translucent	5.3	1.8	2.9	Short, medium	25.4	8.9	16.0	1.2	5.0
BRRI dhan37 (ck)	72.8	93.4	Good	White belly	5.3	1.8	2.9	Short, medium	22.4	8.0	15.30	1.3	5.0
BRRI dhan38 (ck)	72.2	91.6	Very Good	White belly	6.0	1.9	3.1	Medium, slender	23.3	9.1	16.30	1.3	4.6

ER=Elongation ratio, IR=Imbibition ratio.

Table 3. Physico-chemical and cooking properties of local aromatic rice varieties.

Variety/line	Milling outturn (%)	Head rice yield (%)	Length (mm)	Breadth (mm)	L/B ratio	Size and shape	Amylose (%)	Protein (%)	Cooking time (min)	ER	IR
Sakor	70.0	63.5	4.1	2.2	1.9	Short, Round	24.0	7.1	16.0	1.5	3.5
Sagardana	69.5	62.5	5.0	1.9	2.6	Medium, Bold	24.1	7.6	13.30	1.3	3.2
Nunia	68.5	61.7	5.2	2.1	2.4	Medium, Bold	23.1	8.6	15.30	1.3	3.0
Chini Sagar (2)	71.1	66.8	4.3	2.0	2.1	Short, Bold	21.2	8.4	14.0	1.2	3.0
Meny	73.7	67.7	4.3	2.1	2.0	Short, Bold	20.8	7.3	14.0	1.2	3.0
Tilkapur	70.6	62.9	5.1	1.9	2.7	Medium, Bold	21.9	7.6	14.0	1.3	2.7
Kalobhog	70.4	59.9	4.6	1.8	2.5	Short, Bold	22.2	7.5	14.0	1.3	3.0
Jabsiri	69.9	63.9	4.6	1.9	2.4	Short, Bold	21.9	7.7	13.0	1.4	3.0
Kalgochi	67.5	59.3	5.0	2.9	1.7	Medium, Round	24.3	5.7	18.30	1.6	2.7
Chinisakkor	71.7	66.5	4.2	2.0	2.1	Short, Bold	20.6	7.8	13.0	1.4	4.0
Chini atob	70.5	63.2	4.1	2.2	1.8	Short, Round	20.0	6.6	13.0	1.7	3.6
Noyonmoni	69.9	54.7	5.1	1.8	2.8	Medium, Bold	20.4	9.2	13.0	1.3	3.2
Saubail	68.7	62.4	5.2	2.1	2.5	Medium, Bold	20.9	7.7	14.30	1.3	3.6
Chinigura	71.4	66.2	4.0	2.0	2.0	Short, Bold	19.1	8.3	13.0	1.3	4.0
Kolomala	73.7	65.7	4.2	2.0	2.1	Short, Bold	19.3	10.2	13.0	1.3	2.7
Begunmala	72.6	66.7	4.4	2.0	2.2	Short, Bold	19.1	8.1	15.0	1.6	3.5
Tulsimoni	67.5	62.0	3.9	1.9	2.1	Short, Bold	19.6	8.6	14.0	1.3	3.2
Jirabuti	71.9	67.9	3.7	2.1	1.7	Short, Round	18.2	8.4	14.0	1.2	3.0
Rajbut	69.1	64.4	5.2	1.7	3.0	Medium, Bold	20.6	9.1	13.0	1.1	3.0
Soru Kamina	71.0	69.1	3.9	2.1	1.8	Short, Round	21.2	7.6	12.30	1.2	3.0
Kamini soru	70.7	67.0	4.1	2.0	2.0	Short, Bold	20.1	6.6	12.30	1.1	2.7
Doiaguru	70.4	67.6	3.8	2.0	1.9	Short, Round	19.7	8.1	13.0	1.2	3.0
Premful	72.5	49.2	3.7	1.7	2.1	Short, Bold	20.2	8.2	13.0	1.2	3.0
Begun bichi	66.7	12.2	4.2	2.3	1.8	Short, Round	20.2	10.0	15.0	1.5	3.0
Elai	67.6	53.3	7.4	1.8	4.1	Extra long, Slender	25.0	6.7	15.30	1.2	3.0
Gua masuri	69.1	61.7	5.2	1.8	2.8	Medium, Bold	21.8	9.3	14.0	1.3	4.0
Luina	69.5	61.8	4.7	1.8	2.6	Short, Bold	22.5	8.1	13.0	1.2	3.6
Lal soru	71.5	66.2	4.9	1.8	2.7	Short, Bold	20.1	7.6	12.30	1.3	3.0
Chini kanai	72.7	68.5	3.7	2.1	1.7	Short, Round	20.8	7.3	13.30	1.4	3.6
Kalijira (I)	68.3	56.2	4.1	2.0	2.0	Short, Bold	20.8	7.1	13.30	1.3	4.3
Rajbhog	71.1	63.8	4.8	1.8	2.6	Short, Bold	20.4	8.0	13.0	1.2	3.6
Baoibhog	71.6	67.1	4.3	1.8	2.4	Short, Bold	21.2	9.5	13.0	1.1	4.3
Baoi jhaki	72.1	67.6	4.1	2.0	2.1	Short, Bold	21.0	8.0	14.0	1.5	3.0
Jirabhog	70.4	66.9	4.0	2.0	2.0	Short, Bold	21.5	8.2	13.30	1.3	4.0
Uknimodhu	72.3	68.5	4.0	1.9	2.1	Short, Bold	20.2	8.7	13.30	1.3	3.2
Ranisalui	68.4	56.9	5.4	2.8	1.9	Medium, Round	20.5	7.8	18.0	1.5	4.0
Jira dhan	70.1	67.0	3.8	2.0	1.9	Short, Round	21.4	6.7	12.30	1.3	3.6
Gandhakusturi	67.0	49.1	5.6	2.8	2.0	Medium, Bold	20.0	7.2	18.30	1.5	3.6
Sakkor khora	72.3	70.2	4.0	2.3	1.7	Short, Round	20.3	8.0	14.30	1.5	3.6
Badshabhog	72.9	66.2	4.0	2.0	2.0	Short, Bold	20.0	7.8	13.0	1.4	3.6
Jirakatari	72.3	68.3	4.0	2.0	2.0	Short, Bold	20.7	8.1	13.0	1.3	3.0
Desi katari	68.2	63.4	5.0	1.9	2.6	Medium, Bold	22.0	7.7	13.30	1.3	3.2
Sugandhi dhan	69.8	55.5	5.3	2.0	2.6	Medium, Bold	23.0	8.8	16.0	1.2	3.5
Kalijira (II)	66.5	46.4	5.1	1.9	2.7	Medium, Bold	20.3	9.4	12.30	1.3	3.2
Jesso balam	69.1	62.2	3.8	1.8	2.1	Short, Bold	20.2	9.0	13.30	1.4	4.0
Dakshhi	72.1	67.0	4.3	2.6	1.6	Short, Round	19.7	9.5	16.30	1.5	3.6
Hatisail	71.0	59.2	3.9	2.1	1.8	Short, Round	20.4	11.3	15.0	1.3	4.3
Khasa	71.2	67.1	3.8	1.8	2.1	Short, Bold	20.5	11.0	13.0	1.3	4.0
Buchi	66.4	49.8	4.8	2.9	1.6	Short, Round	25.6	7.2	18.30	1.4	3.0
Awned-1	70.5	59.0	5.1	2.5	2.0	Medium, Bold	22.5	8.2	15.0	1.3	2.7
Black	67.3	40.3	4.7	2.9	1.6	Short, Round	24.2	8.4	19.30	1.2	2.7

Table 3. Continued.

Variety/line	Milling outturn (%)	Head rice yield (%)	Length (mm)	Breadth (mm)	L/B ratio	Size and shape	Amylose (%)	Protein (%)	Cooking time (min)	ER	IR
Straw	70.0	60.2	7.2	2.2	3.3	Extra long, Slender	22.6	8.8	16.30	1.2	2.7
Dubsail	69.7	66.9	4.2	2.3	1.8	Short, Round	21.7	9.1	14.0	1.3	3.0
Duksail	69.5	67.9	4.5	2.5	1.8	Short, Round	23.3	9.8	18.30	1.3	3.6
Khaskani	72.5	67.3	4.0	1.8	2.2	Short, Bold	21.7	8.5	12.0	1.4	4.0
Khazar	63.4	21.7	6.4	1.9	3.3	Long, Slender	21.7	11.3	16.0	1.1	2.7
Basmati sufaid 106	63.5	29.5	5.9	1.9	3.1	Medium, Slender	21.8	8.4	13.0	1.6	4.3
BR5 (ck)	68.5	65.9	4.1	2.1	1.9	Short, Round	21.7	8.5	14.0	1.3	3.2
BRRI dhan34 (ck)	70.7	66.1	4.0	1.8	2.2	Short, Bold	22.6	7.7	13.0	1.4	3.0
BRRI dhan37 (ck)	74.2	68.4	5.5	1.8	3.0	Medium, Bold	23.1	8.2	13.0	1.2	3.6
BRRI dhan38 (ck)	72.8	64.7	6.1	1.9	3.2	Long, Slender	23.8	8.3	13.30	1.2	4.0
BRRI dhan50 (ck)	62.1	40.3	6.5	1.5	4.3	Long, Slender	26.0	9.7	15.0	1.2	3.0

Rice varieties are categorized as long, medium, short and slender, round or bold according to their length and L/B ratio respectively. In the present study length, breadth and L/B ratio varied significantly and they ranged between 3.7 to 7.4 mm, 1.5 to 2.9 mm and 1.6 to 4.3 respectively. Most of the rice varieties are found to have short and bold or short and round in their appearance (Table 3).

A wide range of cooking time (12:00-19:00 minutes) was found for the assessed aromatic rice varieties and it is found that all the varieties were within the acceptable range of cooking time. The highest value 1.7 of elongation ratio of cooked rice was found for the variety Chini Atob and the lowest value was 1.1, found for four varieties. Imbibition ratio of all the varieties was found within the acceptable range.

The amylose and amylopectin ratio in the rice grain influence the cooking and eating characteristics of rice. In the present study, amylose content ranged between 18.2 percent for Jirabuti to 26.0 percent for BRRI dhan50 (Table 3). Rice varieties were classified into waxy (0-2%), very low (3-9%), low (10-19%), intermediate (20-25%) and high (>25%) on the basis of their amylose content. Based on this classification, 55 rice varieties had intermediate amylose content which indicates that they may cook dry, fluffy, and less tender and become harder upon cooking, which is acceptable. Protein greatly influences the eating quality of rice. Results of the present study indicated only 14 varieties displayed high protein content (>9%). The protein content ranged between 5.7 percent for Kalgochi to 11.3 percent for Khazar and Hatisail (Table 3).

GRAIN QUALITY CHARACTERISTICS ASSESMENT

Effect of rice cropping season and location on chemical properties (Amylose and protein content) of BR3

The study was conducted to determine chemical properties (amylose and protein content) of BR3 cultivated in Boro season in five BRRI regional stations (RS) including BRRI head quarters (HQ).

BR3 rice samples collected from five different BRRI RSs were analyzed for amylose content and protein content by using spectrophotometric method and micro-kjeldahl method respectively. The range of protein content was 7.7 to 9 percent in five different stations. The highest value for protein was found to be 9 percent in BRRI HQ and the lowest value was found 7.7 percent in BRRI RS, Rangpur. The range of amylose content was 21.1 to 25.7 percent (Table 4). The highest value of amylose was also found in BRRI HQ and the lowest value was in BRRI RS, Habiganj.

The variations found by the amylose and protein content determination is not deducible because this result is only for the Boro season. The experiment will be continued for the Aus and Aman seasons. After getting the final result of all seasons, statistical analysis will be done.

Table 4. Effect of rice cropping season and location on chemical properties (Amylose and Protein content) of BR3.

Location	Protein (%)	Amylose (%)
BRRI HQ, Gazipur Head Office	9.0	25.7
BRRI RS, Barisal	8.0	24.2
BRRI RS, Habiganj	8.5	21.1
BRRI RS, Satkhira	8.7	24.1
BRRI RS, Rangpur	7.7	25.6

Physico-chemical properties determination of sticky rice in hill tracts.

The study was conducted to determine the physico-chemical and cooking qualities of local rice varieties collected from different areas of Bandarban hilly district for identifying specific grain quality characteristics for further use in breeding purpose of the development of high yielding low amylose rice varieties for the people of hill tracts in Bangladesh.

Local rice varieties were analyzed for the determination of milling performances (milling outtrun and head rice yield), physico-chemical properties of milled rice (length, breadth, L/B ratio, size and shape, amylose and protein content) and cooking properties (cooking time, elongation ratio and imbibition ratio) by using GQN laboratory methods.

Milling outturn of analyzed 12 local varieties varied between 68.5 to 74.0% whereas the milling outturn of the check variety BR26 was 68% (Table 5). So milling outturn of all the local varieties were found to be satisfactory. In the study, all the rice varieties showed head rice yield ranged from 16.3 to 69%, of which Binni (Black) (16.3%) had shown very low head rice yield. All the varieties showed head rice yield less than 70 percent but the head rice yield value of Knaruktai was 69 percent.

Rice varieties are categorized as long, medium, short and slender, round or bold according to their length and L/B ratio respectively. In the present study length, breadth and L/B ratio varied significantly and they ranged between 4.5 to 7.1 mm, 2.4 to 3.5 mm and 1.4 to 3.2 respectively. Most of the rice varieties are found to have long and bold or long and round in their appearance (Table 5).

A range of cooking time (16-24 minutes) was found for the assessed aromatic rice varieties and it is found that all the varieties were found within the acceptable range of cooking time except the variety Knaruktai, which has cooking time of 24 minutes (Table 5). The highest value 1.6 of elongation ratio of cooked rice was found for the variety Knaruktai atob and the lowest value was 1.1, found for two varieties. Imbibition ratio of all the varieties was found within the acceptable range.

In the present study, a wide range of amylose content was found for all the varieties and it was 7.2 to 25.9 percent (Table 5). The lowest amylose content was 7.2 percent for the varieties Oikhongpru and Boli. The variety Binni (white) had a very close value of amylose content (7.5%) with the lowest value. The highest amylose content (25.9%) was found for the variety Pongdocraksui. Two varieties named Mongthon and Totke had

Table 5. Physico-chemical properties determination of sticky rice in hill tracts.

Variety/line	Milling outturn (%)	Head rice yield (%)	Length (L) mm	Breadth (B) mm	L/B ratio	Size and shape	Amylose (%)	Protein (%)	Cooking time (min)	ER	IR
Oikhongpru	68.5	45.3	6.9	2.5	2.7	Long, Bold	7.2	8.6	16.0	1.1	3.0
Boli	69.4	32.0	6.6	3.4	1.9	Long, Round	7.2	7.9	20.0	1.2	3.2
Gungdi	70.5	59.2	6.7	3.5	1.9	Long, Round	18.3	8.7	19.0	1.2	3.5
Chili	74.0	58.2	6.4	3.2	3.2	Long, Slender	18.9	8.4	18.30	1.2	3.2
Rohnquin	72.0	50.6	6.9	2.5	2.7	Long, Bold	19.0	8.6	19.0	1.1	3.5
Mongthon	73.0	54.2	6.6	2.3	2.8	Long, Bold	22.1	8.1	21.0	1.3	4.6
Pongdocraksui	71.1	58.8	6.1	2.5	2.4	Long, Bold	25.9	8.0	20.0	1.4	4.6
Pedi	73.6	51.2	5.3	3.3	1.6	Medium, Round	18.3	8.7	21:0	1.4	3.5
Knaruktai	72.4	69.0	4.5	3.2	1.4	Short, Round	19.7	9.4	24:0	1.6	3.5
Binni (White)	73.0	57.1	7.1	2.5	2.8	Extra Long, Bold	7.5	8.5	21:0	1.2	4.3
Binni (Black)	66.0	16.3	5.9	2.4	2.4	Medium, Bold	10.2	8.3	16:30	1.2	3.5
Totke	71.0	47.0	6.1	2.1	2.9	Long, Bold	21.1	8.3	17:30	1.2	3.5
BR-26	68.0		6.0	1.6	3.8	Long, Slender	22.7	8.4	19:30	1.3	4.1

intermediate amylose content. All other varieties had low amylose content.

All the varieties showed high protein content (>7%). The highest protein content (9.4%) was found for the variety Knaruktai and the lowest was for the variety Boli (7.9%).

INDIGENOUS RICE PRODUCTS QUALITY

The quality of indigenous rice products of some high yielding rice varieties

The study was conducted to evaluate the quality of indigenous rice products. Indigenous rice products (puffed, popped and flattened rice) of some modern varieties are produced for human consumption. In the rural areas of Bangladesh, these products are consumed as breakfast food and also used in different festival programmes. A few BRRI varieties (BRRI dhan41, BRRI dhan42, BRRI dhan45, BRRI dhan48 and BRRI dhan50) were used for this purpose to compare the quality of indigenous products. Varieties were selected on the basis of size and shape (length >6mm). The following parameters were considered to evaluate qualities: fully and partially puffed/popped/flattened rice, 1000 product weight, volume expansion, elongation of length-breadth and protein content.

Puffed rice. Among the tested varieties, the fully puffed rice yield varied from 9.6 to 55.0 percent and the range of partially puffed rice was 22.0-85.6 percent, whereas the standard fully puffed rice yield was 78.9 percent (Table 6). The range of 1000 puffed rice weight was 13.0-19.4 g and the volume of 50 g puffed rice was 340-460 mL. Length and breadth increased 50.7-91.7 percent and 40.0-95.0 percent respectively comparing with milled rice. Both length and breadth are lower than standard one for all the varieties. Comparing the results with the standard, these varieties are not suitable for making puffed rice.

Popped rice. The range of fully and partially popped rice was 69.0-90.3 percent and 9.0-30.2 percent respectively. Among the varieties, BRRI dhan41and BRRI dhan42 showed better quality than the standard (BR16). Weight of 1000 popped rice of all varieties was less than standard except BRRI dhan45. The volume of 50 gm popped rice was higher in BRRI dhan50 and BRRI dhan48 was the lowest. Length and breadth increased more than that of puffed rice for all the varieties (Table 7). It might be concluded that the studied varieties are suitable for popped rice production.

Flattened rice. Flattened rice of five varieties was produced by local commercial flattened rice producer. Total yield of flattened rice varied from 41.5 to 89.3 percent. The highest (89.3%) was found for BRRI dhan41 and the lowest (41.5%) for BRRI dhan50 (Table 8). The weight of 1000 flattened rice was less than standard one except BRRI dhan45 and the lowest weight was observed for BRRI dhan50 (13.7 g). The volume of all the varieties was lower than BR16. The enlargement of length and breadth varied from 74.2 to 123.3 and from 87.0 to 125.0 percent respectively over the milled rice. The range of protein content was 8.1-9.7 percent. Considering above properties, BRRI dhan41, BRRI dhan42 and BRRI dhan45 can be used for commercial purpose to produce flattened rice.

Table 6. Quality parameters of puffed rice made from modern rice varieties.

Variety	Fully puffed (%)	Partially puffed %)	Broken (%)	1000-wt (g)	50 g volume (mL)	Length increase (%)	Breadth increase (%)	Protein content (%)
BRRI dhan41	42.3	52.2	4.7	17.5	450	91.7	95.0	8.6
BRRI dhan42	17.6	75.2	6.4	15.0	340	50.7	52.4	11.7
BRRI dhan45	9.6	85.6	3.8	19.4	350	87.1	65.2	9.2
BRRI dhan48	29.1	66.2	3.2	15.8	410	75.0	69.6	11.6
BRRI dhan50	55.0	22.2	21.4	13.0	460	66.7	50.0	8.9
BR16	78.9	18.9	1.9	19.2	490	106.5	105.0	7.6

Table 7. Quality parameters of popped rice made from modern varieties.

Variety	Fully popped (%)	Partially popped %)	Broken (%)	1000-wt (g)	50 g volume (mL)	Length increase (%)	Breadth increase (%)	Protein content (%)
BRRI dhan41	85.5	13.7	0	20.0	680	151.6	140.0	7.6
BRRI dhan42	90.3	9.0	0	16.3	850	120.0	147.7	9.9
BRRI dhan45	80.8	17.8	0	22.3	600	112.9	117.4	8.0
BRRI dhan48	69.6	30.2	0	18.0	550	73.3	91.3	9.1
BRRI dhan50	80.0	16.0	2.7	14.2	930	110.6	166.7	8.4
BR16	82.2	16.5	0.4	22.0	830	138.7	150.0	7.9

Table 8. Quality parameters of flattened rice made from modern rice varieties.

Variety	Fully flattened (%)	Partially flattened %)	Broken (%)	1000-wt (g)	50 g volume (mL)	Length increase (%)	Breadth increase (%)	Protein content (%)
BRRI dhan41	89.3	0	10.4	19.6	120	123.3	125.0	8.5
BRRI dhan42	87.2	0	12.4	20.0	110	92.3	100.0	9.3
BRRI dhan45	64.9	0	34.5	24.0	120	118.0	108.7	8.1
BRRI dhan48	74.8	0	24.2	15.8	120	80.0	87.0	9.7
BRRI dhan50	41.5	0	58.0	13.7	100	74.2	113.3	9.4
BR16	75.6	0	23.8	20.2	140	137.1	125.0	7.0

Hybrid Rice Division

SUMMARY

During T. Aman season 2011, fifty-five test crosses and 54 (A × R) crosses were made from source nursery. Sixty test crosses (F_1s) were evaluated for their pollen fertility status of which one entry has been shown complete sterile and it was immediately backcrossed with its corresponding male parent for conversion. Thirty-five BC_6 generations were designated as new CMS lines and included into CMS maintenance and evaluation nursery. Ninety-one CMS lines along with their respective maintainer lines were maintained by hand crossing.

Fifty-five (55) test crosses and 83 (A × R) crosses were made using seven CMS lines in Boro season 2011-12 from source nursery. Twenty-two test crosses (F_1s) were evaluated for their pollen fertility status of which one entry has been shown complete sterile and it was immediately back crossed with its corresponding male parent for conversion. Eight BC_6 generations were stable in terms of pollen sterility and other desirable agronomic characteristics and shifted to CMS nursery as new CMS line in the background of corresponding elite maintainer lines. A total of 104 CMS lines along with their respective maintainer lines were maintained by hand crossing.

At observational trial in Gazipur, during T. Aman 2011 only two hybrids viz Jin23A/BR7013-62-1-2R and BRRI11A/BRRI16R were shown about 1.5 t/ha (28.30%) and 1.7 t/ha (32.01%) yield advantage over BR11 and 1.2 t/ha (21.43%) and 1.4 t/ha (25.0%) over BRRI dhan49. In Boro 2011-12 seasons seven hybrid combinations out of 83 found higher yielder over BRRI dhan28, BRRI dhan29 and BRRI dhan50. All of the selected hybrids showed yield potentiality above 7.72 t/ha and produced yield more than 1 ton over BRRI dhan28 and 2 tons over BRRI dhan50 with growth duration around 150 days.

In T. Aman 2011, CMS line seed yield 85 kg/plot (2.0 t/ha) and 60 kg/plot (1.6 t/ha) were obtained from BRRI10A/B and IR58025A/B respectively. On the other hand, during Boro 2011-12 season, CMS line seed yield of 65 kg (2.30 t/ha), 58 kg (2.4 t/ha) and 45 kg (1.7 t/ha) were obtained from BRRI10A/B, BRRI11A/B and IR58025A/B respectively. A total of 50 kg (2.6 t/ha), 62 kg (2.85 t/ha) and 180 kg (1.80 t/ha) hybrid seeds were collected from BRRI10A/BRRI10R, BRRI11A/BRRI15R and IR58025A/BRRI10R respectively.

During the reporting year, hybrid rice breeding component supplied 3,63.5 kg of parental lines and hybrid seeds among 34 growers including seven seed companies, BADC and farmers.

DEVELOPMENT OF PARENTAL MATERIALS

Source nursery. A total of 55 test crosses and 54 (A × R) crosses were made using 7 CMS lines during T. Aman season 2011. Fifty-five test crosses and 83 (A × R) crosses were made using seven CMS lines during Boro season 2011-12.

Test cross nursery. During T. Aman 2011, sixty test crosses (F_1s) were evaluated for their pollen fertility status of which one entry (Gan46A/Morberekan) have been shown complete sterile and it was immediately back crossed with their corresponding male parents for conversion and none produced desired standard heterosis over check variety. In Boro 2011-12, 22 test crosses were evaluated and got only one combination (V20A/PR15) shown complete pollen sterility and it was immediately back crossed with their corresponding male parents for conversion.

Back cross nursery. Thirty-five BC_6 generations were stable in terms of pollen sterility and other desirable agronomic characteristics and shifted to CMS nursery as new CMS line in the background of corresponding elite maintainer lines. Other BC generations were advanced for next generations (Table 1) and in Boro season 2011-12, eight BC_6 generations were stable in terms of pollen sterility and other desirable agronomic characteristics and shifted to CMS nursery as new CMS line in the background of corresponding elite maintainer lines (Table 2).

CMS maintenance and evaluation nursery. Ninety-one CMS lines were maintained by hand crossing for seed increase and genetic purity and 104 CMS lines were maintained by hand crossing in Boro 2011-12 for seed increase and genetic purity.

Breeding for BB resistance rice hybrids. Forty-six test crosses (F_1s) were made using six CMS lines during T. Aman 2011.

Table 1. List of newly developed CMS lines from Backcross Nursery during T. Aman 2011.

Combination	Source	Grain type	Seed amount
A-1/PR203	1.1. BC_6F_1/P	Medium	60
A-2/PR69	2.2. BC_6F_1/P	Slender	65
A4/PR40	3.3. BC_6F_1/P	Bold	50
A6/PR77	4.4. BC_6F_1/P	Medium	55
A6/PR10	5.5. BC_6F_1/P	Bold	60
A-28/PR32	6.6. BC_6F_1/P	Medium	70
A-6/PR167	7.7. BC_6F_1/P	Medium	55
A-7/PR16	8.8. BC_6F_1/P	Slender	60
A 11/PR53	9.9. BC_6F_1/P	Medium	60
A-12/PR79	10.10. BC_6F_1/P	Medium	65
A29/PR1	11.11. BC_6F_1/P	Bold	100
A-18/PR2	12.12. BC_6F_1/P	Medium	80
A-43/PR3	13.13. BC_6F_1/P	Medium	65
A-48/PR106	14.14. BC_6F_1/P	Slender	50
A28/PR190	15.15. BC_6F_1/P	Bold	120
A-29/P58	16.16.BC_5F_1/P	Bold	100
A-30/PR187	17.17. BC_6F_1/P	Slender	65
A-32/PR191	18.18. BC_6F_1/P	Medium	50
A-34/PR 94	19.19. BC_6F_1/P	Medium	55
A-38/PR54	20.20. BC_6F_1/P	Medium	50
A-46/PR11	21.21. BC_6F_1/P	Medium	70
A-44/PR88	22.22. BC_6F_1/P	Slender	55
A-46/PR33	23.23. BC_6F_1/P	Medium	60
A-47/PR8	24.24. BC_6F_1/P	Medium	50
A-50/PR14	25.25. BC_6F_1/P	Medium	70
A-48/PR24	26.26. BC_6F_1/P	Slender	65
A47/PR26	27.27. BC_6F_1/P	Slender	60
A43/PR31	28.28. BC_6F_1/P	Slender	80
A-48/PR204	29.29. BC_6F_1/P	Medium	60
A50/PR5	30.30. BC_6F_1/P	Medium	60
A-50/PR96	32.32. BC_6F_1/P	Medium	55
A-50/PR181	33.33. BC_6F_1/P	Bold	85
A52/PR112	34.34. BC_6F_1/P	Bold	60
D. ShanA / Kajallata	35.35. BC_6F_1/P	Slender	65
IR68888A/ Purbachi	36.36. BC_6F_1/P	Bold	85

DS : P_1=17 Jul 2011, P_2/F_1=20 Jul 2011, P_3=Jul 23 2011; DT : 13 Aug 2011.

Breeding for salinity and submergence tolerant hybrid rice variety. Seventeen test crosses were made using two CMS lines during Boro 2011-12.

Breeding for BB resistant rice hybrids. Eighty-five materials, including 41 maintainer and 44 restorers, were screened in BRRI experimental field under the supervision of Plant Pathology Division. Standard screening protocols were used to screening the materials. Only five entries were found resistant to bacterial blight having disease severity score 1-3.

Evaluation of parental lines and hybrids

Out of 71 hybrids two hybrid combinations were selected based on yield, duration and grain type (Table 3). In Boro 2011-12, out of 94 hybrids seven hybrid combinations were selected based on yield, duration and grain type (Table 4). None of the hybrids showed superiority over check variety BRRI hybrid dhan2 and BRRI hybrid dhan3. Upon commercial seed production feasibility of these selected hybrid combinations multilocation trials will be conducted and based on satisfactory yield advantage over check, hybrid combination will be submitted to SCA trials.

Seed production of parental lines and hybrids

CMS line multiplication of released hybrids. Seed yield 85 kg/plot (2.0 t/ha) and 60 kg/plot (1.6 t/ha) were obtained from BRRI10A and IR58025A respectively (Table 5). In Boro 2011-12, seed yield of 65 kg (2.30 t/ha), 58 kg (2.40 t/ha) and 45 kg (1.7 t/ha) were obtained from BRRI10A/B, BRRI11A/B and IR58025A/B respectively (Table 6).

F_1 seed production of BRRI hybrid dhan2, BRRI hybrid dhan3 and BRRI hybrid dhan4 in Boro 2011-12. Seed yield were obtained 50 kg (2.6 t/ha), 62 kg (2.85 t/ha) and 180 kg (1.80 t/ha) from BRRI10A/BRRI10R, BRRI11A/BRRI15R and IR58025A/BRRI10R respectively (Table 7).

Table 2. List of newly developed CMS lines from backcross nursery in Boro 2011-12.

Designation	Parent	BC generation	Grain type
BRRI68A/B	IR68888A/PR31	1.1. BC_6 BCN,B-2011-12	Slender
BRRI69A/B	BR17A/PR114	2.2. BC_6 BCN,B-2011-12	Medium
BRRI70A/B	IR68888A/PR6	3.3. BC_6 BCN,B-2011-12	Medium
BRRI71A/B	IR68888A/PR86	4.4. BC_6 BCN,B-2011-12	Medium
BRRI72A/B	New A/PR44	5.5. BC_6 BCN,B-2011-12	Bold
BRRI74A/B	A-2//PR90	7.6. BC_6 BCN,B-2011-12	Medium
BRRI75A/B	A-2/PR62	8.7. BC_6 BCN,B-2011-12	Medium
BRRI76A/B	A-4/PR4	9.8. BC_6 BCN,B-2011-12	Medium

DS : P_1 =6 Dec 2011; P_2/F_1=9 Dec 2011; P_3=12 Dec 2011; DT : 23 Jan 2012.

Table 3. Results of observational trials (OT) in T. Aman 2011.

Entry	Designation	Plant ht (cm)	E/T	DFF	SF (%)	DTM	Yield (t/ha)	Grain type	Yield advantage (%) over		
									Ck-1	Ck-2	Ck-3
1	Jin23A/BR7013-62-1-2R	98.0	7.0	92	78.0	118	6.8	S	28.30	21.43	9.67
2	BRRI11A/BRRI16R	101.7	7.5	95	80.0	122	7.0	M	32.01	25.0	12.90
Ck-1	BR11	115	8.0	113	75.4	143	5.3	B	-	-	-
Ck-2	BRRI dhan49	98.5	7.7	107	74.09	132	5.6	M	-	-	-
Ck-3	BRRI hybrid dhan4	110	8.0	93	81.5	120	6.2	S	-	-	-

DS : 6 Jul 2011; DT : 28 Jul 2011; S=Slender, M=Medium, B=Bold.

Table 4. Results of observational trials (OT) in Boro 2011-12.

Entry	Designation	Plant ht (cm)	E/T	DFF	FL (cm)	PL (cm)	SF (%)	DTM	Yield (t/ha)	Grain type	Yield advantage over				
											Ck-1	Ck-2	Ck-3	Ck-4	Ck-5
1	Jin23A/PR326	86.5	7.8	115	26.8	31.8	82.13	141	7.72	S	19.69	5.03	34.73	-	-
2	Jin23A/PR344	87.4	8.1	113	22.6	24	87.69	137	8.07	S	25.12	9.78	40.84	-	-
24	BR10A/BR26R	99.8	9.4	120	22.4	22.4	92.88	146	7.95	S	23.26	8.16	38.74	-	-
26	BR10A/PR506	102.6	8.6	123	28.4	23	79.41	148	8.21	S	27.29	11.70	43.28	3.66	-
49	BR11A/PR326	98.8	9.6	116	24.6	22	86.5	141	8.36	S	29.61	13.74	45.90	5.56	-
65	GuiA/BR15R	99.8	9.4	120	22.4	22.4	92.88	146	7.85	S	21.71	6.80	37.10	-	-
76	WanA/BR22R	103.4	6.2	124	20.2	23	90.99	150	8.26	S	28.10	12.38	44.15	-	-
Ck-1	BRRI dhan28	102	13.2	116	26	22.2	89.89	140	6.45	S	-	-	-	-	-
Ck-2	BRRI dhan29	92.6	11.8	131	21	23.2	74.09	156	7.35	S	-	-	-	-	-
Ck-3	BRRI dhan50	83.8	13.6	129	19.6	19.8	77.12	154	5.73	S	-	-	-	-	-
Ck-4	BRRI hybrid dhan2	97.6	8.6	125	21.6	22.8	84.82	150	7.92	M	-	-	-	-	-
Ck-5	BRRI hybrid dhan3	102	8.6	125	21.8	24.2	86.52	149	8.52	M	-	-	-	-	-

DS : 10 Dec 2011; DT : 22 Jan 2012; S=Slender, M=Medium.

Table 5. CMS multiplication of BRRI10A and IR58025A lines during T. Aman-2011.

Combination	Plant ht (cm)		50% flowering (days)		PER (%)	OCR (%)	Yield	
	A line	B line	A line	B line	A line	A line	(kg/plot)	(t/ha)
BRRI10A/B	85	88	71	72	78	39	85	2.0
IR58025A/B	86	92	79	79	77	36	60	1.6

DS : B_1=1 Jul 2011, A/B_2=4 Jul 2011, B_3=7 Jul 2011; DT : 25 Jul 2011; DS : B_1=3 Jul 2011, A/B_2=6 Jul 2011, B_3=9 Jul 2011; DT : 27 Jul 2011. PER=Panicle exertion rate, OCR= Out crossing rate.

Table 6. CMS line multiplication of BRRI hybrid dhan2, BRRI hybrid dhan3 and BRRI hybrid dhan4 in Gazipur, Boro 2011-12.

Combination	Plant ht (cm)		50% flowering (days)		PER (%)	OCR (%)	Yield	
	A line	B line	A line	B line	A line	A line	A line (kg/plot)	A line (kg/ha)
BRRI10A/B	82	83	122	121	85	46	65	2300
BRRI11A/B	84	84	123	124	87	49	58	2400
IR58025A/B	81	80	120	120	80	44	45	1700

DS : B_1=29 Nov 2011, A/B_2=2 Dec 2011, B_3=5 Dec 2011; DT : 31 Dec 2011; DS : B_1=1 Dec 2011, A/B_2=4 Dec 2011, B_3=7 Dec 2011; DT : 4 Jan 2012; DS : B_1=3 Dec 2011, A/B_2=6 Dec 2011, B_3=9 Dec 2011; DT : 5 Jan 2012.

Table 7. F_1 seed production of BRRI hybrid dhan2, BRRI hybrid dhan3 and BRRI hybrid dhan4 in BRRI Gazipur, Boro 2011-12.

Combination	Plant ht (cm)		50% flowering (day)		PER (%)	OCR (%)	Yield	
	A line	B line	A line	B line	A line	A line	F_1 seed (kg/plot)	F_1 seed (kg/ha)
BRRI hybrid dhan2	82	90	122	122	88	46	50	2600
BRRI hybrid dhan3	83	89	123	124	87	48	62	2850
BRRI hybrid dhan4	80	89	120	121	85	41	180	1800

DS : R_1=27 Nov 2011, A=30 Nov 2011, R_2=3 Dec 2011; DT : 30 Dec 2011; DS : R_1=3 Dec 2011, A=7 Dec 2011, R_2=11 Dec 2011; DT : 6 Jan 2012; DS : R_1=1 Dec 2011, A=4 Dec 2011, R_2=7 Dec 2011; DT : 3 Jan 2012.

Agronomy Division

SUMMARY

It was possible to obtain sufficient tillers from BRRI dhan29 of the main plot, which was used to retransplant 3-4 times more area than main plot in 15 December and 30 January transplanting.

The highest grain yield was observed from 45-day-old seedlings with 20- × 20-cm spacing plus four seedlings per hill, which is followed by 35-day-old seedlings with 20- × 20-cm spacing plus four seedlings per hill.

BR7474-60-5-3 produced higher grain yield in T. Aman season than BR11 (check variety) but it was statistically similar with the check and the percent heterosis was not satisfactory.

None of the tested entries produced higher grain yield than BRRI dhan28, BRRI dhan47, BRRI dhan50 and BRRI dhan55 (the check varieties) in Boro season.

About 22-27 percent urea could be saved in Aman and Boro seasons respectively without sacrifying grain yield if two-third of urea was applied as top dress along with 2-3 percent urea spraying maintaining 3.5 percent urea solution instead of last top dress. The study needs further evaluation.

Among the treatments weed free and herbicide + 1 HW treated plot produced higher grain yield irrespective of fertilizer doses. Though weed free treated plot showed higher grain yield but herbicide + 1 HW treated plot is economically more viable.

Among the treatments, the highest grain yield was obtained from 25- × 15-cm spacing (6.63 t ha^{-1}) when USG was deep placed followed by 20- × 20-cm spacing (6.20 t ha^{-1}) than 20- × 15-cm spacing (6.16 t ha^{-1}).

Among the tests of different time of USG deep placement, the highest grain yield was obtained from 15 DAT USG deep placement (6.77 t ha^{-1}) followed by 10 DAT USG deep placement (6.72 t ha^{-1}) than 5 DAT USG deep placement (6.36 t ha^{-1}).

Almost three ton yield advantage over control and 500 kg over recommended rate was obtained though the nutrient amount was less than recommended rate.

Water hyacinth allowed to grown in waste water for 20-30 days and then this water might be used for irrigation to obtain similar grain yield of fresh water treated pot.

Though nutrient manger based fertilizer use may save fertilizer cost but it depends on knowledge level of the users. It is difficult to collect correct information for nutrient manager right now. It requires further improvement.

Grain yield and fertilizer dose of nutrients across the farmers' fields showed spatial variability. The application of appropriate fertilizer dose NPK @ 147, 25, 50 kg ha^{-1} may increase rice yield and minimize cost in all fertility grades of soil to a certain level, which is possible with farmers' present knowledge level.

Among the treatments recommended doses of fertilizer with USG application produced higher yield (4.66 t ha^{-1}) followed by recommended doses of fertilizer with 25% additional gypsum application (4.52 t ha^{-1}) and recommended doses of fertilizer with LCC based nitrogen management (4.44 t ha^{-1}).

Soil test based (STB) fertilizer application produced the highest yield in Aman season.

Among the tested varieties/lines, Joli, Rangpuri (Sada) and Mi-Chocho have allelopathic potentials and more inhibitory character to suppress weeds in laboratory condition

Evaluation of herbicide with Pretilachlor, Butachlor, Pyrazosulfuran-ethyl, Mefenacet + Bensulfuran methyl, Bensulfuran methyl+ Acetachlor and Pyrazosulfuron ethyl 0.6%+ Pretilachlor 34.4% group control weed effectively in transplanted field.

On the basis of FGD, researchable issues were identified and accordingly adaptive trials and other related activities are in progress.

SEEDS AND SEEDLINGS

Seedlings in the seedbed are damaged by cold in different parts of Bangladesh in Boro season. In such situation farmers are in extreme need of seedling to transplant immediately.

Effect of tiller separation on rice yield

An experiment was conducted at BRRI farm, Gazipur during Boro season in 2010-11 and 2011-

12. Forty-day-old seedling of BRRI dhan29 was planted on 15 and 31 December 2010 and 15 and 30 January 2011. In both the years, 2-3 seedlings per hill were transplanted maintaining 20- × 20-cm spacing in 16 m^2 plot. The tillers were separated at 40 days after transplanting from the 8 m^2 main plot (Mother plot) leaving 8 m^2 undisturbed (control plot) and replanting was done in the new field maintaining 2-3 tillers per hill. Treatments were: T_1=Transplanting at 15 December and tiller separating at 25 January, T_2=Transplanting at 31 December and tiller separating at 10 February, T_3=Transplanting at 15 January and tiller separating at 25 February and T_4=Transplanting at 30 January and tiller separating at 12 March. Fertilizer was applied as urea, TSP, MOP and gypsum @ 265, 100, 100 and 60 kg/ha. Temperature, plant characters and yield data were recorded.

More tillers were obtained from 15 December and 30 January transplanting might be due to higher temperature in both the years. About 3-4 times more area could be covered with the tillers obtaining from 15 December and 30 January planting (Figs. 1 and 2). Transplanting at 15 January produced lower tillers at 40 DAT due to low temperature and covered least new area. Growth duration of tiller splitted plot was higher than control plots (undisturbed) and decreases with the advancement of transplanting dates. Grain yield was higher in control plot followed by mother plot (Table 1). Results indicate that maximum new area coverage and satisfactory grain yield from splitted tillers transplantation was

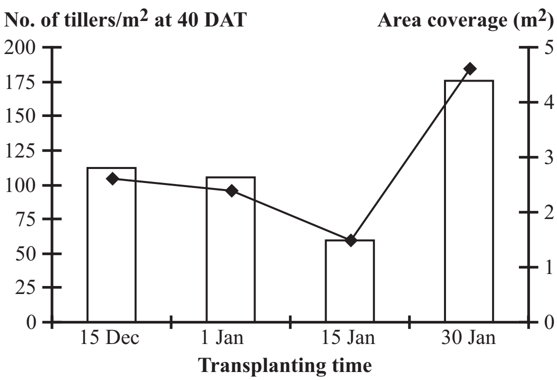


Fig. 1. Effect of planting time on tiller production and new area coverage by tiller separation in Boro 2010-11, BRRI, Gazipur.

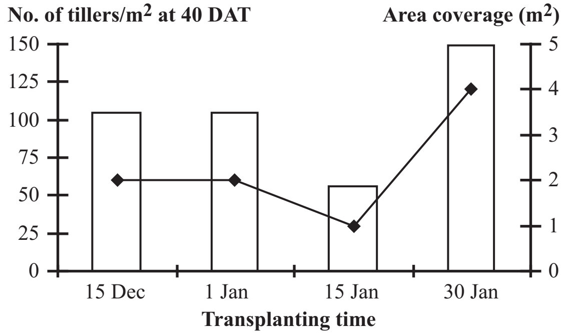


Fig. 2. Effect of planting time on tiller production and new area coverage by tiller separation in Boro 2011-12, BRRI, Gazipur.

obtained from 31 December transplanting. It was possible to obtain sufficient tillers from the main plot, which was used to retransplant 3-4 times more area than main plot in 15 December and 30 January transplanting.

Optimizing number of seedlings per hill, spacing and seedling age to enhance the productivity of rice for saline area

The experiment was conducted at Pakhimara of Kalapara thana under Patuakhali district in Boro 2012. It was an on station trial in on farm situation. The salinity levels of Pakhimara cannel was 1.5 dS/m in December 2011. In between March and April 2012 the salinity increased upto 12-13 dS/m. After on set of rain the salinity level decreased immediately and after that it increased sharply. Twenty-five-, 35- and 45-day-old seedlings were transplanted on 20 January 2012 with two and four seedlings per hill maintaining 15- × 20-cm, 20- × 20-cm and 25- × 25-cm spacing. The experiment was conducted in split-split design with seedling age in the main plot and spacing and seedling number per hill in the sub plots. Treatment combinations of the experiment were 18 with three replications. Unit plot size was 20 m^2. Recommended package of practices was followed for raising seedlings and for other intercultural operations. This experiment was followed staggered seedbed preparation with 10 days interval so that transplanting can be done on same day. In field, urea, TSP, MP, gypsum and zinc sulphate was applied at the rate of 250-100-120-68-7.5 kg ha^{-1}. Full TSP, MP, gypsum and zinc

Table 1. Effect of tiller separation on growth duration and yield of rice in Boro, BRRI, Gazipur.

Treatment	Boro 2010-2011						Boro 2011-2012.					
	Growth duration (day)			Grain yield (t/ha)			Growth duration (day)			Grain yield (t/ha)		
	Cont	Moth	Split	Cont	Moth	Split	Cont	Moth	Split	Cont	Moth	Split
T_1	174	177	181	7.08	5.56	4.49	175	178	185	5.08	4.94	4.63
T_2	168	172	177	7.44	7.18	6.23	167	168	175	5.30	5.01	4.99
T_3	164	169	169	6.87	5.94	5.26	162	163	167	7.16	7.11	4.70
T_4	155	159	161	5.86	5.60	5.18	153	155	163	6.69	6.22	4.68

T_1=Transplanting at 15 December and tiller separating at 25 January, T_2=Transplanting at 31 December and tiller separating at 10 February, T_3=Transplanting at 15 January and tiller separating at 25 February and T_4=Transplanting at 30 January and tiller separating at 12 March.

sulphate was added as basal. Nitrogen was applied in three equal splits at 15 DAT, maximum tillering and at panicle initiation stage.

Data revealed that water salinity in the crop field ranged from 3.5-6.5 dS/m throughout the growing season irrespective of treatment. Table 2 shows seedling mortality (%) under different seedling ages, densities and seedling per hill. Higher seedling mortality was found from 25-day-old seedlings irrespective of seedling density and spacing, which decreased the grain yield of BRRI dhan47. Lower seedling mortality was observed in 45-day-old seedlings. Table 3 shows the interaction effect of seedling age with seedling density and spacing. Results indicates that the highest grain yield was observed from 45-day-old seedlings with 20 × 20-cm spacing plus four seedlings per hill, which is followed by 35-day-old seedlings with 20- × 20-cm spacing plus four seedlings per hill. Overall 45-day-old seedling gave more than 4 t ha^{-1} yield where 35- and 25-day-old seedling produced more than 3 and 2 t ha^{-1}.

Table 2. Seedling mortality (%) under different seedling ages, densities and seedling per hill.

Treatment	Seedling mortality (%)			Average
	R_1	R_2	R_3	
$A_1S_1D_1$	22	18	15	18
$A_1S_1D_2$	50	24	23	32
$A_1S_1D_3$	41	35	34	37
A_1S2D1	23	18	18	20
A_1S2D_2	32	24	23	26
A_1S2D_3	63	37	25	41
$A_2S_1D_3$	16	15	14	15
A_2S_2D1	6	6	6	6
$A_2S_2D_2$	4	4	3	4
$A_2S_2D_3$	6	4	5	5
$A_2S_1D_1$	4	4	4	4
$A_2S_1D_2$	5	5	5	5
$A_3S_1D_2$	3	3	4	3
$A_3S_1D_3$	4	5	4	4
$A_3S_2D_1$	2	1	1	1
A_3S_2D2	2	2	1	2
$A_3S_2D_3$	5	4	3	4
$A_3S_1D_1$	1	1	2	1

Table 3. Grain yield of BRRI dhan47 as affected by seedling age, density and spacing in salinity prone area of Pakhimara, Kalapara.

Seedling density × spacing		Grain yield (t ha^{-1})
25-day-old seedlings		
S_1D_1		2.37
S_2D_1		2.49
S_3D_1		2.32
$S1D_2$		2.82
S_2D_2		2.35
S_3D_2		2.28
Average		2.44
35-day-old seedlings		
S_1D_1		2.34
S_2D_1		3.52
S_3D_1		3.68
S_1D_2		4.55
S_2D_2		4.02
S_3D_2		4.38
Average		3.75
45-day-old seedlings		
S_1D_1		4.31
S_2D_1		3.74
S_3D_1		3.72
S_1D_2		4.09
S_2D_2		4.78
S_3D_2		3.58
Average		4.04
LSD (0.05) :	Seedling age	0.27
	Seedling density	0.94
	Spacing	0.48
	Density × spacing	0.39
	Seedling age × density × spacing	0.67
CV (%)		11.7

Spacing: 15- × 20-cm (S_1), 20- × 20-cm (S_2), 25- × 25-cm (S_3)
Density: D_1 = 2 seedling $hill^{-1}$, D_2 = 4 seedling $hill^{-1}$.

PLANTING PRACTICES

Effect of planting time on growth and yield of advanced lines in T. Aman

An experiment was conducted at BRRI HQ farm, Gazipur in Aman 2011. Six promising lines BR7465-1-2-4, BR7474-60-5-3, BR7465-1-4-1, BR7875-5(Nil)52-HR1, BR7878-5(Nil)72-HR6 and BR7873-5(Nil)51-HR6 were tested and compared with BR11 (standard check). Thirty-day-old seedling was transplanted during 16 July to 1 October at 15-day interval. Single seedling was transplanted following 20- × 20-cm spacing. The treatments were distributed in a split-plot design, where placing planting dates were in the main plots and promising lines/varieties in the sub-plots with three replications. Fertilizers were applied @ 85-20-50-10 kg ha^{-1} N-P-K-S as urea, TSP, MOP and gypsum. All fertilizers except urea were applied as basal during final land preparation. Urea was applied as top dress in three equal splits at active tillering (AT), maximum tillering (MT) and 5-7 days before panicle initiation (PI) stages respectively.

The promising line BR7474-60-5-3 performed well giving on average 7-8 percent higher grain yield than the check variety BR11 planted up to 1 August and beyond that none of the promising line produced yield over check BR11 (Table 4). The growth duration of the tested entries gradually decreased with the advancement of planting dates. However, the growth duration of the promising line BR7474-60-5-3 and check variety BR11 is almost similar irrespective of planting dates.

BR7474-60-5-3 produced higher grain yield than the check but it was statistically similar with the check and the percent heterosis was not satisfactory.

Effect of planting time on growth and yield of advanced lines in Boro

In Boro season, promising lines BW328, BR7323-4B-1, IR72579-B-B-2-3-3, BR7105-4R-2, BR7358-5-3-2-1, BR7358-30-3-1 and BR7372-18-3-3 were tested and compared with BRRI dhan28, BRRI dhan47, BRRI dhan55 and BRRI dhan50 (standard ck). Forty-day-old seedlings were transplanted during 30 December to 10 February at 10 days interval. Single seedling was transplanted at 20- × 20-cm spacing. The treatments were distributed in a split-plot design, placing planting date in the main plots and promising lines/varieties in the sub-plots with three replications. Fertilizers were applied @ 120-35-60-10 kg ha^{-1} N-P-K-S as urea, TSP, MOP and Gypsum. All fertilizers except urea were applied as basal during final land preparation. Urea was applied as top dress in three equal splits at active tillering (AT), maximum tillering (MT) and 5-7 days before panicle initiation (PI) stages.

None of the tested entries produced higher grain yield than the check varieties (Table 5).

FERTILIZER MANAGEMENT

Urea spraying as an alternate method of N fertilizer application

The experiments were conducted at the BRRI HQ farm, Gazipur, during T. Aman and Boro seasons of 2011-12. Thirty-day-old seedlings of BRRI dhan49 were transplanted on 25 July 2011 at 20- × 20-cm spacing in T. Aman and 43-day-old seedlings of BRRI dhan29 were transplanted on 19 January 2012 at 20- × 20-cm spacing in Boro season. The treatments were:

Table 4. Effect of planting time on yield and growth duration (in the parenthesis) of advanced line/check in Aman 2011-12, BRRI, Gazipur.

Advanced line/variety	Planting time					
	16 July	1 Aug	16 Aug	1 Sep	16 Sep	1 Oct
BR7465-1-2-4	4.35 (134)	4.41 (128)	3.55 (127)	2.89 (125)	2.27 (129)	1.47 (130)
BR7474-60-5-3	4.80 (140)	4.81 (136)	3.83 (132)	2.93 (130)	2.88 (133)	1.68 (134)
BR7465-1-4-1	4.02 (141)	3.69 (137)	3.43 (133)	2.71(128)	2.25 (130)	1.70 (130)
BR7875-5 (Nil)52-HR1	4.33 (140)	4.65 (136)	3.75(131)	3.35 (129)	2.26 (125)	1.68 (126)
BR7878-5 (Nil)72-HR6	3.33 (135)	3.73 (130)	3.83 (126)	2.96 (125)	1.99 (127)	1.44 (129)
BR7873-5 (Nil)51-HR6	2.93 (119)	3.00 (113)	2.91 (110)	1.72 (107)	1.72 (110)	1.37 (112)
BR11 (ck)	4.47 (143)	4.41 (138)	4.10 (134)	3.65 (131)	2.91 (132)	2.00 (134)
CV (%)			5.23			
LSD			0.3956			

Table 5. Effect of planting time on yield and growth duration (in parenthesis) of advanced lines/varieties in Boro 2011-12, BRRI, Gazipur.

Advanced line/variety	Grain yield (t/ha)					
	Planting date					
	30 Dec	15 Jan	30 Jan	15 Feb	1 March	15 March
BW328	3.19 (153)	3.15 (146)	3.04 (144)	3.07 (137)	2.02 (137)	0.33 (134)
BR7323-4B-1	3.56 (157)	3.54 (150)	3.01 (146)	3.16 (142)	2.07 (137)	0.21 (134)
IR72579-B-B-2-3-3	4.66 (161)	4.76 (150)	3.50 (146)	3.01 (142)	2.13 (137)	0.40 (133)
BR7105-4R-2	4.76 (151)	4.91 (150)	3.41 (145)	3.41 (143)	2.03 (137)	0.60 (132)
BRRI dhan28 (ck)	3.39 (153)	3.33 (147)	3.89 (138)	3.72(132)	1.68 (129)	0.97 (128)
BRRI dhan47 (ck)	4.58 (153)	4.53 (150)	3.23 (144)	3.0(144)	1.77 (137)	0.73 (137)
BRRI dhan55 (ck)	4.45 (157)	4.50 (153)	3.73 (148)	3.1(147)	1.82 (137)	0.80 (136)
BR7358-5-3-2-1		3.27 (150)	3.55 (146)	3.25(146)	1.35(137)	0.77 (134)
BR7358-30-3-1		4.10 (149)	2.89 (138)	2.45 (132)	1.96 (125)	1.54 (125)
BR7372-18-3-3		4.57 (148)	3.65 (144)	3.13 (139)	2.42 (135)	0.80 (133)
BRRI dhan50		4.12 (153)	3.23 (149)	2.53 (144)	1.77 (137)	0.22 (134)
CV (%)	6.68					
LSD (0.05)	0.5658					

- BRRI recommended N management, top dressed at 15-20, 30-35 DAT and at PI stage (T_1),
- two-third N of recommended dose top dressed at 15-20, 30-35 DAT along with 3.5% urea spraying at PI stage (T_2),
- two-third N of recommended top dressed at 15-20, 30-35 DAT along with 3.5 percent urea spraying at PI and booting stage (T_3),
- two-third N of recommended dose along with 3.5 percent urea spraying at MT, PI and booting stage (T_4) and
- without N application (control=T_5).

The amount and application time of first two urea top dresses was same irrespective of treatments and then N was applied according to the treatments except control plot. An equal dose of P and K were applied for all the treatments. Insects and weed control were done as and when necessary for all the treatments.

The tallest plant was observed in BRRI recommended N management treatment. Plant height did not vary significantly due to the application of nitrogen. Almost similar trend was recorded in case of panicle no./m^2 (Table 6). However, the highest grains per panicle was found in urea top dressed plus three times urea spray (T_4). The highest percentage of spikelet sterility was found when urea was top dressed (BRRI recommended N management=T_1) followed by urea top dressed plus urea spraying treated plots (T_2, T_3, T_4 treatments). The variation of grain yield among the treatrments was statistically insignificant. However, 8 percent higher grain yield was recorded when urea was top dressed plus urea spraying treated plot (T_4) over N top dressed as per BRRI recommended management (T_1). Application of N as per BRRI recommended management (T_1) showed the highest amount of straw production than other treated plots. Probably this was due to the application of more amount of nitrogen (175 kg urea/ha) in (T_1) that reflected on increase straw yield due to taller plant and more plants per unit area.

In Boro season, most of the parameters showed almost similar trend as observed in Aman season. The tallest plant height and higher no. of panicle per unit area, higher percentage of spikelet sterility and more straw yield was recorded in BRRI recommended N management (T_1). However, more grains per panicle was observed in urea top dressed plus spraying of urea treated plot (T_4). The variation of grain yield of rice did not vary significantly due to the application of nitrogen either only top dressed or urea top dressed plus spraying treatments. Although application of N as per BRRI recommended management (T_1) had 7 percent more grain yield than urea top dressed plus urea spraying treatment (T_3). Probably, long duration variety BRRI dhan29 responded well at the higher rate of N application (220 kg urea/ha) in T_1 treatments.

Table 6. Influence of urea spraying on some plant parameters and grain yield of rice, Aman and Boro 2011-2012, BRRI, Gazipur.

Treatment	Plant ht (cm)	Panicles (no. m^{-2})	Grains (no./pan)	Sterility (%)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
			T. Aman 2010			
BRRI recommended N management (T_1)	123.37	265	123.79	21.45	3.93	7.02
2/3 rd N + 3.5% urea spraying at PI stage (T_2)	121.96	249.67	125.88	19.69	4.09	6.33
2/3 rd N + 3.5% urea spraying at PI & booting stage (T_3)	123.3	262.33	124.88	15.68	3.93	6.88
2/3 rd N + 3.5% urea spraying at MT, PI & booting stage (T_4)	122.67	257	134.13	15.34	4.23	6.65
No nitrogen (T_5)	122.96	238.33	122.67	14.14	3.52	6.83
CV (%)	2.13	10.16	12.39	20.83	18.86	15.93
LSD (0.5)	4.58	45.27	27.4	6.3	1.3	1.88
			Boro 2012			
BRRI recommended N management (T_1)	92.23	319	96.23	20.40	5.79	6.73
2/3 rd N + 3.5% urea spraying at PI stage (T_2)	91.83	278	106.25	15.43	5.76	6.39
2/3 rd N + 3.5% urea spraying at PI & booting stage (T_3)	91.73	297.33	112.31	14.14	5.39	6.55
2/3 rd N + 3.5% urea spraying at MT, PI & booting stage (T_4)	91.80	258.33	116.89	13.39	5.63	5.54
No nitrogen (T_5)	84.10	186.68	98.70	13.32	4.40	4.58
CV (%)	3.88	21.78	11.52	20.19	7.11	19.32
LSD (0.05)	6.14	102.1	21.39	5.42	0.67	2.02

About 22 percent urea in Aman and 27 percent urea in Boro could be saved without scarifying grain yield if two-third of urea was applied as top dress along with 2-3 percent urea spraying maintaining 3.5 percent urea solution instead of last top dress. The study needs further evaluation.

Fertilizer and weed management options for wet direct seeded rice by drum seeder

An experiment was conducted at BRRI HQ farm, Gazipur during Boro 2011-12. The fertilizer packages (N-P-K kg/ha) were; F_1=120-26-33, F_2=140-36-43, F_3=160-46-53, and the weed control options were W_1=Sirius 10WP (pyrazosulfuran ethyl) + 1 HW (at 45 DAS), W_2=Weed free, W_3=BRRI weeder at 30 and 45 DAS, W_4=No weeding. BRRI dhan28 was sown on 15 December in wet direct seeded condition by drum seeder. The treatments were distributed in split-plot design placing fertilizer in the main plot and weed management options in sub plot with three replications.

The highest number of panicles (365) was found where higher doses of fertilizers (160-46-53 kg/ha N-P-K) were applied, which produced 3.11 percent higher yield over the lowest doses (120-26-33 kg/ha N-P-K). Almost similar response was observed in case of grains per panicle, 1000-grain wt and grain yield. Higher dose of fertilizer application had a positive impact on yield component parameters resulting higher grain yield of rice (Table 7). Significantly the highest number of panicle/m^2 (372) was found in weed free plot, which is 10.38 percent higher over no weeding plot. Similar trend was also observed in case of grains per panicle. Significantly the highest grain yield (5.54 t/ha) was found in weed free plot because of higher number of panicles and higher grains per panicle. Grain yield from weed free plot was 88.44 percent higher over no weeding plot (Table 8). Significant interaction effect was found in case of 1000-grain wt and grain yield. The highest 1000-grain wt was found in Herbicide + 1 HW plot with fertilizer doses 120-26-33 kg/ha N-P-K and 160-46-53 kg/ha N-P-K. Significantly higher grain yield was also observed in weed free and Herbicide + 1 HW plot irrespective of fertilizer doses. This is due to higher panicles and grains per panicle (Table 9).

Among the treatments weed free treated plot and herbicide + 1 HW treated plot produced higher grain yield irrespective of fertilizer doses. Though weed free treated plot showed higher grain yield but herbicide + 1 HW treated plot was economically more viable.

Effect of spacing on the performance of USG on HYV rice yield and nutrient status Boro season

An experiment was conducted at BRRI HQ farm, Gazipur to find out and recommend the proper

Table 7. Effect of fertilizer options on yield and yield contributing characters of BRRI dhan28, Gazipur, Boro 2011.

Fertilizer (NPK kg/ha)	Panicle/m^2	Grain/panicle	1000-grain wt (g)	Grain yield (t/ha)
120-26-33	354	66b	20.65	4.62
140-36-43	362	70b	20.77	4.77
160-46-53	365	74a	20.93	4.85
CV (%)	2.59	4.2	1.19	5.03

In a column means followed by a common small letter(s) did not differ significantly at the 5% level by DMRT.

Table 8. Effect of weeding options on yield and yield contributing characters of BRRI dhan28, Gazipur, Boro 2011.

Weeding option	Panicle/m^2	Grain/panicle	1000-grain wt (g)	Grain yield (t/ha)
Herbicide + 1 HW	368a	77a	21.30	5.34a
Weed free	372a	79a	21.09	5.54a
BRRI weeder (2 times)	363a	71b	20.80	5.15a
Noweeding (control)	337b	52c	19.94	2.94b
CV (%)	2.59	4.2	1.19	5.03

In a column means followed by a common small letter(s) did not differ significantly at the 5% level by DMRT.

Table 9. Interaction effect of fertilizer and weeding options on yield and yield contributing characters of BRRI dhan28, Gazipur, Boro 2011.

Weeding option	Panicle/m^2	Grain/panicle	1000-grain wt (g)	Grain yield (t/ha)
	Fertilizer (NPK kg/ha) 120-26-33			
Herbicide +1 HW	365	72	21.01ab	5.18ab
Weed free	368	77	21.04ab	5.44a
BRRI weeder	363	67	20.73b	4.94b
No weeding	318	47	19.84c	2.92c
	Fertilizer (NPK kg/ha) 140-36-43			
Herbicide +1 HW	368	75	21.43a	5.31ab
Weed free	371	79	21.10ab	5.58a
BRRI weeder	362	71	20.67b	5.21ab
No weeding	345	50	19.89c	2.96c
	Fertilizer (NPK kg/ha) 160-46-53			
Herbicide +1 HW	371	84	21.47a	5.53a
Weed free	377	80	21.13ab	5.61a
BRRI weeder	364	75	21.01ab	5.30ab
No weeding	348	59	20.09c	2.94c
LSD (%)	NS	NS	0.4237	0.4095
CV (%)	2.59	4.2	1.19	5.03

In a column means followed by a common small letter(s) did not differ significantly at the 5% level by DMRT.

spacing and effectiveness of USG for sustainable Boro rice production. Different spacings were- T_1=20- × 20-cm, T_2=20- × 15-cm , T_3=25- × 15-cm, T_4=25- × 25-cm, T_5=Random transplanting and T_6=20- × 20-cm line sowing. The experiment was laid down in RCB design with three replications. The tested variety was BRRI dhan29 and plot size was 4- × 6-m. Transplanting was done with two seedlings per hill and the seedling age was 40 days. All fertilizer was applied before transplanting following BRRI recommended rate except N. Nitrogen was applied form of 2.7 g USG. The USG was deep placed between four hills at seven days after transplanting. Grain yield was significantly affected by different spacing on the performance of 2.7 g. USG deep placement on BRRI dhan29 at BRRI HQ farm, Gazipur. Among the tested spacing, the highest grain yield was obtained from 25- × 15-cm spacing (6.63 t ha^{-1}) when USG was deep placed followed by 20- × 20-cm spacing (6.20 t ha^{-1}) than 20- × 15-cm spacing (6.16 t ha^{-1}). Lower grain yield (3.02 t ha^{-1}) was recorded from wider spacing 25- × 25-cm followed by 20 cm line sowing (4.02 t ha^{-1}) than random transplanting or farmer practice (4.92 t ha^{-1}) as shown in Figure 3.

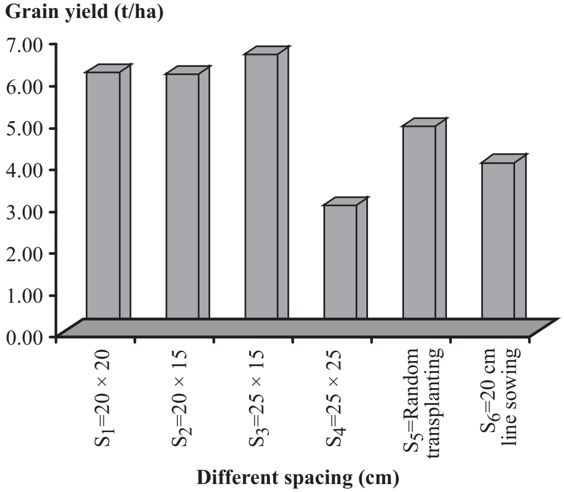


Fig. 3. Effect of spacing on the performance of USG on BRRI dhan29 yield and nutrient status in Boro 2012 at BRRI HQ farm, Gazipur.

Effect of USG placement time on the performance of USG on HYV rice yield and nutrient status in Boro season

An experiment was conducted at BRRI HQ farm, Gazipur to find out and recommend the appropriate time of USG application and effectiveness of USG for sustainable Boro rice production. Total six times of USG placement were tested under the experiment. The spacing was T_1=20- × 20-cm spacing, T_2=20- × 15-cm spacing, T_3=25- × 15-cm spacing, T_4=25- × 25-cm spacing, T_5=Random transplanting and T_6=20- × 20-cm line sowing. The experiment was laid down in RCB design with three replications. The tested variety was BRRI dhan29 and plot size was 4- × 6-m. Transplanting was done with two seedling per hill and the seedling age was 40-day-old. All fertilizer was applied before transplanting following BRRI recommended rate except N. N was applied form of 2.7 g USG. The USG was deep placed between four hills as per treatment after transplanting.

Grain yield was significantly affected by different date of 2.7 g USG deep placement on the performance of BRRI dhan29 at BRRI farm, Gazipur. It was observed that grain yield was increased with the increasing USG deep placement time from 5 DAT to 15 DAT and maximized when USG was deep placed at 15 DAT after that grain yield was reduced with the increased time of USG deep placement. Among the tested times of USG deep placement, the highest grain yield was obtained from 15 DAT USG deep placement (6.77 t ha^{-1}) followed by 10 DAT USG deep placement (6.72 t ha^{-1}) than 5 DAT USG deep placement (6.36 t ha^{-1}). The lowest grain yield (3.71 t ha^{-1}) was recorded from without nitrogen treatment followed by 25 DAT USG deep placements (5.51 t ha^{-1}) than 20 DAT USG deep placement (6.08 t ha^{-1}) as shown in Figure 4.

Performance evaluation of NPK Briquette on HYV rice yield and nutrient status in Boro season at different locations

An experiment was conducted at BRRI HQ farm, Gazipur, BRRI RS, Barisal and farmer's field at Babuganj, Barisal to find out and recommend the effectiveness of NPK briquette fertilizer deep placement (FDP) for rice in tidal flooded soil and heavy texture soil and to recommend NPK briquette for sustainable Boro rice production. Total eight treatments were tested under the experiment. The treatments were:

- T_1 = Prilled urea as recommended dose at three splits and recommended PKS and Zn fertilizer was applied as basal at final land preparation,
- T_2=One 2.70 gram USG will be placed at the centre of each four hills + recommended PKS and Zn fertilizer was applied as basal at final land preparation,
- T_3=Two 2.40 gram NPK briquette was placed at the centre of each four hills (N-P-K

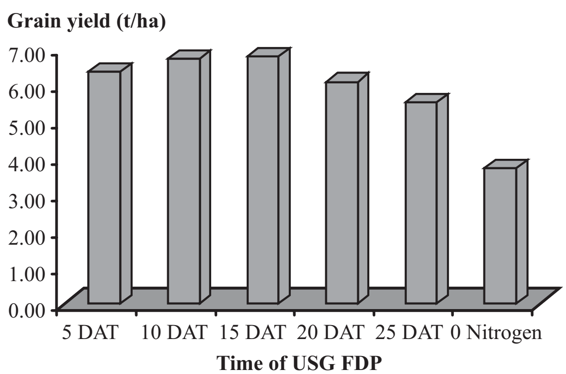


Fig. 4. Effect of different date of USG FDP on the performance of BRRI dhan29 yield and nutrient status in Boro 2012 at BRRI HQ farm, Gazipur.

ratio=7.0-1.6-2.0 and doses of NPK=87 kgh^{-1} N, 20 kgh^{-1} P and 25 kgh^{-1} K and S and Zn as recommended,

- T_4=One 3.40 gram NPK briquette was placed at the centre of each four hills (N-P-K ratio=9.1-2.4-3.5 and doses of NPK=57 kgh^{-1} N, 15 kgh^{-1} P and 22 kgh^{-1} K) and S and Zn as recommended,
- T_5=NPKS and Zn doses were same as T_3 but sources were USG, TSP, MP,
- T_6=NPKS and Zn doses were same as T_4 but sources were USG, TSP, MP,
- T_7=Absolute control and
- T_8=N alone for PU.

The experiment was laid out in RCB design with three replications. The tested variety was BRRI dhan29 and plot size was 4- × 6-m. Transplanting was done with two seedling per hill and the seedling age was 40-day-old. All fertilizer was applied as per treatment before and after transplanting. The USG and briquettes were deep placed between four hills as per treatment after transplanting.

Grain yield was significantly affected by different treatment at different location on the performance of BRRI dhan29 (Fig. 5). It was observed that grain yield was increased when 2.4 g NPK briquette was deep placed (T_3) over all the locations. Almost three ton yield advantage over control and 500 kg over recommended rate (T_1) was obtained though the nutrient amount was less than recommended rate. But it was observed that

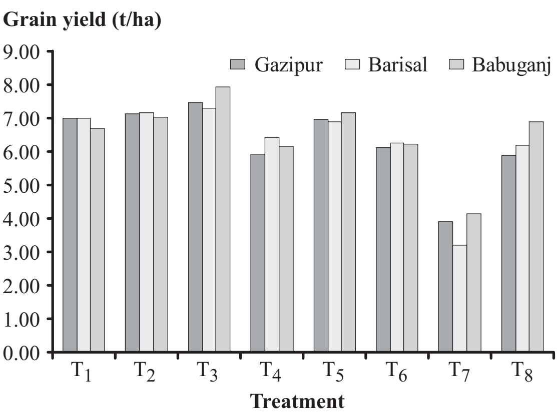


Fig. 5. Effect of NPK briquette on BRRI dhan29 yield and nutrient status in Boro 2012 at different locations.

3.40 g briquette deep placement (T_4) did not perform well and grain yield was less than all other treatment except control treatment.

Field verification of improved nutrient management based on nutrient manager for rice in Faridpur region

The concept of site-specific nutrient management (SSNM) for rice was developed in the mid-1990s with the aim of dynamic field-specific N, P and K fertilizer management to optimize the balance between supply and demand of nutrients. The present study was under taken to evaluate the field specific fertilizer guideline obtained from Nutrient Manager compared to farmer's fertilizer management and BRRI fertilizer recommendation and to minimize the fertilizer cost.

The experimental domain is located at Singria and Khapura, Faridpur, Poddererchar and Gobra, Gopalganj and Char Doulath Khan and Char Doulath Khan (South) villages of Madaripur district (AEZ-12). We selected total of 108 farmers of which 18 from each village. Fields in the villages were categorized into high, medium and low land. Six plots in each land type were selected for the participatory experiment in each site. Double rice cropping (Fallow-Aman-Boro) is the main cropping system in those villages. The study was conducted during Boro 2012 at different soil fertility grades. Farmer grown rice seedlings of 40-60 days were transplanted. Cultivated varieties were BRRI hybrid dhan2, BRRI dhan29, BRRI hybrid dhan3, Hira2, BRRI dhan28, Agrani, Meghna, Super8, Rajkumar, Sunarbangla, Rupali, Shati and Modumoti2. Transplanting time ranged from mid January to last week of February. Each farmer's field represents one replication. Experimental design was split-split plot. In each farmer's field three treatments: i) Farmers practice (NPK @ 185-200, 20-25 and 25-30 kg ha^{-1}), ii) Nutrient Manager based nutrient (NPK @ 85, 8 and 12 kg ha^{-1}) and iii) BRRI recommended fertilizer dose (NPK @ 147, 25 and 50 kg ha^{-1}). Some farmer used USG (2.7 g). Initial soil samples were collected from different selected plots and were analyzed in the laboratory. Required amounts of NPK were applied through urea, TSP and MP respectively, as per treatment. Full dose of TSP and MP were applied during final land preparation; urea was applied at 25 and 40 and 55 days of transplanting. Data on grain yield were recorded from the harvested area of 6 m^2 per plot and converted into ton per ha basis.

Fertilizer practices exerted significant influences on grain yield irrespective of location and land type (Tables 10, 11 and 12). Medium high and low land produced the highest grain yield in all locations. Minimum grain yield was obtained from high land. BRRI recommended fertilizer yielded maximum grain yield followed by farmers' practices. Nutrient manager based fertilizer produced lower grain yield. Farmers applied over dose of urea but under dose of TSP and MP. Again they did not applied S and Zn fertilizer.

Farmers applied imbalanced fertilizers. Though Nutrient Manger based fertilizer save fertilize cost, it is knowledge based. It is difficult to collect correct information for nutrient manager. It requires further improvement.

Table 10. Rice yield as affected by different nutrient management practices at farmers' field, Faridpur, Boro 2012.

Treatment	Grain yield (t/ha)		
	High land	Medium land	Low land
	Singria		
Farmers' practice	7.33	7.57	7.82
Nutrient manager	6.62	7.07	7.42
BRRI recommended	7.55	8.56	7.45
	Khapura		
Farmers' practice	6.52	6.47	6.44
Nutrient manager	6.07	5.99	6.59
BRRI recommended	7.33	6.74	7.38

Table 11. Rice yield as affected by different nutrient management practices at farmers' field, Gopalganj, Boro 2012.

Treatment	Grain yield (t/ha)		
	High land	Medium land	Low land
	Poddererchar		
Farmers' practice	8.56	6.76	8.92
Nutrient manager	7.40	6.62	8.08
BRRI recommended	8.15	7.66	9.15
	Gobra		
Farmers' practice	8.97	7.79	9.10
Nutrient manager	8.41	6.97	7.91
BRRI recommended	9.22	7.87	9.14

Table 12. Rice yield as affected by different nutrient management practices at farmers' field, Madaripur, Boro 2012.

Treatment	Grain yield (t/ha)		
	High land	Medium land	Low land
	Char Doulat Khan		
Farmers' practice	6.54	6.77	6.84
Nutrient manager	6.96	6.84	6.24
BRRI recommended	6.74	7.38	6.39
	Char Doulat Khan (South)		
Farmers' practice	5.73	5.17	6.14
Nutrient manager	5.21	4.97	5.52
BRRI recommended	5.26	5.21	5.77

Farmers' participatory site specific nutrient management in Faridpur region

The experimental domain is located at Singria and Khapura, Faridpur, Poddererchar and Gobra, Gopalganj and Char Doulath Khan and Char Doulath Khan (South) villages of Madaripur district (AEZ-12). We selected 108 farmers of which 18 from each village. Fields in the villages were categorized into high, medium and low land. Six plots in each land type were selected for the participatory experiment in each site. Double rice cropping (Fallow-Aman-Boro) is the main cropping system in those villages. The study was conducted during Boro 2012 at different soil fertility grades. Farmer grown rice seedlings of 40-60 days were transplanted. Cultivated varieties are BRRI hybrid dhan2, BRRI dhan29, BRRI hybrid dhan3, Hira2, BRRI dhan28, Agrani, Meghna, Super8, Rajkumar, Sunarbangla, Rupali, Shati and Modumoti2. Transplanting time ranges from mid January to last week of February. Each farmer's field represents one replication. Experimental design was split-split plot. In each farmer's field, four treatments: NPK, -N, -P and -K were tested. Initial soil samples were collected from different selected plots and were analyzed in the laboratory. Required amounts of N, P and K @ 147, 25 and 50 kg ha^{-1} were applied through urea, TSP and MP respectively, as per treatment. Full dose of TSP and MP were applied during final land preparation; urea was applied at 25 and 40 and 55 days of transplanting. Data on grain yield were recorded from the harvested area of 6 m^2 per plot and converted into ton per ha basis.

The crop growth in nitrogen omission plot was poor compared to other treatments in all the trial plots throughout the growing season. Growth difference between NPK treated plots and omission of P or K plot was not obvious (Tables 13, 14 and 15). Maximum grain yield was found in low land followed by high land in each location. The highest yields were obtained from NPK treated plots in each location irrespective of land type (Tables 13, 14 and 15). The grain yield of NPK treated plots was higher than omission of N, P and K plots in all locations. The yield of P and K omission plots were similar. The highest yield was obtained from NPK treated plot followed by P and K omission plots and the lowest from N omission plot. Difference between -P and -K plots was not significant and difference between -N and -P or -K was significant.

In this study, grain yield and fertilizer dose of nutrients across the farmers' fields showed spatial variability. The application of appropriate fertilizer dose may increase rice yield and minimize cost in all fertility grades of soil to a certain level, which is possible with farmers' present knowledge level.

Table 13. Rice yield as affected by different nutrient management practices at farmers' field, Faridpur, Boro 2012.

Treatment	Grain yield (t/ha)		
	High land	Medium land	Low land
	Singria		
-N	5.33	6.00	5.93
-P	7.05	6.55	7.26
-K	6.84	7.29	7.65
NPK	8.22	8.79	8.47
	Khapura		
-N	5.30	4.92	4.96
-P	6.62	5.98	7.04
-K	6.46	5.65	7.45
NPK	7.58	7.66	7.46

Table 14. Rice yield as affected by different nutrient management practices at farmers' field, Gopalganj, Boro 2012.

Treatment	Grain yield (t/ha)		
	High land	Medium land	Low land
	Poddererchar		
-N	6.49	5.86	7.50
-P	7.50	7.19	9.00
-K	8.31	7.74	8.53
NPK	8.69	6.84	9.55
	Gobra		
-N	7.85	6.70	7.60
-P	9.04	7.43	8.13
-K	9.01	8.20	8.85
NPK	9.33	8.14	9.42

Table 15. Rice yield as affected by different nutrient management practices at farmers' field, Madaripur, Boro 2012.

Treatment	Grain yield (t/ha)		
	High land	Medium land	Low land
	Char Doulat Khan		
-N	4.81	5.68	5.06
-P	6.43	6.61	5.74
-K	6.78	7.08	6.72
NPK	7.25	6.82	6.39
	Char Doulat Khan (South)		
-N	3.55	3.78	4.03
-P	5.06	4.84	5.64
-K	5.10	4.93	5.75
NPK	5.07	3.97	5.77

Nutrient management practices and soil amendments for dry season rice in coastal salt affected soils for raising productivity

The coastal areas of Bangladesh cover more than 30 percent of the cultivable lands of the country. About 53 percent of the coastal areas are affected by salinity. Among the coastal district patuakhali is more vulnerable to salinity. Due to global climate change salinity area is increasing day by day. The farmers are facing lots of stress like flash flood, drought and salinity in different stages of the crop production. Considering these issues the experiment was conducted to minimize soil salinity by nutrient management and soil amendment and raising productivity of rice under salt affected area.

The experiment was conducted at Pakhimara of Kalapara thana under Patuakhali district in Boro 2012. This is on station trial in on farm situation. The salinity level of Pakhimara channel was 1.5 dS/m in December 2011. During the March-April 2012 the salinity increases upto 12-13 dS/m. After one set of rain the salinity level decreased immediately and after that it increases sharply. Forty-day-old seedlings of BRRI dhan47 was transplanted on 20 January 2012 with two seedlings hill^{-1} with 20- × 20-cm spacing. Treatments of the experiments were:

- T_1=Cow dung @ 5 t/ha,
- T_2=Ash @ 1 t/ha + 50% recommended rates of

urea, TSP, MP, gypsum and zinc sulphate,

- T_3=Oil cake @ 0.25 t/ha + 50% of recommended of urea, TSP, MP, gypsum and zinc sulphate,
- T_4=BRRI recommended doses @ 250-100-120-68-7.5 kg ha^{-1} of urea, TSP, MP, gypsum and zinc sulphate,
- T_5=T_4 + 25% additional urea,
- T_6=T_4 + 25% additional MP (at MT stage),
- T_7=T_4 + 25% additional gypsum,
- T_8=RD of TSP, MP, gypsum and zinc sulphate and application of USG at 10 DAT,
- T_9=RD of TSP, MP, gypsum and zinc sulphate and application of prilled urea with LCC,
- T_{10}=Farmers practice with normal urea (200 kg urea ha^{-1}) and
- T_{11}=Farmer practices with heavy urea (300 kg urea ha^{-1}).

The experiment was laid out in RCB with three replications. Unit plot size of the experiment was 4- × 5-m. Salinity level was monitored weekly by EC meter through the season. Cowdung, ash, oil cake, urea, TSP, MP, gypsum and zinc sulphate was applied as per treatment as basal and other fertilizer management was done as per treatment. Recommended package of practices was followed for other intercultural operations.

Figure 6 shows the water salinity dynamics. Data revealed that water salinity in the crop field ranged from 3.5-7.5 dS/m throughout the growing season irrespective of fertilizer treatment. Table 16 indicates the grain yield of BRRI dhan47 as affected by different fertilizer treatments. Among the treatments recommended doses of fertilizer with USG application produced higher yield (4.66 t ha^{-1}) followed by recommended doses of fertilizer with 25 percent additional gypsum application (4.52 t ha^{-1}) and recommended doses of fertilizer with LCC based nitrogen management (4.44 t ha^{-1}). Other fertilizer treatment and soil amendments did not have any contribution to increase grain yield of BRRI dhan47.

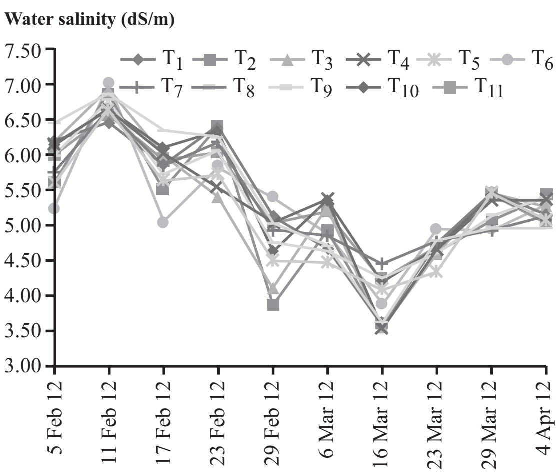


Fig. 6. Fluctuation of water salinity over time under different fertilizer management and soil amendment.

LOW INPUT MANAGEMENT

Influence of fertilizer package on green super rice in Aman season

An experiment was initiated in T. Aman 2011 at BRRI HQ farm, Gazipur. The treatments were: A. Variety i) V_1=GSR (HUA565) and ii) V_2=BRRI

Table 16. Grain yield of BRRI dhan47 as affected by fertilizer management in salinity prone area of Pakhimara, Kalapara under Patuakhali district.

Treatment	Grain yield (t ha^{-1})
T_1	2.61
T_2	2.11
T_3	2.71
T_4	4.01
T_5	2.98
T_6	3.43
T_7	4.52
T_8	4.66
T_9	4.40
T_{10}	3.45
T_{11}	3.7
LSD (0.05)	0.72
CV (%)	11.92

T_1=Cow dung @ 5 t/ha, T_2=Ash @ 1 t/ha + 50% recommended rates of urea, TSP, MP, gypsum and zinc sulphate, T_3=Oil cake @ 0.25 t/ha + 50% of recommended of urea, TSP, MP, gypsum and zinc sulphate, T_4=BRRI recommended doses @ 250-100-120-68-7.5 kg ha^{-1} of urea, TSP, MP, gypsum and zinc sulphate, T_5=T4 + 25% additional urea,T_6=T_4 + 25% additional MP (at MT stage), T_7=T_4 + 25% additional gypsum, T_8=RD of TSP, MP, gypsum and zinc sulphate and application of USG at 10 DAT, T_9=RD of TSP, MP, gypsum and zinc sulphate and application of prilled urea with LCC, T_{10}=Farmers practice with normal urea (200 kg urea ha^{-1}), T_{11}=Farmer practices with heavy urea (300 kg urea ha^{-1}).

dhan33 (ck) B. Fertilizer rate i) NPK as of STB fertilizer rate ii) 25% less NPK of STB iii) 50% less NPK of STB and iv) Absolute control (no fertilizer).

Single seedlings were transplanted on 8 August at 20- × 20-cm spacing. The treatments were distributed in RCB design with three replications. The STB fertilizer dose was 78-19-35-5 kg ha^{-1} N-P-K-S as urea, TSP, MOP and gypsum. The fertilizers were applied according to the treatments. All fertilizers, except urea, were applied as basal during final land preparation. Urea was applied as top dress in three equal splits at active tillering (AT), maximum tillering (MT) and 5-7 days before panicle initiation (PI) stages, respectively.

Results indicates that soil test based (STB) fertilizer application gave the highest yield for both the varieties (Table 17). Variation of grain yield, straw yield, grains per panicle and sterility percentage for fertilizer rate and variety interaction was insignificant (Table 18). Higher spikelet sterility was observed with decreasing rate of fertilizer. Growth duration of HUA565 ranges from 104-110 days and BRRI dhan33 matured within 113-120 days.

WEED MANAGEMENT

Potential allelopathic effect of some rice cultivars on *Echinochloa crusgalli*

Nine rice cultivars were used for this study. The nutrient solution of urea, TSP and MP were prepared and poured in petridishes. Iron meshes were placed into each petridishes by a sterile forceps. The pregerminated rice seed were placed on iron mesh and allowed for root growth. The weed seeds were placed on another petridish for germination. Then the root exudates of rice cultivars were applied regularly on petridishes containing weed seeds and allowed for 14 days of weed seedling growth. Then the weed seedlings were removed gently. Their root length, shoot length and dry matter (oven dried at 90°C for three days) was measured. The percentage reduction of root and shoot length were determined by using the formula- Percent reduction= 100(LC- LT)/LC where LC is the length of root or shoot of the control treatment (untreated weeds) and LT is the length of root or shoot of the treated weeds.

Significant reduction of root length of weeds was observed due to allelopathic effect of rice varieties (Table 19). Significantly the highest root

Table 17. Grain and straw yield and growth duration of GSR at different fertilizer rates in Aman 2010-11, BRRI, Gazipur.

Fertilizer rate	Grain yield (tha^{-1})		Straw yield (tha^{-1})		Growth duration (day)	
	V_1	V_2	V_1	V_2	V_1	V_2
NPK as of STB fertilizer rate	3.57	3.60	3.1	3.7	110	120
25% less NPK of STB	3.24	3.36	2.9	3.5	110	118
50% less NPK of STB	2.90	3.11	2.8	3.5	108	118
Absolute control	2.96	2.00	2.0	2.8	104	113
CV (%)	4.53		10.02			
LSD (5%)	08.618		1.162			

V_1=GSR (HUA565), V_2=BRRI dhan33 (ck).

Table 18. Panicle m^{-2}, grains per panicle, 1000-grain wt and sterility percentage of GSR at different fertilizer rates in Aman 2010-11, BRRI, Gazipur.

Fertilizer rate	Panicle m^{-2}		Grain/panicle		1000-grain wt		Sterility (%)	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
NPK as of STB fertilizer rate	144	158	141	144	17.5	25.4	14	23
25% less NPK of STB	139	150	130	136	16.79	24.35	15	31
50% less NPK of STB	129	133	117	121	16.69	23.99	18	33
Absolute control	134	120	114	112	16.69	24.09	21	38
CV (%)	9.24		6.45		3.17		10.47	
LSD (0.05)	NS		16.64 (5%)		NS		5.201 (5%)	

V_1=GSR (HUA565), V_2=BRRI dhan33 (ck).

Table 19. Allelopathic effect of rice varieties/lines on reduction of root, shoot length and dry weight of *E. crusgalli* in Aman 2011, BRRI, Gazipur.

Variety name	% reduction		
	Root length	Shoot length	Dry wt (g)
Shoni	44.90b	45.22b	54b
Joli	76.67a	74.18a	69.83a
Rangpuri (Sada)	77.39a	76.73a	69.80a
Kasia Panja	31.48c	37.07c	46.67bc
Boilam	26.80c	37.56c	47.83bc
Boteswar (2)	24.26c	38.39c	44.56c
Mati-Char	16.28d	37.95c	44.50c
Begum Bahar	49.69b	50.03b	48.56bc
Mi-Chocho	76.62a	71.43a	70.39a
Rajashail	78.63a	77.32a	71.78a
CV (%)	8.49	6.87	7.96

Small letters in a column compare means at the 5% level by DMRT.

length reduction of *Echinichloa crusgalli* was observed due to root exudates of Rajashail (78.63%) which is statistically similar with Joli (76.67%), Rangpuri (Sada) (77.39%), Mi-Chocho (76.62%). On the other hand, the lowest root length reduction was found in Mati-Char (16.28%). The highest shoot length reduction of *Echinochloa crusgalli* was found due to the root exudates of Rajashail (77.32a %) which is statistically similar with Joli (74.18%), Rangpuri (Sada) (76.73%), Mi-Chocho (71.43%). However, the lowest shoot length reduction was found in case of Kasia Panja (37.07%). The highest dry matter reduction was observed in Rajashail (71.78%), which is statistically similar with Joli (69.83%), Rangpuri (Sada) (69.80%), Mi-Chocho (70.39%) and the lowest dry matter reduction was found in Mati-Char, which is 53.90 percent

Among the tested varieties/lines, Joli, Rangpuri (Sada) and Mi-Chocho have allelopathic potentiality and more inhibitory character to suppress weeds in laboratory condition.

Evaluation of candidate herbicides

Eighteen herbicides were evaluated in BRRI HQ farm, Gazipur of which five were Pretilachlor (Profit 500 EC, Remit 500EC, T-Chlor 500 EC, HICHLOR 500 EC and Defeat 500 EC), six Pyrazosulfuron ethyl (MEGAFURON 10 WP, Weed Clean 10 WP, Genesun 10 WP, Glorious 10 WP, Grass Clean 10 WP and Pariza 10 WP), three Butachlor (Butapen 5G, Rajchlor 5G and Sitachlor 5G), one Mefenacet + Bensulfuran methyl (Clean up 53 WP), two Bensulfuran methyl+ Acetachlor (Nirmul 18 WP and Jhilik 18 WP) and one Pyrazosulfuron ethyl 0.6%+ Pretilachlor 34.4% (Remover 35 WP). Weed control efficiency of all these herbicides was compared with control (unweeded) treatment. The treatments were assigned in a RCB design with three replications. Forty-day-old seedlings of BRRI dhan29 were transplanted on 25 January at 20- × 20-cm spacing with 2-3 seedlings per hill. Fertilizers were applied as urea, TSP, MOP and gypsum @ 265, 100, 100 and 60 kg/ha. Pre emergence herbicides were applied at four days after transplanting and post emergence herbicides at two leaf stage of weed. Weed sampling was done at 50-55 DAT for counting number of weed and their dry biomass. Weed control efficiency was calculated on weed dry weight basis.

Pretilachlor group. These herbicides @ 1 L/ha controlled *Echinochloa crusgalli* (85%), *Oxalis europea (*87%), *Scirpus maritimus* (17%), *Cynodon dactylon* (20%), *Monochoria vaginalis* (88%) and *Cyperus difformis* (81%).

Butachlor. These herbicides @ 25 kg/ha controlled *Echinochloa crusgalli* (23%), *Oxalis europea* (88%), *Scirpus maritimus* (26%), *Cynodon dactylon* (36%), *Monochoria vaginalis* (88%) and *Cyperus difformis* (81%).

Pyrazosulfuran ethyl group. These herbicides @ 125 g/ha controlled *Echinochloa crusgalli* (28%), *Oxalis europea* (89%), *Scirpus maritimus* (66%), *Cynodon dactylon* (39%) *Monochoria vaginalis* (90%) and *Cyperus difformis* (84%).

Mefenacet + Bensulfuran methyl group. These herbicides @ 1 kg/ha controlled *Echinochloa crusgalli* (48%), *Oxalis europea* (89%), *Scirpus maritimus* (59%), *Cynodon dactylon* (28%), *Monochoria vaginalis* (88%) and *Cyperus difformis* (85%).

Bensulfuran methyl+ Acetachlor group. These herbicides @ 2.5 kg/ha controlled *Echinochloa crusgalli* (12%), *Oxalis europea* (87%), *Scirpus maritimus* (88%), *Cynodon dactylon* (47%), *Monochoria vaginalis* (64%) and *Cyperus difformis* (83%).

Pyrazosulfuron ethyl 0.6%+ Pretilachlor 34.4%. These herbicides @ 800g/ha controlled *Echinochloa crusgalli* (21%), *Oxalis europea* (86%), *Scirpus maritimus* (88%), *Cynodon dactylon* (27%), *Monochoria vaginalis (*85%) and *Cyperus difformis* (82%).

The evaluated herbicides could be used to control weed effectively in transplanted rice field.

NATURAL RESOURCE MANAGEMENT

Effect of waste water on plant growth and development

Water pollution is a problem in irrigated rice ecosystem. Use of waste water has adverse effect on crop growth and metabolism. Hence, the present study was adopted to find out changes in crop growth due to waste water use and to determine the toxic substance uptake by the plant.

The experiment was conducted in pots (30 cm diameter × 25 cm depth) during January to May 2012 in net house, BRRI HQ, Gazipur. The treatments were distributed in CRD with four replications. The pot was filled with clay loam soil (13.4 kg) and mixed with fertilizer @ 1.61 g TSP pot $^{-1}$, 1.74 g MOP pot $^{-1}$ and 0.94 g gypsum pot $^{-1}$. Urea was applied @ 1.12 g pot $^{-1}$ as top dressed at 15 days after transplanting (DAT), 30 DAT and 50 DAT. Pots were put in the net house of Agronomy Division. Forty-day-old seedlings were transplanted in the pot. Each pot had three hills and 2-3 seedlings hill^{-1}.

The treatments were-

- Continuous use of waste water,
- Continuous use of fresh water,
- Growing water hyacinths in waste water for five days and then residual water used as irrigation,
- Growing water hyacinths in waste water for ten days and then residual water used as irrigation,
- Growing water hyacinths in waste water for 15 days and then used as irrigation,
- Growing water hyacinths in waste water for 20 days and then residual water used as irrigation and
- Growing water hyacinths in waste water for 30 days and then residual water used as irrigation.

The yield and yield components data were recorded at harvest. Collected data were analyzed statistically by using the statistical package MSTAT.

Results indicates that plant height varied significantly among the treatments. The shortest plant was found in the treatment where continuous waste water was applied (T_1). Panicle/hill, grains/panicle and sterility percentage did not vary significantly among the treatments (Table 20). However, more number of panicle/hill was observed in the fresh water treated pots (T_2) while less number of panicle was found in waste water treated pot. Almost similar trend was recorded in case of grains/panicle. The highest spikelet sterility was observed in waste water treated pot and the lowest was found in the pot where water hyacinth was grown in waste water for 30 days and then residual water was used as irrigation (T_7). The variation of grain yield of rice was significant among the treatments. The grain yield was drastically reduced due to the use of waste water as irrigation. However, water hyacinth grown in waste water for about 30 days and used as irrigation water have positive effect on grain yield, which was almost similar to fresh water treated plot. Thus, the purification of waste water by growing water hyacinth (about 30 days) has a positive effect using as irrigation water in rice field.

Water hyacinth allowed to grown in waste water for 20-30 days and then this water might be used for irrigation to obtain rice yield similar to grain yield of fresh water treated pot.

Climate change impacts, vulnerability and adaptation: sustaining rice production in Bangladesh (Bioforsk-BRRI-CEGIS Collaborative Project)

Farmers' group discussion (FGD) is the mean of understanding of the farmer's status, their resources, problems and opportunities of agricultural production. Through FGD, the planners and researchers could make a sustainable plan or programme to address the farmers' problems and to utilize the available resources. The FGDs were conducted in Rajshahi and Barisal

Table 20. Effects of waste water on the grain yield and yield components of different treatments in Boro 2011-12, BRRI, Gazipur.

Treatment	Plant ht at harvest (cm)	Panicle/hill	Grain/panicle	Sterility (%)	Grain yield (g pot^{-1})
T_1	67.79	3.09	56.6	35.22	9.5
T_2	73.5	4.25	85.64	26.42	13.99
T_3	70.0	3.5	74.16	27.54	10.66
T_4	72.29	3.54	90.43	27.32	12.58
T_5	70.79	3.64	86.58	33.77	10.19
T_6	74.17	3.75	75.07	30.81	11.21
T_7	73.41	3.86	83.98	25.6	12.48
CV (%)	4.16	23.1	28.68	13.87	17.26
LSD (0.05)	4.33	1.23	32.84	14.22	3.68

T_1=Continuous use of waste water, T_2=Continuous use of fresh water, T_3=Growing water hyacinths in waste water for five days and then irrigated, T_4=Growing water hyacinths in waste water for 10 days and then irrigated, T_5=Growing water hyacinth in waste water for 15 days and then irrigated, T_6=Growing water hyacinths in waste water for 20 days and then irrigated and T_7=Growing water hyacinth in waste water for 30 days and then irrigated.

regions during 21 April to 5 June 2012 in Rohanpur, Chotodadpur and Jinarpur Blocks under Gomastapur upazila of Chapai Nawabganj district; Ayhy, Nabagram and Bidirpur Blocks under Godagari upazila and Kaliganj, Mundumala and Kalma Blocks under Tanore upazila were selected for Rajshahi regions. On the basis of FGD, researchable issues were identified and accordingly adaptive trials and other related activities are in progress.

Rajshahi study site

Population density at Godagari, Tanore and Gomostapur upazila varies from 726 to 877 persons/km^2. Male female ratio is almost 1:1. Number of agricultural block, the grass root level extension service providers, ranged from 16 to 27 per upazila. The highest number of landless farmers was recorded in Tanore upazila (52.69%), whereas the lowest number in Gomastapur upazila (19.21%). The highest marginal farmers (40.48%) were found in Godagari upazila (Table 21). There was a decreasing trend of percent farmers from marginal to large with an exception in Gomastapur ie marginal and small farmers were near about same. In general, large farmers were less than five percent in the locality.

The major crops of Rajshahi project site are rice and wheat (Table 22). Rice grows mainly in three seasons, whereas wheat grows only in the winter. The minor crops grown are potato, tomato, gram, maize, egg plant etc Boro-Fallow-T. Aman is the major cropping pattern of the study sites followed by Boro-T. Aus-T. Aman with an exception in Gomastapur upazila, where Boro-Fallow-Fallow is the second one (Table 23).

In general, rice and wheat are the major crops grown in the surveyed areas. The minor crops grown in the surveyed blocks are tomato, potato, mustard, gram, maize, vegetables and spices (onion, garlic, turmeric etc). But in some blocks, in addition to rice, wheat, tomato and potato are cultivated as major crops at Ayhy, Mundumala and Kalma blocks. However, most of the farmers are not happy with rice and wheat crop production because of their lower price. So, they want to produce high value crops to make the farming a profitable enterprise.

It is revealed that climatic variations compared to 15 years back adversely affected rainfall and its distribution pattern, temperature, drought duration, ground water reserve, pest, disease and irrigation costs.

Fifteen years back, farmers used to cultivate local rice varieties like Kalokuchi, Shaitta, Dharial, Sonasail, Mugi, Raghusail, Magusail, Jhingasail etc and a few HYV rice such as BR10, BR11, IR20. Now they mostly grow Pariza, Sada Sawrna, Guti Sawrna, BINA dhan7 and BRRI dhan39, which cover 100 percent land in T. Aman season. But due to improved irrigation facility and availability of new variety they are cultivating BRRI dhan28 and BRRI dhan36 that covers about 70-80 percent land in Boro season. Farmers are growing short duration rice variety to escape drought in T. Aman. To minimize irrigation water requirement, farmers are

Table 21. Farmers category based on land holdings of different upazila in Rajshahi region.

Farm family	Godagari		Tanore		Gomastapur	
	No.	(%)	No.	(%)	No.	(%)
Landless (<0.2 ha)	10874	28.05	16046	52.69	7735	19.21
Marginal (0.21-0.6 ha)	15694	40.48	6677	21.92	11151	27.69
Small (0.61-1.0 ha)	6022	15.53	2968	9.75	11105	27.58
Medium (1.01-3.0 ha)	4700	12.12	3709	12.18	8205	20.37
Large (>3.0 ha)	1483	3.82	1056	3.47	2075	5.15
Total	38773	100	30455	100	40271	100

Table 22. Land use with crops of different upazila in Rajshahi region.

Item	Upazila		
	Godagari	Tanore	Gomastapur
Total land (ha)	47563	25939	31812
Total cultivable land (ha)	39525	22665	24850
Total cultivable fallow (ha)	215	333	325
Single cropped land (ha)	5100	344	8010
Double cropped land (ha)	20742	7844	11250
Triple cropped land (ha)	13683	14497	5590
Cropping intensity (%)	221	262	191
Major crops	Rice, wheat, tomato	Rice, wheat, mustard	Rice, wheat, mustard
Minor crops	maize, mustard, onion, gram	potato, tomato, gram, maize, bringal	potato, tomato, maize, gram

Table 23. Main cropping patterns with area coverage of different upazila in Rajshahi region.

Cropping patterns	% area coverage
Godagari	
Boro-Fallow-T. Aman	33
Boro-T. Aus-T. Aman	13
Fallow-Aus-T. Aman	12
Tanore	
Boro-Fallow-T. Aman	42
Boro-T. Aus-T. Aman	21
Potato-T. Aus-T. Aman	4
Gomastapur	
Boro-Fallow-T. Aman	28
Boro-Fallow-Fallow	24
Fallow-T. Aus-T. Aman	18

growing tomato, mustard, potato etc in dry season.

Grazing land has decreased tremendously because of increased cropping intensity and so does the soil fertility. Irrigation facility has been increased because of BMDA, but forest/vegetation has decreased moderately. Insect pests and diseases have highly increased. There is also environmental influence on human health and biodiversity. Crow and kite has been decreased tremendously but the number of jackals and frequency of earth quake has been increased as mentioned by the farmers of that locality. Brick field is establishing in crop fields and removal of top soil for making bricks is a great concern for agricultural productivity. Moreover, fruit setting in mango and coconut would be jeopardized from smoke of brick kiln.

Table 24 summarize the constraints for agricultural development. Lack of quality seed, inadequate drought tolerant varieties, high pest prevalence, low soil organic matter content, extreme high and low temperature etc are the bottlenecks of agricultural development in studied areas.

During FGD, farmers of Rajshahi site showed great concern for some of the issues on agriculture and environment, which are summarized as follows:

Emerging issues

- Replacement/transformation of crop land to mango orchard
- Sharp decline of groundwater because of its over withdrawal in Barind tract area
- Development of brick kiln in the crop field and removal of top soil for making bricks
- Use of pond water solely for fish culture

Researchable/dissemination issues

Based on discussion with the farmers following research activities could be taken:

Table 24. Major constraints of climatic change on crop production and livelihoods.

Gomastapur	Godagari	Tanore
	Crop production related	
Lack of quality seed	Lack of quality seed	Lack of quality seed
Lack of proper production technology	Lack of proper production technology	Lack of proper production technology
Lack of drought tolerant variety	Lack of drought tolerant variety	Lack of drought tolerant variety
High pest infestation	High pest infestation	High pest infestation
High input cost	High input cost	High input cost
Low production price at harvest period	Low production price at harvest period	Low production price at harvest period
Low organic matter in the farm	Low organic matter in the farm	Low organic matter in the farm
	Technological improvement to drought tolerance	Technological improvement to drought tolerance
	Lack of training	Lack of training
	Environment related	
High temperature during dry period	High temperature during dry period	High temperature during dry period
Low winter duration	Low winter duration	Low winter duration
Uneven distribution of rainfall	Uneven distribution of rainfall	Uneven distribution of rainfall
	Water resources related	
Lack of availability of irrigation water	Improve the surface water availability from the Padma	Lack of availability of irrigation water
Lack of pond water use in crops	Excavation of canal for irrigation	Lack of pond water use in crops
High irrigation cost	Excavation of existing ponds	High irrigation cost
Increased water level depth	Increased water level depth	Increased water level depth
	Credit related	
Credit problem at cultivation time	Credit problem at cultivation time	Credit problem at cultivation time
High interest rate for borrowing money from NGO's and money lenders	High interest rate for borrowing money from NGO's and money lenders	High interest rate for borrowing money from NGO's and money lenders
	Others	
Reduce the middlemen activity	Reduce the middlemen activity	Reduce the middlemen activity
Direct purchase from the farmers	Direct purchase from the farmers	Direct purchase from the farmers

Variety
- Selection/release and dissemination of drought tolerant varieties
- Production of quality seeds at farmers level
- Adoption of foreign varieties- why?

Cultural practices
- Quality seedling production at farmers level
- Cropping schedule has to be found out
- Introduction of high value crops
- Integrated nutrient management
- Soil conservation and health improvement
- Mechanization
- Integrated pest management
- Yield gap minimization

Water management
- Water saving technology
- Assessment of water resources
- Rain water harvest and storage
- Installation of mini DTW- why?
- Assessment of water resources for domestic and commercial purposes

Environment issues
- Influence of unusual temperature and crop production
- Soil fertility and productivity depletion
- Water quality and
- Biodiversity

Socio-economics
- Land tenure system
- Marketing channel
- Women decision making in production process
- In-migration- why?
- Decision making in agricultural production process

Barisal site

Population density at Kalapara, Amtoli and Patharghata upazila varied from 378 to 445 persons/km^2. Male female ratio was almost 1:1. Number of agricultural block, the grass root level extension service providers, ranged from 17 to 30 per upazila.

Categories of farmers based on land holding varied in different upazilas. The highest percentage of landless farmers was recorded in Patharghata upazila (13.79 percent), whereas the lowest in Kalapara upazila (9.73 percent The highest proportion of marginal farmers was also found in the same upazila (33.09 percent Table 25). In Kalapara and Amtoli upazilas, the majority was large farmers.

The major crop of those localities is rice. Rice is grown mainly in T. Aman and T. Aus seasons, whereas pulse are grown in winter season. The minor crops grown are potato, chili, mustard, sunflower, watermelon, groundnut and spices etc. Pulse-Fallow-T. Aman (55 percent) is the major cropping pattern in Kalapara upazila followed by Rabi crops-Fallow-T. Aman pattern (20 percent). Whereas, Grass pea-T. Aus-T. Aman (48 percent) is the major pattern followed by Fallow-T. Aus-T. Aman (24 percent) in Amtoli upazila. The dominant cropping pattern in Patharghata upazila is Fallow-Fallow-T. Aman (40 percent) followed by Grass pea-Fallow/T. Aus-T. Aman pattern (25 percent).

On average, marginal, landless and small farmers are more (23 to 28.67 percent) in Kolapara upzilla. There are a few large farmers (5-9 percent), but this figure is high compared to other areas of the country. There are a very few migrant farmers in the area.

In general, rice is the major crops grown in the surveyed areas. The minor crops grown in the surveyed blocks are vegetable, grass pea, sunflower, maize, potato, green gram, sweet potato, chili etc. In some blocks, sunflower is the newly introduced crop during Rabi season for overcoming the salinity effect. Farmers can do nothing but to grow rice because of prevailing agro-ecological conditions in that locality. There are limited scopes to grow crops in winter season because of shortage of fresh water. They want to produce more crops to make the farming a profitable enterprise by developing facility of sweet water in dry period.

Farmers mentioned that amount of rainfall has decreased compared to the situation 15 years back with more uneven distribution in the recent years, and prolonged droughts. Temperature and cyclones have slightly increased. Although crop production is higher than near past, insect pest and diseases have increased greatly. Moreover, pesticide resistance is developing. Fresh water source is decreasing over the years because of siltation in rivers and canals. Although livelihood has increased compared to the last decade indebtedness has also increased.

Fifteen years ago, farmers used to cultivate local rice varieties like Kajalsail, Sadamota, Lalmota, Laxmibilash, Rajasail, Shaitta, Brindamoni, Rangalaxmi, Shitabhog, Kutiagni, Betichikon, Jhingasail, Matichak etc and a few HYV rice such as BR11, BR22. Now they mostly grow Sadamota, Vajan, BR11, BR22, BR23, BRRI dhan27, BRRI dhan40, BRRI dhan41, BRRI dhan49 etc, which cover 60-99 percent land in T. Aman and about 90 percent land in T. Aus season. But due to shortage of fresh irrigation water during Boro season, BRRI dhan28 and BRRI dhan29 is cultivated in limited areas (about 10 percent land). Farmers are growing short duration and salinity tolerant rice variety to escape salinity effect in later part of T. Aman season. Better saline resistant rice and other crop varieties are very much needed.

Seasonal fallow land is used for grazing in studied areas. Farmers mentioned decreased soil

Table 25. Farmers category based on land holdings of selected upazilas in Barisal region.

Farm family	Kalapara		Amtoli		Patharghata	
	No.	(%)	No.	(%)	No.	(%)
Landless (<0.2 ha)	3438	9.73	5733	12.09	3468	13.79
Marginal (0.21-0.6 ha)	1495	4.23	13098	27.63	8322	33.09
Small (0.61-1.0 ha)	7877	22.30	18623	39.29	6723	26.73
Medium (1.01-3.0 ha)	7314	20.71	7510	15.84	5986	23.80
Large (>3.0 ha)	2490	7.05	2439	5.15	650	2.58
Total	35318	100.00	47403	100	25149	100

fertility and fresh water availability and they are very much worried about future agriculture. Forest areas have decreased moderately. Insect pests and diseases have highly increased. There is also environmental influence on human health and biodiversity. Adulterated food is a great concern for their health.

The status of agricultural productivity, competition for natural resources and health and safety hazards are moderate to important in scale having variable levels of concern in the surveyed areas. Drudgery for women has decreased in every surveyed upazilas. There is less poverty and unemployment, but indebtedness has increased compared to the last decade.

Constraints for agricultural development in Barisal project site

- Lack of quality seed, inadequate saline tolerant varieties, high pest prevalence, adulterated fertilizers, lack of farm machinery, lack of training on modern crop production technology, etc are the bottlenecks of agricultural development in the studied areas.
- Lack of fresh water in dry season is the greatest challenge for agricultural development.
- Moreover, intrusion of saline water is destroying ecological and hydrological balance of that locality. Since agriculture is the main source of income in the studied areas, livelihood improvement depends on agricultural development.

During FGDs, farmers of Barisal region showed great concern for some of the issues on agriculture and environment, which are summarized as follows:

Emerging issues

- Sedimentation of water reservoir and crop fields
- Increased water salinity and its distribution towards main land

Researchable/dissemination issues

Based on discussion with the farmers following research activities could be taken:

Variety

- Selection/release and dissemination of salt tolerant crop varieties
- Production of quality seeds at farmers level

Cultural practices

- Quality seed and seedling production at farmers level
- Planting time adjustment for avoiding salinity damage
- Introduction of high value crops
- Integrated nutrient management
- Mechanization
- Integrated pest management

Water management

- Assessment of water resources for crop production
- Rain water harvesting and storage

Environment related

- Impact of climatic change on crop production
- Shrimp cultivation in Gher with brackish water and soil properties
- Biodiversity.

Socio-economics

- Land tenure system
- Marketing and communication systems
- Decision making process in crop production and processing

Soil Science Division

SUMMARY

In Boro season, the estimated optimum N rate was 150 kg/ha for the tested lines BR7358-5-3-2-1, BR7358-30-3-1, BR7372-18-3-3 and BRRI dhan50. Along with them, the optimum rate of K for BRRI dhan51 and BRRI dhan54 was 100 kg/ha while it was 50 kg/ha for BRRI dhan52 and BRRI dhan53 in T. Aman season. In Boro 50 kg K/ha is enough to produce optimum rice yield for all the tested varieties (BRRI dhan28, BRRI dhan55, BRRI dhan57 and BRRI dhan58). Twenty-five percent higher N/NP/NK/PK fertilizers need to be applied with STB dose depending on location for obtaining optimum rice yield. Long term missing element trial in BRRI HQ, Gazipur revealed that omission of N or K from complete treatment (NPKSZn) significantly decreased yield in both Boro and T. Aman seasons. Higher yield decrease was observed in Boro than T. Aman season due to omission of P fertilizer. At both BRRI RS Rangpur and Barisal the omission of N or K in Boro significantly lowered yield while in T. Aman only N omission produced such results. Thus, to get optimum yield fertilization of NPKSZn is necessary. Soil test based (STB) dose is a good option for obtaining higher rice yield either in double or triple rice cropping pattern. Straw surface mulch immediately after establishment of rice with minimum tillage builds up soil organic carbon compared to rice straw incorporation in soil with minimum tillage. Higher level of water arsenic (193-462 ppb) of shallow tube well was found at two unions (Alibabad and Korola) of Faridpur sadar upazila and two unions (Keragachi and Jalalabad) of Kolaroa upazila under Satkhira district. Urea deep placement in the form of USG or NPK briquette is a key factor for efficient utilization of N fertilizer and obtaining higher rice yield as well as reduces N loss which perhaps decreases N_2O emission in the atmosphere.

SOIL FERTILITY AND PLANT NUTRITION

Effect of N rates on rice yield

The investigation was undertaken to determine the N response behaviour of some BRRI MVs and promising lines in BRRI HQ farm, Gazipur. The soil of the experimental field was clay-loam in texture and neutral in reaction (pH 6.8). Organic C, total N, available P and exchangeable K of the soil was 1.1%, 0.13%, 6.04 ppm and 0.15 meq/100 g soils respectively. The available S and Zn (EDTA extracted) of the soil was 6.78 ppm and 2.1 ppm respectively. The N doses for Boro were 0, 50, 100, 150 and 200 kg N/ha. The test varieties/promising lines were BR7372-18-3-3, BR7358-30-3-1, BR7358-5-3-2-1 and BRRI MV rice (BRRI dhan50) in Boro 2012. A flat STB dose of PKS @ 12-36-13 kg/ha were applied. The experimental design was split-plot with N fertilizer doses in main plot and varieties in sub-plots. Added N level and the yield of different rice varieties/promising lines for Boro season showed quadratic relationship (Fig. 1). All the tested lines responded up to the rate of 150 kg N/ha.

Effect of K rates on rice yield

The investigation was undertaken to determine the K response behaviour of promising lines and BRRI MVs at BRRI HQ farm, Gazipur. The experiment was conducted in a long-term permanent K response plot during T. Aman and Boro seasons. The initial soil exchangeable K was 0.18 meq/100g at starting of the experiment in Boro 2003. The exchangeable K status in soil ranged from 0.08 to 0.12 meq/100g soil after the harvest of T. Aman 2010. In T. Aman, K rates were 0, 25, 50, 75, 100 kg/ha and for Boro seasons were 0, 50, 100, 150 and 200 kg K/ha. The design of the experiment was split-plot with K rates in the main plot and the varieties in the sub-plot. Each plot received a blanket STB dose of NPS @ 145-25-24 kg/ha and 97-15-14 kg/ha in Boro and T. Aman seasons respectively. The test varieties were BRRI dhan51, BRRI dhan52, BRRI dhan53 and BRRI dhan54 in T. Aman and those for Boro season were BRRI dhan28, BRRI dhan55, BRRI dhan57 and BRRI dhan58. A significant interaction was observed between varieties and potassium rates during T. Aman 2011. The grain yield of BRRI dhan51 and BRRI dhan54 increased with increasing K rates up to 100 kg/ha while BRRI dhan52 and BRRI dhan53 increased yield up to 50 kg K/ha beyond that the yield increase was minimum (Fig. 2). In Boro season, a significant yield increase (average over

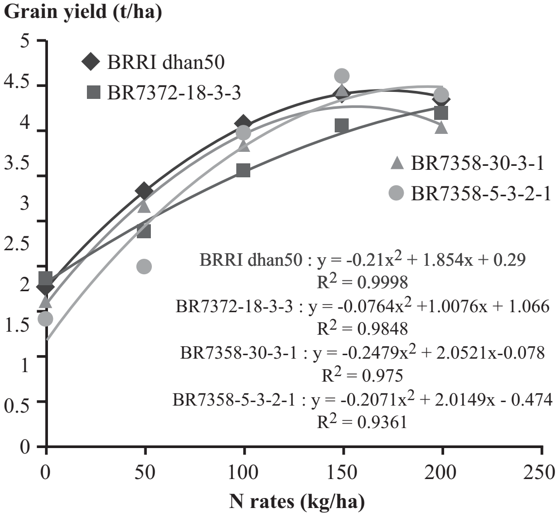


Fig. 1. Response of some Boro rice varieties to N rates at BRRI HQ farm, Gazipur, 2011-12.

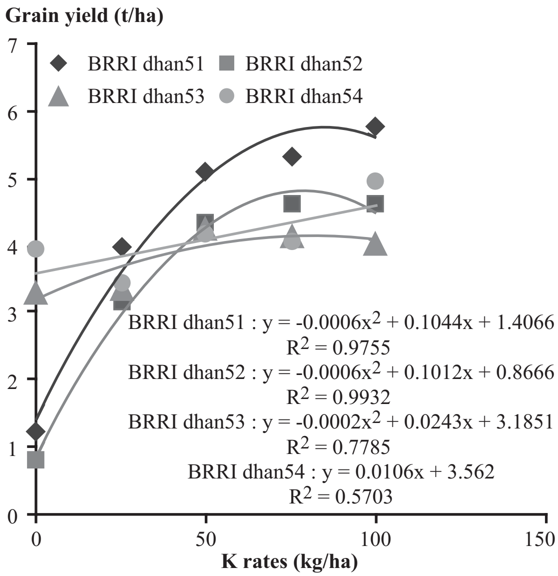


Fig. 2. Response of T. Aman rice to K rates at BRRI HQ farm, Gazipur in 2011.

varieties) was found at 50 kg K/ha and beyond that rate yield increase was not significant (Fig. 3). It means 50 kg K/ha is enough for obtaining optimum yield of the tested varieties in Boro season.

Fertilizer management for rice and rice based cropping patterns in unfavourable ecosystems of Bangladesh

The present study is undertaken to find out the

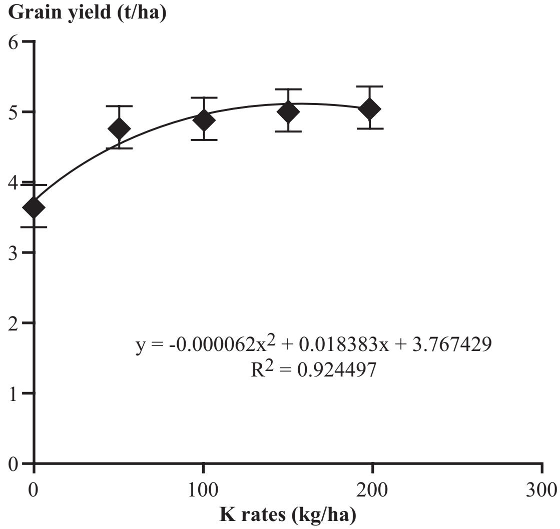


Fig. 3. Response of Boro rice to K rates at BRRI HQ farm, Gazipur in 2011-12.

proper fertilizer management packages through inorganic amendments for rice-based cropping systems under different unfavourable ecosystem. The selected areas with their characteristics and cropping patterns are given below:

Location (AEZ)	Characteristic	Cropping pattern
Gongachara, Rangpur (AEZ-3)	Submergence and cold area	Boro-Fallow-T. Aman
Tanore, Rajshahi (AEZ-26)	Drought prone and cold area	Boro-Fallow-T. Aman
Babuganj, Barisal (AEZ-13)	Tidal flood ecosystem	Boro-Fallow-T. Aman
Sonagazi, Feni (AEZ-18)	Char and saline area	Boro-Fallow-T. Aman
Baniachang, Habiganj (AEZ-21)	*Haor* area	Boro-Fallow-Fallow

Table 1 presents the initial soil characteristics of the experimental sites during T. Aman 2011 and Boro 2011-12. The rate of N, P and K were calculated on the basis of initial soil nutrient status. The experimental treatments are as follows:

- T_1=100% NPKSZn (STB);
- T_2=T_1 + 25 % N;
- T_3=T_1 + 25 % N P;
- T_4=T_1 + 25 % N K;
- T_5=T_1 + 25 % PK;
- T_6=T_1 + 25 % N P K;
- T_7=75% of T_1 and
- T_8 =Absolute control.

Table 1. Initial soil properties of the experimental sites in 2011-12.

Parameters	Rangpur		Rajshahi		Barisal		Sonagazi		Habiganj
	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	Boro
Texture	Silt loam	Silt loam	Silt loam	Silt loam	Silty clay loam	Silty clay loam	Clay loam	Clay loam	Clay
pH (1:2.5)	6.04	6.43	7.22	7.03	6.55	6.84	7.42	6.79	4.91
Org. C (%)	1.06	0.70	1.22	0.84	1.74	1.04	0.93	0.71	1.34
Total N (%)	0.11	0.06	0.12	0.08	0.17	0.10	0.09	0.07	0.13
Avail. P (ppm)	34.8	16.0	10.4	8.2	20.4	17.4	10.8	9.5	1.6
Exch. K (Cmol /kg)	0.10	0.13	0.24	0.11	0.13	0.17	0.17	0.27	0.29
Avail. S (ppm)	5.1	14.4	11.3	8.0	19.1	19.9	82.8	13.1	31.2
Avail. Zn (ppm)	0.4	0.98	0.8	2.5	0.7	1.5	0.4	Trace	2.3
EC (dS/m)	-	-	-	-	-	-	-	0.65	-

The design of the experiments was randomized complete block (RCB) design with three replications. During T. Aman season, one-third N, 1/2 K and all other inorganic fertilizers were applied at final land preparation in Rangpur site. The first top dress (One-third N) was applied at 18 DAT. The rest one-third N and half K was applied at 55 DAT. In other locations one-third N and all other inorganic fertilizers were applied at final land preparation. The first top dress (One-third N) was applied at 20 DAT. The rest one-third N was applied at 40 DAT. Similarly in Boro, one-third N and all other inorganic fertilizers were applied at final land preparation. The first top dress (One-third N) was applied at 25-30 DAT. The rest one-third N was applied at 55-60 DAT. Necessary intercultural operations were done as and whenever required.

In T. Aman 2011, soil test based (STB) fertilizer dose with additional 25% N treatment produced the highest yield in Rangpur and Sonagazi sites than any other nutrient combination treatment but in Barisal STB dose produced the highest yield (Table 2). In Boro, the yield increase scenario varied from location to location with different fertilizer combination (Table 2). In Rangpur site, STB dose + 25% NP produced significantly higher yield than STB dose. Similarly for Rajshahi site STB dose + 25% NK and for Habiganj site STB dose + 25% PK produced significantly higher yield than STB dose or any other treatment combination. It appears from the result that an extra 25% N/NP/NK/PK fertilizer need to be applied with STB dose depending on location for obtaining optimum rice yield.

IDENTIFICATION AND MANAGEMENT OF NUTRIENT DEFICIENCY PROBLEMS

Long-term missing element trial at BRRI HQ farm

The experiment was initiated on a permanent layout at the BRRI HQ farm, Gazipur in Boro 1985 viewing missing element approach using 12 treatments in RCB design with four replications (Table 3). Since Boro 2000, each plot was split to include a reverse treatment, and additional varieties, BRRI dhan29 and BRRI dhan31 to evaluate the reverse trends of missing elements. In Boro season NPKSZn @ 120-25-35-20-5 kg/ha was used but in T. Aman it was 100-25-35-20-5 kg/ha. After the 47^{th} crop, the treatments were modified with the omission of Zn fertilizer because of its sufficiency in the soil. The STB dose of NPKS was 138-10-80-5 kg ha^{-1} and 100-10-80-5 kg/ha^{-1} respectively. The rate was calculated from complete treatment soils after 47^{th} crop using Fertilizer Guide-2005 (BARC, 2005) with the yield target of 7.5 t/ha and 6.5 t/ha respectively. In this STB dose, K fertilizer required more than double of previous K dose. Higher level of available S in control plot compared to initial soil may be due to recent industrial urbanization effect and the resultant S dose was decreased. Again in Boro 2009-10, organic materials were used as third modification in T_5, T_8, T_9 T_{10} and T_{11} treatment. Different sources of organic materials were used in selected treatment such as oil cake (OC) (2 t/ha), saw dust (SD) (3 t/ha), cow dung (CD) (3 t/ha), mixed manure (CD-PM-SD-OC=1-1-1-0.5) and poultry manure (PM) (2 t/ha) in T_{10}, T_9, T_5, T_{11} and T_8 treatment and rest of the treatment was kept as

Table 2. Effect of soil test based NPKSZn rate and its different combinations with higher and lower dose on grain yields (t/ha) in 2011-12.

Treatment	T. Aman 2011				Boro 2012				
	Rangpur[1] (BRRI dhan52)	Rajshahi[2] (BRRI dhan56)	Barisal (BRRI dhan44)	Sonagazi (BRRI dhan41)	Rangpur (BRRI dhan29)	Rajshahi (BRRI dhan29)	Barisal (BRRI dhan29)	Sonagazi (BRRI dhan47)	Habiganj (BRRI dhan29)
T_1=100% NPKSZn (STB)[a]	2.94 cde	2.69	5.78 a	4.43 ab	7.00 b	5.76 bcd	7.26 a	5.88 a	6.61 c
$T_2=T_1$ + 25% N	4.04 a	2.63	5.22 ab	4.60 a	7.12 b	5.57 cd	7.02 a	5.79 a	7.41 ab
$T_3=T_1$ + 25% NP	2.87 cde	3.05	5.39 ab	4.29 ab	8.68 a	5.12 d	6.97 a	5.22 a	6.99 abc
$T_4=T_1$ + 25% NK	3.02 cd	3.17	5.54 ab	3.85 b	7.25 b	6.87 a	7.14 a	4.99 a	7.31 abc
$T_5=T_1$ + 25% PK	3.91 ab	3.06	4.95 ab	4.07 ab	7.41 b	6.41 ab	6.98 a	5.82 a	7.59 a
$T_6=T_1$ + 25% NPK	3.39 bc	2.34	5.45 ab	4.24 ab	6.67 b	5.13 d	7.34 a	5.05 a	7.17 abc
T_7=75% of T_1	2.55 de	2.98	5.41 ab	4.07 ab	7.44 b	6.02 bc	7.10 a	5.81 a	6.73 bc
T_8=Control	2.40 e	2.42	4.70 b	3.84 b	4.39 c	2.19 e	3.57 b	3.10 b	3.10 d
LSD % (0.05)	0.57	-	0.62	0.63	1.00	0.81	0.78	0.85	0.62
Significant level	**	NS	*	*	**	**	**	**	**
CV (%)	10.4	19.6	6.7	8.6	8.1	8.6	6.7	9.3	5.4

T. Aman 2011 : [a]$T_1=N_{84}-P_5-K_{46}-S_{14}-Zn_{1.6}$ (Rangpur), $T_1=N_{80}-P_{11}-K_{14}-S_{11}-Zn_{0.64}$ (Rajshahi), $T_1=N_{64}-P_3-K_{39}-S_8-Zn_{1.3}$ (Barisal), $T_1=N_{90}-P_{11}-K^{30}-S_4-Zn_{1.5}$ (Sonagazi). [1]The experimental plot was inundated due to flood and was infested by the pest. [2]The ails (levee) of the experimental plot were inundated several times due to heavy rainfall and during flowering stage (11 Oct 11) the experimental plot was affected by the hot wind. **Boro 2012 :** [a]$T_1=N_{187}-P_{13}-K_{75}-S_{15}-Zn_{1.1}$ (Rangpur), $T_1=N_{174}-P_{27}-K_{84}-S_{19}-Zn_0$ (Rajshahi), $T_1=N_{162}-P_{11}-K_{58}-S_{11}-Zn_0$ (Barisal), $T_1=N_{180}-P_{24}-K_{14}-S_{15}-Zn_4$ (Sonagazi) and $N_{144}-P_{36}-K_5-S_3-Zn_0$ (Habiganj). **Significant at the 1% level; *Significant at the 5% level. In a column, the figures having same letter(s) do not differ significantly at the 5% level.

Table 3. Treatment details of long-term missing element experiments at BRRI HQ farm, Gazipur in 1985-2012.

Original treatment 1985	Reverse treatment 2000	Treatment 2009-10	Treatment 2011-12
NPKSZn	All missing	NPKSZn	NPKSZn@138-7-80-3-5 kg/ha
NPSZn (-K)	NSZn (+ K)	NPSZn (-K)	-K
NKSZn (-P)	NKSZn (+ P)	NKSZn (-P)	-P
PKSZn (-N)	PKSZn (+ N)	PKSZn (-N)	-N
NSZn (-PK)	NSZn (+ PK)	Cow dung @ 3.0 t/ha	Cow dung (3 t/ha) + IPNS chem. fert.
NPKS (-Zn)	NPKS (+ Zn)	NPKS (-Zn)	-Zn
NPKZn (-S)	NPKZn (+ S)	NPKZn (-S)	-S
NPK (-SZn)	NPK (+ SZn)	Poultrymanure@ 2 t/ha	Poultry manure (2t/ha) + IPNS chem. fert
NP (-KSZn)	NP (+ KSZn)	Saw dust @ 3 t/ha	NPKSZn. @ 138-7-60-3-5 kg/ha
NK (- PSZn)	NK (+ PSZn)	Oil cake @ 2.0 t/ha	Oil cake (2t/ha) + IPNS chem. fert
N (-PKSZn)	N (+ PKSZn)	Mixed manure	NPKSZn @ 138-7-40-3-5 kg/ha
All missing	+ NPKSZn	Control	Control

previous. Only N @ 138kg/ha was applied as top dress in the organic source added treatment. However, during this modification both missing and reverse management plot were merged and considered as one treatment keeping the experimental inception treatment ie twelve treatment.

Again in Boro 2011-12, chemical fertilizers were used as fourth modification in T_9 and T_{11} treatment instead of organic sources. Sixty kilogram of K was used in T_9 and 40 kg K in T_{11} with NPSZn dose as complete treatment (T_1) to observe the change of soil exchangeable K over time.

Omission of each major nutrient (N, P and K) from complete treatment decreased yield significantly than complete treatment (NPKSZn) in both Boro and T. Aman season with an exception of P in T. Aman season (Table 4). The omission of S and Zn did not decrease yield due to its higher availability in soil. When different organic sources were applied only in T_5 (-PK), T_8 (-SZn), T_9 (-KSZn), T_{10} (-PSZn) and T_{11} (-PKSZn) treatments, yield level remains lower than complete treatment but higher than that of control plot except saw dust in T. Aman (Table 4). It might be the reason that the higher carbon and nitrogen ratio of saw dust causes N immobilization in soil. The

Table 4. Effect of long-term missing element on grain yield (t/ha) of Boro and T. Aman rice at BRRI HQ farm, Gazipur 2011.

Treatment	Boro 2011 (BRRI dhan29)	T. Aman 2011 (BRRI dhan49)
NPKSZn*	5.79	4.17
-K	4.03	3.24
-P	5.21	4.10
-N	3.75	3.88
Cow dung	4.66	3.07
-Zn	5.72	4.37
-S	5.90	4.52
Poultry litter	5.53	3.38
Sawdust	3.91	2.91
Oil cake	4.15	3.58
Mixed manure	4.86	3.33
Fertilizer control	2.60	3.12
$LSD_{(0.05)}$	0.52	0.65
CV%	7.8	12.6

*NPKSZn@ 100-7-80-3-5 kg/ha for T. Aman and 138-7-80-3-5 kg/ha for Boro.

trend of grain yield decrease in Boro 2012 due to omission of major nutrients has a similarity with previous Boro 2011 results (Tables 4 and 5). It appears from the Table 5 that addition of 60 kg K/ha with other nutrients as per complete fertilizer treatment produced higher yield than 40 kg K/ha with the same other fertilizer, which was statistically similar as longer period of complete fertilizer treatment.

It means longer period of K omission in soil required higher rates of K fertilizer. It also noted that in Boro 2007 when soil test based fertilizer dose was determined in this experiment the K rate was fixed at 80 kg K/ha with additional increment of 18 kg N/ha produced yield similar as experimental inception yield (Boro 1985).

Table 5. Effect of long-term missing element on grin yield (t/ha) of Boro rice, at BRRI HQ farm, Gazipur in 2011-12.

Treatment	Boro 2012 (BRRI dhan29)
NPKSZn @ 138-7-80-3-5 kg/ha	6.04
-K	3.29
-P	5.50
-N	3.02
Cow dung (3 t/ha) + IPNS chem. fert.	4.99
-Zn	5.65
-S	5.83
Poultry manure (2 t/ha) + IPNS chem. fert	5.82
NPKSZn @ 138-7-60-3-5 kg/ha	5.71
Oil cake (2t/ha) + IPNS chem. fert	5.01
NPKSZn @ 138-7-40-3-5 kg/ha	5.27
Fertilizer control	1.53
$LSD_{(0.05)}$	0.58
CV (%)	8.4

Long-term missing element trial at BRRI regional stations

The experiments were initiated on a permanent layout at the BRRI RS farm, Barisal in Boro 2009, BRRI RS farm, Satkhira and BRRI RS farm, Rangpur in T. Aman 2010 using six treatments (Table 6) in RCB design with three replications. The fertilizer rate of Barisal site was NPKSZn @ 150-15-50-10-1 kg/ha for Boro and 60-15-50-10-1 kg/ha for T. Aman while in Satkhira site it was 100-15-60-10-1 kg/ha for Boro and 65-15-60-10-1 kg/ha for T. Aman. For Rangpur site STB NPKSZn @ 97-7-39-15-0.3 kg/ha was used in T. Aman season where it was 145-10-57-15-0.6 kg/ha in Boro season.

The missing element trial of the regional stations indicated that omission of N or K from complete treatment (NPKSZn) produced significantly lower yield. Omission of other nutrients also decreased yield insignificantly in both Boro and T. Aman seasons (Table 6). Thus, for obtaining optimum yield, fertilization of NPKSZn is necessary.

Effect of continuous wetland intensive rice cropping

The experiment was designed to harvest three rice crops a year to get a target annual yield of 14 t/ha and to evaluate the consequences of intensive cropping under continuous wetland condition on soil fertility. It was initiated in 1971 in a permanent layout with three rice crops (Boro, T. Aus and T. Aman) annually with NPK fertilizer application keeping the soil perpetually wet. In 1982, the field was divided into two sub-plots, one plot received the previous NPK dose and the other plot was maintained as fertilizer control. In 1984, the NPK treatment was modified with the inclusion of S as gypsum because of S deficiency confirmed through soil-plant analysis and green house studies. From 1991, the plot was again divided into five sub-plots to accommodate two N levels with and without S fertilizer comprising four treatments with an absolute control. Since Boro 2000, the experiment

Table 6. Effect of long-term missing element on grain yield (t/ha) at different BRRI RS farms in 2011-12.

Treatment	Barisal		Rangpur		Satkhira
	T. Aman 2011 (BRRI dhan41)	Boro 2012 (BRRI dhan47)	T. Aman 2011 (BRRI dhan49)	Boro 2012 (BRRI dhan50)	Boro 2012 (BRRI dhan47)
NPKSZn	6.44	6.04	6.38	5.14	6.60
NPSZn (-N)	5.65	3.22	4.28	2.02	4.40
NKSZn (-P)	5.96	5.84	6.34	4.28	6.05
PKSZn (-K)	6.35	5.62	6.68	3.20	6.28
NSZn (-S)	6.06	5.84	6.68	4.10	6.13
NPKS (-Zn)	6.06	5.79	6.39	4.22	6.25
LSD (5%)	0.66	0.34	0.65	1.11	0.73
CV (%)	-	-	5.9	15.9	6.8

Barisal : Initial soil: Clay loam, pH (1:2.5)-6.08, Org. C (%)-1.8, Avail. P (ppm)-8.7, Exch. K (meq/100 g soil)-0.26. **Satkhira :** Initial soil: Silty clay loam, pH (1:2.5)-7.7, Org. C (%)-1.26, Total N (%)-0.13, Avail. P (ppm)-11.6, Exch. K (meq/100 g soil)-0.32, Avail. S (ppm)-40. **Rangpur :** Initial soil: Sandy loam, pH (1:2.5)-5.03±0.13, Org. C (%)-0.73±0.02, Total N (%)-0.07±0.00, Avail. P (ppm)-15.43±0.89, Exch. K (meq/100 g soil)-0.13±0.02, Avail. S (ppm)-2.90±0.20, Avail. Zn (ppm) (DTPA)-1.10±0.17.

was modified to accommodate six treatments viz control (native nutrient), reverse control (NPKSZnCu), NPK, NPKS, NPKSZn and NPKSZnCu. The varieties tested in T. Aus, T. Aman and Boro seasons are BRRI dhan48, BRRIdhan46 and BRRI dhan50 respectively. The NPK doses were 140-25-80, 60-15-80 and 60-10-60 kg/ha for Boro, T. Aman and T .Aus respectively. Sulfur, Zn and Cu were applied at the rate of 10, 4 and 1 kg/ha in Boro season only. This experiment is non-replicated. The annual rice production in the unfertilized plot decreased from 6.41 t/ha in 1981 to less than 2 t/ha in 2008, after 28 years of continuous cropping. However, the yield in this treatment is showing slight increasing tendency since the last three years (2.7-3.8 t/ha) (Fig. 4). In contrast, the yield trend in NPKS treatment over the last 31 years showed little bit increasing tendency as of 1981.

The yield of control plot ranged from 0.30 to 2.12 t/ha irrespective of season and annual yield production was 4.14 t/ha per year during 2010-11 (Table 7). On the other hand, its reversed management ie addition of complete fertilizer (NPKSZnCu) yielded (9.49 t/ha per year) equivalent to complete fertilizer treatment (9.01 t/ha per year) (Table 7). It indicates that the soil has capability to produce optimum yield when it receives balanced fertilizer. From the Table 7 it is observed that the application of Zn and Cu (Cu was applied since 2000) decreased annual yield compared to NPKS treatment.

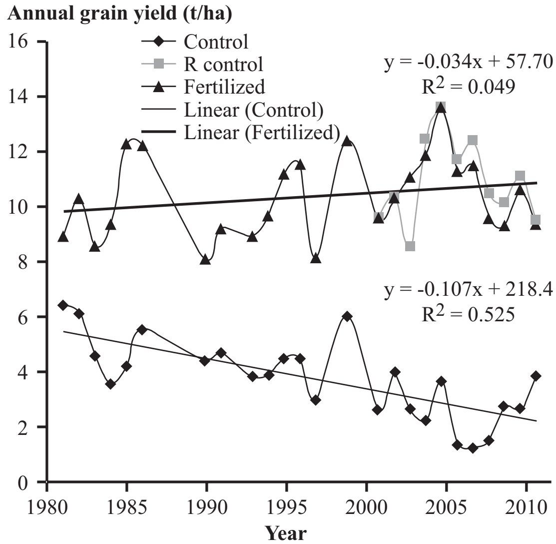


Fig. 4. Change in annual rice production with fertilized and unfertilized perpetually wetland conditions over 31 years.

Effect of double or triple rice cropping on yield maximization and soil fertility

The experiment was initiated in Boro 2009 at BRRI HQ farm, Gazipur in clay loam soil to evaluate the effects of fertilizers and integrated nutrient management under continuous wetland culture for sustainable soil health and productivity. Under this experiment in double cropping pattern (Boro-Fallow-T. Aman) BRRI dhan29 and BRRI dhan49 and in triple cropping pattern (Boro-T. Aus-T. Aman) BRRI dhan29, BRRI dhan43 and BR22 were used as test variety. Four treatment

Table 7. Effect of NPKSZnCu on yield of triple rice crop at BRRI HQ farm, Gazipur, 2010-11.

Treatment	Yield (t/ha)			
	Boro 2010-11	Aus 2011	T. Aman 2011	Annual
Control	0.30	1.72	2.12	4.14
Rev. Control	2.50	3.26	3.73	9.49
NPK	2.31	2.80	3.40	8.51
NPKS	3.66	2.91	3.50	10.07
NPKSZn	2.52	3.00	3.80	9.32
NPKSZnCu	2.61	3.10	3.30	9.01

combinations were tested:

- T_1=Control,
- T_2=STB dose (NPKS @ 160-25-60-20 kg ha^{-1} for Boro, 70-12-48-10 kg ha^{-1} for T. Aus and 84-15-54-14 kg ha^{-1} for T. Aman),
- T_3=STB (50%) + Mixed manure (cow dung 2 t ha^{-1} + ash 1 t ha^{-1}as oven dry basis),
- T_4=Farmers' practice (NPKS @ 80-10-20-10 kg ha^{-1} for Boro, 70-10-15-0 kg ha^{-1} for T. Aus and 70-10-15-0 kg ha^{-1} for T. Aman).

The experiment was laid out in a RCB design with three replications. In Table 8, it was observed that STB dose and 50% STB + Mixed manure (MM) produced identical grain yield but higher than farmers' practice. However, in triple cropping cumulative grain yield is always higher than double rice cropping pattern irrespective of treatment. Annual maximum yield (11.70 t/ha) was obtained with the STB dose in triple cropping. It appears from Table 9 that the yield of Boro 2012 as 10th crop under triple cropping pattern decreased yield in fertilizer control and 50% STB+MM treatment compared to Boro 2011 (7th crop). It indicates that 50% STB+MM treatment could not sustain its inception yield. So this treatment needs to be modified to obtain higher yield for further study.

SOIL AND ENVIRONMENTAL PROBLEMS

Assessment of existing carbon stock in some AEZ soils in Bangladesh

The present study was undertaken to document existing carbon stock in soils of 10 AEZs in Bangladesh through PIU-BARC (NATP Phase-1) project. Soil samples were collected from AEZ 1 to AEZ 10 by the Soil Science Division, BRRI, Gazipur. Out of ten carbon stock of four AEZs' (AEZ 1, 3, 4 and 9) are presented here:

- Old Himalayan Piedmont Plain: Haripur and Ranishankail, Thakurgaon (AEZ 1);
- Tista Meander Flood Plain: Rangpur sadar and Pirgachha, Rangpur (AEZ 3);
- Karatoya-Bangali Flood Plain: Sajahanpur and Dhunat, Bogra (AEZ 4) and
- Old Brahmaputra Flood Plain: Sarishabari and Jamalpur sadar (AEZ 9).

Soil organic carbon (SOC) content (%) is decreasing with increasing soil depth irrespective

Table 8. Annual grain yield of double and triple cropping pattern under continuous wetland condition at BRRI HQ farm, Gazipur in 2010-11.

Treatment	Grain yield (t ha^{-1})			Annual yield (t/ha per year)
	Double cropping			
	Boro 2011	Fallow	T. Aman 2011	
T_1= (Control)	2.54	-	2.87	5.41
T_2= (STB)	5.90	-	3.96	9.86
T_3= (50% STB + MM)	5.82	-	4.06	9.88
T_4= (FP)	4.85	-	3.55	8.40
$LSD_{0.05}$	0.80	-	0.48	-
CV (%)	8.4	-	6.6	-
	Triple cropping			
	Boro 2011	T. Aus 2011	T. Aman 2011	
T_1 =(Control)	2.06	1.46	2.50	6.02
T_2= (STB)	5.54	2.49	3.67	11.70
T_3=(50 % STB + MM)	5.49	2.39	3.33	11.21
T_4= (FP)	4.19	2.73	3.28	10.20
$LSD_{0.05}$	0.62	0.22	0.62	-
CV (%)	7.3	4.9	9.8	-

Table 9. Yield scenario of Boro rice under different treatments of double and triple cropping patterns at BRRI HQ farm, Gazipur in 2011-12.

Treatment	Boro yield (t/ha)			
	Double cropping 2011 (5th crop)	Double cropping 2012 (7th crop)	Triple cropping 2011 (7th crop)	Triple cropping 2012 (10th crop)
T_1= Control	2.54	2.58	2.06	1.75
T_2=STB	5.90	5.59	5.54	5.51
T_3=STB(50%) + MM	5.82	5.14	5.49	5.04
T_4=Farmers' practice	4.85	4.61	4.19	4.16
$LSD_{0.05}$	0.80	0.38	0.62	0.30
CV (%)	8.4	4.2	7.3	3.7

of land types in all AEZ sites. The overall carbon stock of soil in low land condition was higher than that of high and medium high land in all four AEZs (Table 10). In low land situation only Boro rice was grown but in high and medium high land situation T. Aman and Rabi crops were grown. The tillage operation was more in high and medium high land than low land condition, which might be the probable reason of having low soil carbon stock. On the other hand, in low land situation having higher soil carbon stock may be the cause of lower elevation (deposition of top soil through run off) and comparatively longer period of submergence. Carbon stock of soil (0-20 cm) is higher in low land soil type than that of medium high land and high land soil type irrespective of AEZ. Among the four AEZs the highest C stock was found in AEZ-1 irrespective of land type.

Carbon accumulation and its mineralization in soils under AWD and continuous flooding conditions with rice in net house

The experiment was set up at Soil Science Divisional net house, BRRI on 22 March 2011. BR22 was used as test crop to determine the changes of SOC under AWD and continuous flooding condition. In this experiment plastic pots with 27- × 28-cm sized were used. Each pot was filled with 10 kg of bulk soils (AEZ 1). Initially the soil had pH of 4.78 with 1 and 0.1% of OC and total N respectively. The available P and exchangeable K of the soil were also 9.18 ppm and 0.07 meq/100g. Different organic materials such as rice straw, rice root, cow dung and poultry manure were analyzed (Table 11) and incorporated in the pot soils @ 0.0, 0.5, 1.0, 1.5 and 2.0 t C/ha basis for each organic material. The experiment was laid out in RCB design factorial with three replications. Organic materials were considered as factor A and moisture regimes (AWD and continuous flooding condition) were factor B. Twenty-six-day-old seedling were transplanted. Each pot contained four hills followed by two seedlings per hill. Soil samples were collected at 30 days interval up to 180 DAT for the measurement of organic carbon and soil pH.

Carbon content of soil with four organic sources at four levels in both moisture regimes up to 60 DAT ranged from 1.05-1.23%. From 90 DAT to 180 DAT it ranged from 0.61-0.96%. Carbon content in soil did not vary within organic sources and its rates at every sampling time yet the C:N ratios of the organic sources are different. However, it was clearly observed that the organic carbon content in soil decreased slightly at 180 DAT (0.82%) compared to 30 DAT (1.12%) sampling irrespective of organic sources and its rates (Data not shown). It indicates that the addition of organic source or rate did not build up

Table 10. Carbon stock (t/ha) of soil (0-20 cm) in different land types of four AEZs.

AEZ	High land	Medium high land	Low land
AEZ-1	6.46	8.25	14.19
AEZ-3	3.39	6.09	6.45
AEZ-4	4.58	4.58	4.67
AEZ-9	5.98	7.26	11.24

Table 11. Nutrient contents of organic matters applied in the net house experiment.

Source (s)	OC (%) n=3	Total N (%) n=3	Total P (%) n=3	Total K (%) n=3
Rice straw	40	0.50	0.28	0.79
Rice root	24	0.79	0.60	0.56
Cow dung	28	0.85	0.50	0.52
Poultry manure	23	2.28	1.03	1.20

organic carbon in soil over times. Monika *et al,* 2002 also observed that the rate of CO_2-C emission and organic matter decomposition increased with increasing temperature, which is attributed to the depletion of soil carbon. They further noted that 1°C increase in temperature could lead to a loss of 10% of soil organic carbon. Therefore, addition of different organic sources at different levels did not build up organic carbon in soil over times at high temperature (> 35°C) in net house pot experiment.

Carbon sequestration in soils under different tillage method and rice straw management

This experiment was initiated in T. Aman 2010 at the BRRI HQ farm, Gazipur to determine the level of soil organic carbon (SOC), which is influenced by tillage operations, fertility levels under irrigated Rice-Rice cropping pattern. The soil of the experimental field was clay-loam in texture and slightly acidic (pH-6.46). The content of SOC, total N, available P, exchangeable K and available Zn (DTPA) of the soil were 1.57%, 0.1%, 7.5 mg/kg, 0.13 Cmol/kg soil and 1.11 mg/kg soil respectively. Two tillage operations (Minimum and traditional) as factor A and two methods of rice straw management (incorporation and surface mulch @ 5 t/ha) and a control (without rice straw) as factor B were imposed as treatment. The experiment was laid out in two factorial RCB design with three replications. Each plot received a fertilizer dose of NPK @ 75, 10 and 75 kg/ha respectively in T. Aman season and @ 150, 10 and 75 kg/ha respectively in Boro season. BRRI dhan31 in T. Aman season and BRRI dhan29 in Boro season were used as test variety. The grain yield did not influence by rice straw management and tillage operations in T. Aman season whereas the interaction effect of tillage and rice straw management on grain yield of Boro rice was significant in both 2010-11 and 2011-12 (Fig. 5). The addition of rice straw through traditional tillage decreased yield significantly than traditional tillage system without rice straw. The reason of having low yield in straw incorporation treatment might be the immobilization of nutrient in soil by bacteria and unavailability of nutrient to support normal plant growth. The tillage operations system and different method of rice straw management had a significant effect on SOC content after three crops (post harvest soil). Soil organic carbon (2.25%) build up was found in minimum tillage (MT) with surface mulch rice straw (SRS) treatment than initial level (1.57%). However, SOC did not increase in both minimum tillage plot with or without rice straw incorporation (1.5%) compared to its initial value (1.57%).

Effect of different organic materials and fertilizer management on carbon sequestration under Rice-Fallow-Rice cropping pattern

This experiment was initiated in T. Aman 2010 at the BRRI HQ farm, Gazipur to measure the changes of SOC due to addition of various organic materials (Cow dung, poultry manure and rice straw) at different fertility levels over times. The soil of the experimental field was clay-loam in texture and neutral in nature (pH-6.70). The content of SOC, total N, available P, exchangeable K and available Zn (DTPA) of the soil were 1.50%, 0.18%, 7.2 mg/kg, 0.13 Cmol/kg soil and 0.64 mg/kg soil respectively. Five treatments such as rice straw, cow dung and poultry manure with IPNS based chemical fertilizer, soil test based fertilizer (STB) and a fertilizer control were tested. The experiment was laid out in a RCB design with four replications. Organic materials were used at the rate of 2 ton C/ha. The STB dose of NPK @ 75, 10 and 75 kg/ha in T. Aman season and 162, 24 and 75 kg/ha in Boro season was used. BRRI dhan31 in T. Aman season and BRRI dhan29 in Boro season were used as test variety. Then three crops soil samples were collected for the determination of organic C. Two years' result of T. Aman indicates that STB dose and different organic sources with IPNS based fertilizer produces statistically similar grain yield but significantly higher than fertilizer control treatment (Fig. 6). Similar result was also observed in Boro season (Fig. 6) with an exception of treatment poultry manure with IPNS based fertilizer treatment of Boro 2010-11. Three rice cropping decreased soil organic C (1.27%) than initial level (1.50%). Yet the addition of organic sources with IPNS based fertilizer decreased SOC less than STB fertilizer alone. Organic sources with IPNS based fertilizer significantly produced higher root biomass especially in Boro season than STB

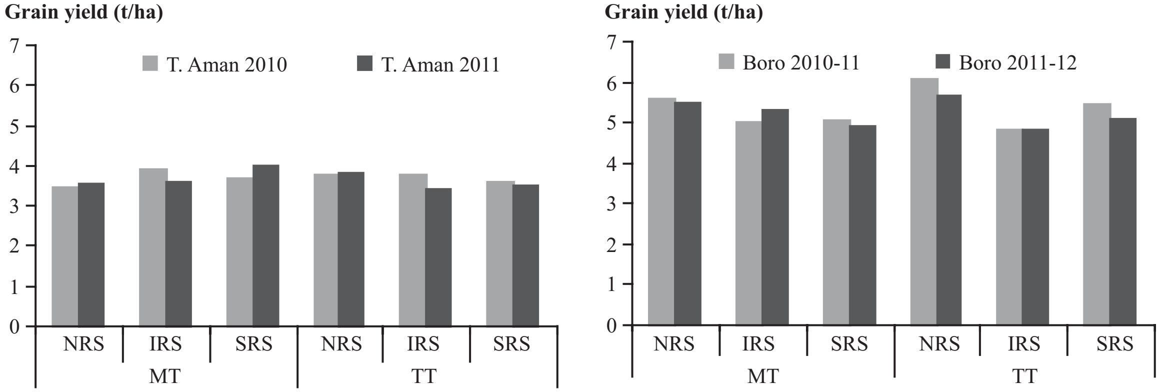


Fig. 5. Interaction effect of tillage and rice straw management on grain yield during 2010-12.

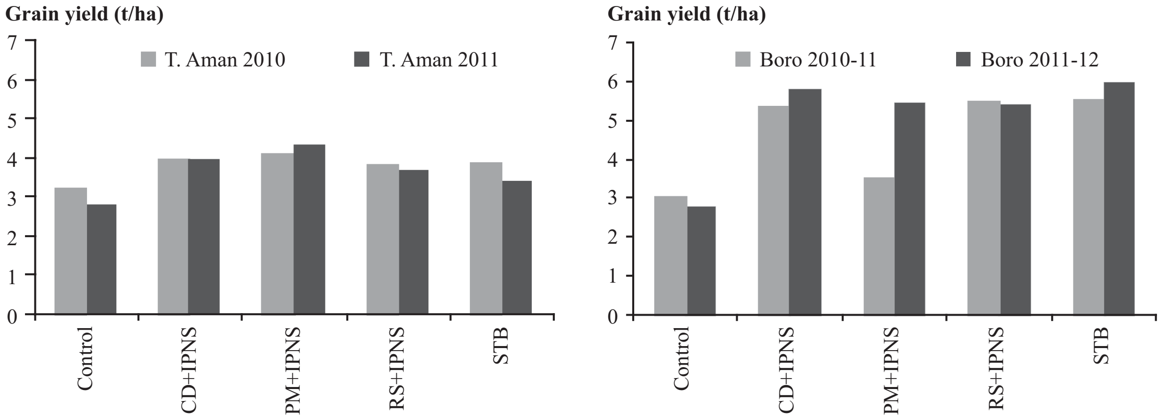


Fig. 6. Effect of organic and inorganic fertilizer management on grain yield of T. Aman and Boro rice in 2010-12.

and fertilizer control treatment (Fig. 7) and might be contributed to increase SOC.

However, the organic materials added into the soil at the rate of 2 ton C/ha basis may not enough to maintain initial soil carbon content (1.50%) in a Rice-Fallow-Rice cropping pattern.

Survey of arsenic status in soil and irrigation water

A survey was done for collecting soil, plant and irrigation water samples from four upazilas of four districts for determination of arsenic (As) status through PIU-BARC (NATP Phase-1) project. It appears from Table 12 that the maximum water As content of Manikganj and Natore district is even lower than the minimum value of Faridpur sadar and Kolaroa, Satkhira district. For this reason the union of Faridpur sadar upazila like Alibabad and Korola, Keragachi and Jalalabad union of Kolaroa upazila under Satkhira district may be considered As hot spots. However, the soil analysis of Faridpur sadar upazila (Table 13) indicates that maximum soil As (>20 ppm) was found at Koijhuri, Alibabad and Maich char union.

Effect of different levels of arsenic containing water management techniques on rice yield and its arsenic content

The experiment was set up at BRRI RS farm, Bhanga, Faridpur (soil As: 12.7 ppm) to see the effect of arsenic contaminated irrigation water on rice yield under AWD and conventional irrigation methods. The experimental design was RCBD with three replications. Two water management methods: AWD and continuous standing water (CSW) were maintained with two sources of water,

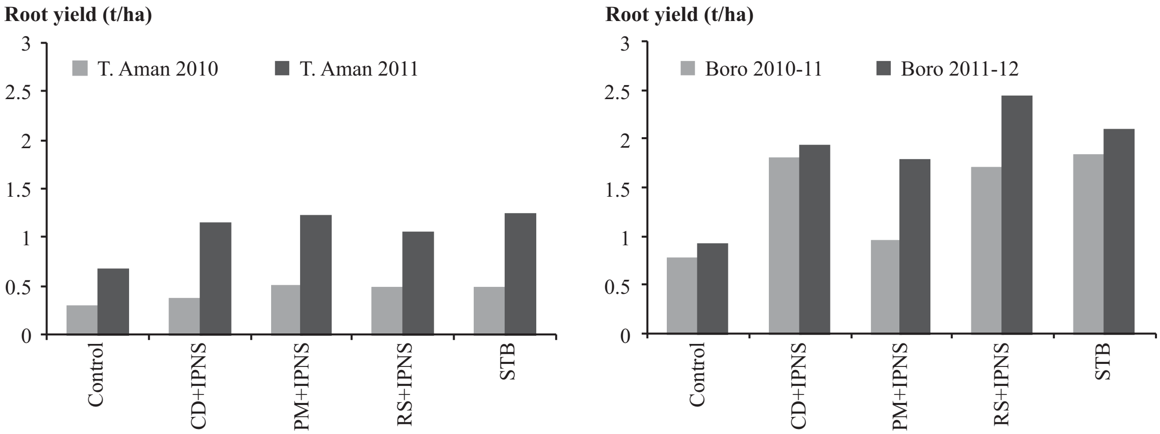


Fig. 7. Effect of organic and inorganic fertilizer management on root yield of T. Aman and Boro rice in 2010-12.

Table 12. Ground water based arsenic hot-spots at upazila level of different districts.

Union with	Arsenic concentration (ppb)		
water source	Minimum	Maximum	Average
	Faridpur sadar		
Alibabad, stw (17)	147	306	220±40
	Kolaroa, Satkhira		
Korola, stw (4)	170	317	245±64
Keragachi, stw (2)	442	482	462±28
Jalalabad, dtw (5)	137	294	193±64
	Sibaloy, Manikganj		
Sibaloy (9)	10	143	55±42
	Nator sadar		
Kholabaria (2)	27	61	44±24

Figure in parenthesis indicates sample number.

Table 13. Soil As status of Faridpur sadar upazila in 2011.

Union	Soil As (ppm)		
	Min.	Max.	Mean
	Faridpur sadar		
Maich char (12)	6.75	35.55	20.19±8.98
Krishnanagar (25)	9.06	14.11	12.20±1.35
Kanaipur (10)	10.27	28.27	16.45±6.55
Ishangopalpur (12)	10.94	25.78	15.14±4.47
Koijhuri (15)	8.54	42.28	22.61±10.88
Alibabad (16)	14.22	39.43	25.39±8.28
Gherda (6)	9.36	15.85	12.64±2.55

Figure in parenthesis indicates sample number.

namely, ground water (GW) and surface water (SW) containing 419 ppb and 25 ppb As respectively. The rates of fertilizers were N, P, K, S and Zn @ 115-20-60-12-3 kg/ha from urea, TSP, MP, gypsum and zinc sulfate respectively. Irrigation water was continuously applied during the first two weeks in all the plots. However, after two weeks, AWD plots received irrigation water only after the recession of the standing water to 15 cm depth. From panicle initiation (PI) to maturity, standing water was kept again in all plots. Both initial and post-harvest soil samples were collected for As analysis. At maturity, the crop was harvested and the grain along with straw yields were recorded. Samples were dried and processed before digestion in tri-acid mixture for As-analysis. In CSW system the grain yield of BRRI dhan28 significantly decreased in case of irrigation with high As content ground water compared to irrigation with low arsenic containing surface water. But such yield decreasing tendency was not observed with AWD irrigation system (Table 14). Post harvest soil arsenic content increased a little bit in continuous standing water condition. In AWD system such increase was not observed in soil; rather surface water irrigation system showed a little bit arsenic decreasing tendency. However, more arsenic content in both straw and grain was found in CSW system than AWD system even though these values are very low in both the irrigation systems irrespective of arsenic content in irrigation water.

Effect of arsenic contaminated irrigation water to some BRRI varieties

Two experiments were conducted at Satkhira and Bhanga, Faridpur BRRI RS farms in Boro 2010-11 seasons to screen rice varieties having low grain As content and are capable of growing up in As contaminated soils. Eleven BRRI rice varieties were used as test crops in a RCB design with three

Table 14. Effect of arsenic contaminated water management technique on rice yield of BRRI dhan28 at Bhanga, Faridpur in Boro 2010-11.

Source	Grain yield (t/ha)	Postharvest soil As (ppm)	Straw arsenic (ppm)	Grain arsenic (ppm)
		Continuous standing water		
Surface water	8.21	13.9	1.79	0.24
Ground water	5.67	13.9	3.43	0.26
		Alternate weting and drying		
Surface water	7.58	11.6	1.55	0.17
Ground water	8.28	12.9	1.73	0.20

Initial soil As =12.7 ppm, STW water As=419 ppb, Pond water As=25 ppb.

replications. In Satkhira 45-day-old seedlings were transplanted while in Bhanga the seedling age was 60 days to avoid cold injury during early to mid January. The rates of fertilizer application in Satkhira were N, P, K, S and Zn @ 120-10-56-10-1 kg/ha from urea, TSP, MP, gypsum and zinc sulfate respectively. In Bhanga, the rates were N, P, K, S and Zn @ 115-20-60-12-3 kg/ha from the same sources. The experimental field was irrigated with STW water contaminated with As (419 µg As/l in Bhanga and 124 µg As/l in Satkhira). Both initial and postharvest soil samples (composite) were collected and analyzed for As. The grain yield of BRRI rice varieties obtained at BRRI RS, Satkhira farm and BRRI RS, Bhanga, Faridpur farm seemed to be optimum (Table 15). In both locations As content of straw and paddy remained at minimum level. It means neither As contaminated irrigation water nor soil As influence As content of BRRI rice varieties.

Greenhouse gas emission trial

Two field experiments were set up in Boro season on 13 February 2012 at BRRI HQ farm, Gazipur to quantify the green house gas (GHG) emission (CO_2, CH_4 and N_2O) from paddy soils, to measure the comparative contribution of different N sources and management to global GHG emission and to minimize the GHG emission from paddy soils by synchronizing plant N demand and efficient N management. However, the greenhouse gas emission record cannot be done due to unavailability of instrumental support during the experimental period and water NH_4-N was determined after application of urea and urea deep placement (UDP). Since NH_4-N enter into N-cycle and nitrification contributes to N_2O emission through the biological oxidation of ammonium (NH_4^+-N) to nitrate (NO_3^--N) following ammonium fertilizer addition in soil may give an idea of N_2O emission from the field.

The soil of experimental field is clay-loam in texture with pH of 6.22. The organic C, total N, available P and exchangeable K of the soil was 1.75%, 0.17%, 16 ppm and 0.25 meq/100g respectively. In both experiments eight treatments

Table 15. Yield performance and arsenic content of different rice varieties influenced by arsenic contaminated irrigation water.

Variety	Grain yield (t/ha)		Arsenic concentration (ppm)			
			Straw		Grain	
	Satkhira	Faridpur	Satkhira	Faridpur	Satkhira	Faridpur
BR3	4.86	4.75	2.47	2.58	0.31	0.31
BR7	-	6.81	-	2.25	-	0.40
BR14	5.10	5.87	4.58	3.46	0.37	0.50
BRRI dhan28	5.84	7.81	5.49	4.36	0.37	0.45
BRRI dhan29	6.44	8.60	2.58	2.60	0.38	0.41
BRRI dhan36	5.90	7.85	3.36	4.57	0.38	0.47
BRRI dhan47	6.17	7.90	2.86	2.68	0.34	0.31
BRRI dhan50	5.23	7.10	2.95	2.69	0.32	0.40
BRRI hybrid dhan1	6.47	8.34	4.87	3.13	0.32	0.63
BRRI hybrid dhan2	6.55	8.11	4.53	3.54	0.29	0.36
BRRI hybrid dhan3	6.61	8.33	4.07	3.88	0.38	0.39
Soil arsenic (ppm)	17	19	Irrigation water (ppb)		124	419

were used (Table 16). All P, K and one-third urea-N were applied at the time of transplanting in respective treatments. The experimental design was RCB with three replications.

The tested variety was BRRI dhan29. Seventy-two-day-old seedlings were transplanted with 20-cm × 20-cm apart. Placement of USG (UDP) and NPK briquette was done at 10 days after transplanting. Water NH_4-N was determined for consecutive seven days during- 1) transplanting, 2) placement of UDP and NPK briquette and 3) urea top dressing. Total N uptake was determined after harvest of the experiment. It was observed that the NH_4-N content in flood water was higher in one-third urea applied as basal than UDP and NPK briquette as deep placement at 78 kg N/ha (Fig. 8). Similar tend was also observed in first one-third urea top dress but in second top dress time the NH_4-N content was comparatively lower than previous urea application and relatively higher than UDP and NPK briquette treatment (Fig. 9). Day after second urea top dress time, rainfall occurred in consecutive five days may dilute NH_4-N content in flood water. It indicates that urea-N incorporation in rice field produced higher flood water NH_4-N and its consequent results may cause higher N loses. However, the flood water NH_4-N content was approximately 2.0 ppm in control plot (Fig. 8). Application of N irrespective of N source and methods of application produced significantly higher yield than N control plot at all rates of N (Table 17). Thus, N application method, its different sources and rates did not influence on grain yield. It means all the N sources are equally effective to produce rice yield. However, 78 kg N/ha produced higher yield than higher rates of N, irrespective of N sources. Therefore, it may be concluded that 78 kg N/ha is optimum or enough to produce higher yield

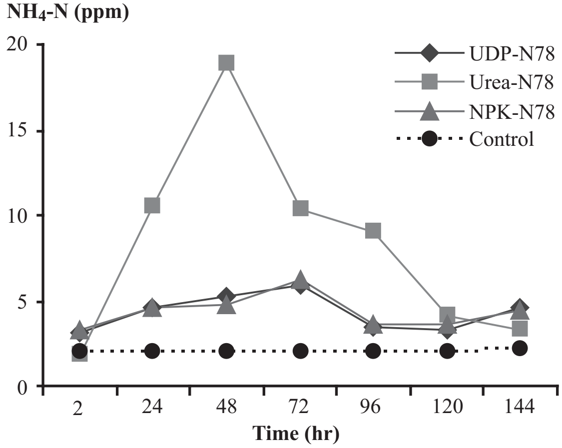


Fig. 8. NH_4-N content in flood water under CSW after application of different N-sources at 78 kg N/ha rate.

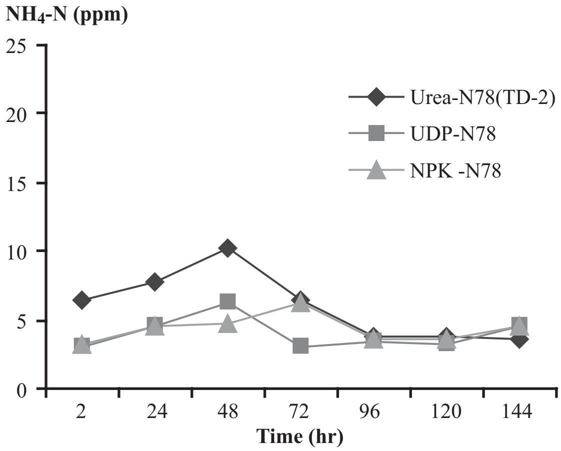


Fig. 9. NH_4-N content in flood water under CSW after application of UDP, NPK briquette and urea second top dress at 78 kg N/ha rate.

Table 16. Treatment description for Boro rice.

Treatment	Description*	N rate (kg/ ha)	P rate (kg/ha)	K rate (kg/ha)	Basal/deep placed N (kg/ha)	1st top-dress N (kg/ha)	2nd top-dress N (kg/ha)
T_1	Check	0	25[a]	64[b]	0	0	0
T_2	UDP (one-2.7 g briq)	78	25[a]	64[b]	78	0	0
T_3	UDP (two-1.8 g briq)	104	25[a]	64[b]	104	0	0
T_4	Urea	78	25[a]	64[b]	26	26	26
T_5	Urea	104	25[a]	64[b]	34	35	35
T_6	NPK (two-2.4 g briq)	78	16[c]	42[c]	78	0	0
T_7	Urea	156	25[a]	64[b]	52	52	52
T_8	NPK (two-3.4 g briq)	102	25[d]	64[d]	102	0	0

*UDP is considered as USG. [a]Applied as TSP, [b]Applied as MoP (KCl), [c]P and K is applied as NPK briquette (T_6 : made with 45 kg urea + 27 kg DAP + 28 kg MoP), [d]P and K is applied as NPK briquette (T_8 : made with 40 kg urea + 30 kg DAP + 30 kg MoP).

Table 17. Effect of urea, UDP and NPK briquette on grain yield and total N uptake at BRRI HQ farm, Gazipur in Boro 2012.

Treatment	Expt. no. 1		Expt. no. 2	
	Grain yield (t/ha)	Total N-uptake (kg/ha)	Grain yield (t/ha)	Total N-uptake (kg/ha)
$T_1=N_0$	4.22	61.72	4.61	66.13
T_2=UDP 78 N	5.15	96.05	5.97	101.06
T_3=UDP 104 N	4.98	90.83	5.72	90.08
T_4=Urea 78 N	5.28	83.07	5.66	86.81
T_5=Urea 104 N	5.08	89.48	5.29	88.79
T_6=NPK briq 78 N	4.80	96.14	5.94	97.47
T_7=Urea 156 N	4.94	90.27	5.90	98.62
T_8=NPK briq 102 N	5.00	94.86	5.70	94.80
$LSD_{0.05}$	0.46	13.70	1.23	20.05
CV (%)	5.30	8.90	12.60	12.70

in moderate soil fertility condition. On the other hand, higher total N uptake was obtained with NPK briquette and UDP than urea-N treatment (Table 17). It indicates that N utilization would be better with deep placement of NPK briquette and UDP for rice production and reduces loss of N. Also deep placement of NPK briquette and UDP is becoming a good method for obtaining higher N use efficiency in rice production. In other words, N_2O formation will be less in the environment, which finally contributes to minimize the adverse effect of greenhouse gas emission.

Irrigation and Water Management Division

SUMMARY

Irrigation applied by AWD practice when water level up to 15 cm below soil surface produced the highest yield (5.56 t/ha) followed by continuous standing water and 30 cm AWD (5.33 t/ha) respectively. Higher yield was obtained from non-protected plots compared to protected plots covered with polythene sheet in levee. Thus, 15 cm AWD is the best water management practice for irrigated Boro production.

Considering specific discharge, an engine speed within 1500-1600 RPM is optimum for earthen canal. For thin polythene pipe with five and four inches diameter, 1450 to 1550 RPM is the optimum and for thick polyethylene and cotton pipe, 1400-1500 RPM is the optimum.

USG in AWD method produced slightly higher yield compared to prilled urea for Boro production. But application of USG alone cannot maintain higher yield in longer duration Boro varieties like BRRI dhan29. Therefore, BRRI recommended additional split of prilled urea as top dress should be incorporated in the USG treated plots for BRRI dhan29 cultivation.

Refinement of AWD experiment showed that irrigation (5-7 cm) application is economically more viable when water level goes below 15 cm from soil surface. It saved 20-25% water and Tk 4,931/ha compared to continuous standing water practice.

Short and long duration varieties like BRRI dhan33 and BR11 were tested to determine the drought sensitivity and to find optimum date of transplanting under climate change situation. Both short and long duration T. Aman varieties suffered less from drought and showed good yield when transplanted from 24 to 31 July. The early transplanting of T. Aman through supplemental irrigation showed effective mitigation of terminal drought at reproductive and vegetative stages in T. Aman production.

Among medium duration varieties, BRRI dhan31 and BRRI dhan49 were found less sensitive to drought stress. On the other hand, long duration varieties having growth duration between 153 and 155 days were found sensitive to drought stress.

In Sonazagi area a good water bearing aquifer existed at a depth from 155 m to 180 m (salinity level ranged from 0.30 to 0.57 dS/m). BRRI dhan28, BRRI dhan47 and BRRI dhan55 were grown during Boro season and yields were 5.52 t/ha, 5.27 t/ha and 5.70 t/ha respectively. All the varieties performed well in irrigated condition. Thus, mono-cropped saline area has been converted into a double cropped area which is a good news for the coastal saline areas. The adjacent farmers have started installing tubewells for irrigating Boro rice. The findings may be disseminated to other areas where similar condition exists.

Rain water harvesting in a reservoir with 25 cm high embankment conserved more water than without embankment, which could increase irrigated Rabi crops area in the coastal region. Rainfed T. Aman (HYV) - Tomato with irrigation cropping sequence is more profitable than other cropping sequences. It was also evident that Rabi crop cultivation with pond water is also profitable in costal saline areas.

In hilly areas, rain water harvesting, ring well renovation, rubber dam or river cross dam in Chegi river and Myani river, hill water conservation from small hill stream by making creek dam could be the good source of surface water in this region. Cultivable land can be increased by proper management of surface water from those sources.

Among the BRRI regional stations (RS) the highest depth of groundwater level (30.16 m) was found in Gazipur during March to April and the lowest (1.4 m) in Kushtia area during September to October. In Barind area, the highest groundwater level depth (32 m) was observed in Nachol area, followed by Godagari (23 m) and Nawabganj (20 m). The overall trend indicates the lowering of groundwater level. The main reason for this declination was excessive withdrawal due to increased demand for both domestic use and irrigation.

BRRI dhan54 could be a good option in Aman season in the polder 30 area (Khulna) considering higher yield potential than the local variety (2.4 to 2.8 t/ha) under water logged condition. In polder 43/2F (Barguna), establishment of Boro rice in

early November might be affected due to cold stress but it can be recovered after temperature increase. It is possible to grow BRRI dhan28 having yield range of 4 to 6 t/ha in polder 30 and more than 6 t/ha in polder 43/2F.

Rabi crops can be grown in polder 43/2F (Barguna) under undrained or unmulched condition if sown in January. To achieve better establishment and better yield of mungbean it needs to be sown early and when the soil moisture is optimum. Therefore, all the Rabi crops can be established earlier with proper drainage, which needs further study for confirmation.

Irrigation cost for Boro production gradually increased over the last 15 years (1989 to 2003). It started to increase at faster rate from 2004 till 2011 with some exception in 2008. After 2011, the projected irrigation cost will increase gradually and it will reach to Tk 16,713/ha in 2031. Crop growing in an area, is closely related to the availability of irrigation water at the farm level. Therefore, steps should be taken to improve on farm water management practice. To ensure a regular water supply to crops, it requires an improved irrigation plan (ie, when to irrigate and how much water to apply). Thus, agricultural extension workers could assist in this regard. In general, policies should be taken to promote water management training to farmers for better understanding of on farm water management.

WATER USE EFFICIENCY IMPROVEMENT

Development of soil moisture declination model under AWD for rice production

The experiment was conducted at BRRI HQ farm, Gazipur to assess the soil moisture dynamics for AWD irrigation practices, which revealed that the highest yield (5.56 t/ha) was obtained from 15 cm AWD plots followed by continuous standing water and 30 cm AWD plots (5.33 t/ha). Irrespective of treatment, higher yield was obtained from non-protected plots compared to the protected plots with polythene sheet in levee. The above data indicates that 15 cm AWD is the best water management practice for irrigated Boro production.

Assessment of performance of low cost water distribution pipes for minor irrigation

An experiment was conducted at BRRI HQ farm, Gazipur to assess the performance of low cost water distribution pipes, which revealed that irrespective of distribution systems the fuel consumption and pump discharge increased with increase in engine speed. Discharge per unit fuel consumption showed that less amount of water obtained for unit fuel consumption for both the higher and lower engine speed. The optimum engine speed gives the highest volume of water for unit fuel consumption. The optimum engine speed for thin polythene pipe (5 inches diameter) was 1547 RPM and the corresponding specific discharge was 91 m^3 per lit of fuel. The optimum engine speed for thin polythene pipe (4 inches diameter) was 1540 RPM and the corresponding specific discharge is 86.85 m^3 per lit of fuel. The optimum engine speed for thick polythene pipe (3 inches diameter) was 1525 RPM and the corresponding specific discharge was 85 m^3 per lit of fuel. The optimum engine speed for cotton pipe (3 inches diameter) was 1520 RPM and the corresponding specific discharge was 83.25 m^3 per lit of fuel.

Considering specific discharge an engine speed within 1500-1600 RPM is optimum for earthen canal. For thin polyethylene pipe with five and four inches diameter 1450 to 1550 RPM is the optimum. For thick polyethylene and cotton pipe 1400-1500 RPM is the optimum.

Validation of crop model ORYZA2000 under AWD irrigation systems

A field test was conducted at BRRI farm to validate the crop model ORYZA2000 under AWD conditions. The treatments were composed of three irrigation levels (I_1=continuous standing water; I_2=Irrigation when water level reached 15 cm below soil surface and I_3=Irrigation when water level reached 20 cm below soil surface) and three nitrogen levels (N_0=No nitrogen**;** N_1=Prilled urea applied @ 220 kg/ha and N_2=USG applied @ 70 gm between four rows). Irrigation applied in AWD method (when water level was 15 cm below soil surface) produced higher yield than that of continuous standing water application. AWD method up to 20 cm water depletion below soil surface reduced rice yield significantly. There was no interaction effect of irrigation methods, nitrogen sources and varieties on the yield of Boro rice. USG produced slightly higher yield (but not significant) than that of prilled urea when applied for short duration variety BRRI dhan28. But only USG cannot increase or maintain yield of longer duration Boro like BRRI dhan29.

Refinement of AWD irrigation technique for rice cultivation

The study was conducted to determine the optimum depth of water level for irrigation after disappearing of standing water and to determine the economic profitability of AWD method for Boro rice cultivation. The treatments were: T_1= Continuous standing water; T_2=Irrigation (5-7 cm) when water level is 15 cm below the soil surface; T_3=Irrigation (5-7 cm) when water level is 20 cm below the soil surface and T_4=Irrigation (5-7 cm) when water level is 50 cm below the soil surface

Table 1 shows the performance of Boro production under AWD method. It reveals that the maximum number of irrigations (11 nos.) was required in treatment T_1 followed by treatments T_2, T_3, and T_4. The total water supply (rainfall and irrigation) for different treatments ranged from 1100 mm to 680 mm. To maintain continuous standing water, maximum irrigation water was needed and that was 1100 mm, but in AWD treatments those were 880 mm, 720 mm and 680 mm (Table 1). Water use efficiency is the most important criterion to rationalize AWD practice. The water productivity varied among the irrigation treatments and it ranged from 5.45 to 7.60 kg/ha-mm (Table 1). The highest water productivity (7.60 kg/ha-mm) was in T_3 and the lowest (5.45 kg/ha-mm) was in T_1. The total rainfall during the season was 215 mm. The grain yield was found significantly influenced by different AWD irrigation treatments. The highest grain yield was obtained in T_2 (6.20 t/ha) and the lowest was in T_4 (4.70 t/ha).

Economic analysis

Table 2 presents the economic analysis of AWD practices. Practicing AWD method about 220 mm, 380 mm and 420 mm irrigation water was saved in treatments $T_{2,}$ T_3 and T_4 respectively. The maximum benefit of AWD method was Tk 4,931/ha in T_1. But in T_3 and T_4 were not economically profitable because it decreased yield due to more water stress. In AWD method, when water level goes 15 cm below the soil surface then irrigation (5-7 cm) is economically more viable for Boro production. It saved about 20-25% irrigation water without reducing yield; even in some cases it increased yield from 0.2 t/ha to 0.5 t/ha. Therefore, the additional benefit of AWD method was Tk 4931/ha over the continuous standing water practice (Table 2).

UTILIZATION OF WATER RESOURCES IN RAINFED ENVIRONMENT

Terminal drought mitigation through integrated approaches for T. Aman production

The experiment was conducted at BWDB farm, Kushtia to find out the suitable approaches for terminal drought mitigation in T. Aman production. Two approaches were demonstrated. These were: i) Water management (W_1=Supplemental irrigated and W_2=Rainfed condition) and ii) Transplanting dates (T_1=Date of transplanting 10 July, T_2=Date of transplanting 17 July, T_3=Date of transplanting 24 July and T_4=Date of transplanting 31 July).

Water management approach. Crop was timely transplanted by using supplemental irrigation without waiting for rainfall in $W_{1,}$

Table 1. Yield and water application and water productivity for Boro production.

Treatment	Irrigation (no.)	Total water (mm)	Yield (t/ha)	Water saved over T_1 (%)	Yield increased over T_1 (%)	Water prod. (kg/ha-mm)
T_1	11	1100	6.00	-	-	5.45
T_2	8	880	6.20	20	33.33	7.10
T_3	6	720	5.50	25	- 8.33	7.6
T_4	5	680	4.70	38	-21.67	6.9

Table 2. Benefit of AWD method over continuous standing water for Boro production.

Treatment	Water applied (mm)	Water price (Tk/ha)	Benefit from saved water over T_1		Yield (t/ha)	Return (Tk/ha)	Benefit from additional yield over T_1		Maximum benefit over T_1 (Tk/ha)
			Saved water (mm)	Saved water price (Tk/ha)			Additional rice yield (t/ha)	Additional rice price (Tk/ha)	
T_1	885	5355	-	-	6.0	108000	-	-	-
T_2	665	4024	220	1331	6.2	111600	0.2	3600	4931
T_3	505	3056	380	2299	5.5	99000	-0.5	-9000	-6701
T_4	465	2813	420	2541	4.7	84600	-1.3	-23400	-20859

whereas in W_2, transplanting was delayed due to waiting for sufficient rainfall for land preparation. W_1 was transplanted on 17 July when W_2 was transplanted on 31 July. The yield performance of both treatments showed the impact of terminal drought at the reproductive stage (Table 3). Huge amount of yield loss (1.33 t/ha) was found in rainfed condition compared to W_2 due to terminal drought and it was about 30% yield of W_1. Terminal drought at reproductive and vegetative stages could be effectively mitigated by early transplanting of T. Aman rice through supplemental irrigation.

Transplanting date approach. Table 4 shows drought mitigation through alternate transplanting dates. For BRRI dhan33, the highest level of drought was observed for transplanting date 10 July. Table 4 also shows that the variety faced drought in vegetative stage for different transplanting dates except 31 July transplanting. Again drought in ripening stage was observed for all transplanting dates. In case of BR11, the highest level of drought was observed in vegetative stage for 10 July transplanting date, but no drought was observed for 31 July transplanting date. BR11 rice suffered mostly from drought during ripening stage as the drought was higher than that of other two stages for all transplanting dates. Figures 1 and 2 present the drought pattern during the rice growing period (BRRI dhan33 and BR11 respectively). BRRI dhan33, transplanted on 31 July, yielded higher (5.05 t/ha) than the other treatments (Table 4). The rice did not suffer from drought during its vegetative and reproductive stages. It only faced drought in the ripening stage and total drought amount throughout the growing season was the lowest (57.04 mm) for the rice transplanted on 31 July. For BR11, the highest yield (5.27 t/ha) was found for 24 July and the lowest yield (4.52 t/ha) was observed for 17 July transplanting (Table 4). It was found that both the varieties suffered less drought and performed better for transplanting between 24 July and 31 July. Though total drought levels were higher for different transplanting dates of BR11 compared to those of BRRI dhan33, yet yield performance of BR11 was better.

Relative drought tolerance for short, medium and long duration T. Aman varieties

The study was undertaken to find out suitable T. Aman varieties for drought prone area. Table 5 shows the details of growth duration, varieties and their yield levels under rainfed and supplementary irrigated condition. It reveals that the mean yield of the short duration varieties were almost similar for both supplementary irrigated and rainfed plots. The yield of medium duration varieties were 6-11% higher in the supplementary irrigated plots. On the other hand, the mean yield of the long duration varieties was 13-18% higher in the supplementary irrigated plots. Among the medium duration varieties BRRI dhan31 and BRRI dhan49 were found less sensitive to drought stress. In case of long duration varieties having growth duration between 141 days to146 days, BR11 and BRRI dhan40 were found less sensitive to drought stress. But long duration

Table 3. Drought mitigation through water management approach in T. Aman 2011.

Treatment	Plant ht (cm)	Panicle (no./m^2)	Yield (t/ha)	Yield loss in rainfed condition (t/ha)	Yield loss (%)
W_1=Supplemental Irrigation	119	256	5.85	1.33	29.42
W_2=Rainfed condition	112	244	4.52		

Table 4. Yield and yield components for different transplanting dates, T. Aman 2011.

Treatment	Plant ht (cm)	Panicle (no./m²)	Yield (t/ha)	Plant ht (cm)	Panicle (no./m²)	Yield (t/ha)
		BRRI dhan33			*BR11*	
T_1=10 July	112	218	3.55	113	252	5.01
T_2=17 July	107	220	3.70	113	244	4.52
T_3=24 July	106	225	4.44	111	254	5.27
T_4=31 July	104	244	5.05	109	209	4.62

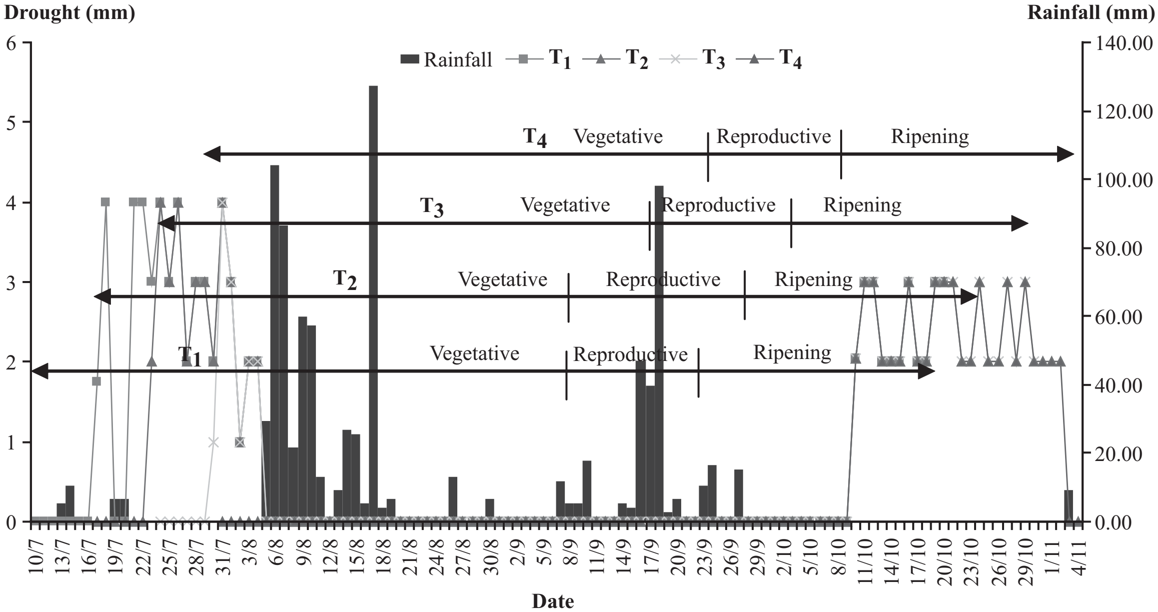


Fig. 1. Drought patterns for BRRI dhan33.

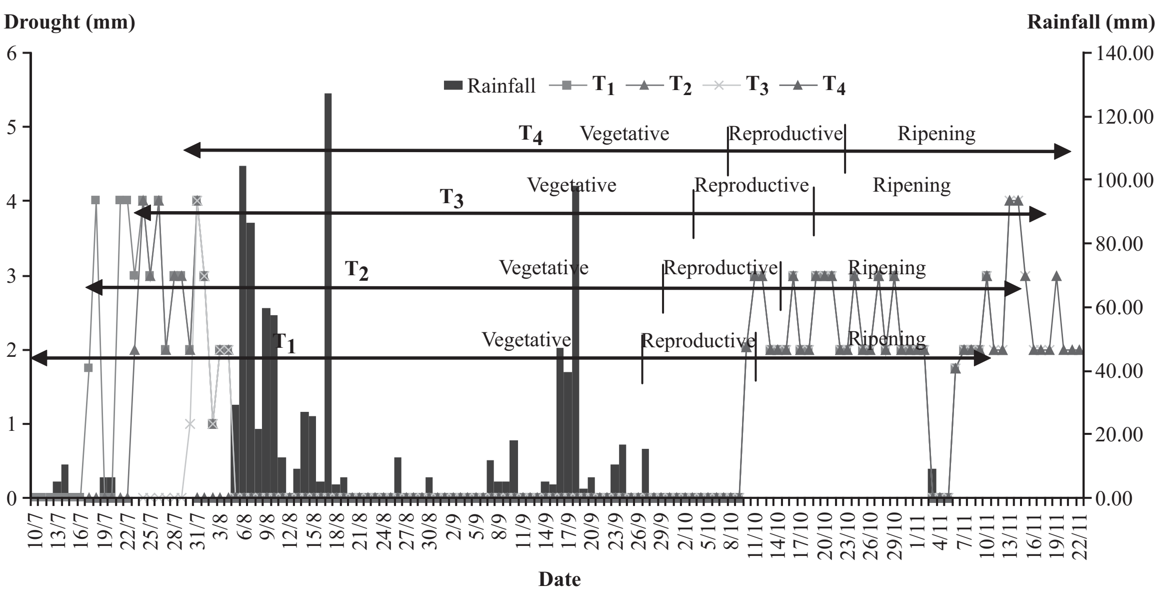


Fig. 2. Drought patterns for BR11.

Table 5. Relative drought tolerance of BRRI developed T. Aman varieties.

Variety	Irrigated plot			Rainfed plot			Yield	Yield
	Date of harvest	Growth duration (day)	Yield (t/ha)	Date of harvest	Growth duration (day)	Yield (t/ha)	difference (t/ha)	reduction (%)
				Short growth duration				
BRRI dhan33	Nov 01	117	4.00	Nov 01	117	3.90	0.11	2.6
BRRI dhan39	Nov 05	121	3.97	Nov 05	121	3.74	0.23	5.8
				Medium growth duration				
BR25	Nov 15	131	4.80	Nov 15	131	4.27	0.52	10.9
BRRI dhan31	Nov 22	138	4.41	Nov 22	138	4.11	0.29	6.6
BRRI dhan49	Nov 22	138	4.83	Nov 22	138	4.54	0.29	6.0
				Long growth duration				
BR11	Nov 25	141	5.42	Nov 25	141	4.74	0.68	12.6
BR23	Dec 07	150	4.98	Dec 07	150	4.25	0.72	14.5
BRRI dhan30	Nov 28	144	5.23	Nov 28	144	4.34	0.89	16.9
BRRI dhan40	Nov 30	146	5.40	Nov 30	146	4.59	0.80	14.9
BRRI dhan41	Dec 07	153	5.27	Dec 07	153	4.47	0.80	15.1
BRRI dhan44	Nov 28	155	5.11	Nov 28	155	4.21	0.90	17.6

varieties having growth duration between 153 days to155 days, BRRI dhan41 and BRRI dhan44 were found sensitive to drought stress (Table 5).

LAND PRODUCTIVITY IMPROVEMENT IN THE SALINE ENVIRONMENT

Exploration of fresh groundwater resources for increasing crop production in coastal region

The study was conducted to explore fresh groundwater for increasing crop productivity in Sonazagi area. A test STW having 7 cm diameter was designed and installed at BRRI RS, Sonagazi in April 2009. It was found that a good water bearing aquifer exists at a depth from 155 m to 180 m (510 ft - 590 ft). The pump was discharging groundwater with salinity level ranged from 0.30 to 0.57 dS/m, which was fresh and much below the permissible maximum limit. BRRI dhan28, BRRI dhan47 and BRRI dhan55 were grown during Boro 2012. The yield of those varieties were 5.52, 5.27 and 5.70 t/ha respectively (Table 6). All the varieties performed well in irrigated condition. The mono-cropped area has been converted into a double cropped area, which is a good news for the coastal saline areas. The adjacent farmers have started installing tubewells for irrigating Boro rice. The findings may be disseminated to other areas where similar condition exists. But long-term effects of groundwater extraction in coastal saline areas should be monitored.

Assessment of farm reservoir use for irrigation in Sonagazi coastal area

A farm reservoir (FR) having size 6- × 6-m with a depth of 2 m, side slope 1:1, storage capacity 34.67 m^3 was used for the experimental purpose. It has 225 m^2 service areas (crop area) as catchment area to collect runoff for FR. FR area was 16% of the service area. Twenty-five centimeter height embankment was constructed around the pond to store 9.77 m^3 extra rainwater than that of the normal FR capacity. Two inlets were provided in FR to collect runoff. When FR

Table 6. Yield performances of Boro varieties under STW irrigation system in Sonagazi.

Variety	Plant ht (cm)	Effective tiller (no./hill)	Sterility (%)	1000-grain wt (g)	Irrigation water salinity (dS/m)	Yield (t/ha)
BRRI dhan28	88.2	19	16	20.3	0.30-0.57	5.52
BRRI dhan47	97.9	16	18	22.9		5.27
BRRI dhan55	100.6	20	15	23.2		5.70

Transplanted : 7 February 2012.

was filled up to the soil surface, then inlets were closed. In Aman season, 41-day-old seedlings of BRRI dhan32 were transplanted with 20- × 20-cm spacing on 7 August and were harvested on 6 November 2011. During the Aman (July-November) season, total rainfall was 1025 mm. It was observed that there was no water shortage in Aman season due to rainfall, even though rainfall was less during later part of the T. Aman season. The grain yield was 4.07 t/ha.

BARI tomato variety 'Raton' was cultivated followed by BRRI dhan32 in Aman season. Twenty-seven-day-old seedlings of tomato were transplanted in dibbling method on 18 December, 2011 after T. Aman harvest. Plant to plant and line to line spacing were 50 cm. One meter buffer zone between two plots and 30 cm drain was provided in each plot to drain out the excess water. Irrigation water was provided from the FR by hand sprinkler to irrigate the experimental plots by coupling the sprinkler with discharge pipe of a small centrifugal pump. Table 7 shows the yields of tomato in rainfed and irrigated conditions. The higher yield of tomato (47.22 t/ha) was obtained in irrigated condition and lower yield (40.04 t/ha) in rainfed condition. From the study, the highest rice equivalent yield (REY) was recorded in Rainfed T. Aman (BRRI dhan32)-Irrigated Tomato (33.13 t/ha) pattern followed by Rainfed T. Aman (BRRI dhan32) Rice-Rainfed Tomato (28.71 t/ha) in the experimental plots (Table 8) and the lowest REY was found in Rainfed T. Aman Rice (BRRI dhan32)-Fallow plots (4.07 t/ha). The variation in equivalent yield was mostly governed by irrigated Rabi crop (tomato).

Survey on surface water use and its scope for crop production

A survey was conducted in Khagrachari district to evaluate the present surface water utilization status and future scope of utilization. Discussion and survey with pre-designed questionnaire were conducted with different officials eg DAE, OFRD of BARI and farmers. Water sources were small hill springs, hill streams (Chara), creek dam, surface canal and rivers (Chengi and Mayni). In Sadar, Panchari, Diginala, Mohalchari, Matiranga, Ramgarh, Manikchari and Laxmichari upazilas, the surface water sources were found 49, 44, 34, 26, 8, 13, 15 and 17 nos respectively. The total agricultural land under cultivation by those surface water sources were as follows: 998 ha in Sadar upazila, 1939 ha in Panchari upazila, 138.7 ha in Diginala upazila, 70.98 ha in Mohalchari upazila, 121.5 ha in Matiranga upazila, 842 ha in Ramgarh upazila, 519.5 ha in Manikchari upazila and 39 ha in Laxmichari upazila. In Khagarchari district, total 2942 nos LLP (diesel operated), 93 nos LLP (electricity operated) and 11 nos shallow tube well (STW) were found in operation.

Table 7. Water used for tomato production under rainfed and irrigated conditions in Sonagazi.

Treatment	Amount of water applied (mm)				Rainfall (mm)	Total water used (mm)	Fresh yield (t/ha)
	1st. irrigation	2nd. irrigation	3rd. irrigation	Total			
T_0=Rainfed condition	-	-	-	-	0	0	40.04
T_1=Irrigated condition	10	23	24	57		57	47.22

Table 8. Total rice equivalent yield (REY) of crops under rainfed and irrigated conditions in Sonagazi.

Cropping sequence	Yield (t/ha)			Total REY
	T. Aman	Rabi	Rice equivalent	(t/ha)
Rainfed T.Aman (BRRI dhan32)-Fallow	4.07	-	-	4.07
Rainfed T. Aman (BRRI dhan32)-Rainfed Tomato	4.07	40.04	24.64	28.71
Rainfed T. Aman (BRRI dhan32)-Irrigated Tomato	4.07	47.22	29.06	33.13

Note: Local market price- Rice price = Tk 16.25/kg; Tomato price = Tk 10.00/kg.

$$REY = \frac{\text{Crop price (Tk/t)} \times \text{Yield (t/ha)}}{\text{Rice price (Tk/t)}}$$

SUSTAINABLE MANAGEMENT OF GROUND WATER

Monitoring of ground water fluctuation and safe use in different geo-hydrological regions

The study was conducted at BRRI HQ farm Gazipur, BRRI RS farms Rajshahi, Comilla, Bhanga, Kushtia, Rangpur Satkhira and Habiganj. Figure 3 shows the maximum and minimum groundwater level at different BRRI RSs during 2011-12. In Satkhira the field was inundated in water and the observation well was submerged in water for more than four months. So, the ground water level was above the ground surface. During the reporting period maximum lowering of groun dwater table was observed in March/April and minimum in September/October. The highest depth (30.16 m) was found in Gazipur and the lowest (1.4 m) in Kushtia area.

Figure 4 presents the maximum and minimum ground water table depth from 2000 to 2012. The results shows that the ground water level at BRRI HQ farm, Gazipur is declining year by year and it is not fully recharged after the monsoon. In 2000, the maximum groundwater level was about 15 m from the ground surface, which is more than 30 m in 2012. So the lowering is about 15 m in 12 years, which is very alarming. The lowering is due to increased pumping demand and scant rainfall from November to March.

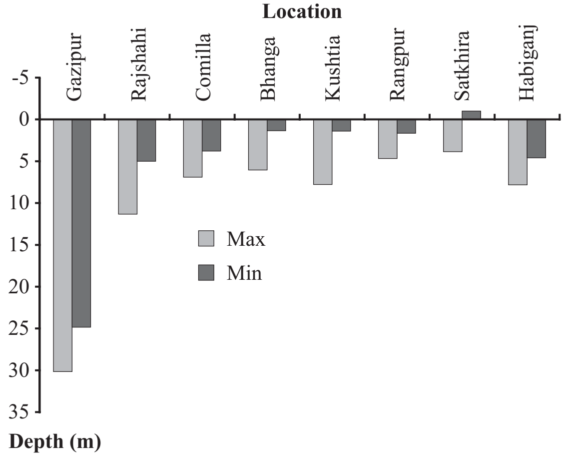


Fig. 3. Fluctuation of GWL at different BRRI RSs in 2011-12.

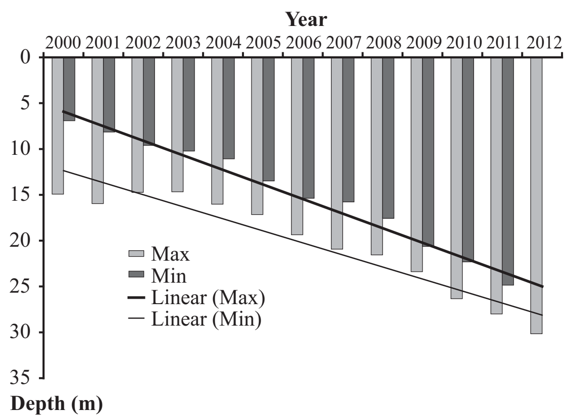


Fig. 4. Maximum and minimum GWL at BRRI HQ in 2000-12.

Ground water level at BMDA Project, Rajshahi

Groun dwater level monitoring data were collected from an intensive irrigated area (BMDA Project, Rajshahi) for the period 2006-12 (Fig. 5). The data were collected from nine upazila of three districts. The upazilas are Godagari, Tanore and Paba of Rajshahi district; Nawabganj, Gomostapur and Nachol of Nawabganj district; Naogaon, Mohadebpur and Dhamoirhat of Naogaon district. It was observed that in most of the upazillas the maximum groundwater level is going downward day by day, except one or two years in a few locations. The overall trend indicates the lowering of groundwater level. So this finding also supports the BRRI findings. The main reason for this declination is excess withdrawal due to increased demand for both domestic and irrigation. The highest groundwater level depth (32 m) was observed in Nachol area, followed by Godagari (23 m) and Nawabganj (20 m) in 2012. The lowest groundwater level depth was observed in Paba (2.5 m) in 2007, Gomostapur (2.5 m) in 2011 and Naogaon (2.6 m) in 2007. The above information indicates that out of nine upazilas, five (Paba, Gomostapur, Naogaon, Mohadebpur and Dhamoirhat) are suitable for operating shallow tubewell (STW) in T. Aman season only. No upazila is suitable for using STW during the critical period (March/April) of Boro season.

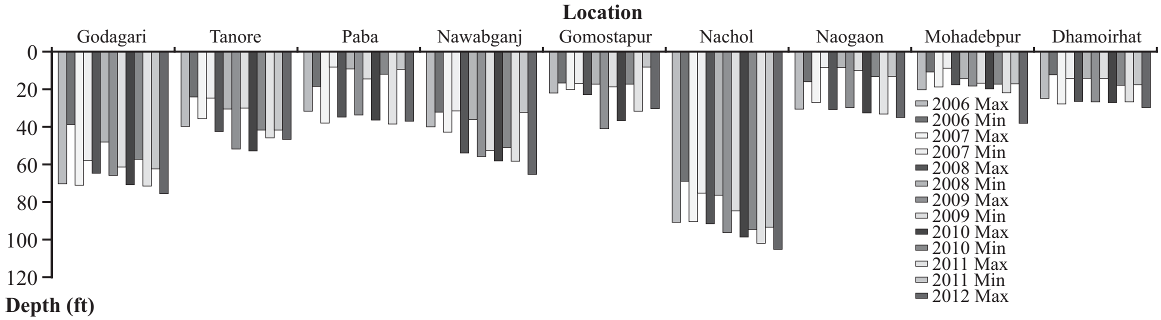


Fig. 5. Maximum and minimum depth (ft) of GWL at BMDA project, Rajshahi.

TECHNOLOGY VALIDATION IN THE FARMERS' FIELD

Crop and water management for crop intensification in coastal region

Cropping system trials in Aman season. In polder 30 (Hatbati, Batiaghata, Khulna), rainfall started in May and reached at maximum in third week of July that caused high water level in the field and delayed transplantation. About 600 mm and 370 mm rainfall occurred in August and September respectively. Pond or field water level in the experimental field at polder 30 was not affected by only rainfall but it was a combined effect of water intake from the adjacent river through sluices and rainfall. In September, the field water was drained out during low tide to enhance crop establishment of local Aman. Rainfall was almost stopped after first week of October and to irrigate the local Aman, all the polder area was flooded by river water and maintained high depth of water, which was about 30-40 cm. Rice was submerged in water several times in the growing season due to high water level in the field, ie after transplanting, during mid tillering and after flowering. Electrical conductivity (EC) of soil was monitored in the growing season of Aman. Soil EC remained within 4 dS/m when land was submerged but it increased to about 6 dS/m at unsaturated condition due to capillary rise of saline ground water (Fig. 6).

Yield components of two rice varieties, BRRI dhan49 and BRRI dhan54 showed that BRRI dhan54 was about 20 cm taller than BRRI dhan49 and its growth duration was also longer than that of BRRI dhan49. Panicle length of BRRI dhan54 is longer than BRRI dhan49 but the productive panicle was found higher in BRRI dhan49. Grain yield from harvested sample showed higher yield in BRRI dhan54 (Fig. 7). BRRI dhan54 produced higher grain (4.6 t/ ha) than that of BRRI dhan49

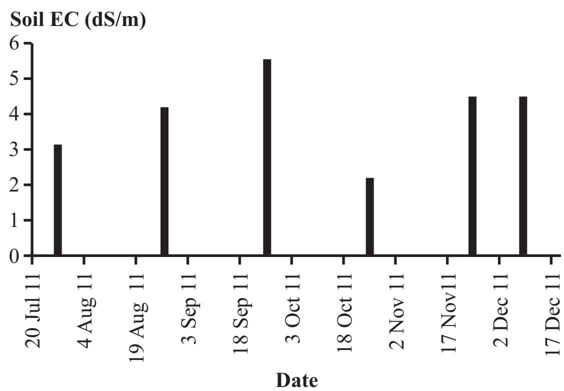


Fig. 6. Soil salinity (dS/m) during Aman season at Batiaghata, Khulna.

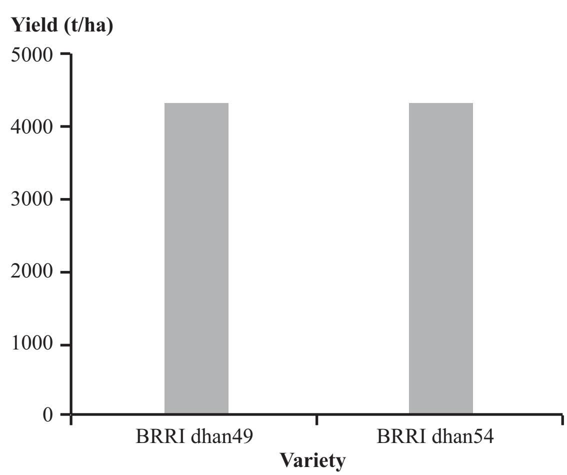


Fig. 7. Yield of Aman at Batiaghata, Khulna.

(4.3 t/ ha). Both the variety produced good yield despite submergence at different stages of growth.

Boro rice performance in polder 30 and 43/2F. Boro production in both the polders (Khulna and Barisal) suffered due to low temperature in early stage and growth was stunted upto end of February 2012. Minimum temperature was about 10°C during first two weeks of February. Although river water EC of polder 30 increased from first week of March 2012, the canal water EC was remained below 4 dS m-1 during the whole growing season of Boro (Fig. 8) as the sluices were closed and saline water intrusion was controlled.

Yield of BRRI dhan28 increased with delayed planting in polder 30. Because earlier planted rice was affected by low temperature and the later one had a better establishment and had higher yield (Fig. 9). The first seeded crop was also attacked by the red nematode that also reduced crop growth and yield. But in polder 43/2F, BRRI dhan28 recovered from the cold stress as it was transplanted five days later than that of in polder 30 and also free from soil pest attack. In polder 43/2F, BRRI dhan28 showed a decreasing trend in yield (Fig. 9) because the late seeded crop (D3) was damaged by stem borer, as the whole area was fallow and the Boro was only crop remained in the field.

Performance of Rabi crop in Khulna (Polder 30). Yield of sesame varied from 0.1 to 1.6 t/ha among the management treatments and

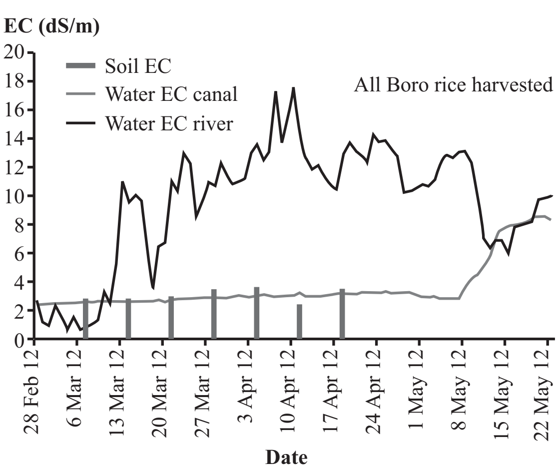


Fig. 8. Soil EC during Boro 2012 in Khulna.

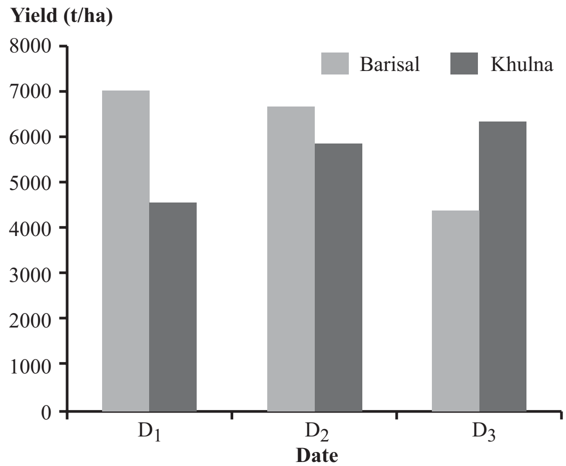


Fig. 9. Yield of BRRI dhan28 in Barisal and Khulna.

drainage options. The highest yield (1.63 t/ ha) of sesame was obtained in mulched farmers cultivar (M4).Yield was higher in undrained plots compared to the drained plots. The highest yield (1.16 t/ ha) of sesame in drained plot was obtained when sown in line and applied fertilizer with farmers' variety (M3) followed by mulched treatments (M4) (0.58 t/ha). Mungbean yield varied from 0.35 t/ha to 1.6 t/ ha among all the treatments. Mungbean yield was higher in undrained plots than that of drained plots like sesame. The yield difference among the drained and undrained treatment was about 0.66 t/ha in M4 and M5. Farmers managed mungbean had the lowest yield in both drained and undrained treatments (Fig. 10).

Performance of Rabi crop in Barguna (Polder 43/2F). Table 9 shows yield of Rabi crops such as maize, sunflower and mungbean established in drained and undrained plots with mulched and unmulched conditions. Maize yield was higher (varied from 9.18 t/ha to 10.03 t/ha) in mulched plots in both drained and undrained conditions. Similarly, sunflower also produced similar yield among the drained and mulched treatments (3.80 to 3.89 t ha-1). Mungbean also followed the same trend (0,32 to 0.37 t ha-1). Yield of mungbean was very low than the normal condition, because the emergence was low as the soil moisture was less due to late establishment. These results indicates that the drained and undrained plots moisture was almost similar and

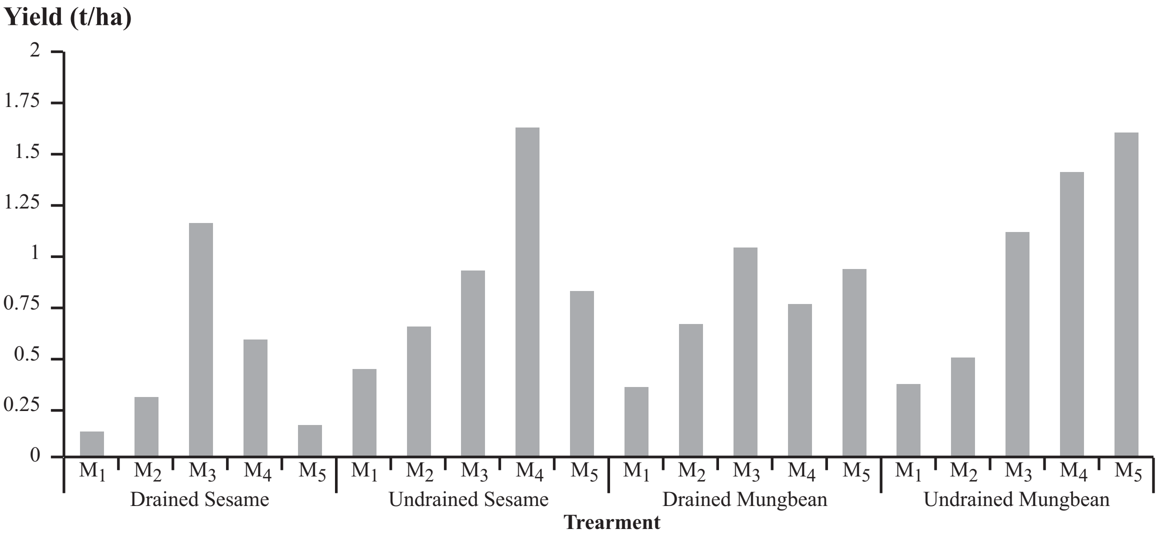


Fig. 10. Yield of sesame and mungbean under different management options in polder 30 (Khulna).

Table 9. Yield (t/ha) of Rabi crops in Barguna (Polder 43/2F).

Crop	Drained		Undrained	
	Mulched	Unmulched	Mulched	Unmulched
Maize	9.65	9.38	10.03	9.18
Sunflower	3.89	3.83	3.80	3.82
Mungbean	0.32	0.34	0.32	0.37

the mulching could not play effective role to conserve moisture in the soil profile.

Rabi crops can be grown in polder 43/2F under undrained or unmulched condition if sown in January. To achieve better establishment and better yield of mungbean it needs to be sown early and when the soil moisture is optimum. So all the Rabi crops can be established earlier with proper drainage which needs further study for confirmation.

Projection of irrigation cost

Irrigation cost is increasing year by year due to increasing fuel, electricity and labour costs. It also increases due to pumping of water from deeper water table. Guesselquist (1992) mentioned that for villages where the water charge was collected in cash, per hectare irrigation charges were Tk 2,803 for low-lift pumps (LLP), Tk 4,150 for deep tubewells (DTW) and Tk 4,051 for shallow tubewells (STW). IIMI (1995) reported that in the 1993-94 irrigation season the average per hectare irrigation charge was Tk 6,181 and 4,219 for STW and DTW, respectively, which were 41 and 34% higher than 1988-89.

Autoregressive integrated moving average (ARIMA) models were used to predict irrigation cost trend over next 20 years using time-series data from 1987 to 2011 (collected from various sources: Guesselquist, 1992; IIMI,1995; Anon, 2004-2009, and Sarker, 2000). Figure 11 reveals that actual and forecasted irrigation cost for Boro rice production gradually increased over the last 15 years (1989 to 2003). It started to increased

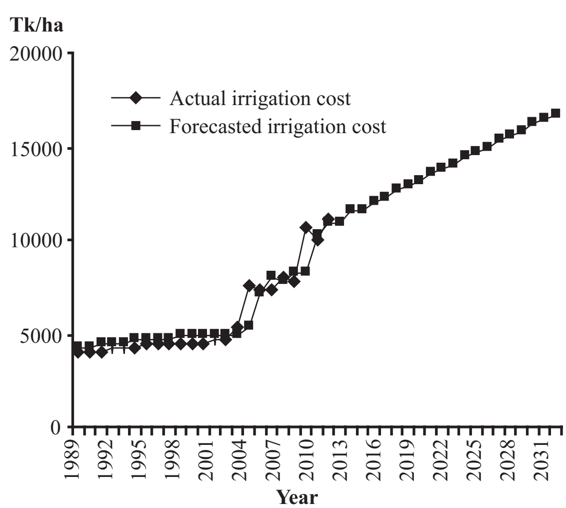


Fig. 11. Actual and projected irrigation cost (Tk/ha).

faster rate from 2004 till 2011 with some exception in 2008. After 2011, the projected irrigation cost will increase gradually and it reaches to Tk 16,713/ha in 2031 (Fig. 11).

Availability of irrigation water at the farm level related to the crops grown. Irrigation water scarcity and high prices decreased the crop area and thus reduced input use and net farm income of all types of farms. Therefore, steps should be taken to improve on farm water management practices (Minimize water distribution loss and practicing alternate wetting and drying methods etc). To ensure a regular water supply to crops, it requires an improved irrigation plan (ie when to irrigate and how much water to apply). Thus, irrigation cost could be minimized. Agricultural extension workers could assist in this regard. In general, policies should be taken to promote water management training to farmers for better understanding of on farm water management.

Plant Physiology Division

SUMMARY

Based on the visual score and survivability, nine genotypes out of 41 were found saline tolerant in comparison with checks. Yield potential of advanced line IR72579 is higher compared to other genotypes though the yield (g/pot) was same as tolerant variety BRRI dhan47 at 3 and 6 dS/m salinity level. In submergence screening, among the tested genotypes, nine were found with very good recovery status of which survivability score is 3. Twenty-eight genotypes were showed good recovery status with survivability score 5. Out of 71 genotypes seven performed well in deep rooting which could be used in further breeding programme. At maturity, 304 hills tolerant to cold at the reproductive stage were collected from 10 F_2 crossing line. For quality rice seedling production in winter, 12-hour water layered (2-4 cm) at night time in seedbed was suitable for healthy seedling raise avoiding cold injury. Twenty-four-hour covered seedbed with polythene sheet was preferred for avoiding cold injury where water was not available or scarce. The seeds of Aman season's crop had high dormancy than that of Aus and Boro seasons. The seeds stored in freeze condition exhibited long viability period followed by polythene packet and *motka* storage. Among all the varieties stored in polythene packet and *motka,* BRRI dhan48 showed the highest viability up to 330 days. Automatic weather station (WatchDog 2900ET) can measure and record/log daily weather fluctuations more accurately than manual system.

SALINITY TOLERANCE

Screening of rice genotypes at high salinity stress of the seedling stage of rice in Boro season

To identify salt tolerant advanced breeding materials at seedling stage of 41 rice genotypes along with three check varieties (BRRI dhan47, FL478 and IR29) were tested following the method of Glenn *et al.* 1997. Among 41 genotypes, only nine genotypes showed visual score 3 to 5 that is tolerant to moderately tolerant (Table 1).

Yield performance of rice genotype as affected by salinity stress for whole growth period

The experiment was conducted to observe the yielding ability of rice genotypes at different salinity levels in the net house of Plant Physiology Division of BRRI in B oro season 2011. Seven genotypes namely BRRI dhan47, BINA dhan28, FL478, IR29, BRRI dhan28-saltol, BR7105 and IR72579 were considered for this study. Plants have grown in perforated plastic pots (drilled and lined with canvas) filled with grinded soil. After 30 days of sowing salinization was made by adding NaCl in the bucket, at 3 dS, 6 dS and 9 dS/m. One set of plants was used as control.

The plant height was increased progressively with the age of the plants reaching maximum at about 80 days after sowing in all genotypes (Fig. 1). Plant height was markedly reduced at 9 dS/m salinity level compared to control during the whole growth period in BRRI dhan47, BINA8 and IR72579. However, plants could not survive at 9 dS/m salinity level after 21 days and 42 days in IR29 and BRRI dhan28 saltol respectively. There was some difference observed during the growth period of BRRI dhan47 and BINA8 for control plants compared to 3 and 6 dS/m salinity level, though finally it was same in control and 3 to 6 dS/m salinity level. The plant height of FL478 was more or less same in 0, 3 and 6 dS/m salinity level.

The tiller number per plant was also markedly reduced at different salinity level compared to control during the whole growth period of rice genotypes (Fig. 2). In BRRI dhan28 saltol, BRRI dhan47 and Fl478 the tiller number was markedly differ during the whole growth period at 3 dS/m salinity level but finally they produced same number of tiller as control. In IR72579 tiller number markedly differed at saline condition compared to control. BINA8 also showed the same trend. Tiller number was remarkably reduced in IR29 and BRRI dhan28 saltol at 6 dS/m salinity level.

Yield was the highest in advanced breeding line IR72579 followed by BRRI dhan28-saltol in the non-saline conditions (Fig. 3). Grain production was found to differ under salt stress conditions compared to control in all genotypes. But the reduction of grain yield was not same in all

Table 1. Salinity tolerance score and survivability (percentage) of 41 genotypes in Boro 2011-12.

Designation	Score	Survivability (%)	Designation	Score	Survivability (%)
IR72593-B-13-3-1	9	0	IR86385-97-2-1-B	7	60
IR76397-2B-6-1-1-1-1	6	50	IRRI 126	7	50
IR77674-3B-8-1-3-13-2-AJY	9	10	IR09T484	4	90
IR78806-B-B-16-1-2-2-AJY	9	30	IR85178-5-3-1-1	9	20
IR77664-B25-1-2-1-3-12	9	10	IR83412-6-B-3-3-1-1	9	10
AGAMI MI	9	20	IR83435-6-B-6-2-1-1	9	30
IR45427-2B-2-2B-1-1	4	80	IR83484-3-B-7-1-1-1	9	30
IR71829-3R-89-1-1	6	60	IR10T119	9	0
IR76393-2B-7-1-1-3-1	5	70	IR84095-AJY3-1-SD04-B	9	30
IR77674-3B-8-2-2-14-2-AJY	9	10	IR84095-AJY3-8-SD02-B	9	20
BR7105-4R-2	4	90	IR83408-B-AJY-1-SD02-1	9	20
IR72579-B-3-2-3-3	9	20	IR83462-B-AJY4-3-SD03	9	20
BRRI dhan28-Saltol	9	0	IR77674-3B-8-2-28-2-AJY10	9	10
BINA dhan8	9	20	FL416	9	30
IR85178-5-3-1	9	40	IR89574-6	9	0
IR87832-303-1-B	9	20	IR10T108	9	0
IR84927-9-1-1-1-AJYI-B	9	30	IR84089-7-3-AJY1-B	5	80
IR85178-5-3-1-1-1-AJYI-B	Not germinate		IR85212-73-1-1-1	9	10
IR85197-9-3-3-2-AJYI-B	7	70	BRRI dhan47	5	80
IR83416-7-B-12-3-1-3-AJYI-B	4	90	FL478 (Tolerance ck)	3	100
IR87868-7-AJYI-B	9	50	IR29 (Susceptible ck)	9	0
IR87868-9-AJYI-B	7	60			
IR87888-3-AJYI-B	4	90			

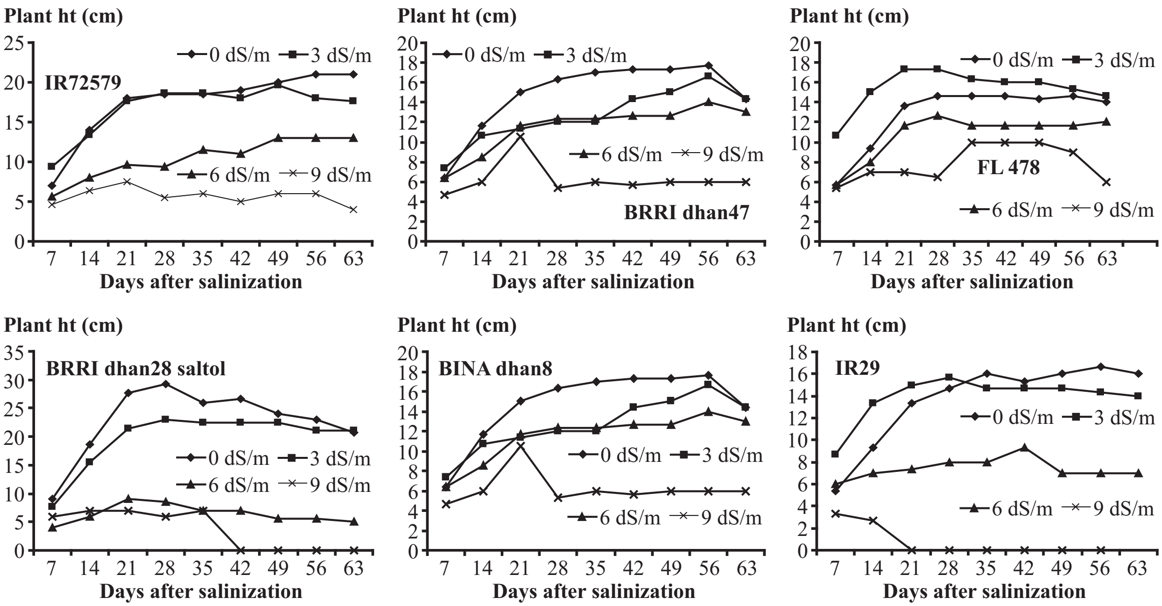


Fig. 1. Plant height during vegetative growth as affected by different salinity levels.

genotypes at the same salinity level. At 3 dS/m salinity level the lowest reduction was observed in tolerant genotype BRRI dhan47, BINA dhan8 as well as IR72579. This reduction was remarkably higher in BRRI dhan28-saltol and IR29. At 9dS/m salinity level BRRI dhan28-saltol and IR29 could not survive but other genotypes could survive and produced little grain.

Yield potential of advanced line IR72579 is higher compared to other genotypes though the yield (g/pot) was same as tolerant variety BRRI dhan47 at 3 and 6dS/m salinity level. Due to

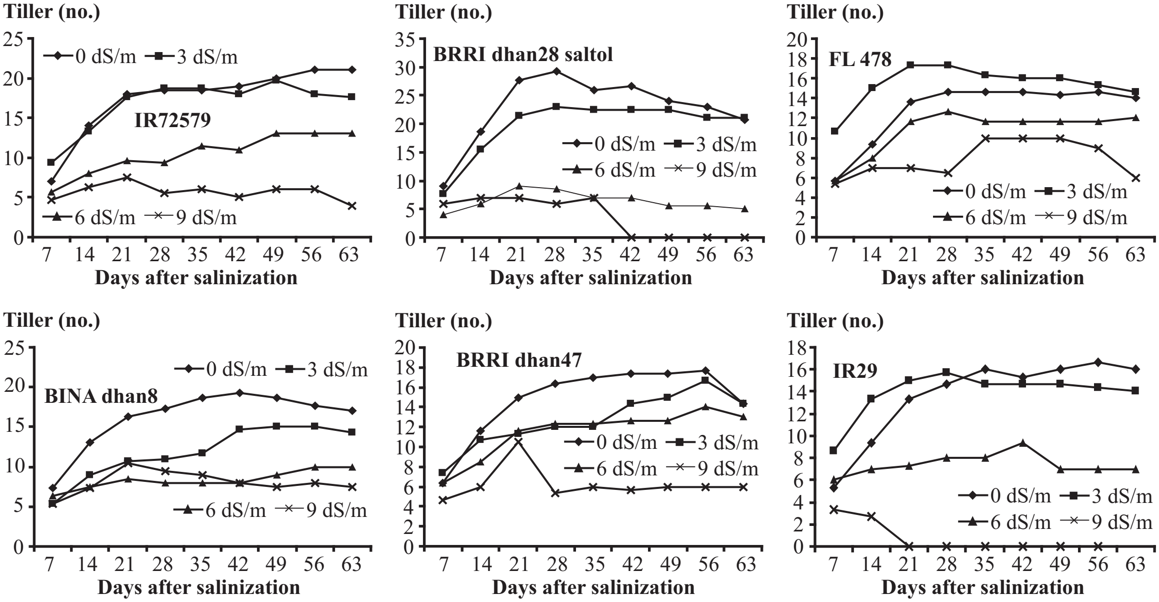


Fig. 2. Tiller number during vegetative growth as affected by different salinity levels.

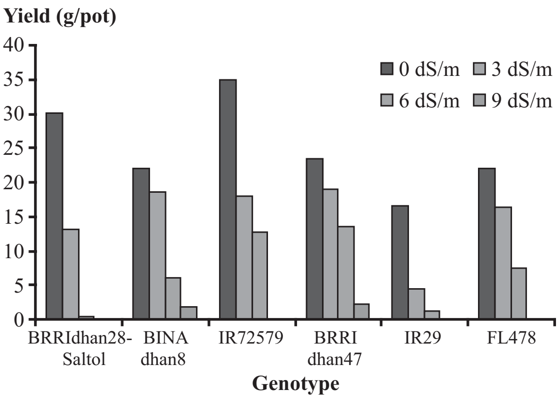


Fig. 3. Yield (g/pot) of different rice genotypes as affected by different salinity level.

disease (BLB) infestation we could not get result in case of another advanced breeding line BR7105.

SUBMERGENCE TOLERANCE

Identification of new sources of submergence tolerance germplasm

A total of 98 genotypes and two checks namely FR13A and BR5 were tested in this experiment. The tested genotypes were (Acc. no. 3: Badsha Bhog, 24: Gabura, 46: Malia Bhangor, 77: Kartik Sail, 78: Kartik Jhul, 79: Lotha, 82: Holid Jaran, 83: Apchasa, 84: Apchasa, 86: Jamal Bhog, 87: Aricha Diga, 88: Jhol Diga, 89: Dhalkatia, 90: Boron, 91: Boron, 92: Dhaldata, 93: Sechi, 94: Sechi Aman, 95: Soider Boron, 96: Lani khama, 97: Hashfal Boron, 98: Kaksmi Diga, 99: Dal katra, 100: Chota Bhawalia, 101: Bhoka Bhawalia, 102: Apchasa, 103: Diga, 104: Manik Diga, 105: Manik Diga, 106: Bhanal Diga, 107: Jatra Motor, 108: Bora Diga, 109: Rangi Khama, 110: Dudh Bhawalia, 111: Goirol, 112: Bhawalia Amon, 113: Hashful, 114: Raj mondal, 115: Gonakray, 116: Kala Mona, 117: Belon Dhan, 119: Gorcha, 120: Luta, 121: Luta, 122: Suna Diga, 123: Gabura, 125: Khoia Motor, 126: Suna Digha, 127: Bhawalia Diga, 128: Diga -2, 129: Diga, 130: Raj bhawalia, 131: Raj bhawalia, 132: Molla Diga, 133: Molla Diga, 134: Bhawalia, 135: Bhawalia, 136: Bhawalia, 137: Bhawalia, 138: Net pasha, 139: Net pasha, 1401: Ijol diga-2, 143: Ijol Diga-3, 144: Bawoi Jhak -3, 146: Bawoi Jhak -4, 146: Bawoi Jhak -6, 147: Bawoi Jhak -2, 157: Chini Sagar, 158: Banshapor, 159: Roshonbok, 160: Dhoilush, 161: Ashmber, 162: Malsiraz, 163: Khirsha moti, 164: Laksmi Bilash, 165: Bazail, 166: Ashini, 167: Buchi, 168: Kaika, 169: Maloti, 170: Katisail, 171: Bazail, 172: Madhu Sail, 173: Shuli Dhan, 174:

Alad kumar, 175: Kumri Amon, 176: Lal chamara, 177: Moriom, 195: Subul Kua, 197: Saror, 198: Fulgainda, 199: Baish Binni, 201: Kumri, 202: Kumarilal, 203: Kumri, 204: Kaisha Binni, 206: Kaisha Binni, 207: Kaisha Binni). Table 2 shows the light intensity, water pH and temperature of submergence period. Among the tested genotypes, nine genotypes were found with very good recovery status of which survivability score was 3 and 28 genotypes were found with good recovery status having survivability score 5 (Fig. 4, Tables 3 and Table 4).

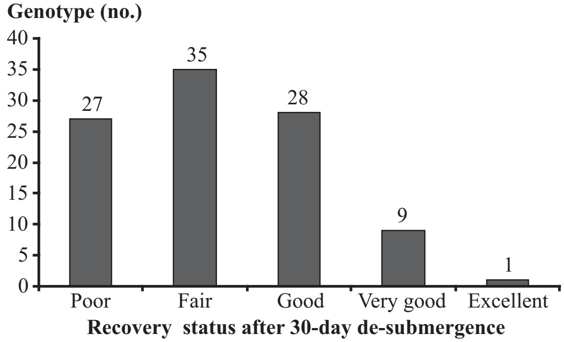


Fig. 4. Frequency distribution of rice germplasm under submergence condition.

Characterization of rice germplasm for identifying new sources of submergence tolerance

The experiment was conducted to observe visual score and survivability of rice germplasm at the seedling stage under complete submergence condition. A total of 100 genotypes and two checks namely FR13A and BR5 were evaluated in this experiment. The tested genotypes were (Acc. no. 208: Koha Binni, 209: Lal binni, 210: LAL BINNI, 211: Laksmi Bilash, 212: Neel Kumari, 213: Rotisail, 214: Gabal Sail(Blam), 215: Dushor, 217: Lao Bhug, 218: Luha Garaa, 220: Raimihi, 221: Sham Rash, 222: Gopal Bhog, 223: Gohul sail, 224: Depa Dhan, 225: Dud sar, 226: Dhulaiti, 227: ABC HOYA, 228: Kolom, 229: Sagar dhana, 230: Khirloni, 232: Kataru Bhog, 233: Nuria, 235: Khorma, 236: Kala Binni, 237: Dudrat, 238: Indra Sail, 239: Lal Kumari, 240: Kabra Balam, 241: Birol (5), 242: Pura Binni (3), 243: Kashia Binni(2), 244: Kashia Binni(2), 246: Gurdoi (2), 247: Kali jura (3), 248: Telot, 249: Bazail, 250: Joli Amon, 251: Bazail, 252: Bazail, 275: Naria Bochi, 401: Mukta Har (L), 402: Boira Amon, 403: Lal Pcuria, 404: panzra, 405: Bashi, 406: Bata, 407: Panalli, 408:Muta Ganje, 409: Lcha Dang, 411: Moha Rani, 412: Chcmgul, 413: Shaheb Guta, 414: Raga Sail(6), 415: Jingh Sail (1), 416: Jingh Sail (2), 417: Gorti (2), 418: Suna Mulhi, 419: Suna Sail (4), 420: Dhola Depa, 422: Bakul Sail, 423: Pajre, 424: Binna phul, 425: Khomon dhan, 427: Harma Sail (1), 428: Harma Sail (2), 429: Kali Ray, 430: Nagra dhan, 431: Gainja, 432: Bada dhan, 433: Buchi, 434: Bowal dhan, 436: Neel Kanthi, 437: Kati Sail, 438: Katik Sail, 439: Horma, 440: Raisa phul, 441: Kon Koehur, 443: Jola, 444: Tangul, 445: Bansh phul (1), 447: Tapa Khula, 448: Kasia phul (2), 449: Bawai jhaki, 450: Bas Kolom, 451: Dola Goeha, 453: Kali Bunni, 454: Kolom Depa, 455: Salla, 456: Kolom, 457: Babu Sail, 458: Buta Sail, 459: Mohon Bhog, 460: Pengun, 462: Beto, 463: Ronjoy, 464: Nedan Sail, 465: Hash Raj, 466: Bash phul, 467: Guta Balam). Table 4 shows the light intensity, water pH and temperature of submergence period. Among the genotypes 25 were found better of which survivability ranged from 92-100% and survivability score was 3 (Table 5). Further evaluation will be needed due to damage before recovery.

DROUGHT

Screening for deep rooting ability

Seventy-one rice genotypes (Bangal Dhari, Shamraj, Sham Rosh, Bat Raj Mugi (5), Chini

Table 2. Range of light intensity, pH and temperature of water during submergence period.

Water level	Light intensity (µ mole/m^2/s)		Water pH	Water temperature (°C)
	Before turbidity	After turbidity		
Upper level	1090-1120	-		
Mid level	520-555	100-118	7.5-8	27-30
Lower level	95-114	0-0.57		

Table 3. Submergence tolerance and survivability of the tested genotypes.

Acc. no.	Designation	% elongation	% survivability 5 days after de-submergence	% survivability 30 days after de-submergence	Score	% dry matter increased	Recovery status
24	Gabura	44.4	100	100	3	81.8	Very good
82	Holid Jaran	37.9	100	79	5	67.1	Good
83	Apchasa	43.6	100	79	5	69.8	Good
84	Apchasa	41.1	86	86	5	77.0	Good
86	Jamal Bhog	55.7	93	93	5	76.2	Good
88	Jhol Diga	39.7	100	86	5	74.7	Good
89	Dhalkatia	42.0	93	86	5	75.8	Good
90	Boron	48.9	100	93	5	79.2	Good
91	Boron	45.5	100	100	3	80.0	Very good
92	Dhaldata	42.0	100	100	3	80.5	Very good
93	Sechi	42.4	100	100	3	79.6	Very good
95	Soider Boron	58.8	93	79	5	75.6	Good
97	Hashfal Boron	39.1	100	100	3	80.2	Very good
99	Dal katra	38.5	100	100	3	64.8	Very good
102	Apchasa	59.1	100	79	5	76.2	Good
103	Diga	60.3	100	86	5	69.0	Good
108	Bora Diga	51.4	100	93	5	74.1	Good
109	Rangi Khama	53.1	100	86	5	80.0	Good
110	Dudh Bhawalia	47.8	100	93	5	69.2	Good
113	Hashful	40.9	100	100	3	69.2	Very good
114	Raj mondal	46.7	100	100	3	80.2	Very good
119	Gorcha	45.5	100	86	5	69.0	Good
120	Luta	50.7	93	79	5	71.4	Good
121	Luta	47.9	100	100	3	67.7	Very good
123	Gabura	49.3	100	79	5	62.0	Good
127	Bhawalia Diga	46.8	86	86	5	76.9	Good
128	Diga -2	46.8	93	79	5	73.3	Good
130	Raj bhawalia	43.1	93	86	5	77.8	Good
131	Raj bhawalia	41.2	100	93	5	60.5	Good
135	Bhawalia	31.1	100	86	5	68.3	Good
136	Bhawalia	46.4	100	86	5	68.3	Good
143	Bawoi Jhak -3	45.7	100	79	5	63.9	Good
146	Bawoi Jhak -6	42.3	100	79	5	58.2	Good
165	Bazail	25.8	100	86	5	72.3	Good
166	Ashini	45.3	100	79	5	62.5	Good
171	Bazail	43.6	93	79	5	67.4	Good
173	Shuli Dhan	32.8	86	86	5	62.5	Good
	FR13A (Tolerant check)	16.2	100	100	1	76.4	Excellent
	BR5 (Susceptible check)	32.4	21	7	9	64.7	Poor

Table 4. Light intensity, water pH and water temperature during submergence period.

Water level	Light intensity (µ mole)		Water pH	Water temperature (°C)
	Before turbidity	After turbidity		
Upper level	622-650	-		
Mid level	320-340	60-65	7.6-8	26-28
Lower level	75-80	0-2		

Sakkar, Somon Dori, Sindur Kowta, Chini Atob (2), Chini Atob, Lal Parja, Chemgul, Jingh Sail (1), Dhola Depa, Jhulon, Khomon Dhan, Nagra Dhan, Gainja, Buchi, Bowal Doh, Kaisa Phul, Tangul, Pengun, Hida (5), Halud Jakun, BRRI dhan39, Dola Gocha, BRRI dhan33, Bawai Jhaki, Matia Gorol, Guti Swarna, Kati Sail, Lal Jan, Sheel Komol, Muktahar, Chini Sakkar, Mukta Har (2), Hida, Buna Dhan, Vandona, Azucena, IR78937-B-20-B-B-B, IR74371-70-1-1, IR74371-54-1-1, IR82299-B-306-

Table 5. Submergence tolerance and survivability of the tested genotypes.

Acc. no.	Designation	% elongation	% survivability 5 days after de-submergence	Score	Seedling weight (gm) before submergence
217	Lao Bhug	31.1	100	3	0.20
230	Khirloni	31.8	100	3	0.12
237	Dudrat	30.8	92	3	0.20
248	Telot	22.8	100	3	0.12
250	Joli Amon	22.4	100	3	0.12
252	Bazail	28.5	100	3	0.12
412	Chcmgul	29.9	96	3	0.20
416	Jingh Sail (2)	28.9	96	3	0.20
440	Raisa phul	31.9	100	3	0.20
444	Tangul	30.0	96	3	0.20
449	Bawai jhaki	30.2	100	3	0.12
450	Bas Kolom	21.9	96	3	0.20
451	Dola Goeha	26.9	100	3	0.12
453	Kali Bunni	30.9	100	3	0.12
454	Kolom Depa	23.5	100	3	0.12
456	Kolom	31.8	100	3	0.12
457	Babu Sail	28.6	92	3	0.20
458	Buta Sail	25.4	96	3	0.20
459	Mohon Bhog	23.0	96	3	0.20
460	Pengun	31.3	96	3	0.20
462	Beto	18.4	100	3	0.20
463	Ronjoy	25.0	96	3	0.20
465	Hash Raj	29.3	100	3	0.12
466	Bash phul	27.8	100	3	0.12
467	Guta Balam	29.6	100	3	0.12
	FR13A (Tolerant check)	17.5	100	1	0.12
	BR5 (Susceptible check)	45.0	42	9	0.14

B, IR83387-B-B-125-1, IR83387-B-B-110-1, IR83381-B-B-55-4, IR83383-B-B-141-1, IR83377-B-B-93-3, IR83376-B-B-130-2, BR7873-5*(Nils)-51-HR6, IRRI123, APO (ck), Lalat, IR72, IR80463-B-39-3, IR83381-B-B-6-2, Samba Masuri, IR83614-838-B, IR80416-B-32-3, IR64 (ck), Dangor Deshi India, IR72667-16-1-B-B-3, IR80285-34, IR83614-438-B, Swarna (ck), Ma Hae, Zhenshan 97B, IR78933-B-24-B-B-4, Morichboti) were tested following BRRI, 2006. Out of 71 genotypes seven performed well which could be used for further breeding programme (Table 6).

COLD TOLERANCE

Screening of cold tolerant segregating populations at the reproductive stage in Boro season

Seeds of F_2 generation from different crossings were sown on 15 October 2011. One month-old seedlings and 700 hills were transplanted for each crossing line. The seedlings were transplanted early with an intention to experience cold at the reproductive phase. Plants with better phenotypic look and short duration were selected to grow in the next year for further selection. At maturity 304 hills were collected from whole crossing line (Table 7).

Water management for quality rice seedling production in winter

An experiment was conducted at BRRI experimental farm, Gazipur in Boro (winter) season to:

- Determine the appropriate time of water management to protect seedlings from cold injury,
- Find out effect of water management on seedling elongation and
- Find out yield contribution of water management in rice seedlings.

Table 6. Seedling height, root length, cumulative root length (CRL) and root shoot ratio of 71 genotypes.

Designation	Seedling height (cm)	Root length (cm)	CRL (cm)	Root : Shoot ratio (mg/g)
Bat Raj	71.1	57.5	1229.8	251.2
Bawai Jhaki	61.8	41.5	960.6	260.6
Samba Masuri	46.9	46.5	770.1	240.1
IR80416-B-32-3	45.1	43.0	898.7	292.4
R83614-438-B	41.9	48.0	670.9	249.0
Ma Hae	56.7	52.5	750.8	299.2
Zhenshan 97B	53.0	66.0	1385.0	332.9
Morichboti (ck)	79.1	68.3	1718.3	241.5

Table 7. Number of hill collected from each crossing line at maturity.

Crossing line	Hill (no.)
BR7312-B-56-3-2/IR68334-R-R-B-3	16
BR7687-1-3-2/IR7858-98-2-2-1	21
BR7687-1-3-2/IR79262-24-3-2-3	53
BR7687-1-3-2/HG417-3-119	4
BR7335-35-1-1-3/IR7858-98-2-2-1	37
BR7166-5B-6/IR7858-98-2-2-1	15
BR7166-5B-6/IR79262-24-3-2-3	34
BR7166-5B-5/IR7858-98-2-2-1	27
BRRI dhan28/ZHONG99-76/OM1490	46
BRRI dhan29/ZHONG99-76/OM1490	51
Total	304

The seeding time were followed on the basis of temperature record. First set of seeds were seeded on 25 December and second set of seeds were seeded on 1 January when temperatures were very low. The treatments studied in the seedbed were:

- T_1=12-hour water layered (2-4 cm) at day time;
- T_2=8-hour water layered (2-4 cm) at day time;
- T_3=12-hour water layered (2-4 cm) at night time;
- T_4=24-hour covered seedbed with polythene sheet;
- T_5=8-hour covered seedbed with polythene sheet at day time; and
- T6=Control (without water layered and polythene sheet covered).

The experiment was laid out in a randomized complete block (RCB) design with three replications. Maximum and minimum soil temperature of seedbeds was recorded at 6 hour, 10 hour, and 18 hour times in different treatments during the study period. At the end of experiment ten seedlings were randomly uprooted from each seedbed. Seedbed size was 1- × 1-m. The variation of maximum and minimum soil temperature of seedbeds, observed prior to the imposition of water treatment at 6 am, 10 am and 6 pm, was quite minimum. However, 24-hour covered seedbed with polythene sheet followed by 8-hour covered seedbed treatment, which received no water showed some higher value of temperature compared to other treatments (Table 8). The water temperature was observed during the application was 2-15°C higher than existing soil temperature in seedbeds. Later it gradually increased 1-2°C soil temperature of water layered seedbed treatments. We could have an idea that the warmer water from the tubewell has a direct impact to keep the seedbed warmer for a while. This practice works satisfactorily to keep the seedling better compared to that of treatment where water was not applied. Either day or night water treatments (inundation with 2-4 cm of tube well water). That means, polythene sheet conserved heat in day time which creates a warmer environment in seedbed to protect seedlings from cold injury during night time.

Seedling height in 24-hour covered seedbed with polythene sheet was the highest followed by 8-hour covered one at day time and 12-hour water layered (2-4 cm) at night time treatments (Fig. 5). Plants and roots in polythene sheet covered seedbeds were more lean and thin than that of uncovered seedbed seedling treatments. On the other hand, seedling root length was the highest in 12-hour water layered (2-4 cm) at night time followed by 8-hour covered seedbed with polythene sheet treatment (Fig. 6). Dry matter content of seedling is a major dominating character that controls the seedling establishment after transplantation. The dry matter (shoot and root) weight was the highest in 12-hour water layered (2-4 cm) at night time treatment followed

Table 8. Soil temperature (°C) prior to apply water in seed bed.

Week	Time (hour)	T_1		T_2		T_3		T_4		T_5		T_6	
		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Jan Wk2	6	11.5	11	11.5	10.5	11.5	10.5	12	10	11	11	11	10
Jan Wk3	6	16	10.5	16	10	16.5	10.5	17	10.5	17	10	16.5	10
Jan Wk4	6	15	12.5	15	12	16	12	14	12	15	12	15	12
Feb Wk1	6	14	13	15	13	15	13	15	12	14.5	13	14.5	12
Feb Wk2	6	18	13	18	13	18.5	13	19	13	18	13	18	14
Jan Wk2	10	16	13.5	15	14	15	14	15.5	13	14.5	13.5	14.5	13.5
Jan Wk3	10	19	14	20.5	15	20.5	14.5	21.5	15.5	20.5	15	20	14.5
Jan Wk4	10	18	15	17.5	15	17.5	15	23	16	18.5	15.5	17.5	15
Feb Wk1	10	17	15	16	15	16.5	15	22	16	16	15	16	15
Feb Wk2	10	20.5	16.5	20	16	21	16	24.5	16.5	20	16	21	15.5
Jan Wk2	18	18	15.5	17	14.5	17	15	18.5	15	17.5	15.5	16.5	15
Jan Wk3	18	21	14	22	14.5	22.5	16	24	14.5	23	15	21.5	15
Jan Wk4	18	22	18.5	22	18	22.5	18	23	18	24	17	21	18
Feb Wk1	18	21	19	22	18	20	18	24	18	24	18	20.5	18
Feb Wk2	18	23	20	23	19.5	23	19	25	21	25	18.5	23	19

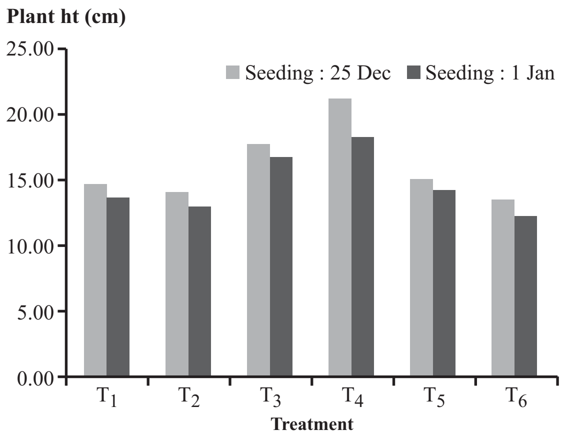


Fig. 5. Seedling height (cm) as affected by water, polyethylene sheet treatment and seeding date.

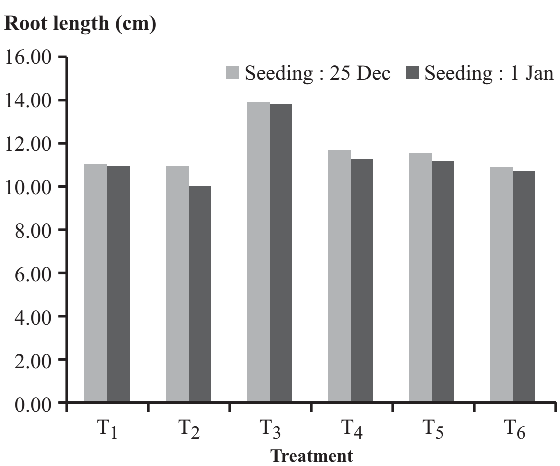


Fig. 6. Root length (cm) as affected by water, polyethylene sheet treatment and seeding date.

by 24-hour covered seedbed with polythene sheet treatment. Twelve-hour water layered (2-4 cm) at night time treatment showed plants and roots are healthy among all the treatments in both the sets (Fig. 7). So, it is concluded that 12-hour water layer (2-4 cm) maintained at night time in seedbed is suitable for healthy seedling raise avoiding cold injury. Twenty-four-hour covered seedbed with polythene sheet is preferred for avoiding cold injury where water is not available or scarce.

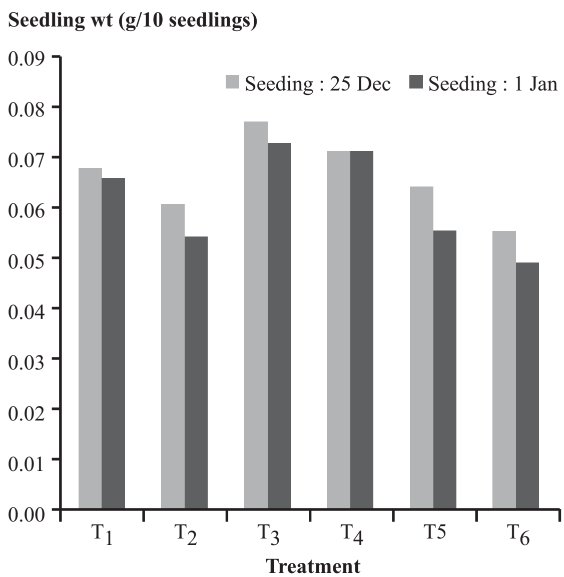


Fig. 7. Seedling weight (g/10 seedlings) as affected by water, polyethylene sheet treatment and seeding date.

SEED PHYSIOLOGY

Dormancy and viability test of some BRRI varieties

Three varieties in Boro, three in Aus and five in Aman season were grown in the field up to maturity using the normal cultural practices in 2008, 2009 and 2010 respectively. Seed were collected, sun dried at 12-12.5% moisture content. The collected seeds were preserved. These seeds were used for dormancy and viability test. For dormancy test, germination test was done at the date of harvest and then at an interval of seven days until the dormancy was broken. For viability test was done when germination percent was 80% or above. To study the effect of storage condition on seed viability, seeds were preserved in different storage medium as polythene packet, *motka* and refrigerator. These seeds were used for viability test. The viability test was done at an interval of 30 days beginning from the date of broken dormancy. This was *in vitro* (petridish) study conducted in 3-replicated CRD.

Seed dormancy

The range of dormancy period varied from 49 to 74 days in Aman season (Table 9). Compared to Aus and Boro the weather during seed developmental stage of Aman crop was cooler, less humid and had low solar radiation. In Aus, BRRI dhan48 showed the highest dormant period for 40 days. In Boro, BRRI dhan45 showed the highest dormant period (29 days) and BRRI dhan50 showed the lowest dormant period (16 days).

Seed viability

In Aus season BRRI dhan48 showed the highest viability up to 330 days and 270 days in case of polythene packet and *motka* storage. BRRI dhan43 showed the lowest viability up to 210 days. In Aman crop, all the varieties were viable up to 180 days in case of polythene packet and *motka* storage condition. BRRI dhan40, BRRI dhan41 and BRRI dhan44 were viable up to 210 days in polythene packet storage (Table 10). In Boro, BRRI dhan45 was viable up to 130 days in *motka* storage but it lost viability after100 days in case of polythene packet storage. BRRI dhan47 and BRRI dhan50 were viable up to 130 days in polythene packet but BRRI dhan50 was viable only up to 70 days in *motka.* Irrespective of season seed viability largely depends on storage condition. High temperature and relative humidity reduces the viability period of the seeds. The seeds of Aman crop had high dormancy than that of Aus and Boro. The seeds stored in freeze condition exhibited long viability period followed by polythene packet and *motka* storage. Among all the varieties stored in polythene packet and *motka,* BRRI dhan48 showed the highest viability up to 330 days.

WEATHER STATION ESTABLISHMENT AND DATA COLLECTION

Establishment of automatic weather station and renovation of manual weather station of BRRI head quarter and different regional station

Plant Physiology Division, BRRI HQ, Gazipur collect weather data from different regional stations since 1975, but recently some weather stations are unable to collect some types of weather data due to damage of some instrument. For this reason and to upgrade our weather station we bought six automatic weather stations and try to set up in different regional stations. We are able to set up automatic weather station and renovate the existing manual ones.

Table 9. Dormant period of some rice varieties grown in Aus, Aman and Boro seasons.

Boro 2008-09		Aus 2009		Aman 2009	
Variety	Day	Variety	Day	Variety	Day
BRRI dhan45	24	BRRI dhan42	29	BRRI dhan40	49
BRRI dhan47	19	BRRI dhan43	28	BRRI dhan41	74
BRRI dhan50	16	BRRI dhan48	40	BRRI dhan44	73
				BRRI dhan46	54
				BRRI dhan49	49

Table 10. Germination percentage of some rice varieties grown in Aus, Aman and Boro seasons.

Boro	Day after harvest							
Polythene packet	40	70	100	130	160	190	220	250
BRRI dhan45	99	99	96	65	34	17		
BRRI dhan47	99	98	96	82	70	37		
BRRI dhan50	99	98	87	85	3	0		
Motka								
BRRI dhan45	100	100	94	80	26	8		
BRRI dhan47	99	99	96	57	57	35		
BRRI dhan50	99	93	72	67	4	0		
Freeze								
BRRI dhan45	100	99	99	96	100	81		
BRRI dhan47	100	100	98	96	100	83		
BRRI dhan50	99	100	98	98	100	98		

Aus	Day after harvest									
Polythene packet	60	90	120	150	180	210	240	270	300	330
BRRI dhan42	100	100	98	98	98	97	97	97	84	57
BRRI dhan43	100	100	97	97	97	96	96	94	38	7
BRRI dhan48	85	100	99	99	98	96	99	99	96	83
Motka										
BRRI dhan42	100	100	100	97	97	96	84	72	13	4
BRRI dhan43	100	100	100	97	97	94	72	62	7	0
BRRI dhan48	100	100	100	96	96	96	95	90	58	32
Freeze										
BRRI dhan42	100	100	100	100	100	100	100	100	100	100
BRRI dhan43	100	100	100	100	100	98	100	100	100	100
BRRI dhan48	100	100	100	100	100	96	100	100	100	100

Aman	Day after harvest						
Polythene packet	60	90	120	150	180	210	240
BRRI dhan40	100	100	100	98	96	82	10
BRRI dhan41	100	100	100	100	98	82	0
BRRI dhan44	100	100	100	100	97	82	6
BRRI dhan46	100	100	100	100	94	48	0
BRRI dhan49	100	100	100	99	96	43	0
Motka							
BRRI dhan40	100	100	100	97	88	63	0
BRRI dhan41	100	100	100	98	95	72	0
BRRI dhan44	100	100	100	98	90	66	9
BRRI dhan46	100	98	98	98	90	55	12
BRRI dhan49	100	99	99	96	86	33	5
Freeze							
BRRI dhan40	100	100	100	100	100	100	100
BRRI dhan41	100	100	100	100	100	100	100
BRRI dhan44	100	100	100	100	100	100	100
BRRI dhan46	100	100	100	100	100	100	100
BRRI dhan49	100	100	100	100	100	100	100

Monitoring of weather parameters through an automatic weather station (WatchDog 2900ET).
Manual weather station with twice data logging per 24 hours are unable to provide clear pictures of actual weather condition. Recent advances of numerous and sophisticated sensors and vast data loggers provide a wide range of automated weather stations with frequent data recording system. Plant Physiology Division of BRRI brought and established six automatic weather stations in the BRRI HQ, Gazipur and five regional stations located at different parts of the country with the help of BRRI Climate Change Trust Fund. Here, we report six month weather element data taken through an automatic weather station established in BRRI HQ, Gazipur.

An automatic weather station '**WatchDog 2900ET**' from Spectrum Technologies, USA was established in the BRRI HQ, Gazipur on 12 February 2012 as per manufacturer's guidelines. After six months of establishment of WatchDog in BRRI HQ on 13 August 2012 all the recorded data were transferred into PC through professional software SpecPro9 and compared with manual weather station data and report here.

Figure 8-14 present the weather elements measured and recorded by WatchDog 2900ET automatic weather station. Automatic weather station WatchDog 2900ET measured and recorded major weather elements more accurately than manual weather station (Table 11). Digital sensors of the WatchDog 2900ET was measured and recorded all of the weather elements more accurately than the manual system. Significant variation was observed by comparing major weather parameters when comparing the data taken by the two systems for a period of five months (Table 11). The variations of weather parameters observed between manual and automatic weather station is mainly due to average of more data point for automatic station (48/day) and digital sensors that can measure and record fractions of changes compared to minimum data point (only 2/day) and the analog system of measurement in the manual weather station. In summary, it can be concluded that automatic weather station (WatchDog 2900ET) can measure and record/log daily weather fluctuations more accurately than manual system, but the data of manual weather station can also be useful to some extent.

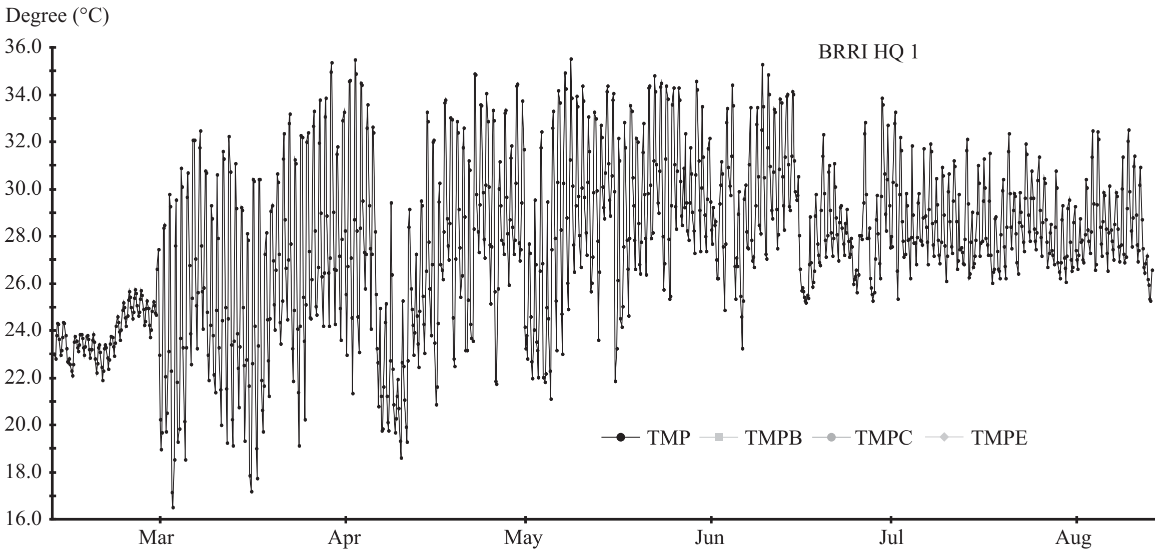


Fig. 8. Graphical representation of the extent of air temperature in celsius (°C) prevails in the BRRI HQ, Gazipur from 12 February to 13 August 2012 recorded by WatchDog weather station.

Table 11. Comparison of major weather elements measured and recorded through manual and automatic (WatchDog 2900ET) weather station in between March to July 2012.

Month	Type of weather station	Air temperature (°C)			Rainfall		Average relative humidity (%)	Total amount of global solar radiation per day (MJ/m^2)
		Max	Min	Average	Total rainfall (mm)	Rainy day		
March	Manual	35.60	15.70	27.11	4.00	1.00	61.64	16.93
	Automatic	36.70	15.30	25.97	5.40	1.00	64.41	19.79
April	Manual	37.50	18.80	28.35	194.80	14.00	72.57	16.30
	Automatic	37.20	18.50	27.18	187.40	14.00	74.79	18.85
May	Manual	38.00	20.20	29.71	121.80	10.00	72.77	15.77
	Automatic	36.20	20.20	29.19	143.40	11.00	74.99	19.21
June	Manual	36.00	22.80	29.04	190.60	16.00	80.98	12.23
	Automatic	36.20	22.90	28.94	222.20	15.00	81.67	13.99
July	Manual	34.00	25.00	28.75	348.40	28.00	81.10	13.96
	Automatic	34.50	25.10	28.51	385.20	29.00	84.43	16.39

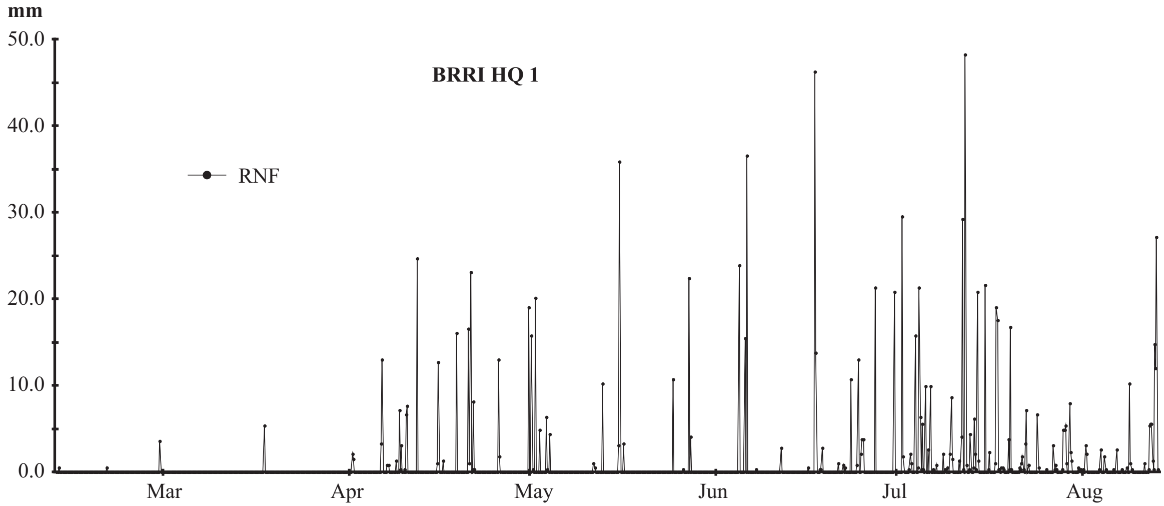


Fig. 9. Graphical representation of the amount of rainfall in millimeter (mm) observed in the BRRI HQ, Gazipur from 12 February to 13 August recorded by WatchDog weather station.

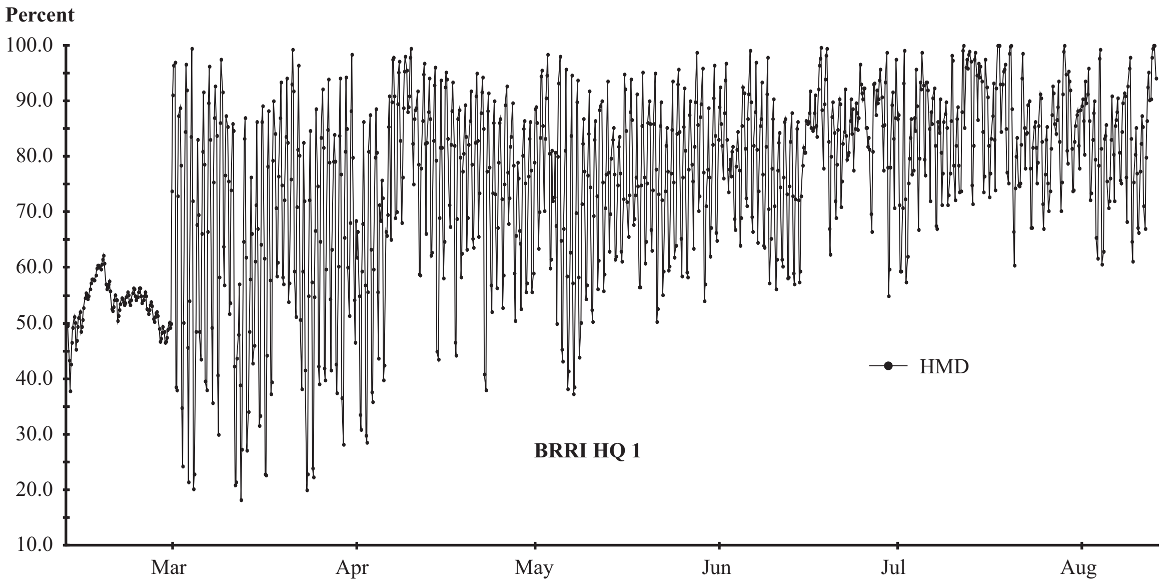


Fig. 10. Graphical representation of the extent of relative humidity in percentage (%) prevails in the BRRI HQ, Gazipur from 12 February to 13 August 2012 recorded by WatchDog weather station.

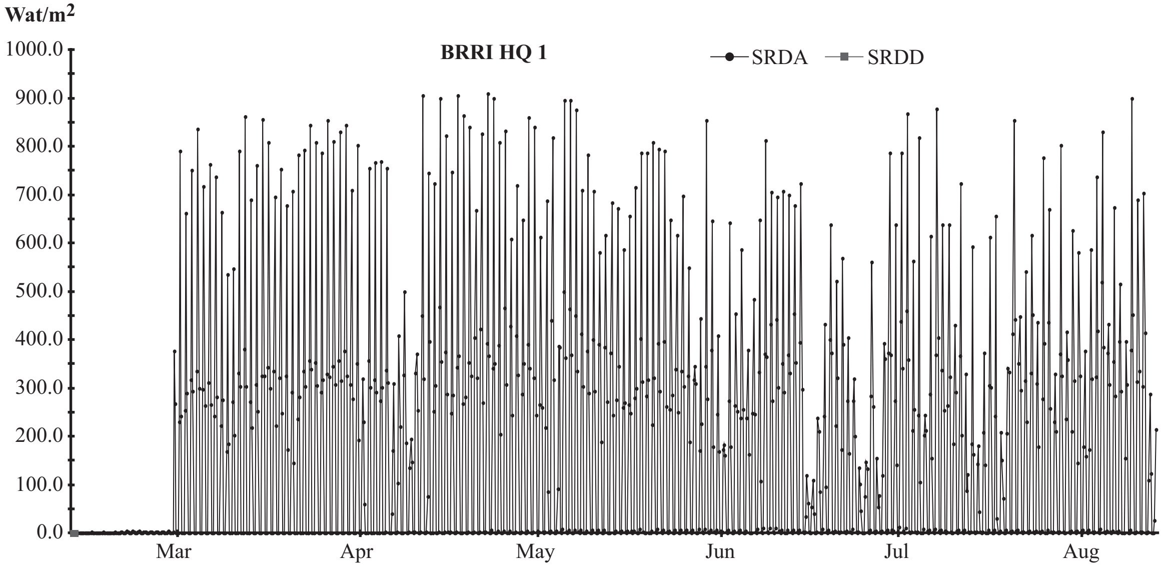


Fig. 11. Graphical representation of the amount of solar radiation in Wat/m^2 observed in the BRRI HQ, Gazipur from 12 February to 13 August recorded by WatchDog weather station.

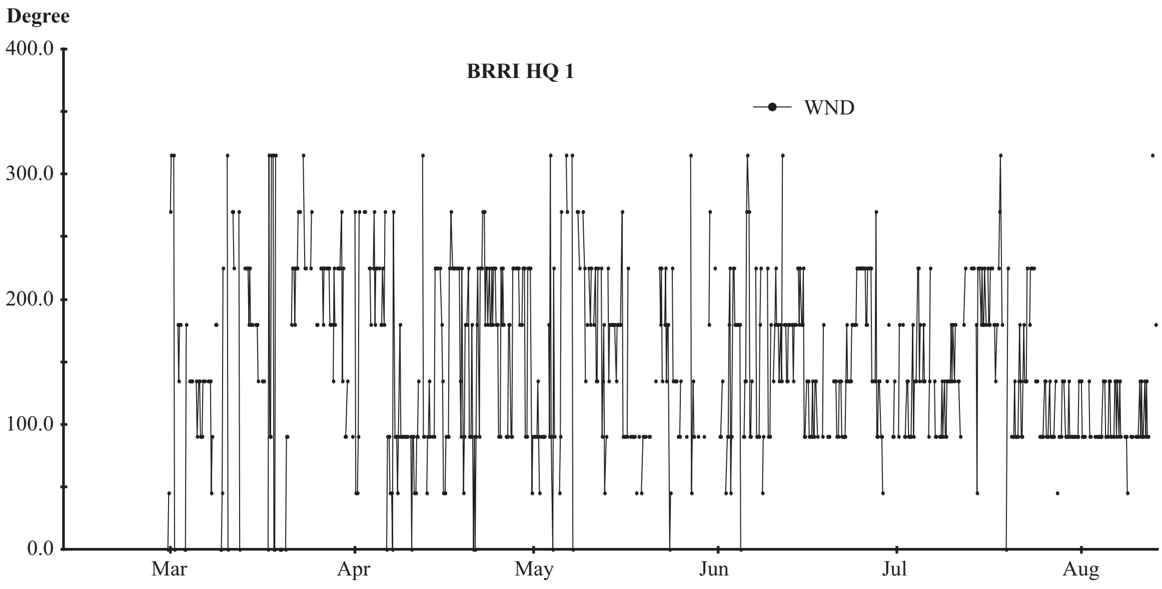


Fig. 12. Graphical representation of the direction of wind in degrees (°C) observed in the BRRI HQ, Gazipur from 12 February to 13 August recorded by WatchDog weather station.

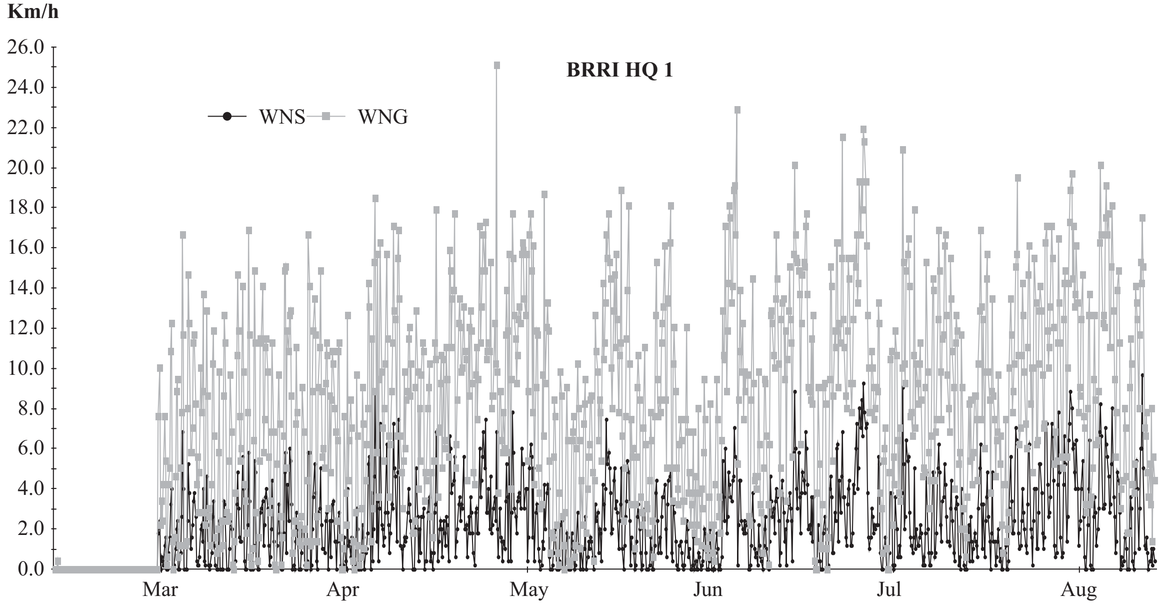


Fig. 13. Graphical representation of the wind speed and wind gust in degrees (°C) observed in the BRRI HQ, Gazipur from 12 February to 13 August recorded by WatchDog weather station.

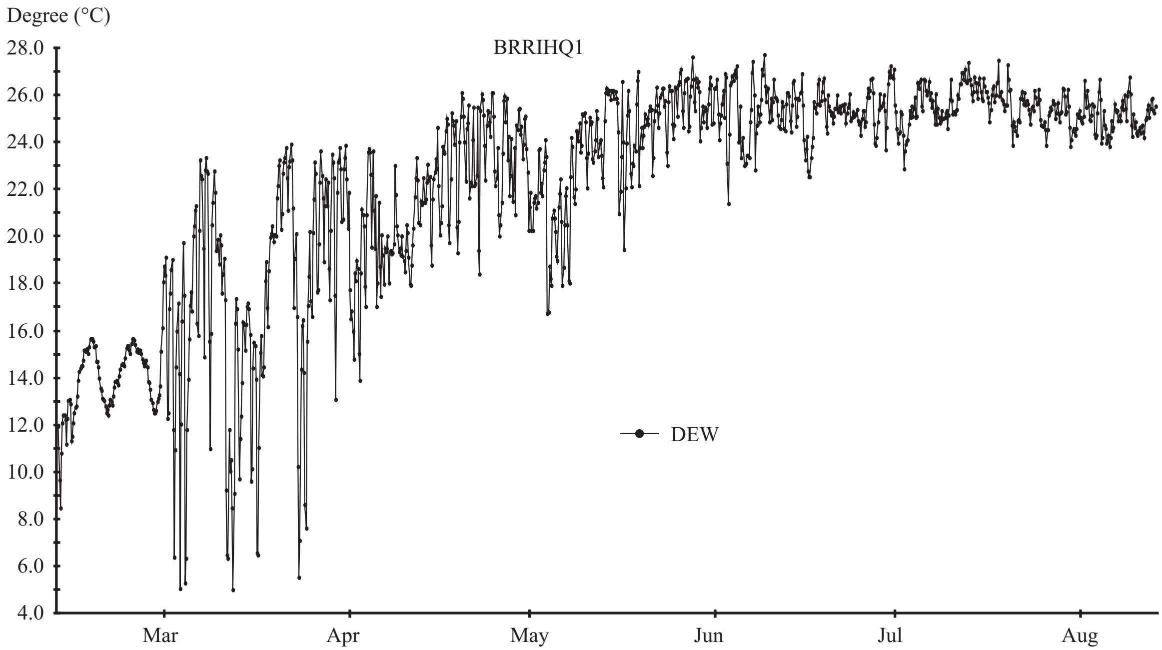


Fig. 14. Graphical representation of dew point temperature in degrees (°C) observed in the BRRI HQ, Gazipur from 12 February to 13 August recorded by WatchDog weather station.

Entomology Division

SUMMARY

Overall insect pest incidence at BRRI HQ farm, Gazipur was low in the reporting year. However, GLH, WLH and GH dominated the pest population in all three seasons. The highest incidences of GLH and WLH were observed in Aus seed beds, but the highest population of GH was found in the T. Aman seed bed.

Higher numbers of natural enemies were found in the Aus and Boro seasons than Aman season. SPD, damselfly, CDB and LBB were the dominant natural enemy population in the reporting year in all three habitats. The domination of SPD population, irrespective of habitat, was observed in the Aus and Aman seasons, but that of LBB was observed in seed beds, grass fallow lands and irrigated rice of the Boro season.

In Sirajganj (a BPH prone area) BPH and WBPH surpassed the ETL in the Boro season. Small brown planthopper was not reported earlier in Bangladesh but has been recorded in the yellow sticky trap in this area.

Chemical control by double nozzle sprayer has been found more effective than single nozzle sprayer in controlling BPH. In an outbreak situation chemical control is essential to avoid ‘hopper burn’ of rice.

Wing span of gall midge varied from 3 to 4 mm. Female longevity was higher than male and the female laid 130-330 eggs during its life time.

Developmental duration from egg to adult of *T. zahiri* (an egg parasitoid of RH) at different temperatures showed that the duration decreased with the increase of temperature up to certain limit and it ranged from 7 to 15 days. Adult longevity of *T. zahiri* depends on diets and the highest longevity of female and male was found when host food plus 25% honey solution was supplied as food.

BRRI dhan42 has been identified to show low yield loss (5%) despite a considerable level of hispa damage. This variety might be recommended for hispa prone areas. BRRI hybrid dhan2 also showed higher hispa damage tolerance than the BRRI hybrid dhan1 and BRRI hybrid dhan3.

A total of 165 insecticides (114 against BPH, 29 against RH and 22 against YSB) were found effective out of 190 insecticides 2011-12.

Thirty-five and four entries were found moderately resistant to BPH and GLH, respectively for further use.

SURVEY AND MONITORING OF RICE ARTHROPODS

Pest and natural enemy incidence at BRRI farm, Gazipur

Population of rice insect pests, their natural enemies and crop damage intensities in five habitats (seed bed, rice ratoon, grass fallow, irrigated rice, and upland rice) was monitored weekly at BRRI HQ farm, Gazipur. From each habitat one hundred complete sweeps were made and the collected pest and natural enemies were counted. Damage intensity due to some major insect pests and their populations was also estimated from 20 randomly selected hills in each week.

The overall insect pest incidence was low in the reporting year. Higher incidences of insect pests were found in Aus and T. Aman seasons than the Boro season (Tables 1, 2 and 3). Green leafhopper (GLH), white leafhopper (WLH) and grasshoppers (GH) were the most abundant pests and found in all the three seasons. The rice fields and seed beds of all seasons harbored higher populations of GLH, GH and WLH than the ratoon and grass fallow habitats.

Higher numbers of natural enemies were found in Aus and Boro seasons than T. Aman season. Spider (SPD), damsel fly (Dam. fly), ladybird beetle (LBB) and carabid beetle (CDB) were the dominant predators (Tables 1, 2 and 3) in all the habitats of the seasons except in a few cases. Like insect pests, the natural enemies also concentrated mostly in seedbed and rice fields in all the seasons.

Weekly counts, taken directly from 20 hills, showed that the population and the damage done by insect pests were below the ETL in all the three rice seasons. GLH and GH were the most abundant pests in hill counts. Damages caused by stem borers (SB), GH, long horn cricket (LHC), rice leaffolder (RLF) and whorl maggot (WM) was observed throughout the year. Among the predators, the CDB in Aus and the spiders (SPD) in

Table 1. Incidence of insect pests and natural enemies in rice and non-rice habitats, Aus 2011, BRRI HQ farm, Gazipur.

Arthropod	Seed bed	Ratoon	G. Fallow	Irrigated rice	Upland rice
			Insect pests (no./100CS/week)		
YSB	0.4	0.33	0.26	1.16	1.08
GLH	126.00	1.86	1.8	7.0	9.45
WLH	9.6	1.13	1.06	2.41	1.81
ZLH	1.4	0.06	0.13	0.0	0.0
GH	17.8	1.33	3.06	4.41	4.63
RB	0.0	0.73	0.06	5.33	1.55
RH	2.2	0.26	0.13	0.66	1.09
Total	157.40	5.70	6.50	20.97	19.61
			Natural enemies (no./100CS/week)		
LBB	4.4	0.93	0.6	3.83	1.81
SPD	6.6	2.66	2.0	6.33	4.18
GMB	4.6	0.0	0.26	0.16	0.0
CDB	0.8	0.33	0.0	3.91	1.0
Dam. Fly	5.0	1.73	1.66	3.83	3.45
STPD	0.0	0.06	0.06	0.0	0.27
Total	21.4	5.71	4.58	18.06	10.71

CS=complete sweep ie sweep net stroke from left to right and right to left.

Table 2. Incidence of insect pests and natural enemies in rice and non-rice habitats, T. Aman 2011, BRRI HQ farm, Gazipur.

Arthropod	Seed bed	Ratoon	Grass Fallow	Irrigated rice
		Insect pests (no./100CS/week)		
YSB	1.07	0.31	0.31	2.0
GLH	7.57	2.32	2.15	30.58
WLH	2.71	1.79	2.05	5.25
GH	18.5	8.0	5.32	5.41
RLF	0.0	0.0	0.15	1.33
RH	0.0	0.0	0.05	0.50
RB	0.0	0.15	0.0	0.33
Total	29.85	12.42	10.03	44.57
		Natural enemies (no./100CS/week)		
LBB	1.64	2.63	0.84	5.08
SPD	4.35	2.26	2.11	10.08
CDB	0.42	0.21	0.1	2.91
Dam. Fly	2.71	1.63	1.42	5.16
STPD	0.07	0.0	0.05	0.0
TB	0.0	0.0	0.15	0.16
Total	9.19	6.73	4.67	23.39

CS=complete sweep ie sweep net stroke from left to right and right to left.

Table 3. Incidence of insect pests and natural enemies in rice and non-rice habitats, Boro 2012, BRRI HQ farm, Gazipur.

Arthropod	Seed bed	Ratoon	Grass Fallow	Irrigated rice
		Insect pests (no./100CS/week)		
YSB	0	0	0	0.08
GLH	6.9	2.57	3.85	6.54
WLH	1.1	0.86	1.15	1.92
GH	4.9	1.85	2.9	2.15
RLF	0.0	0.0	0.0	0.08
RH	0.0	0.0	0.25	0.38
RB	0.0	0.28	0.05	11.15
Total	12.90	5.56	8.20	22.30

Table 3. Continued.

Arthropod	Seed bed	Ratoon	Grass Fallow	Irrigated rice
		Natural enemies (no./100CS/week)		
LBB	8.1	6.14	10.85	9.38
SPD	2.3	1.28	1.8	1.85
STPD	0.8	0.57	0.3	0.0
CDB	0.4	0.28	0.25	0.85
Dam. Fly	1.4	0.71	1.7	2.31
TB	0.9	0.0	0.05	0.0
Total	13.90	8.98	14.95	14.39

CS=complete sweep ie sweep net stroke from left to right and right to left.

Aman and Boro dominated the populations respectively (Table 4).

Pest and natural enemy incidence in light trap

Rice insect pests and their natural enemies were monitored throughout the year by light trap from July 2011 to June 2012 at BRRI HQ, Gazipur and BRRI RS in Comilla and Habiganj.

The incidence of insect pests was higher at Gazipur than those of the regional stations. The total number of insect pests was the highest at Gazipur followed by Comilla and Habiganj. The abundance of GLH, BPH, RLF, YSB and LHC was observed at all the three locations (Fig. 1). Pest incidence of GLH, BPH, YSB and LHC was recorded in May at Gazipur whereas, the peak incidence of RLF was found in August. No definite peaks were shown by these insects in other stations. Yellow stemborer, BPH and RLF had an

Table 4. Insect pest and natural enemy incidence, and damage levels (determined by direct count) in rice, Aus, T. Aman 2011 and Boro 2012, BRRI, Gazipur.

Pest/ natural enemy		Aus (Upland)		Aus (T. Aus)		T. Aman		Boro	
		No./20 hills/ week	Damage (%)	No./20 hills/ week	Damage (%) (%)	No./20 hills/ week	Damage (%)	No./20 hills/ week	Damage (%)
Insect pests									
SB	DH	0.18	0.86	0.8	0.55	0.0	0.68	0.07	0.18
	WH		0.11		0.08		0.20		0.0
BPH		0.0	0.0	0.0	0.0	0.41	0.0	0.07	0.0
GLH		1.09	0.0	1.83	0.0	6.16	0.0	2.15	0.0
GH		2.27	18.66	2.83	3.41	2.16	0.83	1.00	1.06
RH		0.09	0	0.25	0.0	0.08	0.0	0.46	0.0
RLF		0.63	0.07	0.25	0.17	0.08	0.31	0.38	0.11
LHC		1.54	0.41	0.58	0.11	0.08	0.07	0.38	0.07
WM		0.0	0.69	0.0	0.55	0.0	2.73	0.0	3.68
RB		1.09	0.0	1.00	0.0	0.25	0.0	1.61	0
Total		6.89	20.80	7.54	4.87	9.38	4.82	6.12	5.10
Natural enemies									
LBB		0.72		0.66		1.00		2.31	
SPD		1.09		1.25		2.66		3.31	
STPD		0.27		0.0		0.16		0.15	
CDB		1.27		1.91		0.66		0.23	
Dam. Fly		0.63		0.83		0.41		1.61	
Dragon fly		0.27		0.08		0.0		0.0	
Total		4.25		4.73		8.89		7.61	

BPH=Brown planthopper, CDB=Carabid beetle, DH=Dead heart, Dam. fly=Damsel fly, GLH=Green leafhopper, GH=Grass hopper, LHC=Long horned cricket, LBB=Ladybird beetle, RLF=Rice leaf folder, RH=Rice hispa, RB=Rice bug, SB=Stem borer, SPD=Spider, STPD=Staphylinid beetle, WM=Whorl maggot, WH=White head.

additional peak in September-October, November and August respectively.

The highest catch of natural enemies in the light trap was also recorded at Gazipur during the reporting year. LBB and CDB were found at all the three locations. The highest peak of LBB and CDB were observed at Gazipur in June. The highest population of STPD and GMB was captured at Gazipur in May with an additional peak in November (Fig. 2).

Effect of climate change/global warming on yellow stem borer and brown planthopper

To know the impact of climate change on YSB and BPH, monthly YSB and BPH catches from January 2000 to December 2009 were taken from light trap recorded data. The data were analyzed using different mathematical models. The optimal correlation structure of the autoregressive integrated moving average (ARIMA) model was chosen by minimizing Akaike information criterion (AIC), first selecting autoregressive (AR) and moving average (MA) orders and then removing non-significant AR and MA parameters. The residual series of models presented in this study accounted properly for autocorrelation and non-stationarity (tested by Lagrange Multiplier Test and Augmented Dickey-Fuller Unit Root Test respectively). The average per capita growth rate from time t to time $t + \Delta t$ was calculated as $r = \frac{1}{\Delta t} \ln \left(\frac{N_{t+\Delta t}}{N_t}\right)$, where N is the population size (monthly abundance). The average population size during the time interval from time t to time $t + \Delta t$ was calculated as $N = (N_t + N_{t+\Delta t})/2$.

The average temperature and amount of rainfall during the time interval is denoted T and H respectively. We investigated whether r depends on temperature and rainfall by means of a general linear model, $r = \beta_0 + \beta_1 T + \beta_2 T^2 + \beta_3 H + \beta_4 H^2 + \beta_5 TH + \beta_6 T^2 H + \beta_7 TH^2 + \beta_8 T^2 H^2 + e$.

Impact on BPH. Figure 3 shows the effect of temperature and rainfall, which is complex and it shows that the growth rate is expected to increase with temperature and probably also with rain, but not in a straightforward way. It appears that there

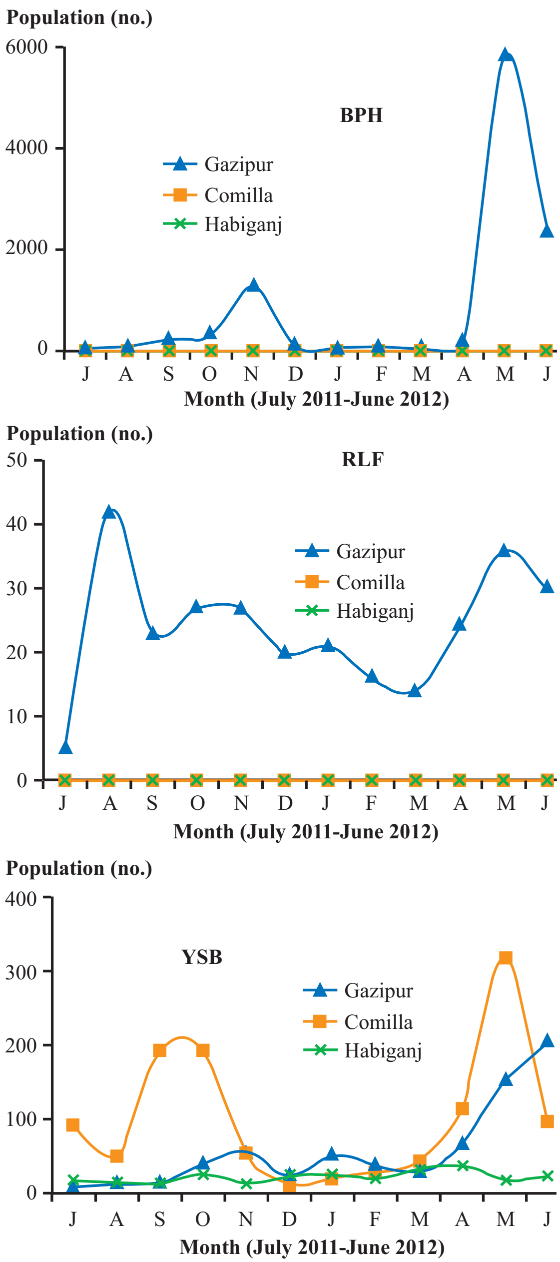


Fig. 1. Major insect pests caught in light trap at BRRI HQ farm, Gazipur and regional stations July 2011-June 2012.

are two seasons where the population can grow. Both seasons are hot, but one is dry and the other wet.

Impact on YSB. Monthly abundance and variation of YSB abundance showes the seasonality of YSB population dynamics (Fig. 4, A-B). April-June and August-November were considered as the high-abundance, and December-March as the low-abundance one. In Bangladesh, there are three major rice crop seasons, Aus (March-August), Transplanted Aman (June-November) and Boro (December-March). The periodogram of monthly YSB log abundance confirmed the seasonality with the strongest periodicity of six months, followed by a weaker periodicity of 12 months (Fig. 4C). This pattern was incompatible with previous field observations that show three peaks of YSB population (1st in April, 2nd in June-July and 3rd in October-mid November) annually in Bangladesh.

The two-peak temporal pattern could be attributed to monthly climate variance. The number of YSBs captured in July was low (Fig. 4, A-B), probably because the borers were in larval and pupal stages. As the life cycle of YSB is 5-9 weeks, the following generation of YSB moths emerged in August. Also, the newly emerged moths laid eggs, the prevailing favourable climatic factors induced rapid development of new frequent generations. These likely resulted in a seasonal abundance peak at August-November in each year (Fig. 4, A-B). From December to February cold and dry weather in induced low abundance seasons (Fig. 5, A-C). Variance partitioning (Fig. 6) showed that the two climate parameters explained 30.2% of the variance in YSB abundance, of which temperature explained 22.7%, precipitation 7.5%. These indicates that effects of temperature and precipitation and their joint effects were significant and that temperature had a higher explanatory capacity of the variance in YSB abundance than precipitation.

After adjusting for serial residual correlation by using a subset ARIMA (12,0,2) $(1,0,1)^{12}$ model, we found that the monthly YSB abundance depended on its own previous demographic history as well as temperature and precipitation ($Y_t=0.458Y_{t-1}-0.518Y_{t-2}+0.306Y_{t-3}+0.002T^2_{t-1}-1.553R^2_t-0.225T_tR_t+7.462R_t$; $R^2 = 0.652$, AIC = 1.153). The subset ARIMA model included AR parameter for lag12, SAR parameter for lag 1, MA parameter for lag 2, and SMA parameter for lag 1, with the other AR and MA parameters coefficients set to zero. Results of simple linear regressions lent

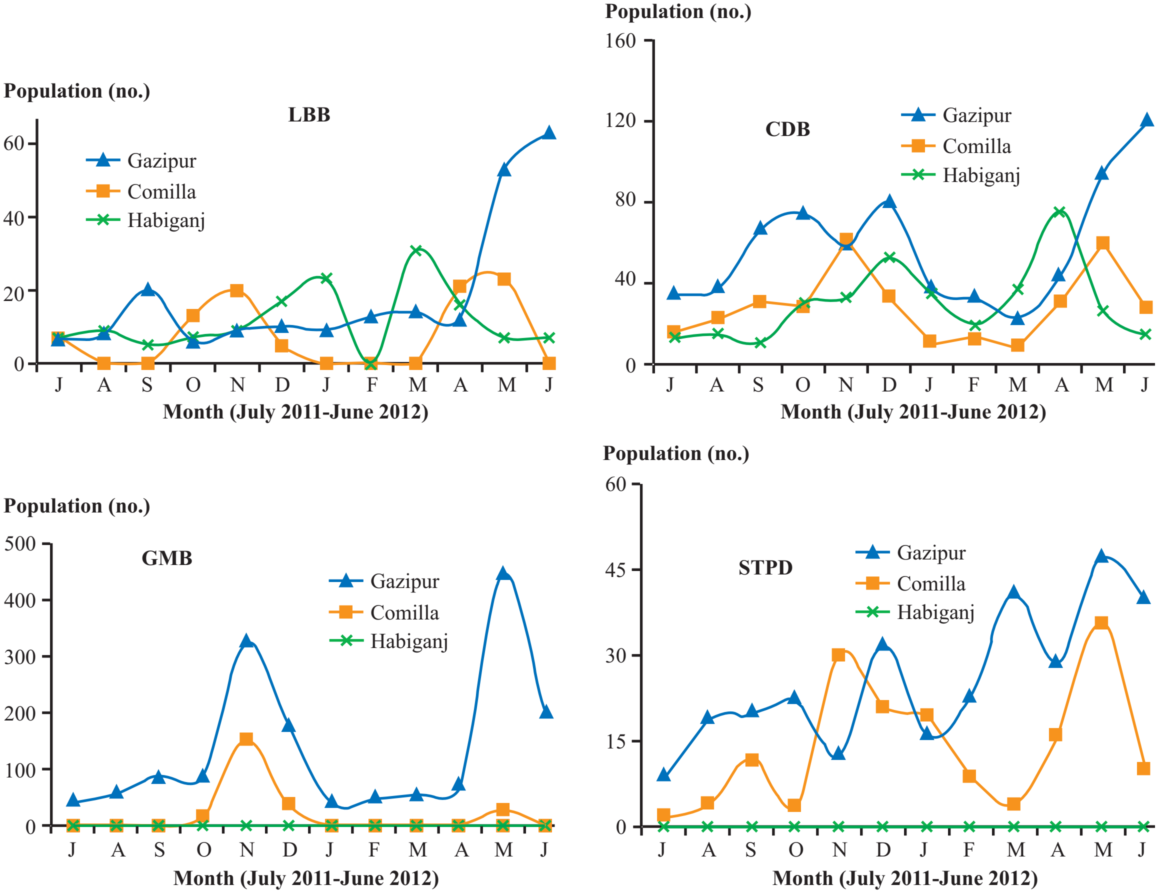


Fig. 2. Incidence pattern of natural enemies of rice insect pest in light trap, BRRI HQ and regional stations, July 2011-June 2012.

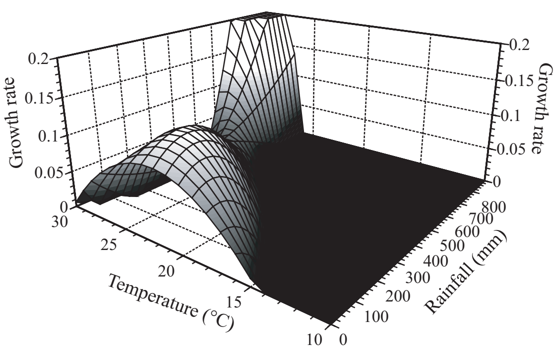


Fig. 3. Predicted per capita growth rate of BPH at different combinations of temperature and rainfall is demonstrated. As the maximum empirical value of *r* was found to be 0.19 day^{-1}, the vertical axis is truncated at this value.

further support that climate variability had a quadratic effect on YSB population (Fig. 7). Temperature may affect YSB abundance negatively at high precipitation level, but positively at intermediate to low precipitation level (Fig. 7A). Precipitation may affect YSB abundance positively when monthly precipitation was <400 mm at high temperature level, and when monthly precipitation was <300 mm at intermediate temperature level. The impact of precipitation on YSB abundance may be negative when monthly precipitation was >400 mm at high temperature level, and when monthly precipitation was >300 mm at intermediate temperature level (Fig. 7B). These results suggested climate variability (eg temperature and/or precipitation rising) may not result in the increase of YSB outbreak frequency. Instead, the YSB outbreak frequency may

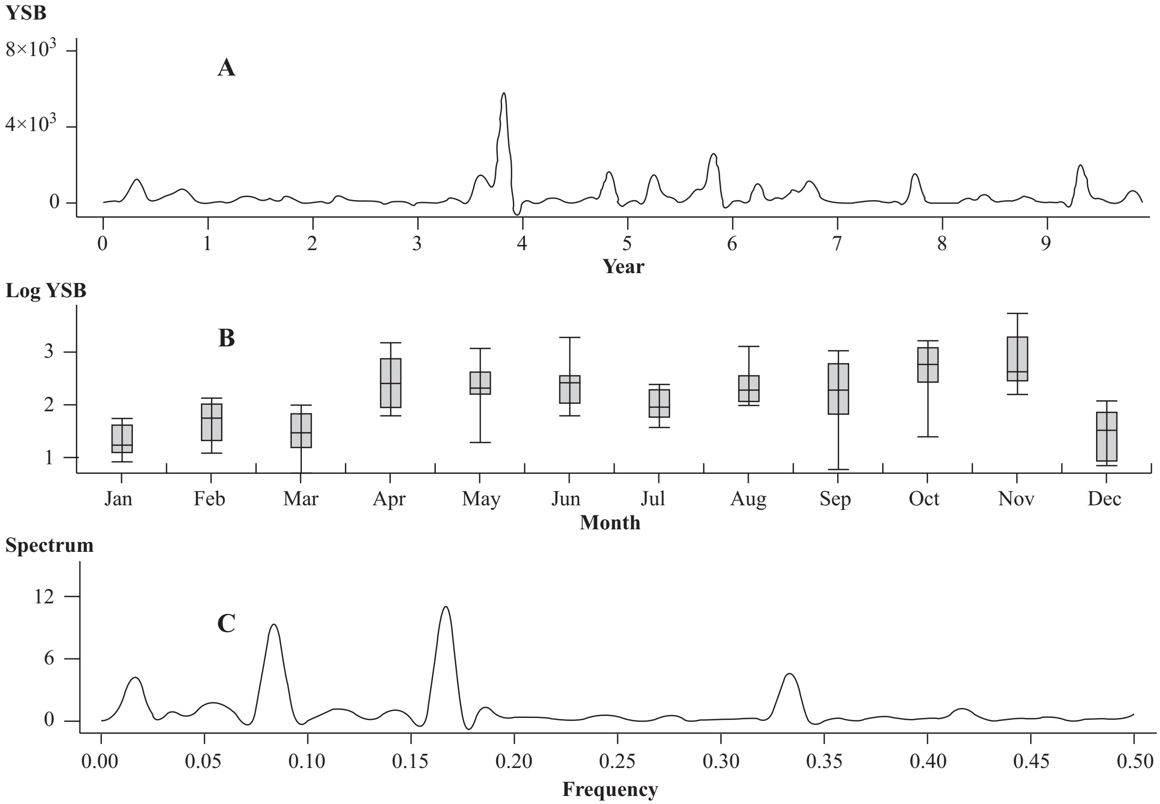


Fig. 4. Monthly abundnace (A), variation (B) and estimated periodogram (C) of YSB, *Scirpophaga incertulas* Walker during January 2000-December 2009.

unexpectedly be reduced that might decrease the risk of outbreaks frequency in rice field.

Figure 8 shows the relationship between growth rate and temperature and rainfall for ln$N$=0, which indicating the per capita growth rate is expected to be high during periods of relatively low temperatures and abundant rainfall, and to be low when high temperatures occur in combination with plenty of rain. Predicted growth rate also supports that outbreak risk of YSB might be reduced in warmer world (Fig. 8). It has to be noted that the model predicts the growth rate also for combination of temperature and rainfall that may not have occurred in the empirical data set. So, care has to be taken when the model is extrapolated to such extreme cases.

Survey and monitoring of BPH and its natural enemies

To monitor the population density, abundance and incidence period of BPH and their natural enemies in the project areas in Sirajganj, the following methods were followed:

Yellow sticky trap. Planthoppers were monitored by yellow sticky traps (15.24- × 25.4-cm) in two control plots of each location. A weekly monitoring in each plot consisted of three replications of sampling. In each replication trapping was done at 10 spots of the field randomly selected diagonally or vertically. At each trapping spot, sticky trap was hold flatly between two plants at the base and the plants were tapped three times to capture insects. The trapped insects (BPH, WBPH, natural enemies ie, SPD, LBB, STPD and CDB, etc) on yellow traps were counted and recorded (Fig. 9). Sticky traps including trapped insects have been preserved in the refrigerator for future use or references.

A considerable number of adult BPH or WBPH and their nymphs were caught in yellow

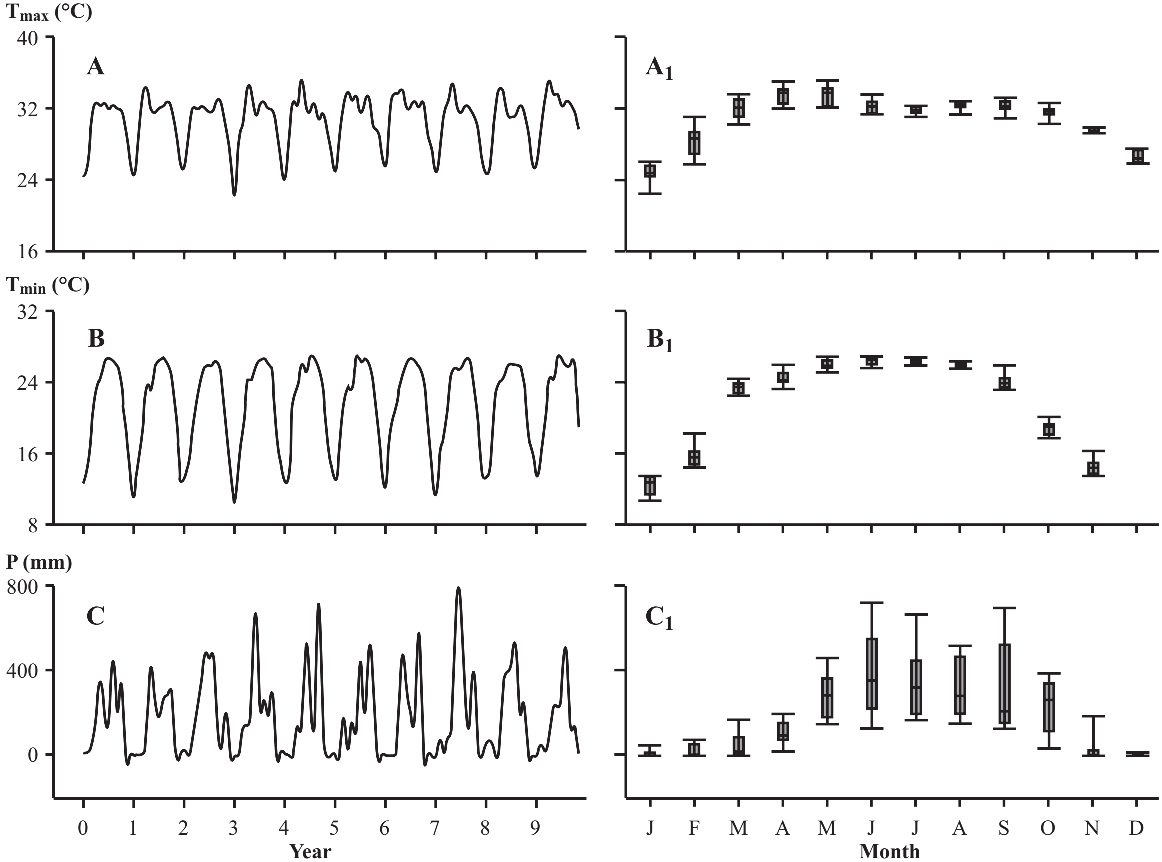


Fig. 5. Temporal plots and variation of monthly maximum (A, A_1) and minimum (B, B_1) temperature and precipitation (C, C_1) in Bangladesh during January 2000-November 2009. T_{max} and T_{min} mean monthly maximum and minimum temperature respectively. P means monthly precipitation.

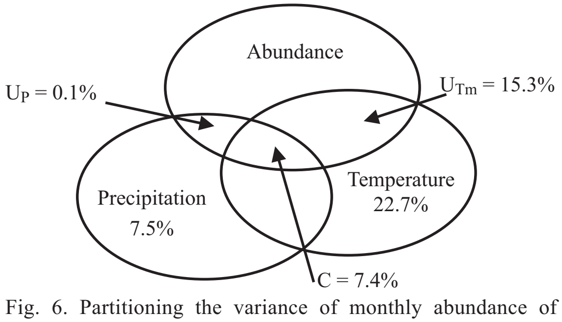


Fig. 6. Partitioning the variance of monthly abundance of *Scirpophaga incertulas* Walker accounted for by climate parameters in Bangladesh. Monthly abundance of S. incertulas was log (x+1) transformed before this analysis. Precipitation and temperature refer to monthly precipitation and the average of monthly maximum and minimum temperature. UTm and UP mean the unique effects accounted for by temperature and precipitation respectively; C means the joint effect accounted for by both temperature and precipitation.

sticky trap. Rice planthopper incidence was at peak in yellow sticky trap catches during crop harvest. Initially, the BPH, WBPH and small brown plant hoppers (SBPH) caught in the yellow sticky trap were very low in field catches but it increased from booting to harvesting stage of the rice crop. The rice fields in Ghargram were infested more than the other two locations (Dobila and Hamkuria). SBPH was not reported earlier in Bangladesh but recently it was trapped in yellow sticky trap during field monitoring of rice plant hoppers (RPH).

In all the locations BPH population surpassed the ETL level during the second week of April (heading-flowering stage of rice). But the WBPH population reached the ETL level earlier than the BPH in the fourth week of March (Panicle initiation-booting/heading stage of rice) in all the locations except Dobila. At Dobila WBPH with

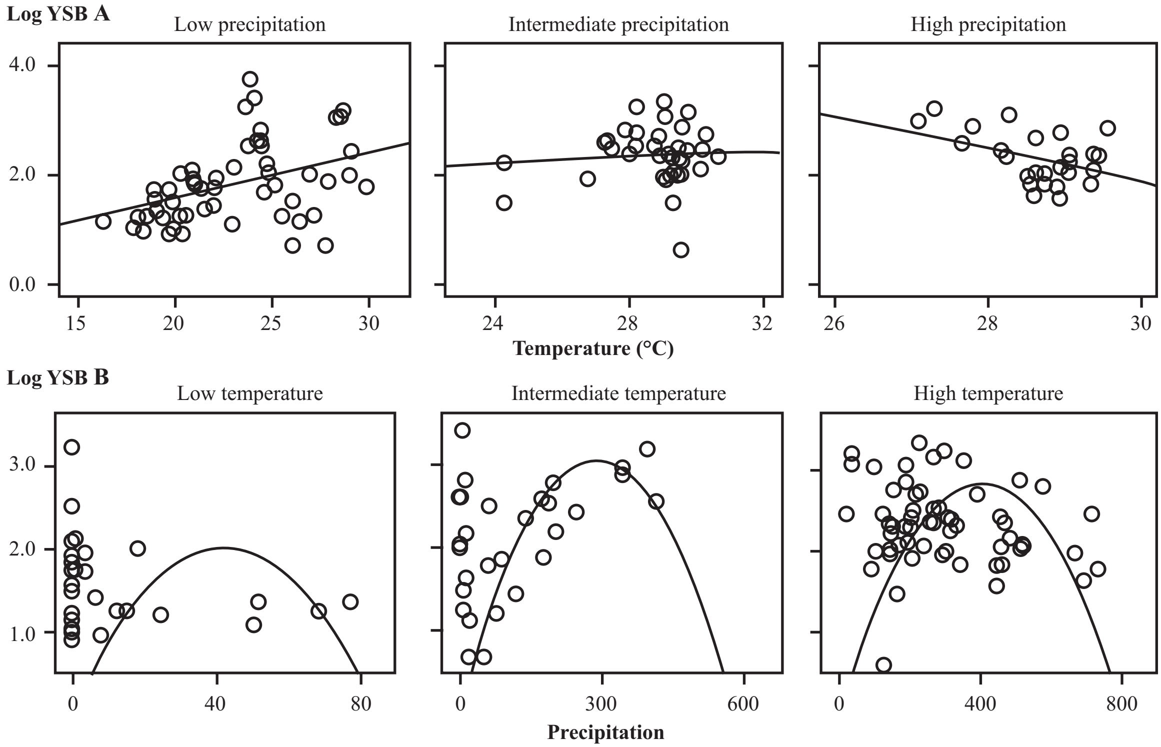


Fig. 7. Quadratic effects and interactions of monthly precipitation (A) and temperature (B) on *Scirpophaga incertulas* Walker in Bangladesh. The response variable monthly abundance of S. incertulas was log (x+1) transformed before analysis. For the simple linear regressions between abundance and temperature at high, intermediate and low precipitation (A), R2=0.971, 0.956 and 0.887 respectively; F=419.783, 389.432 and 203.806, respectively; sig. <0.001, 0.001 and 0.001, respectively. For the simple linear regressions between abundance and precipitation at high, intermediate and low temperature, R2=0.871, 0.644, and 0.188, respectively; F=191.949, 24.374 and 3.367, respectively; sig.=<0.001, 0.001 and 0.050 respectively.

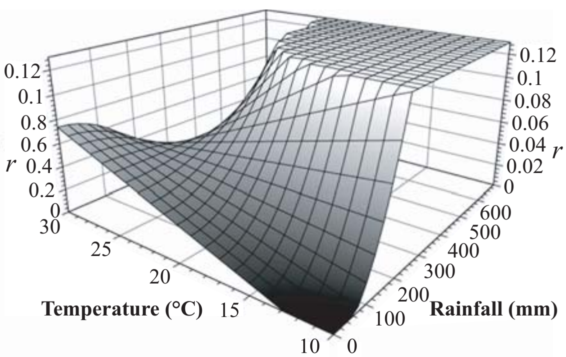
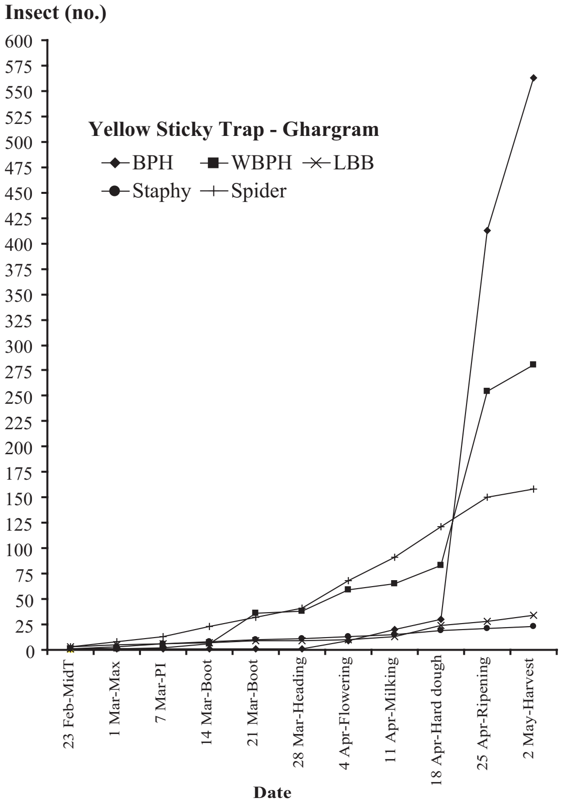


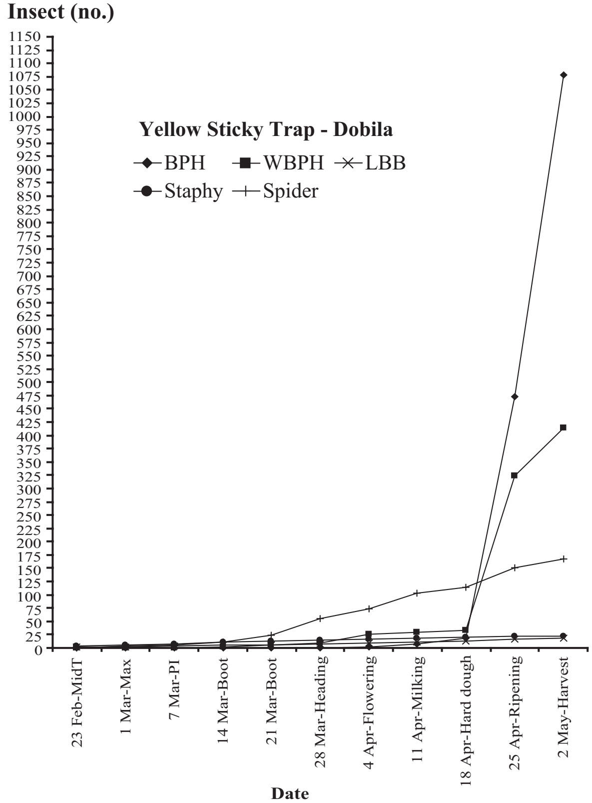
Fig. 8. Predicted per capita growth rate (r) for *Scirpophaga incertulas* at different combinations of temperature and rainfall. As the maximum empirical value of *r* was found to be 0.13day-1, the vertical axis is truncated at this value.

increased population was found in the first week of April (flowering stage of rice). Among the natural enemies, spider population was higher than the others in all the locations. The population of spider started to increase from the first week of March. The LBB and STB population followed a similar trend to that of their preys (BPH, WBPH) ie their population increased with the increase of prey population (Fig. 9).

Light trap. Pensylvannian light traps were installed in three locations (Dobila, Hamkuria and Ghargram) of the project area. The traps were operated dusk to dawn and the insect pests and natural enemies caught in the traps were collected, sorted, counted and the numbers recorded in the data sheet every day. Incidence pattern of BPH and WBPH in the light trap was different from that of the yellow sticky trap. Populations of both the insects were very low in all the locations.

Small brown planthopper (SBPH) was not been found in any light trap but it was recorded in sticky trap with BPH and WBPH. However, SB





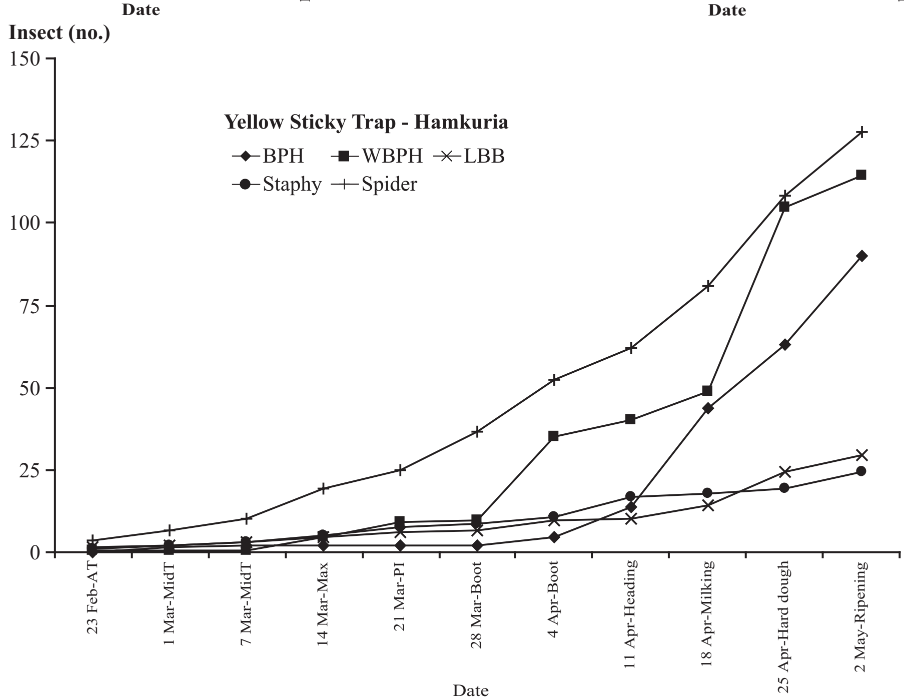


Fig. 9. BPH, WBPH and natural enemies trapped in yellow sticky trap, Ghargram (upper), Dobila (middle) and Hamkuria (lower), Tarash, Sirajganj, Boro 2012.

population showed two small peaks- one in the first week of March and the other in the later part of April. The population of STPB was higher in the light trap than the other natural enemies. The beetle showed a higher incidence during March and the population declined in the following months in all the locations (Fig. 10). The traps could not be operated due to power failure in the Tarash area in the evening resulting in low population trapping of BPH and WBPH. A few light trap samples were preserved in wet (95% ethanol) and in dried condition as reference material.

STUDIES ON THE RICE INSECT PEST AND NATURAL ENEMY BIO-ECOLOGY

Wing span, adult longevity and fecundity of gall midge

Onion shoots with pupae of gall midge were collected from the stock culture at BRRI green house and were reared in a hot humid situation (26 to 30°C and 85 to 95%) until adult emergence. Wing span from the tip of one wing to the end of another wing was measured by an ocular micrometer under binocular microscope. To

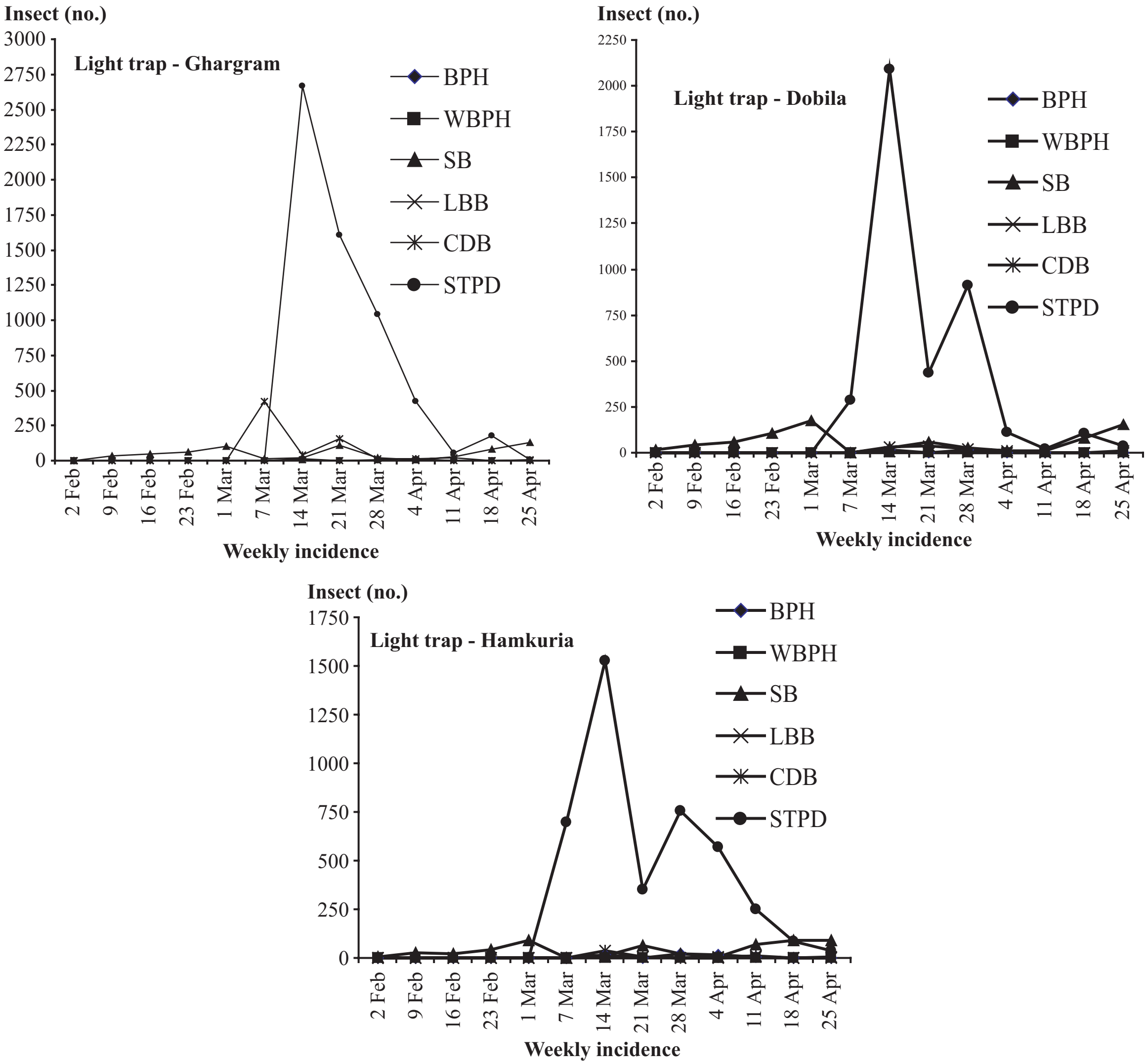


Fig. 10. BPH, WBPH and natural enemies trapped in light trap, Ghargram (upper), Dobila (middle) and Hamkuria (lower), Tarash, Sirajganj, Boro 2012.

determine the adult longevity, male and female insects were reared individually in test tubes. The tubes were examined every half an hour to record the longevity of each specimen. In order to determine the fecundity, mated females were reared individually on rice leaves in test tubes. At the death of each female the number of eggs laid by it was recorded under a binocular microscope.

Wing span of the male gall midge was found 3.0 mm to 3.75 mm (av. 3.25 mm), whereas in case of the females it was 3.25 mm to 4.0 mm (av. 3.8 mm) (Table 5). The male lived for 22- 30 hours (av. 26.6 hrs). On the other hand, female longevity was 50-76 hours (av. 56 hrs) (Table 5). The female laid 130-330 eggs (av. 244.6 numbers) during their life time.

Development duration of *T. zahiri* at different constant temperatures

Twenty pairs of rice hispa were allowed to lay eggs overnight on potted BR3 rice plants. After egg laying, one or two leaf pieces containing 15-20 rice hispa eggs were kept in a test tube. The lower end of the leaf pieces was wrapped with water soaked cotton wools. Single mated females of *Trichogramma zahiri* were introduced into each test tube for egg laying on rice hispa egg for one day. Honey was provided as the food for the parasitoids in the test tubes. The leaf pieces with parasitized hispa eggs were shifted to a new test tube and a new set of hispa eggs were placed in the original tube. The process was continued till the death of the parasitoid. The test tubes with parasitized eggs were placed in the incubator at 18, 22, 26 30 and 34°C in 16L:8D condition. Five test tubes were used for each temperature. The development duration from egg to adult was determined from five cohorts each of 20 male and female *T. zahiri* emergence record at a constant temperature. Thus every trial had 100 replications. The developmental period from egg to adult for male and female parasitoids was compared by one way analysis of variance (ANOVA); SPSS, V. 19; 2011, followed by Turkey's Post-hoc Test at 0.05 level.

Table 5. Wing span and adult longevity of gall midge, BRRI, 2011-12.

Wing span			
Sex	No. of observation (n)	Wing span (mm)	
		Range	Average
Male	25	3.0-3.75	3.25
Female	25	3.25-4.0	3.8
Adult longevity			
Sex	No. of observation (n)	Longevity (hrs)	
		Range	Average
Male	30	22- 30	26.6
Female	30	50-76	56

The ANOVA showed a significant variation in development (egg to adult) duration of *T. zahiri* at different constant temperatures. The mean development duration for the male and female ranged from 7.01 to 15.06 days and 7.36 to 15.19 days respectively (Table 6). The development period for both male and female also varied significantly at different temperatures. The development period for both male and female was the longest at 18°C and the shortest at 34°C. Unlike other *Trichogrammatid* egg parasitoids, female *T. zahiri* did not take significantly longer time to reach adulthood. The Turkey's Post-hoc Test did not show significant variation in the development period of male and females at a particular temperature ($P<0.05$).

It was found that developmental duration of the parasitoid, *T. zahiri* decreased with the increase of temperature irrespective of sex. The average development duration of *T. zahiri* from egg to adult at 18, 22, 26, 30 and 34°C were 15.13, 12.13, 10.28, 7.32 and 7.19 days respectively irrespective of sex. The developmental duration decreased from 15 to 7 days when temperature increased from 18 to 34°C irrespective of sex (Fig. 11). However, the developmental duration remained constant (7 days) at 30 to 34°C.

Adult longevity of *T. zahiri* on different diets

Adult longevity experiment was conducted by captivated three cohorts of five pair (male and female) adult *T. zahiri* in five different test tubes with five different foods including a control (water as the diet). Thus, 15 pairs of *T. zahiri* were reared on each diet. Honey 25%, sugar 25%, host food (RH egg), host food +honey 25%, host food +sugar 25% solutions in cotton wool wrapped with fine mesh nylon net were provided as diets. If any of the adult parasitoids adhered to the water droplet

Table 6. Egg to adult developmental period of *T. zahiri* at different constant temperature in the incubator.

Temperature (°C)	Observations (no.)	Days required for *T. zahiri* emergence (Mean ±SE)	
		Male	Female
18	100	15.06 ± 0.03a	15.19 ± 0.04a
22	100	12.04 ± 0.03b	12.22 ± 0.04b
26	100	10.13 ± 0.03c	10.42 ± 0.04c
30	100	7.14 ± 0.03d	7.49 ± 0.04d
34	100	7.01± 0.03e	7.36± 0.04e
F- value		13910.750**	8197.210**

Data were analysed using ANOVA; **P<0.001; values within the column followed by different letters were significantly different at the 5% level of Tukey's Post-hoc Test.

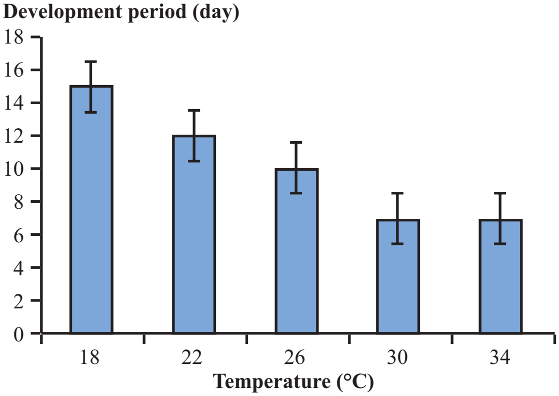


Fig. 11. Developmental duration of *T. zahiri* at different constant temperature.

or honey/sugar solution that was discarded from the record. Survivorship of the parasitoid was recorded every six hours till all the test parasitoids died. The variables, adult male and female longevities among treatments, were compared using from ANOVA, SPSS V. 19; 2011 by Tukey's Post-hoc Test at 0.05 level.

Males of *T. zahiri* lived for 47.2 to 91.2 hours when different diets were provided to the parasitoids. The highest longevity (91.2 hours) was found when honey 25% solution was provided with the host food and the lowest was found in control (Table 7). Female longevity was 4 to 10 hours longer than the male when different diets were provided. Longevity of the female *T. zahiri* ranged from 51.2 to 96.0 hours on different diets. Longevity of both sexes were the highest when 25% honey solution was provided with host food and the lowest in control when only water was used as diet. No significant difference was observed in male longevity when honey and sugar 25% solutions were provided separately with host food. But in case of the female, longevity was found as the highest on honey 25% solution than sugar 25% solution and the difference was significant.

INTEGRATED PEST MANAGEMENT

Validation of the component technologies for BPH management in Sirajganj

To select a suitable package of management technologies for BPH control in HYV Boro rice and to popularize adoption of improved management practices among the participating farmers for controlling BPH in rice.

To validate the component technologies developed so far at BRRI, an experiment was conducted using BRRI dhan29 in farmers' fields at BPH prone area. The treatments were- a) spacing (20- × 20-cm), b) integrated management c) use of single nozzle sprayer, d) use of double nozzle sprayer (insecticide application) and e) control (untreated). In integrated management 10 straw tepees were placed for spider conservation. In addition, duck-weed was introduced in the plot for conservation of green mirid bug (a voracious predator of BPH and WBPH). Only one application of insecticide was made in each of single nozzle and double nozzle sprayer.

Forty farmers having large rice fields (approximately 0.1378 ha) were selected in the project area. Fields were selected randomly to cover the entire rice growing area of the project site. Each of the field /plot was divided into two equal parts. One part of the field remained under the respective farmer's supervision without any intervention. The remaining part was managed

Table 7. Male and female longevity of *T. zahiri* on different diets.

Diet	Observation (no.)	Adults longevity of *T. zahiri* (hour) (Mean ± SE)	
		Male	Female
Sugar 25% solution	15	47.2± 2.98c	51.2 ± 4.06c
Honey 25% solution	15	60.4 ± 4.70bc	70.8 ± 5.82b
Host food (RH egg)	15	67.2 ±5.34b	72.0± 5.65b
Host food+ Sugar 25% solution	15	78.4± 4.95a	84.8± 5.30b
Host food+ Honey 25% solution	15	91.2 ± 5.34a	96.0± 6.33a
Control (Water as diet)	15	21.6± 1.83d	30.1± 2.38d
	F- value**31.513	**36.092	

Data were analysed using ANOVA; **P<0.001; values within the column followed by different letters were significantly different at the 5% of Tukey's Post-hoc Test.

under a single component technology (researcher managed field). Each component was assigned to eight farmers' fields considering as replications. The experiment was laid out in a RCB factorial design.

Incidence of BPH was recorded by collecting data from 20 randomly selected hills along with the diagonal of each field at 10 days interval. The yield was estimated from 20m^2 harvest area from each plot and analyzed statistically. In addition, yield components were also studied by sampling 2 hill × 2 hills from three randomly selected sites of each field. All the data collected were analyzed by using MSTAT.

The abundance of BPH and WBPH in different treatments showed that population of both the hoppers was very low until the last week of April. The population became higher only on 28 April both in research and farmers' managed fields. In all the treatments population of BPH and WBPH were significantly lower than that of the control. Data could not be collected from farmers' managed field on 6 and 17 April due to unavoidable circumstances. There was no significant difference in BPH and WBPH population among the treatments up to 28 April. But at harvest the population of the hoppers crossed economic threshold level in all the treatments and control plots except the plot having sprayed by double nozzle sprayers. Accordingly, significantly higher yield was obtained in double nozzle sprayer operated plot. This was probably due to a better coverage of insecticide application by double nozzle sprayer, which controlled planthoppers efficiently. There was also a significant difference in yield between single and double nozzle sprayer use. Integrated management plot yielded slightly lower than the other treatments (Table 8). Irrigation water in integrated management plot was drained out time to time to suppress the planthopper population, which might have affected the yield in this treatment.

Interaction effect of different treatments and yield with farmers and research managed field also produced similar results as above (Table 9). However, research managed field had slightly higher yield (2.12%) than the farmers managed field (Table 10). Insecticide and other management practices applied in appropriate time and with a right dose in the research managed field might be responsible for the higher yield than the farmers managed field.

While conducting participatory on-farm trial on the planthoppers, different practices done in farmers managed field were monitored. In addition to transplanting, weeding and irrigation, three farmers applied insecticide 1-2 times to control BPH and stem borer. Different insecticides (ie Virtako, Sopcin, Mipcin, Beauty, Heritage, Pikopit) were used for this purpose. Two farmers applied fungicide (Tilt, Sidozol) only once against rice fungal disease. Herbicide (Serial) was also used only once by all the participatory farmers 10 days after transplanting.

Integrated management of rice stem borer in Barisal region

To validate and demonstrate stem borer management technologies, the trial was conducted in farmers' field using BRRI dhan29 in three locations of Barisal sadar upazila. The locations were selected on the basis of uniformities in land

Table 8. Effect of different treatments on the incidence of BPH, WBPH and yield in Boro rice 2012, Tarash, Sirajganj.

Treatment	Population (no./hill)						Yield (t/ha)
	6 March	17 March	27 March	6 April	17 April	28 April	
			Brown planthopper				
Spacing (20 x 20 cm)	0.00	0.00	0.00	0.00	0.13	0.84 b	8.62 b
Integrated management[1]	0.01	0.00	0.00	0.00	0.24	1.78 b	8.08 c
Use of single nozzle[2]	0.00	0.00	0.00	0.07	0.11	0.82 b	8.45 b
Use of double nozzle[3]	0.00	0.00	0.02	0.01	0.51	1.16 b	9.07 a
Control (untreated)	0.01	0.00	0.02	0.07	0.13	7.72 a	8.70 b
LSD (5%)	0.01	0.01	0.03	0.12	0.47	1.95	0.31
			White backed planthopper				
Spacing (20 x 20 cm)	0.00	0.00	0.23	0.05	0.13	0.60 b	8.62 b
Integrated management[1]	0.00	0.01	0.25	0.09	0.13	0.83 b	8.08 c
Use of single nozzle[2]	0.00	0.00	0.22	0.09	0.13	0.58 b	8.45 b
Use of double nozzle[3]	0.00	0.22	0.38	0.11	0.19	0.60 b	9.07 a
Control (untreated)	0.00	0.17	0.26	0.07	0.16	3.82 a	8.70 b
LSD (5%)	0.00	0.12	0.09	0.07	0.09	1.35	0.31

Values within the column followed by different letters were significantly different at the 5% of LSD. [1]Straw tepee established for spider conservation; duck weed introduced for green mirid bug conservation; [2] and [3]One application of insecticide was made.

Table 9. Interaction effect of different treatments on the incidence of BPH and WBPH in farmers and research managed field and on the yield, Tarash, Sirajganj, Boro 2012.

Treatment	Population (no./hill)												Yield (t/ha)	
	6 March		17 March		27 March		6 April		17 April		28 April			
	R	F	R	F	R	F	R	F	R	F	R	F	R	F
						Brown planthopper								
Spacing (20- × 20-cm)	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.27	0.00	0.59c	1.09 c	8.80b	8.44d
Integrated management[1]	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.49	0.00	1.65c	1.91 c	8.02e	8.15e
Single nozzle[2]	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.22	0.00	0.68c	0.96 c	8.64c	8.26e
Double nozzle[3]	0.01	0.00	0.00	0.01	0.03	0.01	0.01	0.00	1.03	0.00	0.86c	1.47 c	9.15a	8.99a
Control (untreated)	0.01	0.01	0.00	0.00	0.02	0.00	0.13	0.00	0.26	0.00	6.33b	9.15a	8.76c	8.63c
LSD 5%	0.02	0.01	0.04	0.17	0.66	2.77	0.44	0.02	0.01	0.04	2.76	2.76	2.76	0.44
						White backed planthopper								
Spacing (20- × 20-cm)	0.00	0.00	0.00	0.01	0.17	0.29	0.11	0.00	0.25	0.00	0.30b	0.91b	8.80b	8.44d
Integrated management	0.00	0.00	0.01	0.01	0.23	0.26	0.19	0.00	0.26	0.00	0.61b	1.04b	8.02e	8.15e
Single nozzle	0.00	0.00	0.00	0.00	0.15	0.29	0.18	0.00	0.26	0.00	0.34b	0.82b	8.64c	8.26c
Double nozzle	0.00	0.00	0.00	0.44	0.32	0.44	0.21	0.00	0.39	0.00	0.31b	0.89b	9.15a	8.99a
Control (untreated)	0.00	0.00	0.01	0.33	0.19	0.33	0.14	0.00	0.31	0.00	4.52a	3.11a	8.76bc	8.63c
LSD 5%	0.00	0.17	0.13	0.09	0.13	1.91	0.44	0.00	0.17	0.13	1.91	1.91	1.91	0.44

R=Research managed filed; F=Farmers managed field; values within the column followed by different letter(s) were significantly different at 5% LSD. [1]Straw tepee established for spider conservation; duck weed introduced for green mirid bug conservation. [2] and [3]One application of insecticide.

Table 10. Research and farmers' management effect on the incidence of BPH, WBPH and yield of farmers and research managed field, Tarash, Sirajganj, Boro 2012.

Treatment	Population (no./hill)						Yield (t/ha)	Yield increase over farmers' management (%)
	6 March	17 March	27 March	6 April	17 April	28 April		
				Brown planthopper				
Research managed	0.01	0.00	0.01	0.06	0.45	2.02	8.67	2.12
Farmers managed	0.01	0.01	0.01	0.00	0.00	2.91	8.49	-
LSD (5%)	0.006	0.0044	0.0157	0.0755	0.2970	1.23594	0.196387	
				White backed planthopper				
Research managed	0.00	0.00	0.21	0.17	0.30	1.22	8.67	2.12
Farmers managed	0.00	0.16	0.32	0.00	0.00	1.35	8.49	-
LSD (5%)	0.00	0.0748	0.059316	0.0419	0.0592	0.85513	0.196387	

type, variety cultivated and other cultural practices. Seedlings were transplanted at 20- × 20-cm spacing in plots measuring 600-800 m^2 in each location. There were four treatments-

- T_1 =Collection of egg mass, sweeping and perching,
- T_2 =Collection of egg mass, sweeping, perching and ETL based insecticides application,
- T_3 =Prophylactic insecticides application, and
- T_4 =Farmers practices (control).

The plots were exposed to natural infestation of the insect pests. Data were collected as dead hearts (DH) at vegetative stage and white heads (WH) at reproductive stage from 20 randomly selected hills along the diagonals of each plot. All other data such as collection of egg mass, sweeping were also taken as required.

In general, stemborer infestation was low at the early stage of the Boro crop. DH counts taken at vegetative stage showed that the infestation level was below the ETL level. More or less a similar infestation level was also found in the reproductive stage. WH counts also did not cross the ETL level. So, ETL based insecticide application was not done during the experimental period. The highest level of DH (2.85%) was observed in T_2 plot although collection of egg mass, sweeping and perching methods were applied in these plots. However, no significant difference was found in the level of infestation of DH and WH among the treatments (Table 11). Prophylactic application of insecticides at 15 days interval failed to show any significant differences in the level of infestation with the other methods (Table 11).

The result of trial conducted in Boro season showed no significant difference in the level of stem borer infestation and yield among the treatments, which indicate that the farmers did not get benefit from the application of insecticides against stem borers in such low level of infestations.

CROP LOSS ASSESSMENT

Relationship between rice hispa (RH) damage and yield loss

To determine the yield losses of different BRRI varieties due to RH damage was studied at BRRI HQ farm, Gazipur during Aus and T. Aman 2011 and Boro 2012 seasons. Three Aus varieties (BRRI dhan42, BRRI dhan43 and BRRI dhan48), four T. Aman varieties (BRRI dhan51, BRRI dhan52, BRRI dhan53 and BRRI dhan54) and three Boro hybrid varieties (BRRI hybrid dhan1, BRRI hybrid dhan2 and BRRI hybrid dhan3) were included in the study. The varieties were grown in plots measuring 5- × 4-m in size. The experiments were designed in RCB with four replications. Forty days after transplanting, four rice hills from each plot (represented as a replication) were covered by white nylon mesh nets and 20 pairs of adult hispa beetles were released in each cage. Similarly, another set of four hills from each of the same plots were also covered by same types of nets but without hispa beetles and were treated as control. The beetles were removed after incurring 60% leaf damage in all the seasons. The plant and yield contributing characters such as tiller number, plant height, stem and leaf weight, panicle number, filled grain number and weight were recorded.

In Aus 2012, yield losses ranged from 4.962% to 50% (Table12). The highest yield loss occurred in BRRI dhan48 (50%) and the lowest in BRRI dhan42 (4.96%). Among the plant and yield contributing characters plant height was reduced due to hispa damage for all the varieties. The

Table 11. Effect of different management practices against stem borers in Barisal, Boro 2012.

Treatment	Dead heart (%)	White head (%)	Yield (t/ha)
T_1=Collection of egg mass, sweeping and perching	0.92	2.17	6.97
T_2=T_1 plus ETL based insecticides application	2.82	1.43	7.46
T_3=Prophylactic insecticides application	0.75	1.16	6.19
T_4=Farmers' practices (Control)	2.25	1.76	6.97
F-value	0.607	0.324	0.689
Significant	NS	NS	NS

Data were analyzed using ANOVA; NS: not significantly different at the 5% level of Tukey's post hoc test.

Table 12. Effect of hispa damage on the yield, yield components and plant characteristics of BRRI varieties, BRRI HQ farm, Gazipur, Aus 2011, T. Aman 2011 and Boro 2012.

Variety	Damage status	Plant height (cm)	Panicle (no./hill)	Leaf wt (g)	Stem wt (g)	Filled grain (no./hill)	Filled grain wt (g/hill)	Yield loss (%)
				Aus 2011				
BRRI dhan42	Infested	86.06 b	6.19 a	8.49 a	3.14 a	236.13 a	7.09 a	
	Control	93.69 a	7.69 a	9.63 a	3.24 a	261.25 a	7.46 a	4.96
	LSD (5%)	5.80	1.85	2.01	0.73	93.45	3.22	
BRRI dhan43	Infested	88.69 b	5.63 b	8.99 b	3.19 b	201.19 a	4.55 a	
	Control	96.69 a	8.69 a	13.98 a	4.03 a	311.69 a	6.33 a	28.12
	LSD (5%)	6.29	2.16	2.87	0.69	110.60	2.21	
BRRI dhan48	Infested	80.31 b	6.44 a	8.71 a	3.37 a	302.38 b	7.78 b	
	Control	87.06 a	7.81 a	10.36 a	3.83 a	583.94 a	15.56 a	50.00
	LSD (5%)	2.99	1.81	2.33	0.65	155.54	3.70	
				Aman 2011				
BRRI dhan51	Infested	77.75 b	9.56b	9.51b	3.21 b	550.75 b	10.64 b	
	Control	85.63 a	11.94 a	13.35 a	5.31 a	911.94a	18.77 a	43.31
	LSD (5%)	3.59	2.37	3.18	1.04	206.79	4.14	
BRRI dhan52	Infested	100.56 b	7.56 b	12.58 b	4.43 b	452.13 b	11.15 b	
	Control	109.56 a	10.13 a	19.28 a	6.90 a	836.06 a	19.81 a	43.72
	LSD (5%)	5.52	1.48	3.19	1.24	170.48	3.15	
BRRI dhan53	Infested	92.88 b	10.13a	9.72 b	2.73 b	604.94 b	14.23 b	
	Control	104.88 a	11.44a	14.10 a	4.06 a	918.61a	20.55 a	30.75
	LSD (5%)	8.27	1.64	3.23	0.89	218.96	6.27	
BRRI dhan54	Infested	97.19 b	8.38 b	10.51 b	3.92 b	494.75 b	12.49 b	
	Control	115.44 a	10.38 a	16.35 a	6.39 a	871.13a	22.57 a	44.66
	LSD (5%)	5.74	1.74	3.13	1.21	236.87	5.45	
				Boro 2012				
BRRI hybrid dhan1	Infested	83.44 b	8.88 a	2.93 a	11.38 a	398.44 b	10.74 b	
	Control	94.63 a	9.63 a	3.74 a	13.57 a	613.69 a	17.13 a	37.24
	LSD (5%)	5.37	2.14	3.54	1.00	148.17	4.15	
BRRI hybrid dhan2	Infested	82.25 b	6.13 a	2.23 a	7.25 b	464.75 a	12.71a	
	Control	87.25 a	7.13 a	2.92 a	9.43 a	604.06 a	15.04 a	15.43
	LSD (5%)	3.89	1.75	2.06	0.92	192.83	4.65	
BRRI hybrid dhan3	Infested	80.50 b	6.44 b	1.98 b	11.38 a	408.69 b	11.74 b	
	Control	87.19 a	8.19 a	3.38 a	11.14 a	661.50 a	17.66 a	33.94
	LSD (5%)	6.15	1.72	9.00	0.66	180.25	3.67	

Values within a column followed by different letters were significantly different at the 5% level.

panicle/hill, leaf weight and stem weight were reduced only in BRRI dahn43. Number of filled grain was affected in case of BRRI dhan48.

Varying degrees of yield losses, ranging from 30.75 to 44.66% for the test varieties were observed in T. Aman season (Table 12). The highest yield loss occurred in BRRI dhan54 (44.66%) and the lowest in BRRI dhan53 (30.75%). Among the plant and yield contributing characters plant height, leaf weight, stem weight, filled grain weight were significantly reduced in damaged plants in comparison to undamaged ones. Panicle no./hill was significantly reduced in the varieties except BRRI dhan53 (Table 12).

In Boro season, yield losses ranged from 15.43 to 37.24% (Table 12). The highest yield loss occurred in BRRI hybrid dhan1 (37.24%) and the lowest in BRRI hybrid dhan2 (15.43%). Plant height was significantly reduced in all the varieties due to rice hispa damage. No significant difference was found in case of panicle number and leaf weight for BRRI hybrid dhan1 and BRRI hybrid dhan2. Filled grain number and filled grain weight were also reduced in the varieties except BRRI hybrid dhan2. Stem weight was affected only in BRRI hybrid dhan2 (Table 12).

EVALUATION OF CHEMICALS AND BOTANICALS

Evaluation of commercial insecticides against major insect pest of rice

To evaluate the efficacy of different commercial formulations of insecticide against major insect pests of rice several trials were conducted at BRRI HQ farm during the reporting year.

Brown planthopper. The experiments were conducted in a large field of BR3 divided into unit plot of 20 m^2. In each of the plots a test insecticide was applied and one hour after spraying of test insecticides, ten 3^{rd}-4^{th} instar BPH nymphs were confined by mylar film cages on four randomly selected rice hills. Each hills represented a replication. Another plot of the same size was used as control without insecticide. Four hills were also selected randomly from the control plots and same numbers of test insect were confined with the same procedure. The granular insecticides were broadcast one day before infestation. Mortality of insects was counted both from treated and untreated plots at 24 and 48 hours after treatment (HAT) and the results were adjusted by Abbott's formula.

Rice hispa. Same procedure like BPH was followed for evaluating insecticides against RH. Adult beetles were used in the trials.

Yellow stemborer. For YSB trial, the field lay-out and unit plot size was similar to as described above. Four randomly selected rice hills per plot were separately infested with the 1st instar larvae emerging from one egg mass. Test insecticides were applied after one to two hours of infestation. The same plants were infested again with new larvae at 48 hours of spraying. The dead hearts were counted at 20 days after insecticide application.

Out of 200 tested insecticides, 114 (32 in Aus, 33 in Aman and 49 in Boro season) against BPH, 29 (11 in Aus, 9 in Aman and 9 in Boro season) against RH (showing more than 80% mortality) and 22 (13 in Aman and 9 in Boro season) against YSB (reduced deadheart 80% or above) were found effective in the trials conducted during the year (Tables 13, 14 and 15).

Table 13. Evaluation of different insecticides against brown planthopper, Aus 2011, T. Aman 2011 and Boro 2012, BRRI, Gazipur.

Insecticide	Dose (f)/ (kg/lt/ha)	Mortality at 48 HAT* (%)
Aus 2011		
Current 70WP (acephate + imidacloprid)	1.75	91.76
Award 40SC (buprofezin)	0.25	100.0
Hicarb 3G (carbofuran)	16.8	100.0
Unitap 50SP (cartap)	1.20	100.0
Digifuran 5G (carbofuran)	10.0	91.00
Splendor 70WG (imidacloprid)	0.0357	100.0
Kreshok Bandhu 200SL (imidacloprid)	0.125	100.0
Paradan 5G (carbofuran)	10.0	88.00
Laphos 20EC (chlorpyrifos)	1.00	100.0
Larvaedan 5G (carbofuran)	10.0	100.0
Freshtap 50SP (cartap)	1.20	100.0
Commando 50SP (cartap)	1.20	100.0
Eurogent 50SC (fipronil)	0.50	82.76
Zabat 25WG (thiamethoxam)	0.06	100.0
Agronil 3GR (fipronil)	10.0	68.96
Rex 20SL (imidacloprid)	0.125	100.0
Mavel XL 25WG (thiamethoxam)	0.06	96.67
Kingfuran 5G (carbofuran)	10.0	93.10
Rajsun 10G (diazinon)	16.8	100.0
Roster 5G (emamectin benzoate)	0.50	58.62
R-Furan 5G (carbofuran)	10.0	82.35
Fasalfuran 5G (carbofuran)	10.0	87.09
Redport 48EC (chlorpyrifos)	0.50	100.0
Lemozim 10GR (diazinon)	16.8	96.96
Prince 3GR(fipronil)	10.0	81.82
Beauty 200SL (imidacloprid)	0.125	97.00
Mc Tara 25WG (thiamethoxam)	0.06	86.00
Filfil 50SP (cartap)	1.20	87.50
Hitler 48EC (chlorpyrifos)	0.50	100.0
Renaphos 48EC (chlorpyrifos)	0.50	47.00
Mactap 50SP (cartap)	1.20	100.0
Aqiphos 480EC (chlorpyrifos)	0.50	100.0
Dhanphos 48EC (chlorpyrifos)	0.50	100.0
Gunfuran 5G (carbofuran)	10.0	82.35
Prolin 50SC(fipronil)	0.50	96.55
T. Aman 2011		
Award 40SC (buprofezin)	0.25	87.05
Splendor 70WG (imidacloprid)	35.7	96.67
Rex 20SL(imidacloprid)	0.125	100.0
Marvel XL 25WG (thiamethoxam)	0.06	94.00
Imidaf 200SL (imidacloprid)	0.125	100.0
Fire 200SL (imidacloprid)	0.125	100.0
Feeder 20SL (imidacloprid)	0.125	96.97
F-Furan 5G (carbofuran)	10.0	93.94
Blefuran 5G (carbofuran)	10.0	82.35
Fair 50SC (fipronil)	0.50	100.0
Microfuran 5G (carbofuran)	10.0	91.76
Monomehypo 90SP (monomehypo)	1.0	90.91
Ravnil 50SC (fipronil)	0.50	100.0
Duranta 5G (carbofuran)	10.0	96.88
Agrozinon 10G (diazinon)	16.8	96.88
Ravzinon 60EC (diazinon)	1.00	100.0

Table 13. Continued.

Insecticide	Dose (f)/ (kg/lt/ha)	Mortality at 48 HAT* (%)
Benten 1.8EC (abamectin)	1.00	100.0
Jarda 20SP (acetamiprid)	0.125	53.57
Dotara 25WG (thiamethoxam)	0.06	85.00
E-phate 75SP (acephate)	0.75	100.0
Segatin 1.8EC (abamectin)	1.00	100.0
Lagent 50SC (fipronil)	0.50	94.00
Dynamic 40EC (dimethoate)	1.0 0	96.67
Fresh furan 5G (carbofuran)	10.0	96.55
Pergent 50SC (fipronil)	0.50	100.0
Panama 20SL (imadicloprid)	0.125	89.29
Ronil 5% SC (fipronil)	0.50	100.0
Hiramon 48EC (chlorpyrifos)	0.50	22.7
Aniter 48EC (chlorpyrifos)	0.50	100.0
Gevin 85WP (carbaryl)	1.50	96.67
Shooter 48EC (chlorpyrifos)	10.0	100.0
Goldifuran 3G (carbofuran)	16.8	96.77
Dhanfan 20EC (carbosulfan)	1.00	96.67
Agronet 50 SC (fipronil)	0.50	100.0
Cooper 20EC (carbofuran)	1.00	100.0
Boro 2012		
Vicar 50SC (fipronil)	0.50	97.00
T-Tap 50 SP (cartap)	1.20	96.67
Totonil 50SC (fipronil)	0.50	96.67
Jamuna 20SL (imidacloprid)	0.125	93.75
Zee-fresh 48EC (chlorpyrifos)	0.50	97.96
Imita 20SL (imadicloprid)	0.125	96.67
Meemnil 50SC (fipronil)	0.50	91.76
Cherry 20SP (acetamiprid)	0.125	57.14
Perfectsulfan 20EC (carbosulfan)	0.50	96.88
Popular gold 48EC (chlorpyrifos)	0.50	93.75
Carbadan 5G (carbofuran)	10.0	85.29
Sacronil 50SC (fipronil)	0.50	97.14
Re-ban 48EC (chlorpyrifos)	0.50	96.88
Agrigent 50SC (fipronil)	0.50	97.96
Nurfuran 5G (carbofuran)	10.0	96.67
Kismot 48EC (chlorpyrifos)	0.50	96.67
Superfos 48EC (chlorpyrifos)	0.50	97.96
Curfew 70WG (imadicloprid)	0.0357	75.00
Profidor 70WG (imadicloprid)	0.0357	82.73
Image 5WG (imamectin benzoate)	0.50	71.43
Razudin 10GR (diazinon)	16.8	97.09
Mayaplus 20SL (imidacloprid)	0.125	93.00
Suzinon 10GR (diazinon)	16.8	90.00
Mimcarb 3G (carbofuran)	16.8	83.00
Manik 20SP (acetamiprid)	0.125	42.86
Polyphate 75SP (acephate)	0.75	97.67
McZinex 60EC (diazinon)	1.00	96.67
McZinex 10G (diazinon)	10.0	81.82
Startap 50SP (cartap)	1.20	97.50
Prasser 5G (imamectin benzoate)	0.50	76.47
Ba-furan 3G (carbofuran)	16.8	90.00
Hit 10G(diazinon)	16.8	93.33
Imida 20SL (imadicloprid)	0.125	70.59
Wintap 50SP (cartap)	1.20	97.14
Winran 5G (carbofuran)	10.0	94.29

Table 13. Continued.

Insecticide	Dose (f)/ (kg/lt/ha)	Mortality at 48 HAT* (%)
AME 20SL (imidacloprid)	0.125	96.88
Agroprid 200SL (imidacloprid)	0.125	85.29
Furasun 5G (carbofuran)	10.0	96.77
Dyfuran 5G (carbofuran)	10.0	84.85
Biogent 50SC (fipronil)	0.50	96.88
Sudin 10G (diazinon)	16.8	94.12
Agrofuran 5G (carbofuran)	10.0	96.97
Bir 25WG (thiamethoxam)	0.06	91.18
Pranha 25WP (buprofezin+isoprocarb)	22.5	93.75
Star 50SC (fipronil)	0.50	96.88
N-Furan 5G (carbofuran)	10.0	83.00
Agent 50SC(fipronil)	0.50	93.94
Digit 60EC (diazinon)	1.00	87.88
Quiz extra 25WG (thiamethoxam)	0.06	91.25
Random Star 25WG (thiamethoxam)	0.06	84.85
Waprocarb 75 WP (isoprocarb)	1.30	83.00
Calta 48EC (chlorpyrifos)	0.50	88.88
Filnon 10G (diazinon)	16.8	91.25
Kubaryl 85WP (carbaryl)	1.50	97.05
Seron 50EC (lufenuron)	0.50	82.50

f=Formulated, HAT=Hours after treatment. *Corrected by Abbott's formula.

Table 14. Evaluation of different insecticides against yellow stemborer, T. Aman 2011 and Boro 2012, BRRI, Gazipur.

Insecticide	Dose (f)/ (kg/lt/ha)	Deadheart reduction over control (%)
T. Aman		
Chlorpyrifos 48EC (chlorpyrifos)	0.50	91.00
Kurasun 5G (carbofuran)	10.0	93.25
Legend 3GR (fipronil)	10.0	88.75
Sunfura 5G (carbofuran)	10.0	94.25
Padmajin 10G (diazinon)	16.8	54.50
Defuran 3G (carbofuran)	16.8	94.25
Kingfuran 5G (carbofuran)	10.0	44.75
Guntap 50SP (cartap)	1.40	96.00
Nicodan 5G (carbofuran)	10.0	65.75
Sarnifuran 3G (carbofuran)	16.8	94.25
S-Furan 5G (carbofuran)	10.0	56.25
Advantage 20EC (carbosulfan)	1.00	74.00
Keenfuran 5G (carbofuran)	10.0	73.75
BT Furan 5G (carbofuran)	16.8	68.00
Bashidhanpuls 5G (carbofuran)	10.0	92.00
Mimtap 50SP (cartap)	1.40	74.00
Meemzinon 10G (diazinon)	16.8	21.05
Prince 3GR (fipronil)	10.0	86.68
Adzoate 5WDG (emamectinbenzoate)	0.50	31.30
Suzinon 10G (diazinon)	16.8	50.00
B-Furan 5G (carbofuran)	10.0	16.25
Amafuran 5G (carbofuran)	10.0	81.25
Aclaim 5G (emamectin benzoate)	0.50	56.67
Rocket 50SP (cartap)	1.40	92.97

Table 14. Continued.

Insecticide	Dose (f)/ (kg/lt/ha)	Deadheart reduction over control (%)
Geviban 20EC (chlorpyrifos)	1.00	64.25
Camfuran 5G (carbofuran)	10.0	90.12
Refute 48EC (chlorpyrifos)	0.50	39.00
Anifuran 5G (carbofuran)	10.0	91.35
Boro		
Ecofuran 5G (carbofuran)	10.0	86.54
Heritage 10G (diazinon)	16.8	86.82
Harvest 3G (carbofuran)	16.8	93.25
Itafuran 5G (carbofuran)	10.0	63.95
Sarnizinon 10G (dazinon)	16.8	89.77
Heera 5G (carbofuran)	10.0	76.45
Digital 10G (diazinon)	16.8	90.83
Crazy 4GR (cartap)	13.5	63.16
Starfuran 5G (carbofuran)	10.0	50.00
Benfuran 5G (carbofuran)	10.0	25.00
Furaban 5G (carbofuran)	10.0	82.80
Zeefuran 5G (carbofuran)	10.0	66.67
Rav-zoom 14.5SC (indoxacarb)	0.50	81.61
Zaza 14.5SC (indoxacarb)	0.50	83.00
Genidin 10G (diazinon)	16.80	83.25

f=Formulated.

Table 15. Evaluation of different insecticides against rice hispa, Aus and Aman 2011 and Boro 2012, BRRI, Gazipur.

Insecticide	Dose (f)/ (kg/lt/ha)	Mortality at 48 HAT* (%)
Aus 2011		
Nemok 50SP (cartap)	0.80	100.0
Siamthion 57EC (malathion)	1.12	97.50
Hilton 50EC (chlorpyrifos)	0.40	100.0
Bicomiprid 20SP (acetamiprid)	0.125	100.0
Positron 3GR (fipronil)	10.0	87.09
Aroma 3GR(fipronil)	10.0	97.00
Koradanplus 5G (carbofuran)	10.0	93.00
Pounder 600EC (diazinon)	1.00	72.0
Cibadin 10G (diazinon)	16.8	88.24
Besttap 50SP (cartap)	0.80	100.0
Delay 20EC (chlorpyrifos)	1.00	100.0
Locker 20SL (imidacloprid)	0.125	88.24
T. Aman		
Borshan 40EC (dimethoate)	1.12	97.00
Spider 50EC (chlorpyrifos)	0.40	97.22
Hilton 50EC (chlorpyrifos)	0.40	100.0
Positron 3GR (fipronil)	10.0	91.66
Besttap 50SP (cartap)	0.8	100.0
Field Star 500EC (chlorpyrifos)	0.4	97.22
Prolin 20EC (chlorpyrifos)	1.0	62.23
Agrotap 50SP (cartap)	0.8	100.0
Dyfos 48 EC (chlorpyrifos)	0.5	100.0
Regiment 50SC (fipronil)	0.5	100.0
Boro		
Kisho 48 EC (chlorpyrifos)	0.50	90.91

Table 15. Continued.

Insecticide	Dose (f)/ (kg/lt/ha)	Mortality at 48 HAT* (%)
Kik 40 EC (dimethoate)	1.12	86.00
Clear 48EC (chlorpyrifos)	0.50	100.0
Mamkiller 48EC (chlorpyrifos)	0.50	100.0
Refute 48EC (chlorpyrifos)	0.50	56.76
Taloar 3G (fipronil)	10.0	81.82
Smooth 75WP (isoprocarb)	1.30	96.67
Wind 75 WP (isoprocarb)	1.30	100.0
Jarda 20SP (acetamiprid)	0.125	97.69
Fasalfos 48EC (chlorpyrifos)	0.50	97.05

f=Formulated, HAT=Hours after treatment. *Corrected by Abbott's formula.

HOST PLANT RESISTANCE

Screenings of lines/varieties against major insect pests of rice

To identify resistant sources against major insect pests, 118 entries (106 advanced lines, nine T. Aman genotypes and three submergence tolerant genotypes) were screened against BPH and GLH during 2011-12. The screening was carried out by seedling bulk test method in the greenhouse of Entomology Division, BRRI. Out of 106 advanced lines (T. Aman and Boro) 16 were found promising against BPH. Out of the nine genotypes for insect resistance in T. Aman, three were found promising against GLH. Out of the three submergence tolerant genotypes, one and two were found promising against BPH and GLH respectively. Table 16 shows the numbers of total materials and the promising entries along with their source, designation and their scores against respective tested insects.

Screenings of IRRI materials against BPH

To identify resistant sources against BPH, 39 IRBPHN (received from IRRI during 2010) were screened against BPH by seedling bulk test method in the greenhouse of BRRI Entomology Division.

Out of 39 IRBPHN materials, 18 materials were found promising against BPH. Table 17 shows the scores of the promising entries with their designation and entry number.

Screening of rice genotypes against gall midge

To identify resistant sources against gall midge, 53 materials (51 test entries and two checks) were

Table 16. Reaction of different materials against BPH and GLH, Entomology green house, BRRI, Gazipur 2009-10.

Seed source/season	Entry (no.)	Target pest	Promising materials	Score
Advanced line (Aman) 2010-11	79	BPH	BR7950-8-1-2	5
			BR7950-11-2-1	5
			BR7629-11-1-2-2-2	5
			BR7611-55-3-3-3	5
			BR7611-70-2-2-2	5
			BR7611-86-3-2-1	5
			BR7611-86-3-2-2	5
			BR7614-52-3-2-1	5
			BR7614-90-3-2-2	5
			BR7803-16-10	5
			BR7799-4-1	5
			BR7799-7-3	5
			BR7950-8-1-2	5
			BR7950-11-2-1	5
			BR7948-15-1-2	5
Advanced linesBoro 2010-11	27	BPH	BR7803-9-1	5
Genotype for insect resistance (T. Aman 2011-12)	5	BPH	None	
		GLH	BR7878-*5(NIL)-72-HR6	5
Submergence tolerant genotypes	3	BPH	PSBRC82-sub1	5
		GLH	IR64-Sub1	1-3
			Ciherang-Sub1	3-5
Genotype for insect resistance (T. Aman 2011-12) Letter no. Breeding-19(1)/600 and Date30/30/2011	4	GLH	BR7358-5-3-2-1	5

Susceptible check- BR3 (for all), Resistant check- T27A, IR64 and Ptb 18 for BPH, WBPH and GLH respectively. Scores were made according to SES.

Table 17. Promising lines of IRRI 2011 materials and their score, Entomology Green House, BRRI, Gazipur 2010-11.

Seed source/season	Entry (no.)	Target pest	Promising materials	Score
BPH resistance materials (IRRI)	39	BPH	IR24	5
			Mudgo	5
			IR65482-4-136-2-2	5
			IR65482-7-216-1-2	5
			ASD7	5
			IR71033	5
			IR62	5
			IR72	5
			Rathu Heenati	5
			IR66	5
			IR74	3
			IR70	3-5
			Babawee	3
			IR22	5
			Utri rajapan	5
			ARC 6650	5
			N Diang Marie	3
			MO 1	3

Susceptible check- BR3 and resistant check- T27A were used. Scores were made according to SES.

screened against gall midge under net house condition. BRRI dhan44 was used as susceptible check, whereas BRRI dhan33 as the resistant check. A plot of 6.1- × 4.2-m was divided into three blocks each measuring 6.1- × 0.9-m. Each material was sown in 90cm long line randomly in every block. Thus the experiment was conducted in RCB design with three replications. At 20 DAT, 200 mated females were released in the net house and allowed to lay eggs on the test materials. A 27-32°C temperature and 80-90% RH situation was maintained in the net house during the experiment.

Onion shoots formed on the test materials were recorded and per cent onion shoot of each line was calculated. The infestation of rice gall midge at net house condition was very low. Although, susceptible check BRRI dhan44 had about 22% onion shoot that was not optimum for varietal screening. No onion shoot was observed in resistant check BRRI dhan33.

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SUMMARY

Survey and monitoring shows that aromatic rices were more susceptible to neck blast disease than the other HYVs. Twenty-five advanced breeding lines were tested against bacterial blight (BB) and sheath blight (ShB) disease and only five materials showed moderately resistance reaction to ShB. Among the tested 85 hybrid materials, only H42 and H61 showed moderately resistant reaction to BB. A total of 224 INGER materials were tested and 10 of them were resistance against the most virulent isolate (BXO9) of BB. The tested pyramid lines showed different types of reaction in different locations and seasons. In most instances, IRBB60, IRBB65 and IRBB66 performed the best against BB pathogen. Among the tested 398 materials, 67 materials found highly resistant against BB with the cluster mean lesion length 1.19 cm. In total, 16 BB races were identified in Bangladesh based on nine NILs. Among them, race 1 is the major race that alone occupied 61% among the 172 tested isolates. Though *Xa21* gene showed susceptible reaction to some isolates, the resistance frequency of that gene was still 89.5% that may be used as candidate gene for developing BB resistant rice variety in Bangladesh.

A total of 220 blast isolates were screened against MLs. Among the 24 resistant genes, *Pish, pi9, pita-2, piz-5 and pita=pi4(t)* showed higher resistance (>80%) against the tested blast isolates. The frequencies of virulent blast isolates against 31 MLs varied widely from nine to 68%. Specific primers were used to confirm the presence of blast resistance genes in rice varieties having Japonica and Indica background. Out of 20 primers, 18 successfully produced bands in the same position with blast resistance MLs. The primer pita 440 for *pita* gene, OSM 89 and RM 7102 for *pita2* gene, AOL51, AOL54 and AOL351 for *pish* gene, NBS3, NBS4, NBS/LRR and NBL2 for *pi9* gene and primers RM 138, RM 166, RM 208 and SUB 3-4 for *pib* gene were effective in producing corresponding bands. In JIRCAS laboratory, Japan 26 blast isolates were tested and found 26 races based on 31 MLs. Blast isolates were categorized into five groups; 10 U blast pathotypes, four for i blast pathotypes, eight for k blast pathotypes, seven for z blast pathotypes and seven for ta blast pathotypes. Dominant blast pathotypes were U73, i4, k100, z05, z07 and ta403.

The mean mycelial growth of *R. oryzae-sativae* ranged from 0.28 to 0.45 mm/hr. Among the isolates, the highest mean growth rate (0.45 mm/hr) was recognized with the Mymensingh isolates followed by Jamalpur (0.42 mm/hr). All the isolates of *R. oryzae-sativae* showed virulence to the rice variety BR11. The highest mean lesion height was found from the isolate My1 followed by Na2. The growth of this fungus reduced at very strong acidic and alkaline pH. Abundant sclerotia were formed at pH level 7 while no sclerotia at pH level 3 and 4 after four days of inoculation. Among the six different C sources for *R. oryzae-sativae* growth, Dextrose was the best (0.43 mm/hr) followed by Sucrose (0.42 mm/hr). The highest sclerotial formation was found in Dextrose.

Among six different N sources, the best mycelial growth of *R. oryzae-sativae* was found in peptone (41.25 mm) followed by yeast (38.25 mm) after four days of incubation. Though peptone was found as the best for mycelial growth, with no sclerotia, while the control plate was fully covered with mycelia after 4 days of incubation and with abundant sclerotia.

The optimum temperature for *F. moniliforme* was 25-30°C and pH was 6. The rate of sporulation was high at 30°C after nine days of incubation. Maximum sporulation was found at pH 6.

Among the tested 19 fungicides, Power Blast and Roton 75WP effectively control sheath blight disease and the disease reduction was 82.07%. The seed testing chemical Vitaflo 200 was insensitive to *Fusarium* but controlled 100% *Curvularia* and *Trichoconis.*

SURVEY AND MONITORING OF RICE DISEASES

Survey of rice blast disease in different AEZs of Bangladesh, T. Aman 2011

To know the geographical distribution and severity of blast disease we surveyed 71 rice fields under 15 locations covering five AEZs- AEZ 1, AEZ 2, AEZ 9, AEZ 20 and AEZ 23. Most of the fields were cultivated by rice varieties BRRI dhan34, Kalojira, Begunbichi, Swarna, Baismothi, Lalpajam, BRRI dhan32, Joli Aman, Swarna, Musuri, Lal Fanja, Dholy Fanja, BR11, Chinigura and Balam. The fields were infected by neck blast and disease incidence ranged from 2 to 90% and severity ranged from 1-9 across the locations (Table 1). The highest disease incidence was recorded at Panchagar and Thakurgaon, while the lowest was at Rangpur and Sylhet regions. The neck blast infection was higher in aromatic rice and local varieties compared to HYVs.

DISEASE RESISTANCE AND MOLECULAR STUDIES

Evaluation of genotypes against bacterial blight and sheath blight disease

Twenty-five advanced breeding lines with standard checks of T. Aman and Boro were screened against bacterial blight and sheath blight disease to identify resistant genotypes. For bacterial blight, plants were inoculated at maximum tillering to booting stage. Most virulent and representative isolate of major race (BXO9) was used to inoculate by leaf clipping method. Data on leaf damaged area were collected 14 days after inoculation. For sheath blight, the plants were inoculated with local *Rhizoctonia solani* culture grown on PDA at PI stage in T. Aman season. Relative lesion height (RLH) was taken at dough to maturity stage.

No tested materials showed resistance against bacterial blight except resistant check IRBB65. In case of sheath blight, BR7465-1-4-1, BR7875-5*(NIL)-52-HR1, BR7673-14-2-1-7-1-HR2, BR7840-2-1-1 and BR7840-54-2-5-1 showed moderately resistance.

Evaluation of hybrid genotypes against bacterial blight disease

Eighty-five hybrid genotypes with standard susceptible check (Purbachi) in Boro season were screened against bacterial blight disease to identify resistant hybrid materials. Artificial inoculation was done by BXO9 at booting stage. Disease reaction was taken 14 days after inoculation.

Among the tested materials, only H42 and H61 showed resistance to bacterial blight isolates, and H44, H50 and H64 were moderately resistance.

International Network for Genetic Evaluation of Rice against bacterial blight disease

A total of 224 INGER materials of the 22nd International Rice Bacterial Blight Nursery (IRBBN) received from IRRI were screened against BB (BXO9) to identify the resistant exotic genotypes. The plants were inoculated at the maximum tillering stage by leaf clipping method.

Table 1. Outbreak of blast in T. Aman 2011.

AEZs	Location	Field surveyed	Disease incidence (%)	Disease severity (scale)	Variety
1	Gaibandha	8	10-20	1-3	BRRI dhan34, Kalogira
	Dinajpur	6	10-20	1-3	Begunbichi
	Panchagar	7	50-90	5-9	Kalogira, Begunbichi, Jirashail
	Thakurgaon	6	50-90	5-9	Kalogira, Begunbichi
2	Rangpur	4	2-5	1	Swarna, BRRI dhan34
	Nilphamary	4	2-5	1	Kalogira
9	Sherpur	8	2-20	1-3	Begunbichi, Baismuthi, Balam
	Jamalpur	5	5-20	1-3	Lalpajam, Kalogira
	Mymensingh	5	2-5	1	Hasikalmi, Nayantara
	Tangail	4	5-20	1-3	Pajam, Begunbichi
20	Sylhet	2	2-5	3	BRRI dhan32
	Habiganj	1	3	1	Joli Aman
	Moulovibazar	2	2-5	1-3	Swarno-Musur
23	Chittagong	7	30-50	3-5	Kalogira, Lal Fanja, BR11, Chinigura
		12	5-25	1-3	Kalogira, Dholy Fanja, BR11
Number of fields surveyed:		71			

Among the tested materials IR70454-144-1-1-3-2, IR73004-3-1-2-1, IR73006-8-2-2-1, IR73012-15-2-2-1, IR76479-48-1-3-1, IR76993-49-1-1, IR78581-12-3-2-2, IR78585-64-2-4-3, IR78806-B-B-19-3-1-AJY 1 and IR79233-1-2-1-2 showed resistance to bacterial blight.

Performance of bacterial blight resistant genotypes (pyramid lines) at different AEZs

Ten bacterial blight (BB) resistant genotypes (pyramid lines) with standard checks were evaluated in Aman 2011 and Boro 2011-12 at BRRI, Gazipur; BRRI RS, Barisal, Rajshahi and Sonagazi farm to know their resistance against BB under natural condition. Thirty-five-day-old seedlings @ 2-3 seedlings per hill were transplanted with 20- × 20-cm spacing in 3- × 2-m plot with three replications. In Rajshahi, plants were inoculated artificially with BB isolates (BXO9). Data on yield components, leaf area damage were taken at dough to maturity stage and leaf area damage was converted to disease severity (0-9) following SES (1996).

The tested pyramid lines showed different types of reaction in different locations and seasons. IRBB60, IRBB65 and IRBB66 showed resistance in T. Aman but moderately resistance in Boro seasons. Though, IRBB21 is a monogenic line, it also performed as pyramid lines. The yield was low in T. Aman compared to Boro. The selected materials would be used for development of durable BB resistant rice variety in Bangladesh.

Screening land races against bacterial blight disease

A total of 398 land races collected from GRS Division, BRRI were screened against bacterial blight disease to identify new resistant sources for developing durable BB resistant rice variety in Bangladesh. The experiment was conducted at greenhouse/net house condition and 21-day-old seedlings were inoculated with the most virulent and representative isolate of major race (BXO9) by leaf clipping method. Data on lesion length, relative lesion length and leaf damaged area were collected 14 days after inoculation. Mean data of each character were analyzed by multivariate analysis viz Principal Coordinate Analysis (PCO), Principal Component Analysis (PCA), Cluster Analysis and Canonical Variate Analysis using Genestat 5.5 [Release 4.1 (PC/Windows NT)].

Among the tested materials, 67 materials showed resistance belong to Cluster X (Table 2). The cluster means of the studied characters such as lesion length, relative lesion length and leaf damaged area were minimum 1.19 cm, 5.80 and 2.53% respectively in cluster X (Table 3).

Study of the pathogenic diversity of bacterial blight pathogen

Pathotypic diversity of 172 BB isolates collected from different regions of Bangladesh were tested using nine near isogenic lines (NILs) to identify the existing races of BB pathogen. Plants were inoculated at maximum tillering stage by leaf clipping method. Data on lesion length were collected 14 days after inoculation. A mean lesion length of <3cm was considered as resistant (R).

The isolates of *X. oryzae* pv. *oryzae* were polymorphic for virulence on the nine NILs (Table 4). In total, 16 BB races were identified based on nine NILs. The major race, Race 1 alone occupied 61.0% of the tested isolates. Though *Xa21* gene showed susceptible reaction to some isolates, the resistance frequency of this gene was still 89.5% (Table 5). *Xa21* appeared as major candidate gene against BB pathogen.

Identification of existing races of *Pyricularia grisea* using monogenic lines

Characterization of pathogenic population of *Pyricularia grisea* from blast endemic areas of Bangladesh was done using differential rice varieties to develop durable blast resistant variety. During T. Aman 2011, 550 blast infected plant samples were collected from AEZ 1 and 2, 9, 20 and 23 (Table 6, Fig. 1). Isolation was done and cultures were purified either by single spore following dilution plate method or mycelial tip culture in water agar method.

Diversity studies were conducted using 220 blast isolates. Seedlings of 220 sets of all the monogenic lines (MLs) were grown in trays in the net house. Three-week-old seedlings of each set were inoculated with a single isolate, kept separated and covered with polythene sheet during

Table 2. Distribution of 398 test entries in 10 different clusters.

Cluster no.	Genotype (no.)	Genotype (Acc. no.)
1	32	449, 450, 453, 468, 495, 507, 522, 529, 532, 539, 559, 1524, 1528, 1534, 1675, 1700, 1770, 1773, 1774, 1890, 1892, 1900, 1905, 1906, 1917, 1918, 1921, 1943, 1949, 2292, 2384.
2	8	456, 457, 466, 488, 499, 525, 531, 1765.
3	30	421, 432, 433, 438, 444, 473, 475, 480, 492, 494, 496, 549, 811, 1851, 1853, 1874, 1914, 2020, 2021, 2034, 2051, 2059, 2280, 2286, 2287, 2297, 2322, 2323, 2324, 2382.
4	55	417, 418, 419, 424, 425, 426, 435, 442, 465, 502, 516, 649, 654, 812, 945, 1203, 1205, 1210, 1289, 1525, 1550, 1551, 1626, 1656, 1671, 1680, 1681, 1687, 1688, 1692, 1695, 1701, 1723, 1882, 1898, 1903, 1908, 1912, 1913, 1923, 1929, 1937, 1950, 1957, 1958, 1986, 1991, 1999, 2003, 2006, 2013, 2024, 2050, 2276, 2325.
5	41	427, 430, 443, 459, 463, 464, 469, 470, 472, 498, 504, 952, 1052, 1212, 1662, 1666, 1696, 1699, 1738, 1746, 1762, 1767, 1883, 1897, 1915, 1927, 1938, 1939, 1947, 1953, 1973, 1974, 1978, 1982, 1998, 2044, 2294, 2298, 2366, 2375, 2385.
6	40	420, 422 , 434, 436, 445, 455, 486, 487, 489, 490, 493, 513, 518, 519, 520, 521, 536, 537, 574, 1216, 1286, 1633, 1641, 1728, 1750, 1751, 1871, 1873, 1895, 1920, 1936, 1954, 2016, 2031, 2043, 2047, 2279, 2281, 2288, 2293.
7	28	451, 454, 458, 462, 467, 479, 500, 1645, 1691, 1729, 1730, 1732, 1733, 1756, 1761, 1768, 1772, 1894, 1902, 1907, 1916, 1922, 1926, 1928, 1955, 1987, 2364, 2379.
8	50	431, 447, 448, 460, 461, 477, 485, 508, 953, 1211, 1213, 1317, 1532, 1546, 1643, 1655, 1682, 1683, 1684, 1707, 1725, 1737, 1752, 1755, 1782, 1872, 1878, 1884, 1901, 1904, 1910, 1911, 1924, 1925, 1945, 1975, 1976, 1994, 2029, 2033, 2042, 2057, 2365, 2369, 2370, 2373, 2374, 2376, 2378, 2383.
9	48	423, 429, 437, 440, 446, 471, 491, 501, 503, 514, 515, 651, 942, 948, 951, 1215, 1323, 1521, 1529, 1549, 1629, 1718, 1740, 1869, 1909, 1930, 1931, 1932, 1934, 1940, 1942, 1944, 1946, 1948, 1951, 1977, 1980, 1981, 1990, 1992, 2004, 2009, 2011, 2012, 2056, 2296, 2367, 2368.
10	67	428, 439, 523, 808, 1202, 1630, 1632, 1642, 1689, 1716, 1717, 1720, 1721, 1739, 1867, 1868, 1876, 1877, 1879, 1880, 1881, 1885, 1886, 1887, 1889, 1891, 1896, 1919, 1933, 1941, 19 52, 1956, 1984, 1995, 1996, 1997, 2000, 2001, 2002, 2014, 2017, 2018, 2019, 2022, 2023, 2025, 2026, 2027, 2028, 2030, 2032, 2035, 2036, 2037, 2038, 2039, 2040, 2046, 2048, 2277, 2278, 2282, 2285, 2290, 2291, 2295, 2371.

Table 3. Cluster means for 398 test entries.

Cluster no.	Cluster means of studied characters		
	Lesion length (cm)	Relative lesion length	Leaf damaged area (%)
1	6.89	29.14	17.51
2	13.21	49.93	38.83
3	3.45	15.33	6.08
4	4.18	15.89	12.31
5	6.27	26.06	23.05
6	5.47	21.77	11.16
7	7.38	34.24	2967
8	5.11	21.75	18.05
9	2.68	10.81	7.96
10	1.19	5.80	2.53

night to maintain favourable condition for disease development. After one week of inoculation disease was scored on each of the MLs for each isolate as resistant and susceptible.

Sets of 31 MLs were sown in trays in the net house for phenotypic differentiation of blast isolates and 220 blast isolates screened against MLs. Three-week-old seedlings were inoculated with spore suspension of each of the isolate and disease data were collected seven days after inoculation. All the tested isolates were found virulent to the universal susceptible variety LTH (Table 7). Among the 24 resistant genes, *Pish, pi9, pita-2, piz-5* and *pita=pi4(t)* showed higher

Table 4. Pathotypic diversity of the 172 isolates of *Xanthomonas oryzae* pv. *oryzae* based on the reaction of nine NILs containing a single gene for resistance.

Race/ Patho type	Isolate (no.)	Isolate (%)	Near-isogenic lines (NILs) and known resistance genes[a]								
			IRBB2 (Xa2)	IRBB4 (Xa4)	IRBB5 (xa5)	IRBB7 (Xa7)	IRBB10 (Xa10)	IRBB11 (Xa11)	IRBB13 (xa13)	IRBB14 (Xa14)	IRBB21 (Xa21)
1	105	61.0	S	S	S	S	S	S	S	S	R
2	3	1.8	R	S	S	S	S	S	S	S	R
3	16	9.3	S	S	S	S	S	S	S	R	R
4	1	0.6	R	S	S	S	S	S	S	R	R
5	3	1.7	S	S	S	R	S	S	S	R	R
6	1	0.6	S	S	S	S	S	S	R	S	R
7	1	0.6	R	S	S	S	S	S	R	S	R
8	18	10.5	S	S	S	S	S	S	S	S	S
9	1	0.6	S	S	S	S	S	R	S	R	R
10	9	5.2	S	S	S	S	S	S	R	R	R
11	3	1.8	R	R	R	R	R	R	R	R	R
12	3	1.8	S	R	R	R	R	R	R	R	R
13	4	2.3	S	R	S	S	S	S	S	S	R
14	2	1.2	R	S	S	S	S	S	R	R	R
15	1	0.6	R	S	S	R	S	R	S	S	R
16	1	0.6	S	S	R	R	S	S	R	R	R

[a]NILs containing a single gene for resistance used to characterize races among 172 isolates. S=susceptible and R=resistance.
Note: A mean lesion length of <3 cm was considered as resistance.

Table 5. Resistance rice genes near-isogenic lines (NILs) for virulence of *Xanthomonas oryzae* pv. *oryzae* isolates and resistance frequency to 172 Bangladeshi isolates.

Near-isogenic lines (NILs)	Resistance gene	Resistance frequency (%)[a]
IRBB2	Xa2	6.4
IRBB4	Xa4	5.8
IRBB5	xa5	4.1
IRBB7	Xa7	6.4
IRBB10	Xa10	3.5
IRBB11	Xa11	4.7
IRBB13	xa13	11.6
IRBB14	Xa14	22.7
IRBB21	Xa21	89.5

[a]Resistance frequency calculated as the ratio of isolates including resistance reaction vs. total isolates tested on each NILs.

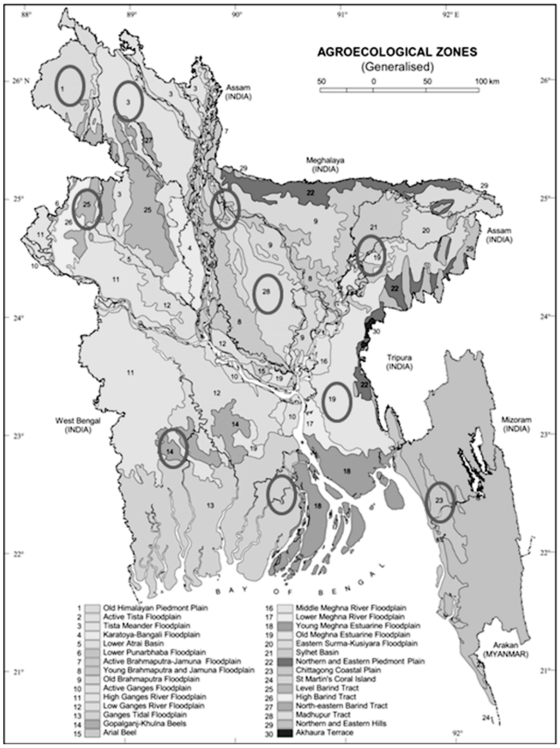
resistance (>80%) against the tested isolates and *pik-s pit, piz-t, pi20(t), pik, pi7(t)* and *pik-m* showed lower resistance to the Bangladeshi isolates. The frequencies of virulent isolates against 31 MLs varied widely from 9 to 68% (Table 7). The distribution of frequencies for virulent blast isolates against the MLs and LTH differed across the locations.

Validation of specific primers on MLs

The study was conducted to validate specific primers on blast resistant MLs. Leaf samples were collected from 14-day-old seedlings. About 3 cm long leaf tips were collected from the plants and

Table 6. Description of blast isolates collected from different AEZs of Bangladesh.

AEZ	District	Variety	Season	Collected sample (no.)
1	Panchagor, Thakurgaon, Dinajpur, Gaibandha	Kalogira, BRRI dhan34, Bagunbichi, Jirashail	T. Aman 2011	210
2	Rangpur, Nilphamari	Swarna, BRRI dhan34, Kalogira	T. Aman 2011	50
9	Sherpur, Jamalpur, Mymensingh, Tangail	Begunbichi, Baismuthi, Balam, Lalpajam, Kalogira, Hasikalmi, Nayantara, Pajam,	T. Aman 2011	220
20	Sylhet, Moulvibazar, Habiganj	BRRI dhan32, Joli Aman Swarno-Musur	T. Aman 2011	5
23	Chittagong, Rangamati	Kalogira, Lal Fanja, BR11, Chinigura	T. Aman 2011	65
	Total			550



Location for collection of blast samples : AEZs and Districts-1=Panchagar, Thakurgaon; 2=Rangpur, Kurigram, Nilphamari; 9=Sherpur, Jamalpur; 11=Rajshahi, Noabganj, Shatkhira; 12=Khulna, Bagerhat; 13=Barisal, Jhalokathi; 19=Comilla, Chandpur, Feni; 20=Sylhet, Habiganj, Moulovibazar; 23=Chittagong; 28=Dhaka, Gazipur, Tangail, Mymenshing

Fig. 1. Location for collection of blast samples from different AEZs of Bangladesh.

Table 7. Resistant frequency of the blast resistant genes against 220 isolates of blast pathogen from Bangladesh.

Designation of IRBL	Resistant gene	Average resistant frequency (n=220)
LTH	none	0.0
US2	none	0.0
IRBLsh-B	*Pish*	90.8
IRBLsh-S	*Pish*	90.7
IRBLb-B	*Pib*	57.8
IRBLt-K59	*Pit*	37.3
IRBLa-A	*Pia*	74.3
IRBLa-C	*pia*	77.0
IRBLi-F5	*Pii*	66.5
IRBL3-CP4	*Pi3(t)*	64.0
IRBL5-M	*Pi5(t)*	64.6
IRBLks-S	*Pik-s*	35.7
IRBLks-F5	*Pik-s*	31.9
IRBLkm-Ts	*Pik-m*	57.6
IRBL1-CL	*Pi1*	56.1
IRBLkh-k3	*Pik-h*	48.8
IRBLkh-K	*Pik*	53.5
IRBLkp-K60	*Pik-p*	57.2
IRBL7-M	*Pi7(t)*	55.1
IRBL9-W	*Pi9*	90.3
IRBLz-Fu	*Piz*	73.9
IRBLz5-CA-1	*Piz-5(Pi2(t))*	80.6
IRBLz5-CA	*Piz-5(Pi2(t))*	80.0
IRBLzt-T	*Piz-t*	42.9
IRBLta2-Pi	*Pita-2*	91.3
IRBLta2-Re	*Pita-2*	85.4
IRBL12-M	*Pi12(t)*	61.4
IRBLta-K1	*Pita=Pi4(t)*	83.9
IRBLta-CP1	*Pita=Pi4(t)*	63.5
IRBLta-CT2	*Pita=Pi4(t)*	66.6
IRBL19-A	*Pi19(t)*	64.6
IRBL20-IR24	*Pi20(t)*	47.0
IRBL11-ZH	*pi11*	72.5

kept inside 1.5 ml microfuge tubes in ice. The microfuge tubes containing the leaf samples were kept in poly bags and placed in the chamber at -20°C freezer and crushed immediately for DNA extraction following standard method. Extracted DNA in 1X TE buffer was stored in a 4°C refrigerator for further use. PCR was performed in 10µl reactions containing around 25ng of DNA template, 1µl 10X TB buffer (containing 200mM Tris-HCl pH 8.3, 500mM KCl), 1.35µl 25mM $MgCl_2$, 0.2µl of 10mM dNTP, 0.5µl each of 10µM forward and reverse primers and 0.1µl of *Taq* DNA polymerase (5U/µl) using GStorm thermal cycler. After initial denaturation for 5 min at 94°C, each cycle comprises 45 sec denaturation at 94°C, 45 sec annealing at 55°C, and 1:30 min extension at 72°C with a final extension for 7 min at 72°C at the end of 35 cycles. The PCR products were run in agarose gel electrophoresis for 2.5 to 3 hours at 100V. The gel was stained in the ethidium bromide for 25 minutes and picture was taken by gel documentation system (Fig. 2).

The primer pita440 bound with corresponding *pita* gene of IRBL 28, 29 and 30 (Fig. 2). Bands from *pita2* genes were produced by the primers OSM 89 and RM 7102. Primers AOL51, AOL54 and AOL351 for *Pish* gene were produce corresponding bands. The presence of *pi9* genes in MLs was confirmed by NBS3, NBS4, NBS/LRR

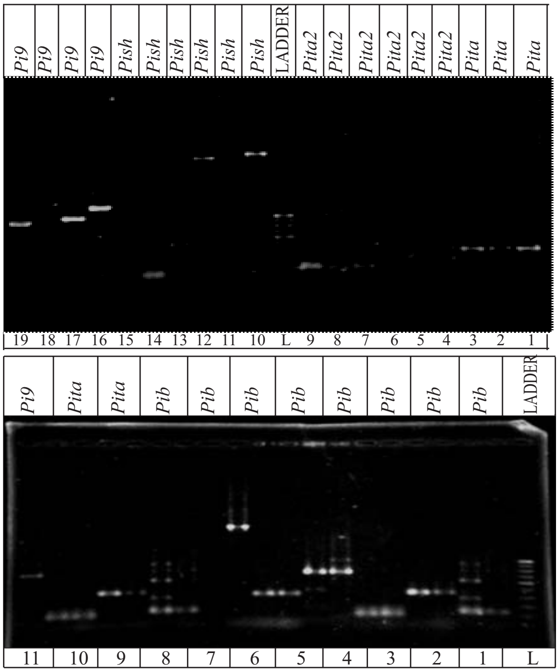


Fig. 2. Confirmation of blast resistant genes *pish, pita, pita2* and *pi9* on blast resistant MLs of rice.

and NBL2 primers. The IRBL 3 and 4 harboring *pib* gene produce bands with specific primers RM 138, RM 166, RM 208 and SUB 3-4.

Seed production of MLs as differential variety

A total of 31 MLs bearing resistant gene against blast and universal susceptible variety (LTH and US2) collected from JIRCAS were grown for seed multiplication. Flowering date (5 and 80%) was recorded to use the information in crossing programme.

Yield of seeds ranged from 200-350 g/m^2 for all of the MLs. The highest seed was obtained from IRBLsh-B and the lowest from IRBLi-F5. Sterility of seeds ranged from 30 to 50%.

Pathogenicity analysis of blast isolates from Bangladesh using differential varieties

The blast samples were collected from AEZ 18 and 19. Isolates were cultured by single spore isolation method, maintained on dried filter paper at -20°C temperature to study the population dynamics. The 25 LTH background monogenic lines holding 23 resistance genes, *Pia, Pib, Pii, Pik, Pik-h, Pik-m, Pik-p, Pik-s, Pish, Pit, Pita, Pita-2, Piz, Piz-5, Piz-t, Pi3, Pi5(t), Pi7(t), Pi9(t), Pi11(t), Pi12(t), Pi19(t)* and *Pi20(t)* were used to determine the pathotypes of the blast isolates. Seeds of MLs and susceptible checks were sown in plastic trays, which contain 35 holes. Plants were inoculated at 17-18 days after seeding. Small pieces of dried filter paper with mycelium were cultured on oat meal agar and incubated for 12 days on two plates for each isolate. After 12 days culture surface was scrapped by tooth brush for sporulation, kept on trays covered by wrapping poly paper and perforated for aeration. After five days 20 ml distilled water (0.01% Tween 20) poured in each plate, gently scrapped with hair brush to collect conidia, filtered by gauze and kept on ice. The spore concentration was standardized to 1×10^5 spores/ml and 20 ml spore suspension sprayed by using a fine atomizer. After spraying plastic trays were kept in dew chamber for 24 hours at 25°C. After one day, trays were transferred to green house. The degree of disease of each seedling was evaluated on the seventh day after inoculation. The reaction was classified on a scale of 0-5, categorized as 0-2 for resistance (R), and 3-5 for susceptible (S). The scores 0-3 and 0-1 were categorized as R for the MLs with *pish* and *pi5* respectively.

Blast isolates were designated and classified by their reaction MLs according to Hayashi and Fukuta (2009). Blast isolates were characterized by the sum of codes in combination of three target R-gene reaction. A total of 26 *Pyricularia grisea* isolate collected from swampy area of Noakhali were characterized against 30 monogenic differential varieties (DVs) targeting 23 resistant genes. LTH and US-2 were used as susceptible check. The lowest virulent frequencies (0%) were found for IRBLta2-Re and the highest (100%) for IRBL19-A and IRBL12-M [US]. Lower virulent were recognized 3.85% with IRBLta2-Pi followed by 7.7% with IRBLta-K1 and IRBLsh-S. In contrast, higher virulent frequencies were 96% for IRBL20-IR24 followed by 92.31% for IRBL12-M, IRBLks-F5 and IRBLks-S. The other DVs showed intermediate values (Fig. 3). These 26 blast isolates were classified into 26 races based on 25 international differential varieties and LTH. Blast isolates were categorized into five groups; 10 for U

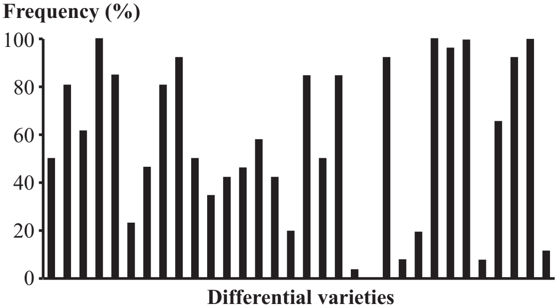


Fig. 3. The frequency of virulence blast isolates in different MLs.

blast pathotypes (Fig. 4), 4 for i blast pathotypes (Fig. 5), 8 for k blast pathotypes (Fig. 6), 7 for z blast pathotypes (Fig. 7) and 7 for ta blast pathotypes (Fig. 8). Dominant blast pathotypes were U73, i4, k100, z05 and z07 and ta403.

Screening rice germplasm against Aggregate sheath (ASS) spot disease

A total of 20 germplasm collected from Genetic Resources and Seed Division, BRRI were tested to identify tolerant/resistant sources against ASS disease. Data on lesion height and relative lesion height were measured 21 days after inoculation.

All the germplasms were sensitive to *R. oryzae-sativae*. The highest RLH was found in Akuee (17.83%) followed by Kalosoti (17.79%)

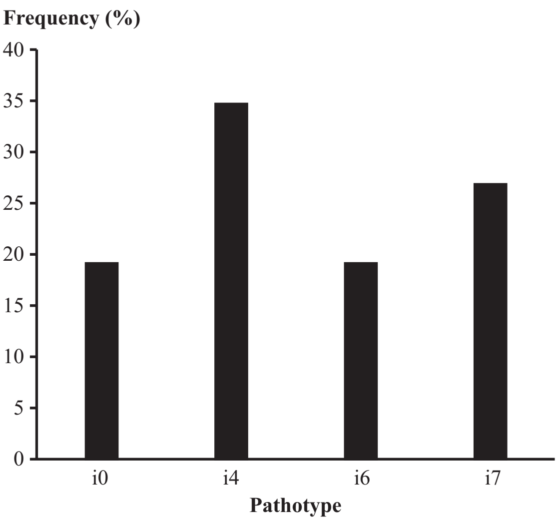


Fig. 4. Distribution of pathotypes based on the reaction of LTH, *pia, pish, pib* and *pit.*

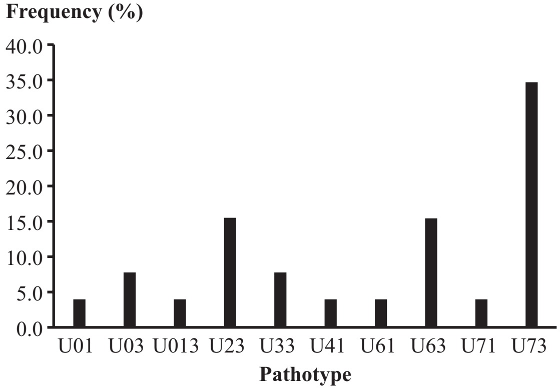


Fig. 5. Distribution of pathotypes based on the reaction of *pii, pi3* and *pi5*(t).

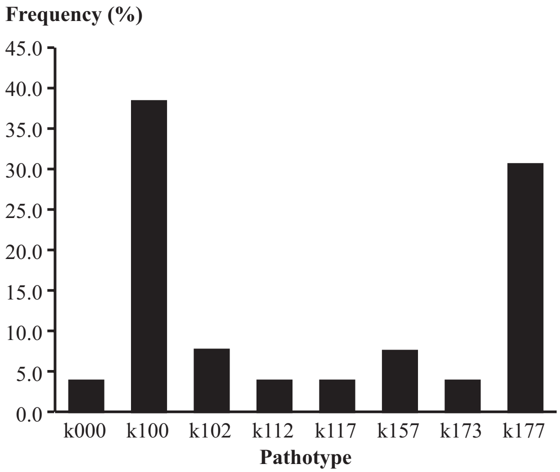


Fig. 6. Distribution of pathotypes based on the reaction of *pik-s, pik-m, pi1, pik-h, pik, pik-p* and *pi7*(t).

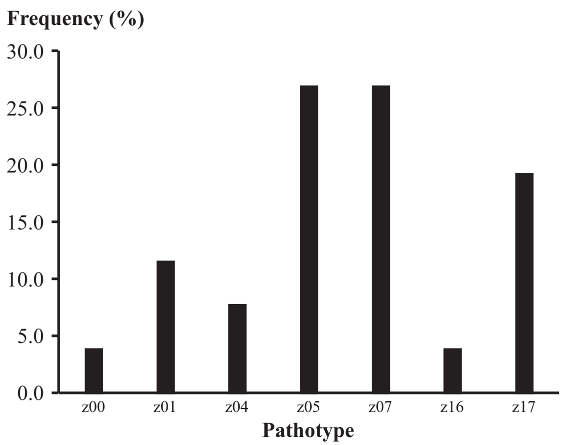


Fig. 7. Distribution of pathotypes based on the reaction of *pi9*(t), *piz, piz-5* and *piz-t.*

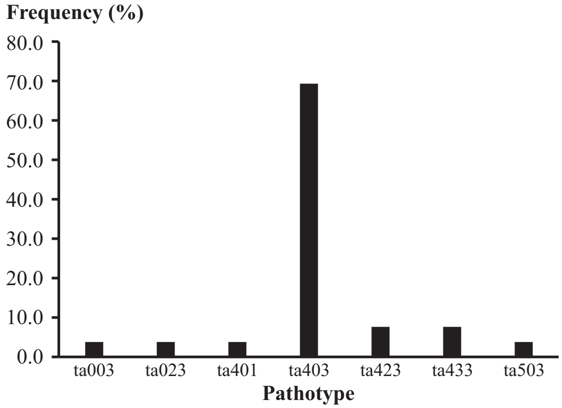


Fig. 8. Distribution of pathotypes based on the reaction of *pita-2, pi12(t), pita pi19(t)* and *pi20(t)*.

and the lowest recorded in Balam (12.39%) followed by Agoan (13.0%). The disease confirmed as minor disease in Bangladesh.

EPIDEMIOLOGICAL STUDIES

Mycelial growth of the isolates of *Rhizoctonia oryza-sativae*

The study was conducted to know the growth rate of *R. oryzae-sativae* collected from different AEZs of Bangladesh. Mycelial disks (6 mm diameter) were transferred aseptically to PDA plates and incubated at 27±2°C. Radial mycelial growth were measured from the center of inoculated plug at 12, 24, 36, 48, 60, 72, 84 and 96 hours after incubation. A completely randomized design was followed with three replications.

The mean mycelial growth rate ranged from 0.28 to 0.45 mm/hr. Among the isolates, the highest mean growth rate (0.45 mm/hr) was recognized with the Mymensingh isolates followed by the Jamalpur isolates (0.42 mm/hr). In contrast, the lowest growth rate was recorded with the Netrokona isolates (0.28 mm/hr) followed by the Thakurgaon isolates (0.29 mm/hr) (Fig. 9).

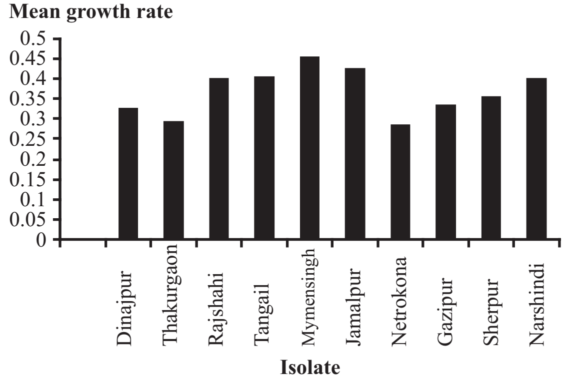


Fig. 9. Mycelial growth rate of *R. oryzae-sativae* isolates.

Pathogenicity test of *R. oryzae-sativae* isolates on BR11

The study was conducted to know the virulence diversity of *Rhizoctonia oryzae-sativae* isolates collected from different AEZs of Bangladesh. Seeds of BR11 were soaked overnight in water and sprouted seeds sown in wet seed bed. Thirty-day-old 2-3 seedlings per hill were transplanted with 15- × 20-cm spacing. Pure culture of each isolate were grown on 9 cm PDA plate and incubated at ambient temperature for five days to allow approximately full plate growth. PDA plates with five-day-old inoculum were divided into eight equal splits. Each portion of the PDA with mycelial plugs was inserted at the base of each hill. Nine rice plants were artificially inoculated with each isolates in every row intervals following RCB design. Data on mean lesion height (MLH) were measured 21 days after inoculation.

The result shows that, all the isolates were pathogenic to the rice variety BR11. The highest MLH was found from the isolate My1 followed by Na2 and the lowest made by isolate Th2 followed by Di1 (Table 8). The disease level was far lower than threshold level.

Effect of pH on mycelial growth and sclerotia formation of *Rhizoctonia oryzae-sativae*

The experiment was conducted to know the effect of different pH on mycelial growth and sclerotia formation of *Rhizoctonia oryzae sativae*. The selected medium, PDA was adjusted at different pH level with addition of Lactic acid and 10N

Table 8. Virulence of *R. oryzae-sativae* isolates.

Isolate	Lesion height (cm)	Incidence (%)
Di1	8.05	44.19
Th1	9.05	45.65
Th2	7.59	47.83
My1	19.41	69.23
Ga1	9.07	65.91
Na2	17.08	58.54

NaOH before autoclave. The pH range was fixed from 3 to 10. Mycelial disks of 6 mm diameter were transferred from the margin of four-day-old colonies at the centre of PDA plates, incubated at 27±2°C. Four replicate plates were used for each treatment. Radial mycelial growth and sclerotial data were measured.

Rhizoctonia oryzae-sativae grew on PDA within the pH range of 3 to 10 and maximum at 6 to 8. Minimum growths were recorded at pH 3 to 5. The growth of this fungus reduced at very strong acidic and alkaline pH. Abundant sclerotia formed at pH level 7 while no sclerotia at pH level 3 to 4 after four days of inoculation (Fig. 10).

Effect of C sources on mycelia and sclerotia of *Rhizoctonia oryzae-sativae*

To know the effect of C sources on mycelial growth 2% of different C sources such as Dextrose, Sucrose, Galactose, Xylose, Fructose and Lactose were mixed separately with 2% agar and 100 ml potato extract for medium preparation. Mycelial disks (6 mm diameter) were transferred from the margin of four-day-old colonies at the centre of PDA plates and incubated at 27±2°C. Four replicate plates were used for each treatment. Radial mycelial growth and sclerotial data were taken.

The results shows that the best mycelial growth was found in Dextrose (0.43 mm/hr) followed by Sucrose (0.42 mm/hr). The most unsuitable source was Fructose (0.26 mm/hr) followed by Xylose (0.35 mm/hr). In case of duration of complete mycelium running, the minimum time was recorded in Dextrose (105 hrs) and maximum found in fructose (172 hrs) followed by Xylose (130 hrs). The highest sclerotial formation was found in Dextrose (Table 9).

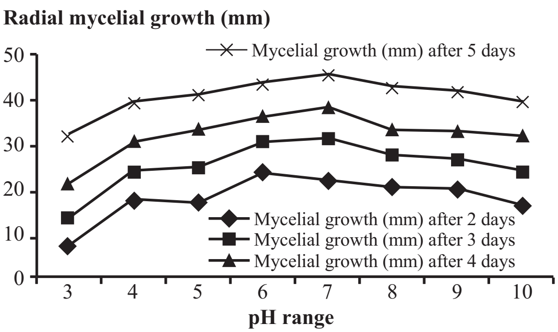


Fig. 10. Effect of different pH level on mycelial growth of *Rhizoctonia oryzae-sativae.*

Effect of N sources on mycelia and sclerotia of *Rhizoctonia oryzae-sativae*

Different N sources on mycelial growth and sclerotia formation of ROS 2% N sources, Peptone, Yeast, KNO_3, $NaNO_3$, NH_4NO_3 and urea were mixed separately with 2% agar and 100 ml potato extract and autoclaved. Mycelial disks (6 mm diameter) were transferred from the margin of four-day-old colonies of the centre of PDA plates and incubated at 27±2°C. Four replicate plates were used for each treatment. Radial mycelial growth and sclerotial data were taken.

Among the N sources the best mycelial growth was found in peptone (41.25 mm) followed by yeast (38.25 mm), while the least in NH_4NO_3 (16.5 mm) after four days of incubation. There was no growth in urea. Though peptone was found as the best N source for mycelial growth, but there was no sclerotia, while the control plate was covered fully, mycelium and abundant sclerotia were formed (Table 10).

Effect of temperature and pH on the growth and sporulation of *Fusarium moniliforme*

We did the experiment to determine the optimum temperature and pH level for growth and sporulation of *F. moniliforme.* By means of core borer, disc from eight-day-old culture of the fungus grown in 10 ml medium were cut proximal to the edge of the colony. Each disc was transferred to the center of a 20 ml plated medium. Plates were wrapped with two sheets of carbon paper to exclude light effect and incubated at 5°, 15°, 20°, 25°, 30° and 35°C temperature in incubator. Colony diameter was measured on the third, sixth and ninth day of incubation and sporulation was measured on ninth day. For each period of measurement and temperature level, four replications were maintained. Colony diameter was measured at the widest point and the average taken minus 5 mm diameter of the culture disc used.

To determine sporulation, 10 ml sterile distilled water was added to each culture and the surface growth was scraped gently without scarifying the agar. The suspension was placed in a

Table 9. Effect of different carbon sources on mycelial growth and sclerotia formation of *Rhizoctonia oryzae-sativae.*

Carbon source	pH	Mycelial growth (mm) after 2 days	Mycelial growth (mm) after 3 days	Mycelial growth (mm) after 4 days	Mycelial growth rate (mm/hr)	Time to complete mycelial run (hr)	Sclerotia formation on 5th day
Dextrose	6.7	22.5	35.5	45	0.43	105	Moderate
Sucrose	6.8	21.5	31	42	0.42	107	Few
Galactose	6.8	17.5	29.5	39	0.41	111	Few
Xylose	6.6	12.25	21.25	31	0.35	130	Nil
Fructose	6.7	10.75	16.75	23.5	0.26	172	Nil

Table 10. Effect of different N sources on mycelial growth of *R. oryzae-sativae.*

Nitrogen source	pH	Nitrogen (%)	Mycelial growth (mm) after 2 days	Mycelial growth (mm) after 3 days	Mycelial growth (mm) after 4 days	Mycelial growth rate (mm/hr)	Sclerotia formation on 5th day
Peptone	6.3	10	20.25	31.25	41.25	0.42	Nil
Yeast	6.0	-	16.75	23.0	38.25	0.40	Nil
KNO_3	7.1	13.86	9.75	17.0	27	0.28	Nil
$NaNO_3$	7.2	16.47	15.25	19.75	29.5	0.31	Nil
NH_4NO_3	6.1	35.0	7.0	12.5	16.5	0.17	Nil
Urea	7.3	47.0	0	0	0	0	Nil
Control	6.7	-	22	34.5	45	0.43	Abundant

test tube and shaken 25 times in an up and down movement over a distance of one foot. Mycelial growth was removed and dilutions were made to facilitate counting of spore. Number of spores per ml was measured by a hemacytometer.

Adequate PDA medium were prepared, poured into nine separate conical flasks and the pH of the flasks was adjusted to seven different pH level such as 4, 5, 6, 7, 8, 9 and 10 by adding 1% lactic acid and 10% sodium hydro oxide solution. All the conical flasks with media were sterilized at 121°C for 15 minutes in an autoclave. For each pH level 20 ml PDA media per sterilized petri plates were poured. Young culture blocks (4 mm diameter) of *F. moniliforme* were placed centrally on the petri plates and incubated at room temperature. Colony diameter was measured on the third, sixth and ninth day of incubation and sporulation was determined after nine days. For each period of measurement and temperature level, four replications were made. Determination of sporulation was also done.

Table 11 shows the effect of different temperature levels and period of measurement on colony diameter of *F. moniliforme.* Culture of the fungus at 25°C produced significantly the widest colony at all the period of measurement than the other level. The fungus did not grow at 5°C regardless of the length of incubation. Colony diameter at 30°C on the sixth day was significantly lower than those of 25°C. However, both the temperature levels at third and ninth days were statistically identical at all levels of temperature except 5° and 35°C. Optimum temperature for sporulation was 30°C and pH ranged from 6-8.

Table 11. Colony diameter in mm of *F. moniliforme* at different temperature levels and period of measurement.

Temperature (°C)	Period (day)		
	3rd	6th	9th
5	0 e	0 f	0 e
15	17.78 c	31.11 d	37.77 c
20	23.99 b	42.27 c	54.11 b
25	30.58 a	58.96 a	75.87 a
30	30.19 a	53.71 b	74.79 a
35	12.58 d	20.53 e	30.55 d

In a column means followed by same letter are not significantly different at the 5% level by DMRT. Each value is an average of four replications.

DISEASE MANAGEMENT

Chemical control of sheath blight disease of rice, T. Aman 2011, BRRI Sonagazi

The experiment was conducted to determine the efficacy of new chemicals against sheath blight disease of rice under artificial inoculation. Nine fungicides, Emiscore, Fiscal 10EC, Green 300EC, Hunchat 75WP, Nato 10EC, Dizole 300EC, Suzala 10EC, Hinzol 10EC, Enstal 5EC were tested with one diseased control. Thirty-day-old seedlings of BR11 were transplanted with 20- × 15-cm @ spacing 2-3 seedlings per hill in plot 3- × 2-m with three replications. Fertilizer and cultural management were done as and when necessary. The plants were inoculated with local *Rhizoctonia solani* culture grown on PDA at PI stage. Eight hills were inoculated from central area at random. Fungicides were sprayed at their recommended dose twice; once at five days after inoculation and again at seven days after the first spray. Relative lesion height (RLH) was taken at the dough to maturity stage.

Among the tested fungicides, only Dizole 300EC was effectively controlled sheath blight disease. In Rajshahi, Power Blast fungicide was effective against ShB.

Chemical control of blast disease of rice, Boro 2011-12, BRRI Gazipur

We did the experiment in blast nursery to determine the efficacy of new chemicals against blast under artificial inoculation. Susceptible variety BRRI dhan29 was sown in lines. Nineteen fungicides were tested with one standard check and one diseased control. Artificial inoculation was done 45 days after sowing. Chemicals were sprayed twice; once at five days after inoculation and the again at 10 days after the first spray. Disease severity was collected two times during the second spray and 10 days after the second spray.

Among the tested chemicals, Roton 75WP performed better than the other tested chemical. It reduced the disease severity 81% and also performed better than the standard check Trooper (78%).

Effect of seed treating chemical Vitaflo 200FF on seed borne fungi and yield of BR11

We conducted an experiment to evaluate the efficacy of Vitaflo 200 in controlling seed borne fungi. Foundation seeds were collected from four different sources such as BRRI, BADC, Akafuji and Konica Seed Company. All the seeds were treated with Vitaflo 200 @ 3 ml/kg seeds during T. Aman 2011. Completely randomized for *in-vitro* and RCB design for field trial was followed for the study. Eight replications for 400 seeds in each treatment were observed for *in-vitro* test and three replications in field trial in a unit plot of 10 m^2. Randomly selected 5 m^2 area was considered for data collection in field trial. Thirty-five-day-old seedlings were transplanted with 20- × 20-cm spacing.

The rate of seed infection of tested seeds was very low. All the seeds were free from *Bipolaris* sp. The chemical was insensitive to *Fusarium,* but controlled 100% *Curvularia* and *Trichoconis* (Table 12). Effects of this chemical on seed germination, seedling growth and yield was insignificant. Thus we conclude that there is no benefit in treating foundation seeds with Vitaflo 200FF.

In-vitro* chemical control of *R. oryzae-sativae

We tested eight fungicides to find out the effective chemicals against *R. oryzae-sativae.* Poison food technique was used with different concentrations (100, 10, 1, 0.5, 0.25 and 0.1 ppm) of fungicides and no fungicide was maintained as control. A mycelial plug (6 mm diameter) cut from four-day-old culture was placed at the corner of each Petri plate. The plates were incubated at 27±2°C in incubator. Mycelial growth was measured in each treatment and percent growth inhibition was calculated using the following formula: $I=(C-T)/C \times 100$, where I=Percent inhibition, C=Growth of fungus in control, T=Growth of fungus in treatment.

Irrespective of fungicide, with the increase of concentration mycelial inhibition was increased. The highest inhibition (93.55%) was recorded at 100 ppm and the lowest (24.36%) at 0.1 ppm. Irrespective of concentration, Carbendazim was found as the best (80.16%) followed by Folicur (69.38%) in mycelial inhibition.

TECHNOLOGY DISSEMINATION

Demonstration of blast disease management in Barisal region

Seven demonstrations were conducted in Barisal sadar upazila, Barisal during Boro 2011-12 to show the blast disease management technique directly to

Table 12. Effect of VitaFlo 200FF on seed borne fungi of foundation seeds var. BR11.

Seed source	Percent seed infection (%)											
	Fusarium spp.[1]			Bipolaris spp.[2]			Curvularia spp.[3]			Trichoconis spp.[4]		
	Control seed	Treated seed	Decrease over control (%)	Control seed	Treated seed	Decrease over control (%)	Control seed	Treated seed	Decrease over control (%)	Control seed	Treated seed	Decrease over control (%)
BADC	7	7	0	0	0	0	0	0	0	0	0	0
BRRI	0	0	0	0	0	0	1	0	100	0	0	0
Akafuji	2	2	0	0	0	0	1	0	100	1	0	100
Konica	0	0	0	0	0	0	0	0	0	0	0	0

[1]Insensitive to Fusarium spp. [2]Used seeds were free from Bipolaris spp. [3]100% Curvularia spp. were controlled (non-pathogenic fungi). [4]100% Trichoconis spp. were controlled (non-pathogenic fungi).

the farmers. BRRI dhan47 was severely affected by leaf blast. Infected rice field was selected and divided into two parts. Chemicals were sprayed twice with recommended doses at 15 days interval in one part and the other served as control. Disease incidence and severity with yield data were collected during harvesting. Blast disease was controlled successfully in farmers' filed and yield increased significantly. All of the tested chemicals such as Trooper, Nativo and Zeal performed equally in controlling blast disease (Figs. 11, 12, 13, and 14).

Field day on blast disease management

A field day on identification and control of blast disease was conducted in Boro 2011-12 at Barisal sadar upazila with the collaboration of DAE using IAPP (BRRI part) fund to teach the blast disease control technique directly to the farmers. Power point presentation on blast disease identification, management and field visit were used as tools of learning method. Two hundred participants attended the programme and learned about blast disease management.

Training on rice disease management and healthy seed production

One-day training on rice disease management and healthy seed production was conducted at Barisal and Rangpur region with the help of DAE using IAPP (BRRI part) fund to teach the SAAO, DAE and farmers on rice disease management and healthy seed production. Five training programmes were conducted at Barisal and five in Rangpur region. Theoretical and practical topics were included in the class schedule. Finally, each of the training was assessed using pre structured questionnaire in pre and post evaluation. A total of 175 SAAOs (Sub Assistant Agriculture Officer), DAE and 131 farmers were trained. Our assessment result shows that SAAO and farmers knowledge level was improved significantly through this training. Before training SAAO's knowledge regarding rice diseases was 40% but after training it increased up to 80-90% while farmer's knowledge level before training was assessed as 0-25% but after training it increased up to 40-80%.

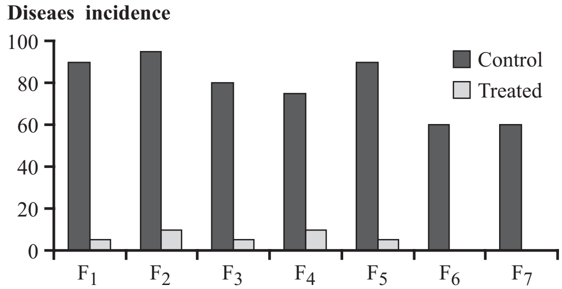


Fig. 11. Effect of chemicals on blast disease incidence. F_1, F_2 and F_3 farmers used Trooper; F_4, F_5 and F_6 used Nativo; F_7 used Zeal.

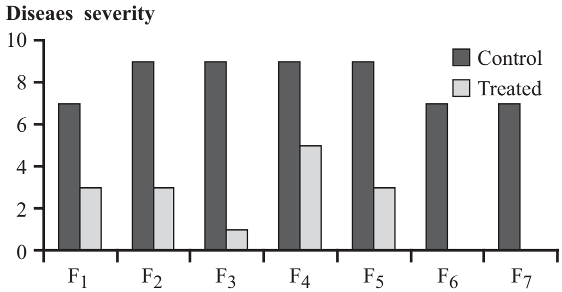


Fig. 12. Effect of chemicals on blast disease severity. F_1, F_2 and F_3 farmers used Trooper; F_4, F_5 and F_6 used Nativo; F_7 used Zeal.

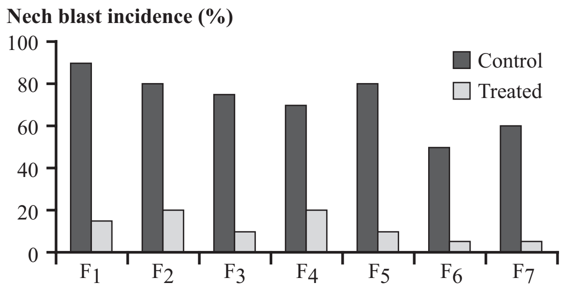


Fig. 13. Effect of chemicals on neck blast disease incidence. F_1, F_2 and F_3 farmers used Trooper; F_4, F_5 and F_6 used Nativo; F_7 used Zeal.

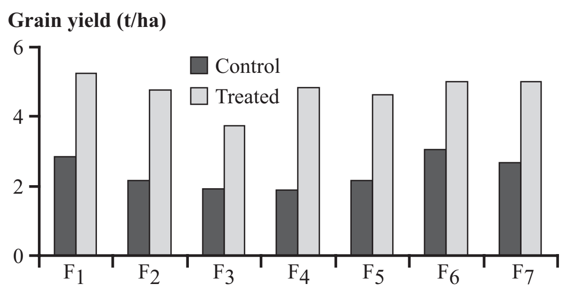


Fig.14. Effect of chemicals on grain yield. F_1, F_2 and F_3 farmers used Trooper; F_4, F_5 and F_6 used Nativo; F_7 used Zeal.

ADVISORY AND CLINICAL SERVICES

The Plant Pathology Division provided advisory and clinical services to farmers, DAE personnel and NGOs in identifying the diseases along with necessary prescriptions. During the reporting year, 200 samples from farmers' field have been diagnosed and control measures were suggested. In addition, we visited several rice fields with the request of DAE and NGO. For necessary investigation of the problem (disease, insects, abiotic stresses etc) suggestion were made accordingly.

Rice Farming Systems Division

SUMMARY

Interventions of farming systems technologies increased the income of landless and small farmers by 17.97 and 36% respectively compared to base year at FSR and D site, Kapasia, Gazipur. Rearing of layer, pigeon and goat helped farmers to increase their income. Spraying mango trees with pesticides and fertilization of jackfruit trees also increased production. LCC based N management practice saved 11 kg and 20.10 kg N/ha and increased the yield of BRRI dhan46 in T. Aman and BRRI dhan28 in Boro season respectively over the farmers' practice. Small farmers who adopted water saving technologies, saved irrigation cost and increased rice yield. Growing vegetables, turmeric and ginger as well as rearing *rohu*, silver carp, *mrigal* and *sorputi* increased farmer's income.

Yield gap experiment at Kapasia showed that the BRRI management practice ie the use of quality seed, LCC and USG contributed to higher yield.

Cropping patterns evaluation in medium highland irrigated ecosystem indicated that the highest rice equivalent yield (REY) could be found from Potato-DT Boro-T. Aman followed by Potato-T. Aus-T. Aman and Boro-T. Aus-T. Aman.

Sesbania application as green manure and weed management in T. Aman rice in Boro-Fallow-T. Aman cropping pattern indicated that *Sesbania* incorporation before T. Aman rice significantly influenced rice yield. *Sesbania* incorporation by applying herbicide 30 days after seeding produced the highest yield.

Use of selective herbicide at 15 DAS is sufficient for Aman rice production in Maize-DS Aus (brown manured by *Sesbsnia*)-DS Aman cropping pattern. One hand weeding was saved in Aman season, which might be due to weed suppression effect of *Sesbania* incorporated during Aus season. Maize intercropped with grasspea-DS Aus with herbicide followed by one hand weeding-DS Aman with herbicide followed by one hand weeding produced the highest REY.

Double transplanting under late situation produced significantly higher yield than that of normal transplanting in both T. Aman and Boro seasons.

In a long-term study with four cropping patterns, Potato-Boro-T. Aman cropping pattern produced the highest REY and gross margin than Boro-Fallow-T. Aman, Boro-T. Aus- T. Aman and Maize- Mungbean-T. Aman in both Rangpur and Gazipur.

Among the three rice cropping patterns the highest yield was obtained from BRRI dhan28-BRRI dhan48-BRRI dhan46 (12.18 t/ha) which was 11-15% higher than the farmer's patterns.

Boro rice grown in costal saline area using fresh reserve water produced 33.70% higher gross return in Boro-Fallow-T. Aman cropping pattern compared to Fallow-Fallow-T. Aman cropping pattern.

Among different cropping patterns with vegetables, Tomato-BRRI dhan42-BRRI dhan33 yielded the highest REY in partially irrigated ecosystem.

Dry seeded Aman rice, BRRI dhan49 produced the highest grain yield at 30 June seeding under Rice-Wheat-Mungbean cropping pattern. While BRRI dhan33 produced the highest yield on 30 July and BRRI dhan53 produced the highest yield on 10 July seeding.

Several activities on validation and delivery of farming systems technologies were carried out in different locations of the country. The activity included promotion of improved cropping pattern packages, demonstration of poultry manure as a source of phosphorus fertilizer, promotion of improved varieties of turmeric cultivation in the homestead and multilocation testing of BRRI dhan46/49-BRRI dhan29-Fallow cropping patterns.

INTEGRATED FARMING SYSTEMS

Intervention of farming systems technologies for improving livelihood of the resource poor farm households

Rice Farming Systems Division of BRRI started farming systems research and development activities at Moison, Kapasia from 2006 by the intervention of farming systems technologies on landless and small farmers to increase income. Before interventions of farming system technologies, benchmark data were collected during 2009. Three farm families from each of landless and small farm categories were selected for interventions. Different farming system technologies were intervened based on the resources and opportunities of the selected farmers. The interventions for landless farmers were production of improved mango in the homestead, rearing of improved breed of layer and pigeon, rearing of goat, fertilization of jackfruit trees and spraying of mango trees and for small farmers' those were N-management through use of LCC in modern Boro and T. Aman rice, water saving technologies in rice, production of high value summer and winter vegetables, fertilization of bearing jackfruit, production of improved tumeric and ginger in the homestead, production of improved mango in the homestead, spraying on mango and litchi fruit trees, polyculture of fish in seasonal pond and rearing of honey bee. The income and expenditure data of the intervened farmers were collected. In this study income included the total amount of products consumed, distributed to the relatives and sale price of different products whereas household expenditure included the total cost of production of the intervened technologies. Results shows that intervention increased the income of landless and small farmers by 17.97 and 36% and expenditure increased by 11 and 84% respectively compared to the base year.

Farmers mostly grow local varieties of mango with poor management. To popularize BARI Aam3 (Amrapali), saplings of BARI Aam-3 were supplied to landless farmers in 2009 and were planted with recommended management practices. Mango hopper was one of the most serious pests in the area. Anthracnose and powdery mildew also cause a huge loss of mango every year. Five bearing mango trees of two landless farmers' were selected for spraying. Tilt 250 EC @ 0.1% were sprayed with the help of foot pump. Spraying was done two times, at flowering and at about pea- size of the mango. Treated plants produced 60 kg, which was 30% higher than non-sprayed plants. Each farmer gained an extra income of Tk 1,725. Seven bearing trees of two landless farmers were fertilized in 2011-12 to increase bearing capacity and production of existing jackfruit trees. N-P-K was applied @ 323-140-250 g/plant. Results indicated that fertilizer application enhanced fruit production by 22 kg/plant, which was 27% higher than unfertilized plants. On average each farmer gained an extra income of Tk 770.

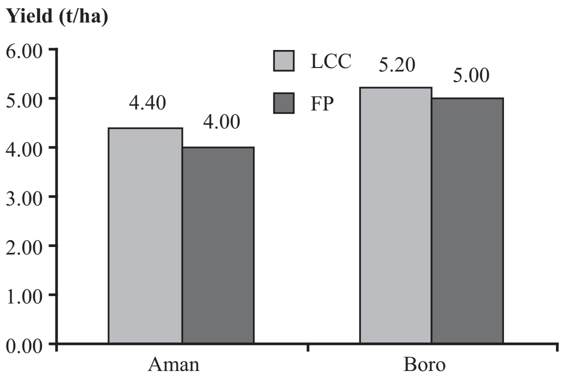
Rearing of pigeon and layer are the viable options to empower the women and to increase income of the landless farmers. Five layers and two pairs of pigeon were distributed to landless farmers at FSR and D site, Moison, Kapasia in September 2011. Average initial price of each of layer and pigeon were 180 and 650 Tk/pair respectively. After rearing, the estimated average price of layer and pigeon with chicks were Tk 2,900 and 4,525 respectively. Three Black Bengal she-goats were distributed to two landless farmers at FSR and D site, Moison, Kapasia in July 2009. Average initial price of goat was Tk 2,100 and after three year rearing, the estimated average price of goat along with kids was Tk 7,750. The result of the study implies that by rearing a she-goat an extra amount of Tk 5,650 could be earned by resource-constrained farmers' within a period of three years.

Seeds of red amaranth, radish, tomato, okra, amaranth, Indian spinach were distributed among three participating farmers increase production and farmers' income. Cash earned by different farmers from growing different vegetables varied from Tk 140 to 7,300. Farmer's participatory production demonstration trials on turmeric and ginger were undertaken to create awareness among farmers in growing turmeric and ginger in unused and or shady places of the homesteads. About 31.6 kg turmeric and 4.2 kg ginger were produced from average homestead area of 38.6 m^2 and 5.0 m^2 respectively and gross margins were Tk 748 and 152 respectively.

Fish culture in seasonal ponds was initiated at the FSR and D site, Moison, Kapasia in July 2011 to increase productivity of the existing ponds and also to increase farm income. Seasonal pond was treated with lime. Cowdung, urea and TSP were applied @ 5 kg, 125 g and 75g per decimal of pond. Rohu, Silver carp, Mrigal and Sorputi were released as mixed culture in three perennial ponds in July 2011. Total fish production was 351.5 kg and cash value was Tk 9,540 from the total pond area of 46 decimal.

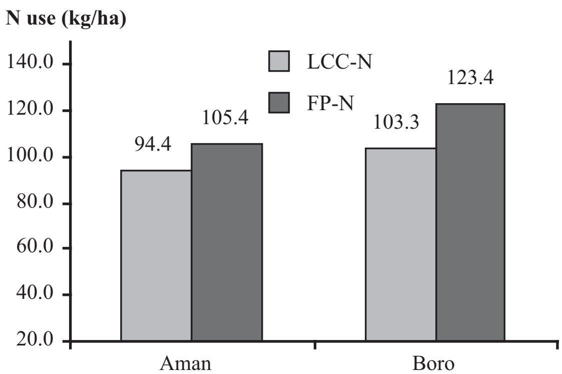
A demonstration trial for promotion of leaf colour chart use was carried out in farmers' fields at Moison, Kapasia, Gazipur during T. Aman 2011 and Boro 2011-12. In T. Aman, BRRI dhan46 and in Boro, BRRI dhan28 was used. Grain yields of T. Aman varieties were increased and N use was decreased under LCC-based N management over the farmers' practice. The average yield increased of BRRI dhan46 was 0.30 t/ha in T. Aman season. On average 11 kg N/ha could be saved by LCC-based N management practice in Aman season over the farmers' practice. In case of BRRI dhan28, average yield was increased by 0.23 t/ha. On average 20.1 kg N/ha could be saved by LCC-based N management practice in Boro season over the farmers' practice (Figs. 1 and 2).

Farmers' participatory demonstration trial was carried out to improve the water use efficiency and save the water resource in rice cultivation at FSR and D site, Moison, Kapasia, Gazipur during T. Aman 2011 and Boro 2011-12. Levee management practice was done in T Aman and alternate wetting and drying (AWD) method was used in Boro season. Three farmers of small farm category were selected for this study. In T. Aman, a field with a levee of 25-30 cm height and traditional levee were maintained. In Boro season, AWD system of irrigation was followed. On average 0.4 t/ha yield was increased in BRRI dhan46 compared to farmer's traditional levee management, which increased Tk 6,500 more income compared to traditional farmer's practice. In Boro season, short duration variety like BRRI dhan28 received 12.6 irrigations in AWD practice, whereas for farmers' practice it was 15. As a result about 2.33 irrigations were saved compared to the farmers practice. The average yield under AWD practice was 5.2 t/ha whereas, for farmers' practice it was 5.0 t/ha.



Grain yield under farmer's and LCC based nitrogen management, BRRI tech. site, Aman and Boro 2011-12.

Fig. 1. LCC based N management and yield.



Nitrogen used under farmer's and LCC based management, BRRI tech. site, Aman and Boro 2011-12.

Fig. 2. LCC based N management and N use.

DEVELOPMENT OF CROPPING PATTERN TECHNOLOGIES FOR DIFFERENT ECOSYSTEMS

Evaluation of crop management options for narrowing the yield gap

Rice yield gap exists between researcher and farmer's plot, which is attributed to many factors. An experiment was undertaken to determine the contribution of different crop production factors in narrowing the yield gap at farm level and to create farmers' awareness in adopting recommended management practice for rice production. The study was conducted at BRRI technology site, Moison, Kapasia, Gazipur in five dispersed farmers' fields during Boro 2010-11 and T. Aman 2011. Each farmer's field was considered as a replication. Seven management options: i) Farmer's practice (FP), ii) FP + quality seed, iii) FP + LCC, iv) FP + USG, v) Recommended management + USG, vi) Recommended management + LCC and vii) BRRI recommended management practices were evaluated in each dispersed farmer's field in each season. Under recommended practice, fertilizer rate for T. Aman and Boro season were 100-10-40-

10-2 and 140-15-40-10-3 kg N-P-K-S-Zn/ha respectively while these were 94-106, 7-10, 20-35, 8-9, 0 and 135-150, 9-11, 20-33, 0, 0 kg N, P, K, S, Zn/ha for farmers' management practice. BRRI recommended management + LCC and BRRI recommended management + USG practices produced significantly higher Boro yield, which was about 39 and 29% higher than the farmers' management practices (5.26/ha) respectively (Table 1). The results revealed that yield advantage of 21% could be attained by recommended management practice while this was 20, 21 and 24% higher than farmer's practice when only quality seeds, USG and LCC were used with farmers' practice. BRRI recommended management and recommended management + USG practices produced significantly higher T. Aman yield, which was about 55 and 48% higher than the farmers' practice (3.25 t/ha) respectively (Table 2). The result of the study revealed that yield advantage of about 42% could be attained by using recommended management + LCC practice while this was 21, 33 and 23% higher than FP (farmer's practice) when only quality seeds, USG and LCC were used with farmers' management practice.

Crop residue and weed management of permanent raised beds

Bed planting in Wheat-Mungbean-Rice cropping systems may be a technique for improving resource use efficiency and increasing the system productivity. A long term experiment was initiated in Rabi season 2006-07 at BRRI experimental farm, Gazipur. Five crop establishment options viz, T_1-permanent beds with 100% crop residue retention ; T_2-permanent bed with 50% crop residue retention; T_3-permanent bed without crop residue retention; T_4-semi permanent bed (new beds with conventional tillage in every wheat season) and T_5-conventional (flat), and two weed control methods viz (W_1) hand weeding and (W_2) herbicide + hand weeding were evaluated in RCB design with three replications in Wheat-Mungbean-DS Aman rice cropping pattern. For the treatments with bed, 70 cm (40 cm top and 30 cm furrow) wide beds with 15 cm height were made. For the treatments with herbicide, non-selective herbicide Roundup was used in transition period between mungbean and rice and the transition period between wheat and mungbean. In Rabi season, wheat was sown on 22 November 2010 and

Table 1. Yield and yield components of Boro rice affected by different management options in Boro-Fallow-T. Aman cropping pattern, Kapasia, Gazipur, 2010-11.

Management option	Grain yield (t/ha)	Panicle (no./m^2)	Filled grain/ (no./panicle)	1000-grain wt (g)
BRRI recommended management + USG	6.76 ab (29)*	322	89 a	23.50
BRRI recommended management	6.38 b (21)	312	86 ab	23.47
BRRI recommended management + LCC	7.32 a (39)	336	89 a	23.66
FP + Quality seed	6.30 b (20)	312	82 bc	23.67
FP + USG	6.39 b (21)	318	84 ab	23.46
FP + LCC	6.51 ab (24)	311	86 ab	23.63
Farmers' practice (FP)	5.26 c	307	77 c	23.10

Mean value in a column followed by a common letter did not differ significantly at the 5% level by DMRT. *Figure in parenthesis indicates yield increase in percent over farmers practice.

Table 2. Yield and yield components of T. Aman rice affected by different management options in Boro-Fallow-T. Aman cropping pattern, Kapasia, Gazipur, 2011.

Management option	Grain yield (t/ha)	Panicle (no./m^2)	Filled grain/ (no./panicle)	1000-grain wt (g)
BRRI Recommended management + USG	4.80 ab (48)	255 ab	60 ab	22.40
BRRI Recommended management	5.03 a (55)	264 a	62 a	22.48
BRRI Recommended management + LCC	4.60 abc (42)	246 ab	60 ab	22.40
FP + Quality seed (QS)	3.92 d (21)	230 bc	54 cd	22.14
FP + USG	4.33 bcd (33)	243 ab	58 bc	22.48
FP + LCC	3.99 cd (23)	231 bc	54 cd	22.20
Farmers' practice (FP)	3.25 e	202 c	50 d	22.08

Mean value in a column followed by a common letter did not differ significantly at the 5% level by DMRT. *Figure in parenthesis indicates yield increase in percent over farmers' practice.

harvested on 20 March 2011. Mungbean was sown on 1 April 2011 after wheat harvest. However, mungbean was damaged due to heavy rainfall. DS rice (BRRI dhan33) was sown on 25 July 2011. DS (BRRI dhan33) rice was harvested on 14 November 2011 and was followed by wheat. Recommended management practices were followed for wheat, mungbean and rice cultivation. Higher grain yield of wheat was (3.00 t/ha) produced by permanent beds with 100 % crop residue retention. Moreover, average wheat and DS Aman yield and gross margin was better in different bed practices than conventional method (Tables 3 and 4). This experiment will be repeated for a valid conclusion.

Evaluation of different cropping patterns in irrigated medium highland ecosystem

In irrigated high and medium high land ecosystem the dominant cropping pattern is Boro-Fallow-T. Aman. A study was designed to intensify the cropping to enhance the system productivity. The experiment was conducted during 2010-11 at the experimental farm, BRRI, Gazipur. The tested cropping patterns were, CP_1=Boro-Fallow-T. Aman (existing), CP_2=Potato-DT Boro-T. Aman, CP_3=Potato-T. Aus-T. Aman, CP_4=Mustard-T. Aus-T. Aman and CP_5=Boro-T. Aus-T. Aman (Photosensitive). The experiment was conducted in a RCB design with three replications. Rice varieties of BRRI dhan29 was used in CP_1 and BRRI dhan28 was used in CP_2 and CP_5. BR26 was used in T. Aus and BRRI dhan46 and BRRI dhan49 were used in T. Aman. Potato and mustard varieties, Asterix and BARI Sorisa-14 respectively, were used in the experiment. Recommended management practices followed in this experiment. The highest REY was obtained from Potato-DT Boro-T. Aman and Potato-T. Aus-T. Aman cropping patterns (19.53 and 16.70 t/ha

Table 3. Yield of wheat, mungbean and rice under different tillage options, BRRI, Gazipur 2010-11.

Crop establishment option	Grain yield (t/ha)		
	Wheat	Mungbean*	Rice
Permanent bed + 100% crop residue (T_1)	3.00 a	-	3.70
Permanent bed + 50% crop residue (T_2)	2.60 ab	-	3.60
Permanent bed without crop residue (T_3)	2.50 ab	-	3.50
Semi-permanent bed without crop residue(T_4)	2.60 ab	-	3.40
Conventional (T_5)	2.40 ab	-	3.35
Weeding			
Hand weeding (W_1)	2.54	-	3.43
Herbicide + hand weeding (W_2)	2.68	-	3.58

*Mungbean was damaged due to excessive rain.

Table 4. Economics of Wheat-Mungbean-DS Aman cropping pattern under different crop establishment and weeding methods in raised bed and conventional method.

Treatment		TVC ('000) Tk/ha			Gross income ('000) Tk/ha			Gross margin ('000) Tk/ha	
		Wheat	Mungbean	Rice	Wheat	Mungbean	Rice	Wheat	Rice
Flat	HW	20.30	-	39.45	42.48	-	49.80	22.14	10.35
	HR + HW	22.26	-	40.10	44.46	-	50.85	22.20	10.75
PB (100%CR)	HW	16.90	-	36.15	46.08	-	54.60	29.18	18.45
	HR + HW	18.72	-	45.54	47.34	-	58.65	28.62	13.11
PB (50% CR)	HW	16.68	-	33.90	45.54	-	53.25	28.86	19.35
	HR + HW	18.51	-	35.55	45.00	-	53.55	26.49	18.00
PB (No CR)	HW	16.33	-	32.25	45.54	-	50.85	29.21	18.60
	HR + HW	17.91	-	32.25	48.60	-	53.10	30.69	20.85
SPB	HW	16.10	-	28.50	42.48	-	48.75	26.38	20.25
	HR + HW	17.88	-	29.25	44.46	-	52.65	26.58	23.40

respectively) followed by Boro-T. Aus-T. Aman (12.82 t/ha), Boro-Fallow-T. Aman (12.63 t/ha) and the lowest from Mustard-T. Aus-T. Aman (11.92 t/ha) cropping pattern (Table 5). The highest REY of the Potato-DT Boro-T. Aman cropping pattern resulted the highest gross return (292.95 Tk /ha) which was 35.33, 38.96 and 34.35% higher than those of Boro-Fallow-T. Aman, Mustard-T. Aus-T. Aman and Boro-T. Aus-T. Aman cropping patterns (Table 5).

Evaluation of *Sesbania* application and weed management practices

Green manuring by *Sesbania* increases the soil's capacity to absorb nutrients and improves soil structure and microbial activity. Moreover, brown manuring practice by *Sesbania* may reduce weed population. An experiment was conducted during Aman season, 2011 at West-byde of BRRI. BRRI dhan49 was used in T. Aman season, where *Sesbania* was incorporated with two different dates (30 DAS and 40 DAS) and methods (Herbicide application and ploughing). The treatments were 30-day-old *Sesbania* applied with herbicide application (S_1), 40-day-old *Sesbania* applied with herbicide application (S_2) and 40-day-old *Sesbania* applied through ploughing (S_3) and no *Sesbania* (S_0). Weeding treatments were hand weeding at 15, 30 and 45 DAT (W_1), at 30 and 45 DAT (W_2), at 45 DAT (W_3) and no weeding (W_4) were executed in the experiment to evaluate the effect of *Sesbania* on weed suppression. In Boro season, BRRI dhan29 was used as blanket crop. The experiment was laid out in RCB design with three replications. Recommended management practices were followed. The highest yield (6.15 t/ha) was obtained from S_2W_1 (*Sesbania* incorporation by applying herbicide 30 days after seeding with hand weeding at 15, 30 and 45 DAT) which was similar to S_3W_1 (*Sesbania* incorporation by applying herbicide 40 days after seeding with hand weeding at 15, 30 and 45 DAT). The lowest yield (3.25 t/ha) was found from S_3W_4 (*Sesbania* incorporation by applying herbicide 40 days after seeding with no weeding) which was similar to S_2W_4 (*Sesbania* incorporation by applying herbicide 30 days after seeding with no weeding) and S_4W_4 (*Sesbania* incorporation by ploughing 40 days after seeding with no weeding). In Boro season BRRI dhan29 was transplanted on 20 January 2011 and harvested on 12 May 11. The grain yield was 6.68 t/ha (Table 6).

Evaluation of intercropping grass pea in maize and *Sesbania*

Rabi maize is planted after the harvest of T. Aman rice. Thus maize planting depends on rice harvest time and the speed of drying of the soil just after rice harvest. Farmers often cultivate long duration T. Aman rice cultivars and harvest in mid-November to early December. Late planting (20 December onwards) may cause yield losses of 22% or more when further delayed and become vulnerable to early monsoon rain, when post-harvest processing becomes difficult. This raises the maize moisture content and the incidence of cob rot diseases resulting in poor quality grain. Late planted maize also suffer from lodging due to pre-monsoonal storms and may also from water logging later in stage. Direct seeded Aman rice if established early, releases the lands early that can be helpful to accommodate maize and helps to increase cropping intensity. On the other hand, early harvest will enable the Aman crop to avoid

Table 5. Yield, REY and economic performances of different cropping patterns, BRRI, Gazipur, 2010-11.

Cropping pattern	Grain/Tuber/Pod yield (t/ha)				REY (t/ha)	Variable costs ('000 Tk/ha)	Gross return ('000 Tk/ha)	Gross margin ('000 Tk/ha)
	Mustard / Potato	Boro	T. Aus/ DT Boro	T. Aman				
Boro-Fallow-T. Aman	-	6.23	-	6.40	12.63c	110.69	189.45	78.76
Potato-DT Boro-T. Aman	12.50	-	5.5	5.70	19.53a	233.10	292.95	59.85
Potato-T. Aus-T. Aman	12.2	-	3.35	5.22	16.70b	212.62	250.50	37.88
Mustard-T. Aus-T. Aman	0.64	-	3.52	5.63	11.92c	116.24	178.80	48.10
Boro-T. Aus-T. Aman		5.00	3.41	4.41	12.82c	130.70	192.30	61.60

In case of REY, means followed by common letters are not different at the 5% level of significance. Price- Potato: 10Tk/kg, Rice: 15 Tk/kg, Mustard: 45Tk/kg.

Table 6. Evaluation of *Sesbania* application and weed management practices on T. Aman yield under Boro-Fallow-T. Aman cropping pattern.

Weeding method	Method of *Sesbania* application			
	S_1	S_2	S_3	S_4
W_1	5.64 b	6.15 a	6.04 a	5.61 b
W_2	4.61 c	5.43 b	5.42 b	5.56 b
W_3	4.15 d	4.15 d	4.61 c	4.49 c
W_4	3.70 e	3.41 f	3.25 f	3.33 f

late season drought during maturity period. But direct seeding also increases potential crop losses from weeds and is viable where farmers can use integrated weed management practices including herbicides. Grasspea (*Lathyrus sativus* L.) can be grown as intercrop with maize as they have short plant stature and quick growing potentials by biologically fixing nitrogen legumes providing a relatively low-cost method of replacing nitrogen in the soil, enhancing soil fertility and boosting subsequent crops yields. Grasspea has also the potential to produce a considerable quantity of green biomass and can inhibit weed growth. DS Aus can be cultivated to intensify the cropping pattern Maize-Fallow-DS Aman. Brown manuring of *Sesbania* or herbicide or hand weeding can effectively control the weed infestation. Therefore, the study has been taken to identify the suitable crop management packages for Maize-DS Aus-DS Aman cropping pattern when grass pea and Sesbania was intercropped with maize and Aus rice respectively as green and brown manuring crops.

The experiment was conducted during 2010-11 at the experimental farms, BRRI, Gazipur. The experiment was designed in a RCB design with three replications. Along with sole maize treatment grasspea was intercropped with maize and incorporated at 25 December during earthing up of maize. Grasspea seeding was done in between maize rows at the time of maize seeding. Direct seeded Aus was cultivated with different management options, viz *Sesbania* intercropped with DS Aus rice and brown manured applying 2, 4-D ethyle easter at 30 DAS (seeding was done in between DS Aus rows at the time of Aus seeding) + one hand weeding at 40 DAS, selective herbicide (Sunrise Super) at 15 DAS followed by hand weeding 30-35 DAS and two hand weeding at 15 and 30-35 DAS. Direct seeded Aman was cultivated with post-emergence herbicide (Sunrise Super) at 15 DAS followed by hand weeding at 30-35 DAS and post-emergence herbicide (Sunrise Super) at 15 DAS. Weed density and dry matter was collected at 15, 30 and 45 DAS from 50×50 cm^2 area both in Aus and Aman season. Recommended crop management practices were followed.

There was no significant yield difference between sole maize and grasspea intercropped maize. But in case of intercropped maize, on average 142 g/m^2 grasspea biomass was added in the soil which may help to improve the soil fertility status. In Aus season, brown manured plots produced significantly lower grain yield than that of selective herbicide and hand weeded plots. Higher weed infestation due to no weeding up to 40 DAS resulting lower grain yield in brown manured plots. Direct seeded Aus with two hand weeding produced the highest grain yield 4.52 t/ha, which was statistically similar with selective herbicide followed by hand weeding at 30 DAS. In brown manured plots, on average 138 g/m^2 biomass was added into the soil, which may improve the soil fertility status. In Aman season, post-emergence herbicide at 15 DAS followed by hand weeding at 30-35 DAS produced higher grain yield than only post-emergence herbicide at 15 DAS treated plot. This study concludes that grasspea in maize and *Sesbania* in Aus rice has little effect on the weed suppression in Aman season. Maize intercropped with grasspea-DS Aus with herbicide followed by 1 hand weeding-DS Aman with herbicide followed by 1 hand weeding produced the highest REY, which was 12.64 t/ha (Table 7).

In Aus season, weed density at 10 DAS in different treatments was similar. But, after 30 DAS weed density was higher in brown manured plots than the others. It might be due to no weeding in brown manured plots up to 40 DAS. After 45 DAS, there was no significant difference in weed density in treatments. In Aman season, weed density at 10 and 30 DAS in different treatments was similar. But at 45 DAS weed density was higher only herbicide applied plots than herbicide followed by one hand weeding (Table 8).

Table 7. Yield of maize, Aus and Aman rice and REY under Maize-DS Aus-DS Aman cropping pattern, BRRI, Gazipur, 2010-11.

Treatment	Grain yield (t/ha)			REY (t/ha)
	Maize	DS Aus	DS Aman	
T_1=Grass pea+Maize-DS Aus+Brown manuring fb HW-DS Aman with herbicide fb 1 HW	5.77	3.76 b	4.49 a	12.11 a
T_2=Maize as T_1-DS Aus with selective herbicide fb HW-Aman as T_1	5.16	4.24 a	4.56 a	12.64 a
T_3=Maize as T_1-Aus as T_1-DS Aman with herbicide	4.90	3.44 b	3.36 b	10.07 c
T_4=Sole maize-Aus as T_1-Aman as T_1	5.74	3.50 b	4.37 a	11.20 b
T_5=Sole maize-DS Aus with selective herbicide fb1 HW-Aman as T_1	4.97	4.26 a	4.53 a	12.04 a
T_6=Sole maize-DS Aus with 2 HW-Aman as T_1	5.00	4.52 a	4.34 a	12.13 a
CV (%)	9.36	6.46	6.79	3.90

Table 8. Weed biomass at different times in DS Aus and DS Aman under Maize-DS Aus-DS Aman cropping pattern, BRRI, Gazipur, 2010-11.

Treatment	Weed biomass (g/m^2)					
	10 DAS		30 DAS		45 DAS	
	Aus	Aman	Aus	Aman	Aus	Aman
T_1	40.39	30.63	50.23 a	22.65	13.56	9.12 b
T_2	39.95	37.70	14.66 b	24.74	15.09	9.41 b
T_3	37.05	31.82	50.91 a	25.44	14.35	13.01 b
T_4	38.56	29.06	56.37 a	27.55	12.58	9.59 b
T_5	39.08	31.09	14.17 b	24.52	16.79	56.02 a
T_6	39.67	22.21	12.75 b	29.56	11.34	9.76 b

Evaluation of double transplanting and normal transplanting of T. Aman and Boro rice

Delayed transplanting of T. Aman and Boro rice decreases rice yield. Farmers sometimes practice double transplanting (DT) to overcome this problem. An experiment was conducted during T. Aman 2011 and Boro 2011-12 seasons at BRRI HQ farm, Gazipur on DT. The design of the experiment was RCB with three replications. In T. Aman season, treatments were: Factor A: Planting methods under different transplanting times: T_1-Normal transplanting with 30- day- old seedling on 25 July; T_2- Normal transplanting with 30-day-old seedling on 25 August; T_3- Normal transplanting with 30-day-old seedling on 25 September; T_4- Normal transplanting with 60-day-old seedling on 25 September; T_5- Double transplanting with (30+30)-day-old seedling (1st TP: 25 August; 2nd TP 25 September; sowing 25 July) and Factor B: Variety: V_1-BRRI dhan49, V_2-BR22 and V_3-BRRI dhan46. In Boro, under factor A: Planting method: T_1-Normal transplanting with 30-day-old seedling on 25 December; T_2-Normal transplanting with 40-day-old seedling on 15 January; T_3- Normal transplanting with 40-day-old seedling transplanted on 25 February; T_4-Normal transplanting with 80-day-old seedling transplanted on 25 February; T_5-Double transplanting with (40+40)-day-old seedling (1st TP: 15 January; 2nd TP 25 February; sowing 5 December). For factor B: Variety: V_1-BRRI dhan28, V_2-BRRI dhan29 and V_3-BRRI dhan45 were used. Nitrogen, P, K, S and Zn were applied as per recommendation. Except urea, all fertilizers were applied during final land preparation. Urea was applied in three equal splits, but in T_4 and T_5 only two splits were applied. Recommended management practices followed for the T. Aman and Boro rice in main field.

The results of the study revealed that the effect of establishment method (EM) and interaction between establishment methods and variety was significant for all parameters in both T. Aman and Boro seasons (Tables 9 and 10). Effect of variety was significant for all the parameters in Boro season but in T. Aman season all the parameters were non significant except grain yield (t/ha). In T. Aman, all the varieties produced the highest grain yield in optimum time normal transplanting method (T_1). In T_1 EM, BRRI dhan46 produced the highest grain yield of 6.66 t/ha followed by BRRI dhan49 (6.38 t/ha) among the tested varieties. While BRRI dhan49 produced the significantly higher (5.81 t/ha) yield than BRRI dhan46 and BR22 in T_2 EM. On the contrary, in T_3 EM, BRRI dhan49 produced lowest yield among the five EM but there is no significant difference between T_3 and T_4 EM for BR22 and BRRI dhan46. Double transplanting (T_5) of all the tested varieties on the same day produced significantly higher yield than T_4 establishment method. The effect of double transplanting was more pronounced in Boro season where all the varieties (BRRI dhan28, BRRI dhan29 and BRRI

Table 9. Effect of planting method and variety on yield and yield contributing characters of T. Aman rice DT and normal transplanting in the main field, BRRI, Gazipur, 2011.

Treatment	Grain yield (t/ha)	Panicle (no./m^2)	Grain (no./panicle)	Sterility (%)
Planting method				
T_1-Normal transplanting with 30-day-old seedling (DOS) (TP: 25 July)	6.33 a	296.66 a	113.91 a	16.14 c
T_2-Normal transplanting with 30 DOS (TP 25 August)	5.20 b	237.77 b	95.40 b	16.04 c
T_3-Normal transplanting with 30 DOS (TP 25 September)	2.38 d	259.77 b	46.47 d	30.83 a
T_4-Normal transplanting with 60 DOS (TP 25 September)	2.44 d	250.88 b	40.61 d	33.41 a
T_5-Double transplanting with (30+30) DOS (1st TP: 25 August; 2nd TP 25 September; sowing 25 July)	3.41 c	249.11 b	62.67 c	22.84 b
Variety				
V_1-BRRI dhan49	3.44 b	261.33	73.50	23.95
V_2-BR22	4.08 ab	252.80	72.98	22.69
V_3-BRRI dhan46	4.33 a	262.40	68.95	24.91
Planting method × Variety				
T_1V_1	6.38 a	275.00 bcd	116.03 a	17.53 de
T_1V_2	5.94 ab	289.33 ab	114.16 a	16.63 de
T_1V_3	6.66 a	325.66 a	111.53 a	14.27 e
T_2V_1	5.81 ab	250.66 bcd	94.80 b	15.60 de
T_2V_2	4.61 cd	230.66 cd	95.20 b	17.07 de
T_2V_3	5.19 bc	232..00 cd	96.21 b	15.43 de
T_3V_1	0.97 h	242.00 bcd	44.93 e	31.97 b
T_3V_2	3.13 ef	268.67 bcd	48.13 de	29.43 b
T_3V_3	3.04 f	268.66 bcd	46.32 e	31.10 b
T_4V_1	1.69 gh	255.33 bcd	46.63 e	30.94 b
T_4V_2	2.76 f	254.01 bcd	42.73 ef	30.97 b
T_4V_3	2.87 f	243.30 bcd	32.47 f	38.33 a
T_5V_1	2.35 fg	283.65 bcd	65.10 c	23.74 c
T_5V_2	3.98 d	221.32 d	64.66 c	19.34 d
T_5V_3	3.90 de	242.33 bcd	58.23 cd	25.44 c
CV(%)	12.05	10.78	8.62	9.20

In a column, means followed by different letters differ significantly at the 5 % level by DMRT.

dhan45) produced similar yield in double transplanting (T_5) to that obtained in normal transplanting (T_2). The lowest yield was obtained in T_4 establishment method except in BRRI dhan29, which was transplanted on 25 February, the same day of double transplanting in normal transplanting method.

Long-term effect of three cropped cropping pattern

The three cropped cropping patterns increased the system productivity, however, studies are lacking on the sustainability of the productivity of the systems and their long term implications on soil fertility. Therefore, a study was designed to determine the long-term implications of Potato-Boro-T. Aman, Maize-Mungbean-T. Aman and Boro-T. Aus-T. Aman cropping patterns on the system productivity, economics and soil fertility. The experiment was conducted during 2010-11 at the experimental farms, BRRI HQ, Gazipur and BRRI RS, Rangpur. The tested cropping patterns were, Potato-Boro-T. Aman, Maize-Mungbean-T. Aman, Boro-T. Aus-T. Aman and Boro-Fallow-T. Aman (check). The experiment was laid out in a RCB design with three replications. Each unit plot was isolated by 1 meter space and 0.2 m high and 0.2 m wide levees. The levees were covered with polythene sheet inserting into the soil both sides of levee to prevent movement of irrigation water. Recommended management practices were followed. Table 11 presents yield, REY and economic performance.

Productivity evaluation of the Boro-T. Aus-T. Aman cropping pattern

Boro-T. Aus-T. Aman cropping pattern is practiced by the farmers at FSR and D site, Toak, Kapasia.

Table 10. Effect of planting method and variety on yield and yield contributing characters of Boro rice under DT and normal transplanting in the main field, BRRI, Gazipur, 2011-12.

Treatment	Grain yield (t/ha)	Panicle (no./m^2)	Grain (no./panicle)	Sterility (%)
Planting method				
T_1-Normal transplanting with 30 DOS (TP: 25 December)	5.64 a	307.44 a	94.75 a	17.37 c
T_2-Normal transplanting with 40 DOS (TP 15 January)	5.09 a	263.77 b	85.71 b	13.29 d
T_3-Normal transplanting with 40 DOS (TP 25 February)	4.02 c	323.77 a	71.60 c	36.32 a
T_4-Normal transplanting with 80 DOS (TP 25 February)	3.81 c	312.22 a	72.15 c	23.96 b
T_5-Double transplanting with(40+40) DOS (1st TP: 15 January; 2nd TP 25 February; sowing 5 December)	4.88 b	319.77 a	92.97 a	11.68 d
Variety				
V_1-BRRI dhan28	4.44 b	311.40 ab	73.32 c	18.10 b
V_2- BRRI dhan29	5.45 a	330.26 a	83.23 b	27.16 a
V_3-BRRI dhan45	4.17 b	274.53 b	93.75 a	16.31 b
Planting method × Variety				
T_1V_1	5.28 c	297.66 bcd	75.19 de	20.13 cd
T_1V_2	6.66 a	355.65 a	93.99 b	21.67 cd
T_1V_3	4.99 cd	269.00 de	115.06 a	10.33 ef
T_2V_1	4.61 de	267.32 de	75.83 de	12.41 e
T_2V_2	5.98 b	280.00 cde	80.76 cd	20.97 cd
T_2V_3	4.70 cde	244.00 e	100.53 b	6.50 f
T_3V_1	4.44 def	328.00 abc	67.12 f	28.02 b
T_3V_2	3.79 g	356.32 a	76.33 de	40.01 a
T_3V_3	3.83 fg	287.00 cde	71.23 ef	40.93 a
T_4V_1	3.75 g	338.33 ab	63.96 f	22.76 c
T_4V_2	4.66 cde	336.00 ab	67.36 f	31.98 b
T_4V_3	3.04 h	262.33 de	85.13 c	17.15 d
T_5V_1	4.13 efg	326.00. abc	84.40 c	7.18 f
T_5V_2	6.18 ab	323.00 abc	97.73 b	21.29 cd
T_5V_3	4.32 efg	310.33 abcd	96.80 b	6.67 f
CV(%)	7.31	8.40	5.15	12.09

In a column, means followed by different letters differ significantly at the 5% level by DMRT.

Table 11. Yield, REY and economic performance of rice, potato and mungbean under different cropping patterns, BRRI HQ, Gazipur and BRRI RS, Rangpur, 2010-11.

Cropping pattern	Grain/Tuber yield (t/ha)				REY (t/ha)	Variable costs ('000 Tk/ha)	Gross return ('000 Tk/ha)	Gross margin ('000 Tk/ha)
	Maize/ Potato	Boro	T. Aus/ Mungbean	T. Aman				
Rangpur								
Boro-Fallow-T. Aman	-	6.97	-	5.99	12.96 b	125.6	252.7	127.1
Boro-T. Aus-T. Aman	-	4.99	3.10	4.51	12.60 b	141.3	245.7	104.4
Maize-Mungbean-T. Aman	5.66	-	*	3.77	-	-	-	-
Potato-Boro-T. Aman	17.45	5.32	-	4.45	17.53 a	218.5	355.0	136.5
Gazipur								
Boro-Fallow-T. Aman	-	6.90	-	6.20	13.1 ab	118.8	235.8	117.0
Boro-T. Aus-T. Aman	-	4.70	4.30	4.90	13.4 ab	146.0	237.6	91.6
Maize-Mungbean-T. Aman	4.00	-	0.84	6.10	11.1 b	123.1	199.8	76.6
Potato-Boro-T. Aman	16.00	4.20	-	5.80	17.8 a	204.6	324.0	119.4

In case of REY, means followed by common letters are not different at the 5% level of significance. *Establishment was not possible due to high soil moisture**,** Price- Potato: 8 Tk/kg, Rice: 18 Tk/kg, Maize: 10-12 Tk/kg, Mungbean: 60 Tk/kg.

Transplanting of T. Aman rice is delayed in this cropping pattern because of late harvesting T. Aus. A study was undertaken during 2010-11 at Toak, Kapasia under Gazipur in six dispersed farmer's fields with RCB design. In Aus season, the treatments were BR26, BRRI dhan48 and local varieties Laughuri and Mala. In Aman, BRRI dhan33, BRRI dhan46, BRRI dhan49 and local varieties Horafdi, Kalizira and in Boro season BRRI dhan28. Recommended management practices were followed in this study. Results revealed that improved pattern, BRRI dhan28-BRRI dhan48-BRRI dhan46 produced the highest grain yield (12.18 t/ha), which was about 10 and 7% higher than the pattern, BRRI dhan28-Laughuri-Horabdi (10.40 t/ha = FP_1) and BRRI dhan28-Mala-Kalizira (10.81 t/ha = FP_2), respectively (Tables 12 and 13). The highest gross return of rice was obtained from the improved cropping pattern, BRRI dhan28-BRRI dhan48-BRRI dhan46 (1,82,700 Tk/ha), which was 15 and 11% higher than the pattern BRRI dhan28-Laughuri-Horabdi (1,56,000 Tk/ha = FP_1) and BRRI dhan28-Mala-Horabdi (1,62,100 Tk/ha = FP_2) respectively.

Evaluation of Boro-Fallow-T. Aman cropping pattern

BRRI has developed two salinity tolerant T. Aman varieties, BRRI dhan40 and BRRI dhan41, a tidal surge tolerant variety, BRRI dhan44 and a salinity tolerant Boro variety, BRRI dhan47. These T. Aman varieties can be introduced to the existing cropping pattern of single T. Aman to increase system productivity and at the same time salinity tolerant Boro variety can be introduced to increase cropping intensity as well as system productivity. Therefore, a study was undertaken to evaluate the productivity of Boro-Fallow-T. Aman cropping pattern with those BRRI varieties in saline area. The experiment was conducted during T. Aman 2011 season at Dacope, Khulna. The design of the experiment was RCB with six dispersed replications. In Aman season, the varieties were BR23, BRRI dhan40, BRRI dhan41, BRRI dhan44, Sadamota and Nonakharchi. T. Aman varieties were sown between 15-31 July on the seed bed of six farmers. Those varieties were transplanted between 3-13 September 2011. In Boro season BRRI dhan47 was sown during 12-15 December and transplanted within 21-26 January 2012.

Table 12. Grain yield of rice under Boro-T. Aus-T. Aman cropping pattern in the farmers' field, Kapasia, Gazipur, 2010-11.

Treatment	Grain yield (t/ha)			Total (t/ha)	Increased over FP (%)	
	Boro	T. Aus	T. Aman		FP_1	FP_2
BRRI dhan28-BR26-BRRI dhan33	4.88	3.10	2.30	10.28	-	-
BRRI dhan28-BRRI dhan48-BRRI dhan33	4.88	3.30	2.30	10.48	13	10
BRRI dhan28-BR26-BRRI dhan46	4.88	3.10	4.00	11.98	15	11
BRRI dhan28-BRRI dhan48-BRRI dhan46	4.88	3.30	4.00	12.18	10	7
BRRI dhan28-BR26-BRRI dhan49	4.88	3.10	3.60	11.58	12	8
BRRI dhan28-BRRI dhan48-BRRI dhan49	4.88	3.30	3.60	11.78		
BRRI dhan28-Laughuri- Horabdi (FP_1)	4.88	2.94	2.58	10.40	-	-
BRRI dhan28-Mala-Kalizira (FP_2)	4.88	3.35	2.58	10.81	-	-

Table 13. Economic productivity of rice under Boro-T. Aus-T. Aman cropping pattern in the farmers' field, Kapasia, Gazipur, 2010-11.

Cropping pattern			Gross return ('000 Tk/ha)	Total (t/ha)	Increased over FP (%)	
Boro	T. Aus	T. Aman			FP_1	FP_2
BRRI dhan28	BR26	BRRI dhan33	10.28	154.2	-	-
BRRI dhan28	BRRI dhan48	BRRI dhan33	10.48	157.2	-	-
BRRI dhan28	BR26	BRRI dhan46	11.98	179.7	13	10
BRRI dhan28	BRRI dhan48	BRRI dhan46	12.18	182.7	15	11
BRRI dhan28	BR26	BRRI dhan49	11.58	173.7	10	7
BRRI dhan28	BRRI dhan48	BRRI dhan49	11.78	176.7	12	8
BRRI dhan28	Laughuri	Horafdi	10.40	156.0	-	
BRRI dhan28	Mala	Horafdi	10.81	162.1	-	-

Recommended management practices were followed. In T. Aman, the grain yield of BRRI dhan44 was 0.48 to 2.3 t/ha higher than other varieties and resulted 10-32% higher gross returns. The highest yield advantage (32%) was found in BRRI dhan44 compared to local varieties. The gross return of BR23, BRRI dhan40 and BRRI dhan41 was 24, 12 and 17% higher than local varieties respectively (Table 14). In Boro season, BRRI dhan47 yielded the highest, 5.29 t/ha where salinity was less than 3 dS/m (0.54-2.93 dS/m) throughout the year. The lowest yield was 2.64 t/ha due to intrusion of saline water from Pashur river breaking embankment. However, in spite of salinity problem, if Boro rice can be grown in that areas at least 33.70% higher gross return can be obtained in Boro-Fallow-T. Aman cropping pattern compared to Fallow-Fallow-T. Aman cropping pattern.

Evaluation of Vegetable-DS Aus-T. Aman cropping pattern

In Bangladesh, Vegetable-Fallow-T. Aman is one of the dominant cropping patterns in highland and medium high land-1. Generally many winter vegetable growing farmers keep their land fallow in Kharif-I season, resulting low cropping intensity. In this ecosystems after harvesting of vegetables there is an option of growing another crop in Kharif-I season. A short duration Aus rice like, BRRI dhan42 can be included for increasing cropping intensity of this ecosystem. So, this study was undertaken to evaluate the Vegetable-BRRI dhan42-BRRI dhan33 cropping pattern in partially irrigated highland ecosystem. The experiment was conducted at East byde, BRRI HQ farm, Gazipur in 2010-11. Four cropping patterns viz Spinach-Red amaranth-BRRI dhan42-BRRI dhan33, Potato-BRRI dhan42-BRRI dhan33, Tomato-BRRI dhan42-BRRI dhan33-and Carrot-BRRI dhan42-BRRI dhan33 were evaluated in RCB design with three replications. Recommended management practices were followed for rice and vegetable. Vegetables were established from last week of November to third week of January 2011. Vegetables were harvested during mid January to 1st week of April. Aus was sown in 2nd week of April and harvested in last week of July. BRRI dhan33 was transplanted on 23 August and harvested on 20 November 2011. Yields of spinach and red amaranth was 17.18 and 1.23 t/ha under Spinach-Red Amaranth-DS Aus-T. Aman cropping patterns. Red Amaranth yield was low due to low temperature followed by spinach. Potato yield was 17.40 t/ha in Potato-DS Aus-T Aman cropping pattern. Tomato yielded the highest (26.97 t/ha) among the vegetables in Tomato-DS Aus-T. Aman cropping pattern. Carrot yield was very poor due to edaphic factor in Carrot-DS Aus-T. Aman cropping pattern. The highest REY (37.24 t/ha) was obtained from Tomato-DS Aus-T. Aman cropping pattern followed by Spinach-Red Amaranth-DS Aus-T. Aman (31.76 t/ha) and the lowest from Carrot-DS Aus-T. Aman cropping pattern. The highest REY of the Tomato-DS Aus-T. Aman cropping pattern resulted the highest gross margin (Tk 5,10,340/ha) which was 15, 74 and 77% higher than those of Spinach-Red Amaranth-DS Aus-T. Aman, Potato-DS Aus-T. Aman and Carrot-DS Aus-T. Aman cropping patterns (Tables 15 and 16).

Table 14. Grain yield and economic productivity in T. Aman and Boro rice in Boro-Fallow-T. Aman cropping pattern, Dacope, Khulna, 2011-12.

Variety	Grain yield (t/ha)	Gross return (Tk/ha)	TVC (Tk/ha)	BCR
		Boro		
BRRI dhan47	4.14 (2.64-5.29)	62100	41415	1.50
		T. Aman		
BR23	4.54	68100	34298	1.99
BRRI dhan40	3.92	58800	34298	1.71
BRRI dhan41	4.14	62100	34298	1.81
BRRI dhan44	5.02	75300	34298	2.20
Local varieties	2.71	51490	27856	1.85

Price of rice (Tk kg^{-1}) = 15 (HYV) and 19 (local).

Table 15. Yields and REY of different crops and of cropping patterns, BRRI HQ, Gazipur, 2010-11.

Cropping pattern	Grain/Tuber/Root yield (t/ha)								REY
	Spinach	Red Amaranth	Potato	Tomato	Carrot	Tomato	DS Aus	T. Aman	(t/ha)
Spinach-Red Amaranth-DS Aus-T. Aman	17.18	1.23	-	-	-	-	2.81	3.72	31.76 b
Potato-DS Aus-T. Aman	-	-	17.40	-	-	-	2.83	4.08	16.58 c
Tomato-DS Aus.-T. Aman	-	-	-	26.97	-	26.97	2.91	4.36	37.24 a
Carrot-DS Aus -T. Aman	-	-	-	-	5.25	-	2.60	3.84	12.27 d
Average	-	-	-	-	-	-	2.79	3.99	24.46
CV (%)		8.31							

In case of REY, means followed by common letter(s) are not different at the 5% level of significance. Price at harvesting time (Tk kg^{-1}): Rice-18, Spinach-25, Red Amaranth-20, Potato-10, Tomato-20 and carrot-20.

Table 16. Economic performances of different cropping patterns, BRRI HQ, Gazipur, 2010-11.

Cropping pattern	Variable cost ('000 Tk/ha)	Gross return ('000 Tk/ha)	Gross margin ('000 Tk/ha)
Spinach-Red Amaranth-DS Aus-T. Aman	139.82	571.68	431.86
Potato-DS Aus-T Aman	167.81	298.44	130.63
Tomato-DS Aus.-T. Aman	162.98	670.32	507.34
Carrot-DS Aus -T. Aman	108.95	220.86	111.91

Evaluation of seeding time and variety on the productivity of dry seeded Aman rice

Wheat-Mungbean-T. Aman cropping pattern is one of the major cropping patterns in northern areas of the country. The potential of the system could not be achieved due to poor performance of existing wheat and mungbean varieties under delayed seeding. Existing cropping pattern can be improved through inclusion of recently released wheat variety BARI Gom26, 27 and mungbean variety BARI Mung-6 and short duration T. Aman varieties. Therefore, this study was undertaken to find out suitable variety for direct seeded Aman rice to increase the productivity of Wheat-Mungbean-Rice cropping pattern. The experiment was conducted during Aman 2011 at the experimental farms, Gazipur. Three Aman varieties were used in the experiment viz BRRI dhan33, BRRI dhan53 and BRRI dhan49. The varieties were direct seeded at 30 June, 10 July, 20 July and 30 July. Before seeding, non-selective herbicide was used in the field. A post-emergence herbicide (Sunrise Super) was also used at 15 DAS followed by hand weeding at 30-35 DAS. BRRI dhan49 produced higher grain yield than other varieties at all seeding time. There was little relationship between seeding time and varieties. BRRI dhan33 produced higher grain yield at 30 July seeding than earlier seeding dates. On the other hand, BRRI dhan49 produced higher yield at earlier establishments. BRRI dhan53 produced the highest grain yield at 10 July. All varieties did not follow any specific trend at different seeding dates. BRRI dhan49 produced the highest grain yield 6.05 t/ha at 30 June seeding (Table 17).

VALIDATION AND DELIVERY OF FARMING SYSTEMS TECHNOLOGIES

Boro-Fallow-T. Aman and Boro-Fallow-Fallow and Boro-Fallow-Local T. Aman are the major cropping patterns at FSR and D site Moison, Kapasia. In T. Aman season farmers usually grow Horafdi, Loita, Telosh, Pajam, Kaliaburi etc as local varieties and BR11, BRRI dhan30 and BRRI dhan40 as HYVs. In Boro season, the most popular variety is BRRI dhan29. Other HYVs practiced by the farmers are BRRI dhan28, BR1, BR14 and BR16. But the total productivity of these patterns were not satisfactory due to poor management practices. Therefore, improved cropping patterns with improved management practices were

Table 17. Grain yield of different DS Aman varieties at different seeding dates at BRRI HQ, Gazipur, 2011.

Seeding time	Grain yield (t/ha)		
	BRRI dhan33	BRRI dhan49	BRRI dhan53
20 June*			
30 June	3.56 e	6.05 a	3.76 de
10 July	3.60 e	5.66 ab	4.49 cd
20 July	3.48 cd	4.82 e	3.41 e
30 July	4.57 e	5.02 bc	3.79 de

*Establishment was not possible due to heavy rainfall.

demonstrated at the site for its rapid dissemination and to increase farmers' income through adoption of improved cropping pattern packages. BRRI dhan29-Fallow-BRRI dhan49, BRRI hybrid dhan2-Fallow-BRRI dhan49 and BRRI dhan29-Fallow-BRRI dhan46 with improved management (IM) and farmers' management (FM) practices were evaluated at FSR and D site Moison, Kapasia during 2010-11. For each pattern six farmers were selected. Recommended management practices were adopted for this trial. Results reveals that improved management practices produced about 27-33% more grain yield than farmers' management practices. BRRI hybrid dhan2-Fallow-BRRI dhan49 produced the highest grain yield (12.03 t/ha), which was about 33% higher than the farmers' management practices (9.08 t/ha) (Table 18). BRRI dhan29-Fallow-BRRI dhan49 produced 32% higher grain yield than the farmers' management practices. On the other hand, in medium highland-2 BRRI dhan46 produced 53% higher grain yield than local variety, Horabdi and BRRI dhan29-Fallow-BRRI dhan46 produced 27% higher grain yield over farmer's practices. Result indicates that the total productivity of a pattern could be increased by adopting improved management practices.

Demonstration of poultry manure as a source of phosphorus fertilizer

Demonstration trial for poultry manure as alternative source of phosphorus fertilizer was carried out at BRRI technology site, Kapasia, Gazipur during Boro season 2010-11 and T. Aman 2011. BRRI dhan29 in Boro 2010-11 and BRRI dhan46 in T. Aman were used in this study. Six dispersed farmers' field were used to conduct this experiment. The treatments were- i) All fertilizers, ii) All fertilizers (-P) and iii) All fertilizers (-P) + poultry manure. In Boro season, all fertilizers (-P) + poultry manure applied plot produced 15% higher grain yield than the all fertilizers (-P) applied plot, which was 10% lower than the all fertilizers applied plot in Boro season (Fig. 3). In T. Aman, all fertilizers (-P) + poultry manure applied plot produced 13% higher grain yield than the all fertilizers (-P) applied plot which was 7% lower than the all fertilizer applied plot (Fig. 4).

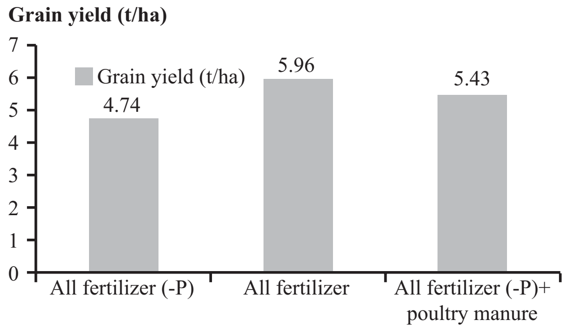


Fig. 3. Grain yield under different fertilizer treatment, BRRI technology site, Kapasia, Boro, 2010-11.

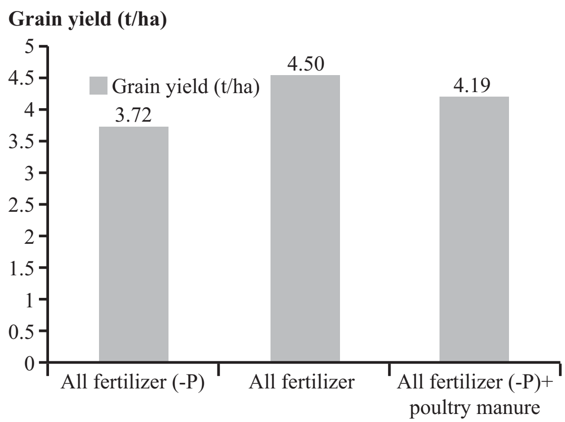


Fig. 4. Grain yield under different fertilizer treatment, BRRI technology site, Kapasia, T. Aman, 2011.

Table 18. Performance of improved cropping patterns, FSR and D site, Moison, Kapasia, 2009-10.

Cropping pattern	Yield (t/ha)						Increase over FM
	Boro		T. Aman		Total		
	IM*	FM**	IM	FM	IM	FM	(%)
BR29-Fallow- BR49	5.98	4.51	4.75	3.64	10.73	8.15	32
BR29-F-BR46(IM)/Horabdi (FM)	5.51	4.87	4.19	2.74	9.70	7.61	27
BR28 (FM)/BHD 2 (IM)-F-BR49	7.34	4.92	4.69	4.16	12.03	9.08	33

*Improved management; **Farmers' management.

Intensification of single and double rice cropping patterns

Single Boro is one of major cropping patterns of Mymensingh region in medium high land inunded up to 90 cm deep and medium low land, respectively. On the other hand, Boro-Fallow-T Aman is the widely practiced cropping pattern in the high to medium high land of irrigated environment. Between T. Aman rice harvest and Boro crop establishment, there is a wet-dry transition period of more than 80 days. Farmers keep their land fallow during this transition period. However, they can easily grow short duration high valued Rabi crops like mustard or potato, which may increase the total productivity of the systems. Short duration Aman variety like BRRI dhan33, BRRI dhan56, BRRI dhan57 and short duration mustard varieties, BARI sarisha14/15 may fit in these cropping systems. The present study has been taken considering the objectives- 1) To intensify the single Boro rice in medium high and medium low land by growing mustard before Boro rice and 2) To intensify and maximize the productivity of Boro-Fallow-T. Aman cropping pattern including short duration Aman and mustard varieties.

Char Kharicha and Alalpur were selected for the improvement Boro-Fallow-Fallow and Boro-Fallow-T. Aman cropping patterns respectively during Rabi 2010-11. After BARI Sarisha15, BRRI dhan28 and double transplanted BRRI dhan29 were demonstrated in two cropping patterns of Boro-Fallow-Fallow and Boro-Fallow-T. Aman along with existing cropping patterns to show the technological advantage of the cropping patterns. In T. Aman 2012, BRRI dhan33 was given in Alalpur block for Mustard-Boro-Fallow-T. Aman cropping pattern. Data on crop management practices followed in different cropping patterns and their productivity were collected and recorded through the joint effort of BRRI and DAE. BARI sarisha15 yielded 1.19-1.24 t/ha. After mustard, BRRI dhan28 and double transplanted BRRI dhan29 were cultivated. Grain yield of BRRI dhan28 was 5.28 t/ha, whereas double transplanted BRRI dhan29 produced 6.71 t/ha grain yield. On the other hand, BRRI dhan29 yielded 7.23 t/ha with farmers' management practices. BARI sarisha15 was cultivated during the wet-dry transition period between Boro and T. Aman to intensify, diversify and maximizing the system productivity. BARI sarisha15 produced 0.935-1.05 t/ha yield. After BARI Sarisha15, BRRI dhan28 and double transplanted BRRI dhan29 produced 5.29 and 5.85 t/ha grain yield respectively. On the other hand, BRRI dhan29 yielded 6.64 t/ha with farmers' management practices (Table 19).

In Char Kharicha block, BARI sarisha15-DT BRRI dhan29-Fallow-Fallow cropping pattern produced highest gross margin (88520 tk/ha) in Rabi season, which was 31% higher than farmers' practice. On the other hand, the gross margin of BARI sarisha15-BRRI dhan28-Fallow-Fallow was 87,500 Tk/ha having 30% advantage over farmers' practice. In Alalpur block, BARI sarisha15-BRRI dhan28-Fallow-BRRI dhan33 cropping cropping pattern produced the highest gross margin (69470 tk/ha) in Rabi season, which earned 23% higher return than farmers' practice. On the other hand, the gross margin of BARI sarisha15-DT BRRI dhan29-Fallow-Fallow was 87500 Tk/ha which was 30% higher than farmers' practice.

Multilocation testing of BRRI dhan29-Fallow-BRRI dhan46/49 cropping pattern

Multilocation trial of BRRI dhan29-Fallow-BRRI dhan46/49 cropping pattern in medium highland phase II was undertaken at three upazilas of Kurigram, Mymensingh and B. Baria districts. Block demonstration was done in five *bigha* land of five farmers at each upazila. Tables 20 and 21 present the management practices followed in Boro and T. Aman seasons both in the recommended and farmers' patterns.

The recommended patterns produced 19-20% higher grain yield and 17-22% gross margin over existing farmers' patterns. The highest yield of 12.35 t/ha and gross margin of Tk 1,22,060/ha from recommended cropping pattern was obtained in Mymensingh followed by Kurigram where the pattern yield and gross margin were 11.91 t/ha and Tk 1,21,000/ha respectively (Table 22).

Table 19. Yield of mustard and Boro rice in Mustard-Boro-Fallow-Fallow cropping pattern along with farmers' practice in Char Kharicha, Mymensingh sadar, 2011-12.

Cropping pattern	Yield (t/ha)			Variable costs ('000 Tk/ha)	Gross return ('000 Tk/ha)	Gross margin ('000 Tk/ha)
	Mustard	Boro/ DT Boro	T. Aman			
	Char Kharicha					
BRRI dhan29-Fallow-Fallow (Farmers' practice)	-	7.23	-	58.99	126.53	67.54
BARI Sarisha15-BRRI dhan28-Fallow-Fallow	1.24	5.58	-	71.53	159.03	87.50
BARI Sarisha-15-DT BRRI dhan29-Fallow-Fallow	1.19	6.71	-	82.46	170.96	88.52
	Alalpur					
BRRI dhan29-Fallow-BINA dhan7 (Farmers' practice)	-	6.64	-	59.63	116.20	56.57
BARI Sarisha15-BRRI dhan28-Fallow-BRRI dhan33	0.934	5.29	-	70.43	139.90	69.47
BARI Sarisha15-DT BRRI dhan29-Fallow-BRRI dhan33	1.05	5.85	-	81.35	149.63	68.28

*Not included in the economic performance, as it is in the field. Price- rice: 16-17 Tk/kg, mustard: 45 Tk/kg.

Table 20. Crop management practices followed in Boro rice in Boro-Fallow-T. Aman cropping pattern, in Kurigram, Mymensingh and B. Baria, 2010-11.

Crop management practice	Kurigram		Mymensingh		B. Baria	
	BR29	BR29*	BR29	Pajam*	BR29	BR28*
Date of sowing	5-8 Dec 10	1 Dec 10	29 Nov 10	10 Dec 10	4-10 Dec 10	3-11 Dec 10
Seedling age (days)	48-51	59	47	63	44-45	47-50
Date of transplanting	23-28 Jan 11	29 Jan 11	15 Jan 11	11 Feb 11	18-21 Jan 11	20-25 Jan 11
Spacing (cm ×cm)	20 × 20	20 × 20	25 × 20	20 × 15	20 × 20	20 × 20
No. of seedlings/hill	2-3	3-4	2-3	3-4	2-3	4-5
Fertilizer rate (kg/ha): N-P-K-S-Zn	138-18-61-10-2.5	79-7.5-37-0-0	172-25-75-15-4	140-15-20-5-0	138-18-61-10-2.5	99-15-20-0-0
No. of weeding	2	3	2	2	2	1
No. of irrigation	12	12	20	20	17	14
No. of pesticide applied	25-28 May 11	29 May 11	1	1	2	1
Date of harvest	5-8 Dec 10	1 Dec 10	13-15 May 11	20 May 11	12-19 May 11	24-30 April 11

* Non-participant.

Table 21. Crop management practices followed in T Aman rice in Boro-Fallow-T. Aman cropping pattern, in Kurigram, Mymensingh and B. Baria, 2011.

Crop management practice	Kurigram		Mymensingh		B. Baria	
	BR46	Panisail *	BR49	BR10 *	BR46	BR49*
Date of sowing	28-29 July 11	15 July 10	16 July 11	19 July 11	26-27 July 11	14-19 July 11
Seedling age (days)	39-40	50	27	35	30-35	30-33
Date of transplanting	7-9 Sep 11	5 Sep 11	12 Aug 11	24 Aug 11	30-31 Aug 11	20-22 Aug 11
Row × hill spacing (cm × cm)	20 × 20	Traditional	20 × 20	20 × 15	20 × 15	20 × 20
No. of seedlings/hill	2-3	4-5	2-3	4-5	2-3	4-5
Fertilizer rate (kg/ha): N-P-K-S-Zn	55-6-19-0-0	63-9-28-0-0	55-6-19-0-0	21-15-10-0-0	55-6-19-0-0	55-3-8-0-0
No. of weeding	1	1	2	2	3	1
No. of irrigation	1	0	-	-	-	-
No. of pesticide applied	2	3	-	-	2	1
Date of harvest	9-10 Dec 10	4 Dec 10	29 Nov 11	5 Dec 11	9-10 Dec 11	1-4 Dec 11

*Non-participated.

Table 22. Grain yield of Boro-Fallow-T. Aman cropping pattern in Kurigram, Mymensingh and B. Baria, 2010-11.

Cropping pattern	Boro (t/ha)	T. Aman (t/ha)	Total (t/ha)	TVC ('000 Tk/ha)		GM ('000 Tk/ha)		Total GM (Tk/ha)	Increased GM (%)
				Boro	T. Aman	Boro	T. Aman		
Kurigram									
BRRI dhan29-BRRI dhan46-Fallow	7.65	4.26	11.91	57.95	32.70	68.85	52.15	121.00	22
BRRI dhan29-Panisail Fallow*	6.62	2.90	9.52	53.26	26.97	50.87	43.53	94.04	
Mymensingh									
BRRI dhan29-Fallow-BRRI dhan49	6.79	5.56	12.35	60.97	39.88	64.64	57.42	122	20
Pajam-Fallow-BR10*	5.65	4.38	10.03	45.83	33.66	58.69	42.99	102	
B.Baria									
BRRI dhan29-Fallow-BRRI dhan46	5.94	5.43	11.37	55.22	33.44	33.58	48.00	81.58	17
BRRI dhan29-Fallow-BRRI dhan49*	5.28	3.98	9.26	41.47	29.92	37.73	29.78	67.51	

*Non-participant.

Agricultural Economics Division

SUMMARY

BRRI dhan28 and BRRI dhan29 were the most popular varieties in Boro season. BR11 is still the dominant variety covering about 22% of the total T. Aman area. In Aus season, the area coverage of BRRI dhan28 was the highest (16%) followed by BR3 (6.95%). BRRI dhan29 was the top yielder in both Boro (5.41 t/ha) and Aus (4.58 t/ha) seasons. BRRI dhan44 ranked top in terms of per unit yield (4.25 t/ha) in T. Aman season. Some hybrid and Indian varieties are being adopted as replacement of MV Aus and Aman due to higher yield performance.

Rice farmers used more seed than the recommended rate and applied lower amount of TSP and MP fertilizer. They received lower amount of gross return from MV Aus and MV Boro owing to higher production cost and lower market price; although, per hectare yield of Boro is higher. MV T. Aman growers received higher net return due to better market prices.

Area under hybrid rice has been declining while area under BRRI dhan29 and other MVs has been fluctuating over the period 2002-11. Although, the yield performance (about 7 t/ha) of hybrid rice and MVs varied in different districts, the yield of hybrid was higher than BRRI dhan28 (5 t/ha) and BRRI dhan29 (6 t/ha). Almost all the producers showed their enthusiasm to continue growing hybrid rice only expecting better yield.

In southern region, major cropping patterns were Rabi/khesari-T. Aus-T. Aman, Rabi-Fallow-T. Aman, Fallow-T. Aus-T. Aman and Boro-Fallow-Fallow, indicating there is a lot of scope to grow rice and other crops in the Boro and Aus seasons. Whereas the major cropping patterns in northern region were Boro-Potato-T. Aman, Boro-Fallow-T. Aman and Tobacco-Jute-T. Aman. The farmers of Barisal region need mainly insect, disease resistant and longer seedlings varieties along with harvester, transplanter, applicator of USG, dryer etc; while the farmers of Rangpur region need mainly insect, disease and drought resistant varieties with long seedlings harvester, transplanter, USG applicator and dryer.

The technology users were enthusiastic to use the given variety for next season. The average volume of sale of Aman paddy (1.69 ton) was higher after the project intervention compared to than that of (1.09 ton) before the project. Average production of Boro was lower in 2011 (4.08 ton) than that of (5.03 ton) 2010 due to cold and drought problem.

During 1971-72 to 1983-84, the growth in area for Aus, Aman and Boro slowed down while the production growth accelerated due to adoption of BRRI developed high yielding rice varieties. There are significant differences in the area, production and yield of different food grains between the period of pre and post establishment of BRRI. It also showed the structural changes in the area and production of different food grains between the periods due to initiation by the World Bank and govt. subsidies on inputs.

FARM LEVEL EVALUATION OF MODERN RICE CULTIVATION IN BANGLADESH

Modern rice varieties are grown all over the country in three seasons namely, Aus, Aman and Boro. BRRI Agricultural Economics Division is carrying out survey to monitor the farm level MV adoption and performance of different rice varieties of 9 different agricultural regions of the country with the following specific objectives to:

- determine the region-wise adoption rate of different MVs in Boro, Aus and T. Aman seasons;
- estimate the yield of different modern and local rice varieties.

A total of 4034 sample farmers were sampled through multistage stratified random sampling technique and interviewed under Boro, T. Aman and Aus seasons.

Adoption of modern rice varieties

The dominant rice varieties in Boro season were BRRI dhan28 and BRRI dhan29, covered 64% of the total Boro area (Table 1). Hybrid and Indian rice varieties covered 11.07 and 4.31% areas, respectively. The overall adoption rate of BRRI varieties was about 74.13% in Boro season. Therefore, the modern varieties covered about 97% area in Boro season. BR11 appeared as the

Table 1. Adoption (%) of Boro rice varieties by agricultural regions of Bangladesh since 2009-10 to 2011-12.

Variety	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	All average
BR1						0.40				0.06
BR2				0.94						0.12
BR8									0.50	0.06
BR12				6.13				6.19		1.11
BR14	1.92			1.42	6.32	1.62		1.03		1.81
BR16					6.32	3.64				1.57
BR19						1.21				0.17
BR24									0.50	0.06
BR26			7.05		7.37					1.86
BRRI dhan28	37.31	46.85	60.26	17.92	29.82	35.22	33.33	26.80	16.08	32.93
BRRI dhan29	24.62	40.56		23.58	32.28	39.68	12.82	2.06	77.89	31.12
BRRI dhan33								2.06		0.12
BRRI dhan47	0.38			16.51		0.40	12.82			3.03
BRRI dhan50		1.40								0.12
All BRRI varieties	64.23	88.81	67.31	66.51	82.11	82.19	58.97	38.14	94.97	74.13
Hybrid	17.31	2.10	9.62	5.19	10.18	9.72	3.42	51.55	4.52	11.07
Indian	10.00	9.09	5.77	9.91	0.35			4.12		4.31
Other MVs	5.00		16.67	5.19	7.37	4.86	37.61	5.15	0.50	7.75
BINA8				0.47	0.35					0.12
China	0.38					2.83	12.82	1.03		1.40
IR50			1.28							0.12
IR60			0.64							0.06
IR8				3.77						0.47
Iratom							8.55			0.58
Minikit	1.15		13.46							1.40
Munsur				0.47						0.06
Nepali Parija	0.77									0.12
Pajam	0.38				0.70	0.40		2.06	0.50	0.41
Purbachi	0.38				2.46	1.62	16.24	1.03		1.86
All MVs	96.54	100	99.36	86.79	100	96.76	100	98.97	100	97.26
All LVs	3.46		0.64	13.21		3.24		1.03		2.74
All	100	100	100	100	100	100	100	100	100	100

prominent rice variety covering 22% areas in T. Aman season. The second and third positions were of BR22 (3.41%) and BRRI dhan32 (2.67%) (Table 2). While adoption rate of Indian varieties was 19.20%. The area covered by BRRI varieties was about 44% in T. Aman. The overall coverage of modern varieties was about 70 percent in T. Aman.

The adoption rate of modern rice varieties in Aus season was about 72.25% of which BRRI varieties was about 43%. BRRI dhan28 ranked the top position (15.57%) followed by BR3 (6.95%) and BR1 (3.68%). The Indian and other MV varieties were about 11 and 16% respectively (Table 3). Area coverage of traditional varieties was about 28%. BBS study result also showed that coverage of MV Aus varieties was 74.80% in 2011-12 Kharif I season.

Yield of modern rice varieties

In Boro season, among all BRRI varieties, BRRI dhan29 was the top yielder (5.41 t/ha) followed by BR14 (5.16 t/ha) and BRRI dhan28 (4.93 t/ha) (Table 4). Average yield of BRRI varieties was 5.07 t/ha. The yield of hybrid rice was 5.76 t/ha.

Among the BRRI varieties in T. Aman BRRI dhan44 was the top yielder (4.25 t/ha) followed by BR11 (3.83 t/ha), BR3 (3.78 t/ha). Overall yield rate of modern varieties was 3.58 t/ha and the average yield of BRRI varieties was 3.64 t/ha (Table 5). In Aus season BRRI dhan29 produced the highest yield (4.58 t/ha). The second, third and fourth position were BRRI dhan28 (4.09 t/ha), BRRI dhan27 (4.08 t/ha) and BR21 (3.90 t/ha). The yield rate of hybrid rice was 4.10 t/ha. Differences between the average yield of MVs (3.49 t/ha) and LVs (2.27 t/ha) was higher (54%) in this season (Table 6).

Trend changes in adoption and yield level

The adoption of modern varieties in T. Aman season increased from 34% in 1990-91 to 70.11% in 2011-12 (Table 7). In the same period, the

Table 2. Adoption (%) of MV T. Aman rice varieties by agricultural regions of Bangladesh, since 2009-10 to 2011-12.

Variety	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	All average
BR2					2.08	0.73				0.29
BR3					0.42	0.36			0.43	0.12
BR6		0.30								0.04
BR7	0.77									0.08
BR10			9.63				3.05	1.23		1.93
BR11	25.00	20.60	15.06	14.55	18.33	33.09	12.69	38.04	26.07	21.59
BR12						2.91				0.33
BR14	0.38			0.31						0.12
BR16			0.49							0.08
BR21								7.98	1.71	0.70
BR22			2.96	1.55	0.83	12.73	6.60	9.20	0.43	3.41
BR23			12.84	1.55			3.05			2.59
BR25						0.36				0.04
BRRI dhan28			0.25				1.02	0.61	1.28	0.29
BRRI dhan29						0.73			0.85	0.16
BRRI dhan30	0.38	2.09	5.19		0.42	0.73		1.23		1.40
BRRI dhan31					0.42					0.04
BRRI dhan32		1.49		0.31	5.83	1.82	19.29		0.85	2.67
BRRI dhan33	0.38	0.30	1.23	3.72			1.02	3.07		1.07
BRRI dhan34	4.62				0.42					0.53
BRRI dhan39		0.90	7.65					0.61		1.44
BRRI dhan40	0.77		1.23	1.86	2.50		1.52		2.14	1.11
BRRI dhan41	0.77		1.98	9.60	2.08	0.36	1.02	1.23	2.99	2.38
BRRI dhan44				0.31		0.73				0.12
BRRI dhan45									0.85	0.08
BRRI dhan49	5.77	1.79								0.86
BRRI dhan56		0.30								0.04
All BRRI Varieties	38.85	27.76	58.52	33.75	33.33	54.55	49.24	63.80	37.61	43.54
All Indian	53.46	38.21	21.98	24.15		1.82		15.95	0.85	19.20
All other MVs	5.00	10.75	1.48	3.72	24.17	6.91	2.54	4.29	9.83	7.36
BINA7	0.38	1.49								0.25
China				0.31					1.28	0.16
IR50								0.61	0.43	0.08
IR52	0.38									0.04
Mamun		5.07								0.70
Minicate	1.92									0.21
Pajam	1.54	3.28	1.48	2.79	17.92	6.91	2.54	2.45	7.69	4.89
Purbachi								0.61		0.04
Horidhan	0.77	0.60			6.25			0.61	0.43	0.86
All MVs	97.31	76.72	81.98	61.61	57.50	63.27	51.78	84.05	48.29	70.11
All LVs	1.92	18.21	18.02	37.15	42.50	34.55	46.19	10.43	50.85	28.08
Aromatic	0.77	5.07		1.24		2.18	2.03	5.52	0.85	1.81
All	100	100	100	100	100	100	100	100	100	100

Table 3. Adoption (%) of MV Aus rice varieties by agricultural regions of Bangladesh, since 2009-10 to 2011-12.

Variety	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Average
BR1			3.45		0.57	21.90	4.44			3.68
BR2			10.34	6.80	10.86		17.22		22.61	6.95
BR3				6.12	10.29	0.48	2.78		1.74	2.61
BR8				1.36						0.24
BR11				0.34			1.11	3.64	0.87	0.48
BR12								1.82		0.12
BR14	1.83	0.43			0.57					0.30
BR16	0.61									0.18
BR20				1.02	1.14	5.24	12.22			2.26
BR21				3.40	0.57	0.95	9.44	24.55		3.39

Table 3. Continued.

Variety	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Average
BR24	1.22									0.12
BR25			0.49							0.06
BR26		3.45	8.87	2.04	1.14	0.48		0.91		2.14
BRRI dhan27			0.99	0.34						0.18
BRRI dhan28	50.00	8.62	21.67	0.34	4.00	33.33	5.56	6.36	18.26	15.57
BRRI dhan29	7.32		0.49	0.68		0.95		1.82	1.74	1.25
BRRI dhan32			0.99							0.12
BRRI dhan33				2.04	0.57			20.00		1.72
BRRI dhan43						0.48	0.56			0.12
BRRI dhan48					1.71	0.95	0.56			0.36
BRRI dhan50						5.24	0.56			0.71
BRRI varieties	60.98	12.50	47.29	24.49	31.43	70.95	54.44	59.09	45.22	42.54
Hybrid	6.10	0.43	4.43		8.57		0.56	8.18	5.22	3.15
Indian	29.27	37.50	9.36	3.40					17.39	10.93
Other MVs	0.61	15.09	5.91	15.65	30.29	10.00	18.89	23.64	30.43	15.63
All MVs	96.95	65.52	67.00	44.22	70.29	80.95	73.89	90.91	98.26	72.25
LVs	3.05	34.48	33.00	55.78	29.71	19.05	26.11	9.09	1.74	27.75
All Varieties	100	100	100	100	100	100	100	100	100	100

Table 4. Yield (t/ha) of Boro rice varieties by agricultural regions of Bangladesh, since 2009-10 to 2011-12.

Variety	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Average
BR1						3.95				3.95
BR2				2.63						2.63
BR8									4.07	4.07
BR12				3.21				3.29		3.24
BR14	5.12			4.94	5.13	5.45		5.44		5.16
BR16					5.22	3.65				4.69
BR19						4.20				4.20
BR24									3.29	3.29
BR26			4.34		4.73					4.59
BRRI dhan28	4.91	5.01	5.25	4.93	5.01	4.61	4.67	4.97	4.77	4.93
BRRI dhan29	5.64	5.37		5.12	5.96	4.97	5.81	3.32	5.35	5.41
BRRI dhan33								4.39		4.39
BRRI dhan47	3.66			4.49		4.74	4.78			4.56
BRRI dhan50		3.74								3.74
BRRI varieties	5.19	5.16	5.16	4.70	5.38	4.75	4.94	4.59	5.23	5.07
Hybrid	6.05	5.29	5.20	5.26	6.70	4.93	6.27	5.47	6.64	5.76
Indian	4.91	4.42	5.04	3.43	4.94			3.10		4.32
Other MVs	3.64		4.43	3.67	4.14	4.28	4.16	3.82	3.56	4.11
BINA8				3.95	3.56					3.76
China	4.94					3.87	3.91	3.95		3.94
IR50			3.43							3.43
IR60			3.49							3.49
IR8				3.32						3.32
Iratom							4.47			4.47
Minikit	3.26		4.63							4.46
Munsur				4.94						4.94
Nepali Parija	3.74									3.74
Pajam	4.19				5.25	2.97		3.95	3.56	4.16
Purbachi	3.95				4.52	5.32	4.19	5.27		4.43
All MVs	5.24	5.09	5.03	4.53	5.42	4.75	4.69	4.95	5.29	5.04
All LVs	3.67		4.12	3.63		3.43		2.60		3.59
All average	5.18	5.09	5.03	4.41	5.42	4.70	4.69	4.92	5.29	5.00

Table 5. Yield (t/ha) of MV T. Aman rice varieties by agricultural regions of Bangladesh, since 2009-10 to 2011-12.

Variety	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Average
BR2					3.56	3.80				3.63
BR3					3.39	3.85			4.09	3.78
BR6		3.33								3.33
BR7	3.46									3.46
BR10			3.60				3.95	3.79		3.66
BR11	4.14	3.89	3.61	3.77	3.56	3.66	3.48	4.41	3.67	3.83
BR12						3.21				3.21
BR14	3.95			2.97				3.56		3.49
BR16			2.96							2.96
BR21								3.74	2.76	3.51
BR22			3.24	3.20	3.61	3.90	2.98	3.65	2.68	3.55
BR23			3.43	3.03			3.22			3.38
BR25						2.64				2.64
BRRI dhan28			3.95				3.29	4.80	3.67	3.52
BRRI dhan29						3.24			3.29	3.27
BRRI dhan30	3.95	3.94	3.27		3.67	3.67		4.68		3.55
BRRI dhan31					3.46					3.46
BRRI dhan32		3.48		4.12	4.18	3.29	2.42		4.24	3.03
BRRI dhan33	2.77	3.00	3.79	3.37			3.51	3.61		3.47
BRRI dhan34	2.28				2.31					2.28
BRRI dhan39		4.07	3.55					4.69		3.63
BRRI dhan40	3.43		4.44	3.30	4.33		3.06		3.29	3.72
BRRI dhan41	4.94		3.46	3.45	2.91	4.61	4.94	4.16	3.18	3.52
BRRI dhan44				3.69		4.53				4.25
BRRI dhan45									3.03	3.03
BRRI dhan49	3.63	4.01								3.74
BRRI dhan56		2.99								2.99
BRRI varieties	3.81	3.86	3.53	3.54	3.67	3.72	3.02	4.16	3.55	3.64
All Indian	3.70	3.67	3.36	2.69		5.32		4.21	4.36	3.51
All other MVs	3.15	4.12	3.30	3.52	3.48	3.16	3.48	3.47	2.67	3.45
BINA7	3.20	3.31								3.29
China				4.94					2.69	3.25
IR50								2.97	2.64	2.80
IR52	1.98									1.98
Mamun		5.11								5.11
Minicate	2.90									2.90
Pajam	3.01	2.86	3.30	3.42	3.31	3.16	3.48	3.52	2.62	3.15
Purbachi								3.46		3.46
Horidhan	4.59	5.19			3.98			3.80	3.59	4.13
All MVs	3.72	3.81	3.48	3.21	3.59	3.70	3.04	4.14	3.39	3.58
All LVs	2.17	2.36	2.68	2.28	2.50	2.43	2.24	3.32	2.20	2.39
Aromatic	2.37	1.42		2.11		2.64	0.52	2.65	2.35	1.91
All	3.68	3.42	3.33	2.85	3.13	3.24	2.62	3.97	2.77	3.22

Table 6. Yield (t/ha) of Aus rice varieties by agricultural regions of Bangladesh, since 2009-10 to 2011-12.

Variety	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Average
BR1			2.42		3.29	3.43	4.08			3.40
BR2			2.64	3.18	2.88		2.81		3.18	2.94
BR3				3.65	3.65	3.62	3.26		4.66	3.65
BR8				3.46						3.46
BR11				3.46			3.29	3.36	3.80	3.41
BR12								3.58		3.58
BR14	4.14	3.56			2.81					3.76
BR16	5.93					2.22				3.45
BR20				3.16	2.80	3.17	3.64			3.42
BR21				3.83	3.71	3.84	4.30	3.68		3.90

Table 6. Continued.

Variety	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Average
BR24	2.82									2.82
BR25			3.46							3.46
BR26		3.79	3.74	3.62	3.95	4.12		2.47		3.72
BRRI dhan27			4.74	2.78						4.08
BRRI dhan28	4.27	4.37	3.86	5.90	3.56	3.79	4.93	4.55	4.20	4.09
BRRI dhan29	4.70		3.88	4.93		3.02		4.69	5.25	4.58
BRRI dhan32			3.05							3.05
BRRI dhan33				2.97	2.96			3.54		3.40
BRRI dhan43						2.63	3.29			2.96
BRRI dhan48					2.82	4.76	3.66			3.61
BRRI dhan50						2.70	1.98			2.64
BRRI varieties	4.31	4.18	3.46	3.51	3.27	3.53	3.61	3.71	3.74	3.68
Hybrid	4.98	4.94	4.60	4.12	2.57		7.41	4.63	4.24	4.10
Indian	3.56	3.46	3.86	2.24					1.14	3.21
Other MVs	3.56	3.58	3.00	2.73	2.92	3.63	3.18	3.14	2.79	3.08
All MVs	4.12	3.64	3.55	3.14	3.04	3.54	3.53	3.65	3.01	3.49
LVs	4.29	2.20	2.48	2.22	2.19	2.34	1.82	3.27	3.71	2.27
All	4.12	3.14	3.20	2.63	2.78	3.31	3.09	3.61	3.02	3.15

Table 7. Changes in the level of adoption and yield of modern rice varieties over the years.

Item	·Period		Differences
	1990-91*	2011-12	
	T. Aman		
Adoption (%)			
Yield (kg/ha)	34.00	70.11	36.11
	3290	3770	290.00 (8.81)
	Boro		
Adoption (%)			
Yield (kg/ha)	88.93	97.26	8.33
	4410	5040	630.00 (14.28)

Figures in parentheses indicate the percent. * National average.

adoption of Boro MVs increased from 88.93 to 97.26%. The increase of yield was much higher in Boro (14.28%) compared to T. Aman (8.81%).

ESTIMATION OF COSTS AND RETURN OF MV RICE CULTIVATION AT FARM LEVEL

A technology is accepted by the farmers if it is economically viable. Moreover, through the cost-return analysis, researchers and planners can get indication in developing a technology, which will help farmers in increasing return and reducing cost. A macro level study was undertaken to address the aforesaid issues with the following specific objectives:

- Determine the level of inputs used in MV Aus, MV T. Aman and MV Boro rice cultivation;
- Estimate the cost of MV rice cultivation in different seasons; and
- Evaluate the profitability of MV Aus, MV T. Aman and MV Boro rice cultivation at the farm level.

Multistage random sampling technique was adopted to select farmers from nine agricultural regions of Bangladesh. The study used a sample survey of 60 of each Aus, T. Aman and Boro rice growing farmers. Data were collected through direct interviewing with questionnaire.

Level of inputs used. As majority of the farming activities were pulling of seedlings and transplanting, weeding and post harvest operations on contractual basis total human labour needed for MV rice cultivation were lower. The highest amount of human labour (107 man-days/ha) was used for MV Boro followed by MV Aus rice (104 man-days/ha) and MV T. Aman (75 man-days/ha, Table 8). The seed rates for MV Aus, MV T. Aman and MV Boro rice were 52, 58 and 52 kg/ha, that means farmer used higher amount of seed than the recommended rate of 35 to 40 kg/ha. Farmers were found to apply comparatively lower amount of TSP and MP fertilizer in MV T. Aman seasons.

Cultivation costs. The cost of rice cultivation included all variable cost items like human labour, animal labour, power tiller, seed, fertilizer, manure, irrigation, insecticides etc. Per hectare human labour costs were Tk 37,766, 34,329 and 44,246

Table 8. Per hectare inputs used for MV rice cultivation in different seasons of Bangladesh, 2011-12.

Input item	Aus	Aman	Boro
Human labour (man-days/ha):	104	75	107
Family labour	38	27	46
Hired labour	66	48	61
Seed	52	58	52
Fertilizer (kg/ha):			
Urea	164	171	263
TSP	73	87	127
MOP	55	55	87
DAP	32	9	-
Gypsum	45	25	79
$ZnSO_4$	6	-	8

for MV Aus, MV T. Aman and MV Boro rice cultivation respectively (Table 9).

Fertilizer cost of Boro (Tk 11,973/ha) and Aus (Tk 8,218/ha) rice cultivation was significantly higher than the cost of T. Aman (Tk 7,323/ha). Irrigation cost was much higher (13.50% of total cost) for MV Boro rice cultivation than that of MV Aus (3%) and MV T. Aman. The cost of cultivation for Boro rice in all the study locations was tremendously higher in comparison to MV Aus and MV T. Aman.

Table 9. Per hectare costs (in taka) of MV rice cultivation in different seasons of Bangladesh, 2011-12.

Item	Aus	Aman	Boro
Seedbed preparation (Tk/ha)	1490	2423	2373
Seed (Tk/ha)	1924	1958	2236
Human labour (Tk/ha):	37766 (54.55)	34329 (48.79)	44246 (42.71)
Family labour	10336	7614	13294
Hired labour	17952	13536	17629
Contract	9478	13179	13323
Land preparation cost (Tk/ha)	6202	6887	7144
Fertilizer (Tk/ha):	8218 (11.87)	7323 (10.41)	11973 (11.56)
Urea	3280	3420	5260
TSP	1971	2349	3302
MOP	990	1100	1740
DAP	960	279	-
Gypsum	315	175	711
$ZnSO_4$	702	-	960
Cowdung cost (Tk/ha)	-	-	2234
Irrigation (Tk/ha)	2086 (3)	-	13986 (13.50)
Herbicide cost (Tk/ha)	-	928	-
Pesticides (Tk/ha)	1806	1422	1776
Variable cost (Tk/ha)	49156	47656	72674
Interest on operating capital @ 9% for 5 months	1115	1036	1612
Land rent (Tk/ha)	18958	21666	29299
Total cost (Tk/ha)	69229	70358	103585

Figure in the parentheses indicates percentage.

Profitability. The yield received by the rice farmers in cultivating MV Aus, MV T.Aman and MV Boro crops were 3,588, 3,956 and 5,509 kg/ha respectively. Higher yield obtained from BRRI dhan28 and BRRI dhan29 in Boro season. However, the MV Boro growers received higher gross return (Tk 82,035 /ha) than MV T. Aman (Tk 74,250/ha) and MV Aus (Tk 56,252/ha) season due to higher yield and market price of their product (Table 10).

Table 10. Comparative costs and return of MV rice cultivation in different seasons of Bangladesh, 2011-12.

Item	Aus	Aman	Boro
Yield (kg/ha)	3588	3956	5509
Paddy price (Tk/kg)	14.08	16.68	13.82
Return from paddy (Tk/ha)	50519	65986	76134
Straw (Tk/ha)	5733	8264	5901
Gross return (Tk/ha)	56252	74250	82035
Variable cost (Tk/ha)	53084	47656	72396
Total cost (Tk/ha)	69229	70358	103585
Gross margin (Tk/ha)	3168	26594	9639
Net return (Tk/ha)	-12977	3892	-21550
Unit cost of production (Tk/kg)	19.29	17.79	18.80
BCR (Undiscounted)	0.81	1.06	0.79

HYBRID RICE TECHNOLOGY AND ITS SUSTAINABILITY AT THE FARM LEVEL

Rapid diffusion of hybrid rice, which promises a yield gain of about 15-20 percent over the best inbred modern varieties, can contribute substantially to maintain the food population balance in the country. The present study was conducted to:

- examine adoption of hybrid rice at the farm level in the selected areas
- identify the factors for shifting land to hybrid rice from inbred rice.
- analyze the profitability of hybrid rice at the farm level.
- assess the level of consumers preferences and identify constraints of hybrid rice.

The study was based on primary data collected during Boro season (2010-11) from five major rice production environments (ie Favorable (Rangpur), Flood prone (Sherpur), drought prone (Rajshahi), Saline (Khulna) and tidal submergence (Barisal). Five hundred farmers were interviewed taking 100 from each production environment.

Land allocation under different rice varieties in different districts during Boro season

In Barisal region, during 2008 area under BRRI dhan28 was 27% and it reduced gradually every year and that of hybrid rice was 24% and it fluctuated over the years. BRRI dhan29 covered 29% area in 2008 and it fluctuated over the years (Table 11). BRRI dhan47 covered 23.65% of their rice land in 2011. The area coverage of BRRI dhan28 slightly fluctuated over the year 2002-08 in saline prone Khulna district. Adoption of BRRI dhan29 is observed to be also very fluctuating in Khulna district. Area under hybrid rice cultivation increased substantially from 2% in 2002 to 35% in 2007 and in 2011 it further reduced to 20%. The area coverage of BRRI dhan28 was observed also very higher in Rajshahi and substantially increased. In Rangpur district, area under BRRI dhan28 increased to 51% in 2007 from 40% in 2004 but it impressively expanded to 77% in 2011. Hybrid rice area was 33% in 2008 and it drastically declined to 15% in 2011. The area coverage of BRRI dhan28 was observed higher in flood prone Sherpur district and it substantially increased to 76% in 2011 from 70% in 2009 (Table 11).

Comparative yield performance of different rice varieties in different districts

In Barisal, yield of BRRI dhan28 and BRRI dhan29 was very stable and its performance was about 5 and 6 t/ha respectively during 2008-11 (Table 12). Yield of hybrid rice was 8 t/ha. In Khulna district, yield of BRRI dhan28 was fluctuating from about 3 to 5 t/ha over the period of

Table 11. Land disbursement to hybrid and MV rice cultivation in Boro season over the years.

Variety	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Barisal										
BR14									1.66	0.45
BR16								0.37		0.45
BRRI dhan28							27	14	16	12
BRRI dhan29							29	39	35	29
BRRI Dhan47										24
BRRI dhan50										0.45
Hybrid							24	33	24	20
Kajla							20	14	23	14
Khulna										
BINA8								1	1	1
BRRI dhan28	70	66	63	76	92	74	75	60	60	60
BRRI dhan29	18	24	15	13	3	1	2	5	5	20
BRRI Dhan47		0	0	0	0	0	0	1	1	0
Hybrid	2	10	18	11	5	35	22	34	23	20
Rajshahi										
BR3										0.40
BRRI dhan28					48	40	45	70	69	65
BRRI dhan29					28	40	28	17	4	17
Hybrid					24	13	17	13	26	18
Kajla						7				
Rangpur										
BR16			12	12	5	4	7	1	1	
BR3			0	1	1	1.5	0	0.5		
BRRI dhan28	60	55	40	30	48	51	55	52	43	77
BRRI dhan29	25	35	19	24	27	15	5	18	13	8
China	0	0	5	4	2	3				
Hybrid	15	10	24	29	17	25.5	33	28.5	43	15
Sherpur										
BRRI dhan28								70	69	76
BRRI dhan29								25	10	13
Hybrid								5	21	10

Table 12. Comparative yield performance of different rice variety in different districts in Boro season during 2002-2011.

Variety Rabi	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
					Barisal					
BR14									4.61	6.92
BR16								3.46		3.95
BRRI dhan28							5.11	5.31	5.10	5.90
BRRI dhan29							6.52	6.39	5.64	6.03
BRRI Dhan47										5.66
BRRI dhan50										7.41
Hybrid							8.48	8.37	8.69	7.98
Kajla							4.54	5.03	4.46	4.86
					Khulna					
Bina8								5.34	4.94	5.07
BRRI dhan28	4.54	4.66	3.36	5.32	5.19	4.94	5.07	4.98	5.06	5.14
BRRI dhan29	6.04	5.32	7.16	5.73	6.00	6.32	7.04	6.32	7.04	6.32
BRRI Dhan47								5.78	5.93	
Hybrid	7.41	7.46	7.15	6.39	6.93	6.99	6.60	6.69	6.33	6.29
					Rajshahi					
BR3										7.19
BRRI dhan28					4.95	5.04	4.94	5.10	5.07	5.62
BRRI dhan29					7.49	6.14	6.66	5.14	5.87	6.55
Hybrid					5.93	7.04	5.58	5.62	6.53	7.20
Kajla						4.192				
					Rangpur					
BR16			4.98	4.42	5.80	4.80	4.06	4.93	4.80	
BR3				5.27				4.21		
BRRI dhan28	5.09	5.11	5.13	4.94	5.41	5.29	5.52	5.53	5.56	5.90
BRRI dhan29	5.56	4.56	4.56	5.56	7.61	6.52	6.19	6.11	6.14	6.53
China			5.53	5.92	5.24	4.67				
Hybrid	10.77	10.36	7.89	7.38	7.64	7.31	7.12	7.11	7.00	7.21
					Sherpur					
BRRI dhan28								4.85	4.80	5.34
BRRI dhan29								5.80	6.68	6.58
Hybrid								7.87	7.70	7.67

2002 to 2011 and in case of BRRI dhan29 yield varied from about 5 to 7 t/ha over the same period. In Rajshahi, yield of BRRI dhan28 was lower (about 5 t/ha) compared to that of BRRI dhan29 and hybrid (about 5 to 7 t/ha). The yield performance of BRRI dhan29 has been fluctuating from 4 to 7 t/ha over the same period but noteworthy (7.61 t/ha) in 2006. In contrary, the yield of hybrid was very outstanding (10.77 t/ha in 2002 and 10.36 t/ha in 2003) but after this period yield of hybrid rice has been very sustainable over the period of 2004 to 2011 (Table 12).

In flood prone Sherpur district, hybrid produced higher yield (about 7 t/ha over the period of 2009 to 2011 compared to that of BRRI dhan28 and 29 although area allocation to hybrid was the lowest in this district. Yield of BRRI dhan28 and BRRI dhan29 was lower but it was quite a bit sustainable over the period of 2009-11 in flood prone area (Table 12).

Comparative input use pattern of MVs and hybrid rice cultivation

Human labour use for hybrid rice cultivation was higher (13% in Barisal, 24% in Khulna, 0.64% in Rajshahi, 8% in Rangpur and 35% in Sherpur district respectively), compared to that of MVs. Farmers used three to four times more seed of MV rice compared to that of hybrid, but price of hybrid seed was eight times higher than that of MVs. Fertilizer, irrigation and pesticide costs were found higher in hybrid rice cultivation compared to that of MV rice cultivation. The yield of hybrid rice was comparatively better than that of MVs (Fig. 1 and Table 13) and the highest was in Barisal district.

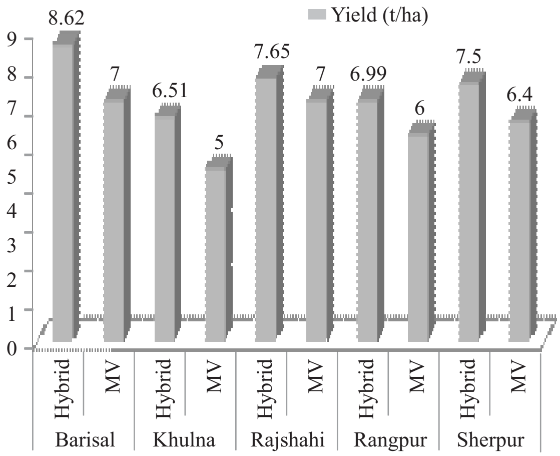


Fig. 1. Comparative yield performance of hybrid and MV rice in the study areas.

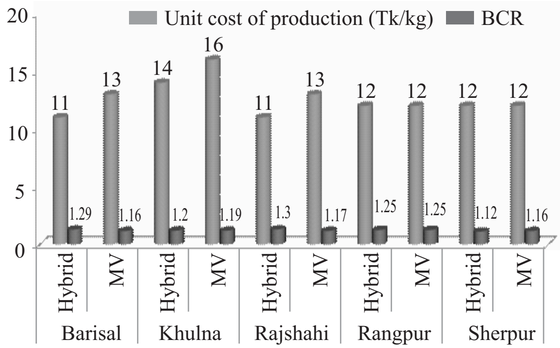


Fig. 2. Comparative unit cost of production and BCR of MVs and hybrid rice cultivation.

Cost and return structure of MVs and hybrid rice cultivation

The unit cost of hybrid rice production was lower than MVs in all districts. In Khulna, unit cost of production was the highest (Tk 16/kg). The yield of both MVs and hybrid in Barisal was quite higher (6,510 and 8,620 kg/ha respectively), which resulted higher gross margin and net return. The BCR of hybrid (1.10) in Barisal and Rajshahi was a bit higher also (Fig. 2 and Table 14).

SOCIO-ECONOMIC ASSESSMENT/ VALIDATION OF RICE TECHNOLOGY NEEDED FOR THE FARMERS IN THE PROJECT AREAS

There is a vast area in the southern and northern part of Bangladesh where the land remains fallow due to different constraints. This study was undertaken in the southern and northern parts of Bangladesh to:

- identify the demographic profile of the farmers of the project areas,

Table 13. Input utilization structure and yield of MV and hybrid rice cultivation in different districts during Boro 2010-11.

Item	Barisal		Khulna		Rajshahi		Rangpur		Sherpur		Average
	Hybrid	MV	Hybrid	MV	Hybrid	MV	Hybrid	MV	Hybrid	MV	
Human labour (man-days/ha)	172	152	137	110	157	156	121	112	150	111	137
Family labour	49	85	30	23	69	57	52	50	63	13	44
Hired labour	123	67	108	87	88	99	70	61	107	89	91
Seed (kg/ha)	12	46	11	58	11	42	11	44	12	39	29
Seedbed preparation (Tk/ha)	2257	2466	2008	2048	1884	2238	2045	1704	1778	2156	2248
Land preparation (Tk/ha)	5557	4563	3972	3832	4240	4687	4778	4104	5911	5900	4694
Fertilizer (kg/ha):											
Urea	271	246	272	214	232	255	253	213	262	197	242
DAP	0	0	0	0	36	48	10	7	139	92	28
TSP	184	137	129	94	97	94	104	85	0	0	90
MOP	128	109	81	63	81	94	120	108	101	82	98
Gypsum	54	0	40	22	61	68	39	34	51	29	42
Zn	10	11	2	0	9	5	3	1	1	0	4
Manure (kg/ha)	69	0	0	0	0	0	3373	2179	2217	3373	1241
Irrigation (Tk/ha)	7160	7645	12695	11943	10294	10112	9088	7856	9904	9949	9633
Pesticides (Tk/ha)	2955	2331	1633	1083	2166	1571	2969	2667	1369	551	1974
Yield (t/ha)	8.62	7	6.51	5.00	7.65	7.00	6.99	6	7.50	6.40	7.00

Table 14. Profitability of MV and hybrid rice cultivation in different districts during Boro 2010-11.

Item	Barisal		Khulna		Rajshahi		Rangpur		Sherpur		Average
	Hybrid	MV	Hybrid	MV	Hybrid	MV	Hybrid	MV	Hybrid	MV	
Humand labour (lab/ha)	34458	34446	27460	22007	31366	32646	24288	22500	30000	22200	27400
Seed (Tk/ha)	3250	1619	3176	2039	2977	1454	3182	1529	3360	1371	2412
Seed prep(Tk/ha)	3957	2466	2008	2048	1884	2238	2032	1704	1778	2156	2246
Lanpr (Tk/ha)	5557	4563	3972	3832	4240	4688	4778	4104	5911	5900	4694
Fertilizer (Tk/ha)	13620	11549	10029	7523	10290	11158	10036	8308	11391	8227	9790
Manure (Tk/ha)	1169	0	0	0	0	0	3373	2179	2217	3373	1241
Irrigation (Tk/ha)	7160	7645	12695	11943	10294	10112	9088	7856	9904	9949	9633
Pesticides cost (Tk/ha)	2955	2331	1633	1083	2166	1571	2969	2667	1369	551	1974
Value of paddy (Tk/ha)	116481	98777	88132	76917	103485	97736	94299	87086	87086	96000	92869
Straw (Tk/ha)	7623	3872	19114	16387	6497	4363	8759	4852	6822	4911	9194
Gross return (Tk/ha)	124104	102649	107246	93304	109982	102100	103058	91938	100033	89207	102063
Total variable cost (Tk/ha)	72126	64619	60974	50473	63218	63868	59747	50846	65930	53727	59390
Gross margin (Tk/ha)	51978	38030	46272	42831	46764	38232	43310	41091	34103	35480	42673
Interest on capital (Tk/ha)	1352	1212	1143	946	1185	1198	1120	953	1236.19	1007	1113
Land rent (Tk/ha)	22500	22500	27500	27500	22500	22500	22500	22500	22500	22500	23793
Total cost (Tk/ha)	95978	88331	89617	78920	86904	87565	83367	74300	89666	77234	84296
Net return	28126	14318	17629	14384	23078	14534	19690	17638	10366	11973	17766
Unit cost of production (Tk/kg)	11	13	14	16	11	13	12	12	12	12	12
BCR	1.29	1.16	1.20	1.19	1.30	1.17	1.25	1.25	1.12	1.16	1.21

Price of urea=Tk 20/kg, TSP=Tk 22/kg, MOP=Tk 15/kg, gypsum=Tk 8/kg, DAP=Tk 30/kg and wage rate=Tk 200 per day.

- collect first hand information on physical, biological, socio-economic and environmental constraints that hinder agricultural crop productivity, and
- know the farmers opinions about the solutions of the constraints regarding rice technologies needed to enhance crop production.

Focus group discussion (FGD) was followed to collect quantitative and qualitative data from Barisal and Patuakhali (Barisal region) and Rangpur, Kurigram and Nilfamari (Rangpur region). Data collection was done using pre-designed questionnaire through inteviewing the sample farmers. Collected data have been analyzed by using simple statistical techniques such as simple mean, percentage and frequency distribution.

Demographic characteristics. In the Barisal region the population below 16 years, adult (16-59 years) and above 60 years old was 39, 49 and 12% respectively. The literacy rate was 69%.The primary occupation of the farmer was agriculture (78%). The average family size was 6. The average owner operated, owner cum tenant and pure tenant farmers were 27, 48 and 25% respectively. About 81% farms have their cell phone and 40% households have electricity. The average farm size was 98 decimal.

In Rangpur region the population of the village was 2,750 (Table 15). The population below 16 years adult (16-59 years) and above 60 years old was 34, 56 and 10% respectively. The literacy rate was 81%. The average age of household was 49 years. The primary occupation was agriculture (89%) (Table 16). The average family size was 5 in number. The average owner operated, owner cum tenant and pure tenant farmers were 48, 26 and 26% respectively (Table 17). About 92% farms have their cell phone and 78% (farmers) households have electricity. The average farm was about 97 decimal (Table 18).

Topography and soil type. In Barisal region about 11, 36, 14, 32 and 7% area of the survey village were upland, medium high land, medium land, medium low land and low land respectively. Most of the soil was clay loam (59%). The second category of soil was sandy loam (19%) In Rangpur region about 30, 9, 41, 1 and 19% area were upland, medium high land; medium land, medium low land and low land respectively. Most of the soil type (42%) was sandy loam.

Livestock population and information sources. In Barisal region on average 140 bullock, 625 milch cow, 363 goat and 44 sheep were found in each village. The farmers gathered information

Table 15. Demographic characteristics of the farmers of the survey villages under some upazilas of four project districts.

Item	South region, Barisal	North region, Rangpur
Area of the village (acre)	725	1162
Total population (no.)	5000	2750
Male (%)	49	50
Female (%)	51	50
Population below 16 years (%)	39	34
Male (%)	52	46
Female (%)	48	54
Adult population (%)	49	56
Male (%)	51	53
Female (%)	49	47
population (above 60 yrs) (%)	12	10
Male (%)	51	43
Female (%)	49	57
Literacy rate (%)	69	81
Male (%)	45	56
Female (%)	55	44
Av. age of HH	45	49

Table 16. Primary occupation of the farmers of the survey villages under some upazilas of some project districts.

Item	South region, Barisal	North region, Rangpur
Agriculture	78	89
Service	14	3
Business	8	8

Table 17. Household (no.) and tenancy (% of the farmers) of the survey villages under some upazilas of four project districts.

Item	South region, Barisal	North region, Rangpur
Farm HH	625	463
Non-farm HH	225	182
female headed	33	23
Av. family size (no.)	6	5
Tenancy (no.):		
Owner operated	160(27)	272(48)
Owner cum tenant	303(48)	147(26)
Pure tenant	163(26)	147(26)
% of farmers with cell phones	81	92
% of HH with electricity	40	78

Figures in the parentheses indicate percent of the farmers.

Table 18. Average farm size (dec) of the farmers of the survey villages under some upazilas of some project districts.

Item	South region, Barisal	North region, Rangpur
Landless	7	6
Marginal	31	25
Small	115	112
Medium	400	521
Large	988	1068
Av. homestead area	15	8
Av. farm size (decimal)	98	97

about new technology mainly from extension personnel. Other sources were research organization, such as BRRI, BARI, neighbouring farmers, NGOs and media. In Rangpur region on average 145 bullock, 303 milch cow, 925 goat and 44 sheep was found. The farmers gathered information about new technology mainly from extension personnel and research organizations. Other sources were neighbouring farmers, NGOs and media.

Socio-economic, biological, environmental and physical constraints. In Barisal region, the major socio-economic constraints faced by the farmers were lack of quality seeds, credit, appropriate knowledge, high price of urea fertilizer, adulterated fertilizers and insecticides, electricity disruption, high labour cost and diesel price, low output price. The main biological constraints were insect disease and rat attack.Tidal submergence was the most important constraint to grow rice in the southern region. Lack of *beri-bund* and uncontrolled sluice gates were the main constraints.

In the Rangpur region, the major socio-economic constraints were lack of quality seeds, lack of credit, lack of appropriate knowledge, high price of urea fertilizer, adulteration of fertilizers and insecticides, electricity disruption, high labour cost and diesel price, low output price. The main biological constraints were insect-disease infestation. Cyclone and flood were the most serious constraints to grow rice in the northern region. Lack of *beri-bund* and uncontrolled sluice gate were also the considerable constraints.

Farmers' opinion about climate change. Most of the farmers were aware about increased temperature, drought, and hot severity. About hundred percent farmers in the region reported that insect and disease resistant varieties are needed to increase the adoption of MV rice. About fifty percent farmers reported that they need drought resistant variety, transplanter and harvester.

New technology needed. In Barisal region insect and disease resistant variety, drought resistant variety, USG applicator, MV rice with less insect infestation, variety with tall seedlings, harvester and transplanter were needed for higher adoption of MV rice (Table 19). In Rangpur, insect

Table 19. New technology needed by the farmers under some upazilas of some project districts.

Technology needed	South region, Barisal	North region, Rangpur
Drought resistant variety	50	75
Flood tolerant variety	-	50
Disease resistant variety	100	100
Insect resistant variety	100	100
Harvester	50	50
Dryer	50	-
less input needed variety	50	25
MV with long seedling	50	-
MV with no lodging	25	25
Hybrid seeds	50	25
Weeding machine	50	25
Applicator of USG	25	25
Transplanter	25	50
Short duration variety	25	25

and disease resistant and flood tolerant rice variety, harvester, transplanter. USG applicator can enhance MV rice adoption.

Cropping patterns and rice area. In Barisal, major cropping patterns were Rabi/khesari-T. Aus-T. Aman (37%), Rabi-Fallow-T. Aman (25%), Fallow-T. Aus-T. Aman (14%) and Boro-Fallow-Fallow (8%). In Boro season, BRRI dhan28, BRRI dhan29 and BRRI dhan47 were dominant variety. In Aus, BR21 and Kaliboro are dominant variety. In T. Aman, only 30% area was covered by MV and BR11 was the most popular variety in the southern region of Bangladesh. T. Aman-Potato-Boro and Boro-Fallow-T. Aman were the important cropping patterns in the Rangpur region. The other important cropping patterns were Tobacco-Jute-T. Aman and Potato-Groundnut-T. Aman-Radish. BRRI dhan28, BRRI dhan29 and hybrid rice were dominant variety in Boro season. While in Aus, only Parija was grown. Swarna was dominant variety in T. Aman followed by BR11.

Farmers opinion on probable solution. In Barisal regions probable solution to overcome the problems are availability of credit, availability of fertilizers at fair price, reduction of adulteration of fertilizers, subsidy on diesel to be given directly to the farmers, adequate number of *beri-bund* and sluice gate. In the Rangpur regions availability of credit in time, reduced price of fertilizers, reduction of adulteration of fertilizers, subsidy on diesel to be given directly to the farmers, adequate *beri-bund* and sluice gate were suggested.

EFFECT OF RICE BASED TECHNOLOGY ON FARM INCOME UNDER CHANGING CLIMATE IN DROUGHT-PRONE AREAS

In response to global warming, sea level may rise by about 30 cm. These changes would increase annual rainfall in Bangladesh. The effect on winter rainfall is uncertain. Climate changes would affect plant and animal growth in Bangladesh. Some effects would be beneficial, such as increased CO_2 enhancing plant growth; some would be detrimental.

BRRI by this time has developed rice varieties and other rice production technologies for most of the stress-prone environments. Therefore, it needs to assess the effect of the given varieties on the farm income in the project area. Present study was under taken to:

- estimate the yield performance of the given rice varieties over the farmers, the existing varieties;
- assess the effect of the given technology on farm income under changing climate; and
- document the farmers' perception on the given rice varieties.

The study was conducted in Poba, Tanore, Chargat and Godagari upazila of Rajshahi district where seed was distributed earlier. The primary data were collected from 40 participants through survey. Before and after project analysis was carried out with the descriptive statistics to assess the effect of rice varieties and training on farm income.

Rice production and disposal pattern. Table 20 presents rice production and its disposal pattern. In Aman 2011, the average rice productivity was higher (3.74 t/ha) than that of 2010 (3.28 t/ha). While average production of rice was lower in Boro 2011 (4.08 t/ha) compared to that of 2011 (5.03 t/ha). The reason might be that the crop was severely affected by cold and drought during Boro 2011.

It was observed that average sale of rice after project intervention was also higher (1.99 ton) compared to that of 2010 in Aman season. The same scenario was found in sale and other uses during Boro 2011. It was further observed that when production increased that lead farmers to

Table 20. Production and disposal patterns of rice before and after project in Rajshahi.

Item	Aman (ton)		Boro (ton)	
	2010	2011	2010	2011
Total production	3.28	3.74	5.03	4.08
Total sale	1.69	1.99	3.00	2.53
seed	0.04	0.04	0.04	0.04
Consumption	0.72	0.81	0.95	0.88
Threshing	0.45	0.60	0.75	0.41
Land rent	0.35	0.29	0.25	0.18
Use for livestock	0.02	0.01	0.02	0.01
Gift	0.01	0.00	0.02	0.02
Loss	0.00	0.01	0.01	0.00

incur some loss due to post harvest operation or storage.

Comparative yield performance of rice varieties before and after project seed use. In Boro 2010, yield of BRRI dhan28 and BRRI dhan29 was found a bit satisfactory (5.10 and 5.62 t/ha) but yield of BRRI dhan29 reduced to 3.19 t/ha in Boro 2011 due to the affection of cold and drought (Table 21). BRRI dhan36 and BRRI dhan50 yielded better than that of BRRI dhan28 and BRRI dhan29. Before and after project seed use, BR11 produced higher yield than that of all other varieties although yield of BRRI dhan56 and BRRI dhan57 (terminal drought tolerant and short duration) were lower (3.05 and 3.89 t/ha).

Table 21. Yield performance of different rice varieties in Rajshahi before and after project.

Variety	Yield (t/ha)			
	Aman		Boro	
	2010	2011	2010	2011
	Aman			
Bina7	1.20	3.44		
BR11	5.37	5.99		
BRRI dhan49	4.82	4.22		
BRRI dhan56	2.57	3.05		
BRRI dhan57		3.89		
Chingul	0.72	1.20		
Minikit	4.19			
Ranjit	3.59			
Sottar		4.61		
Swarna	3.56	3.47		
	Boro			
BRRI Dhan28			5.10	4.73
BRRI dhan29			5.62	3.19
BRRI dhan36				6.30
BRRI dhan50				5.39

Area shifting to new rice varieties after project intervention

Table 22 presents percent area of rice shifted from the existing variety to new rice varieties. Almost all sample farmers before project cultivated BRRI dhan28 and very few farmers used to grow BRRI dhan29. About 31 and 10 percent area was shifted to BRRI dhan50 and BRRI dhan36 from BRRI dhan28. Remaining 52 percent of area was still covered by BRRI dhan28 in Rajshahi.

Similarly before project almost all sample farmers used to cultivate Swarna, an Indian rice variety getting more popularity. So, almost 31 percent area was shifted to BRRI dhan49 from Swarna. Nearly 13 and 8 percent areas were shifted to BRRI dhan56 and BRRI dhan57 respectively. In contrary, 3 and 8 percent area shifted to BRRI dhan51 and BINA dhan7. The rest of the area 31 percent was still covered by Swarna.

Share of farm income from different sources before and after project intervention

Due to the high input cost and low price the income from rice in 2011 (24% of total income) became lower than that of 2010 (30% of total income). Income from livestock in 2010 was observed lower than that of 2011. In contrary, income from all other sources was higher in 2011 than that of 2011 (Table 23). In Rajshahi, it was observed that income from business is relatively higher compared to other sources.

Farmers' perception on the trait of the distributed rice varieties

Table 24 presents farmers' perception on traits of rice varieties. Maximum farmers opinion was that the rice varieties given under the climate change project was good yielder. Almost all the producers reported that the seed quality was very good compared to that of purchased seed. Maximum farmers (70%) said that BRRI dhan49 was with fine grain, 35% farmers reported that price of paddy was higher compared to the other varieties.

Comparative costs of cultivation in MV T. Aman season before and after project seed use

The cost of rice cultivation included variable cost items like human labour, animal labour, power

Table 22. Percent area replacement of the existing varieties by the given variety.

Before-after the project	% area adopted new variety
Boro	
BRRI dhan28-BRRI dhan50	31
BRRI dhan29-BRRI dhan50	8
BRRI dhan28-BRRI dhan36	10
BRRI dhan28-BRRI dhan28	52
Aman	
Swarna-BRRI dhan49	31
Swarna-BRRI dhan56	8
Swarna-BRRI dhan57	13
Swarna-Swarna	38
Swarna-BRRI dhan51	3
Swarna-Bina7	8

Table 23. Level of farm income from different sources before and after project.

Source of income	Annual income before the project seed use (Tk/year)	Annual income after the project seed use (Tk/year)
Rice crop	76213	61020
Nonrice	30233	33258
Livestock and poultry	16950	10954
other farm	5525	7026
Service	10520	12400
Business	95000	101500
Other	15562	31808
Average annual income	250003	257966

tiller, seed, fertilizer, manure, irrigation, insecticides etc. Per hectare human labour costs were found Tk 32,426 and Tk 32,262 for T. Aman in 2010-11 and 2011-12 respectively. Farmers spent money for human labour which incurred major cost of the rice cultivation. Chemical fertilizer cost varied between 15 to 17% of the total production cost in T. Aman 2010-11 and 2011-12. Between two years, total production costs of T. Aman season were more or less same. Therefore, due to use of higher amount of costly inputs like human labour and fertilizer, the cost of cultivation for T. Aman rice in the study locations were tremendously higher in comparison to other inputs in T. Aman season.

Comparative profitability analysis of T. Aman before and after project intervention

The yield received by the rice farmers in cultivating MV T. Aman crop for the year 2010-11 and 2011-12 were 4,106 kg/ha and 4,431 kg/ha respectively. Farmer's obtained higher yield in MV T. Aman because of BRRI intervention (They received training, better management practices and quality seed from the project). However, the T. Aman growers received higher gross and net return (Tk 21,339/ha and Tk 8,365/ha) after project intervention. In 2011-12 T. Aman, BCR was higher due to project intervention.

Comparative profitability analysis of Boro before and after project intervention

Yield performance of MV Boro rice before and after project intervention were 5,288 kg/ha and 51,53 kg/ha respectively. In Boro 2011-12, rice plant was severely affected by cold and even drought. So, yield of all rice varieties detrimentally reduced. However, the MV Boro growers (before project intervention) received higher gross margin (Tk 20,485 /ha) and net return (Tk 4,256/ha) compared to after project intervention due to higher market price of their product and higher yield. So, BCR is greater than after project intervention.

LONG TERM GROWTH ANALYSIS OF FOOD GRAINS

Before the introduction of high yielding varieties of cereals in the mid sixties, the growth performance of almost all crops was more or less

Table 24. Farmers' perception on the trait of the varieties given under the project.

Variety	Farmers' perception on the traits of rice varieties					
	Good yield	Short duration	Tested good to eat	Seed is good	Fine rice	High price
BRRI dhan49	5	31	3	100	77	35
BRRI dhan50	13	0	10	100	100	
BRRI dhan56	5	8	0	100		
BRRI dhan36	3	0	0	100		
BRRI dhan57		13				

uniform (Miah, *et al.* 2009). So, it is worthwhile to examine the present status of growth of cereal crops in a broader spectrum in Bangladesh. The study was design to:

- examine the growth of area, production and yield of food grains in Bangladesh.
- suggest policy measures to enhance the growth rate of cereals.

Time series data on area, production and yield of different food grains from 1947-48 to 2009-10 were obtained from secondary sources. The whole period (1947-09) was divided into three major periods, viz: Period I (1947-48 to 1970-71), period II (1971-72 to 1983-84 and period III (1984-85 to 2009-10).

Five years average was used to estimate fluctuation and an index was prepared to compare the change in area, production and yield of different cereal crops considering 1971-1975, 1981-85 and 1990-95 as base period for rice, wheat and maize crops respectively. Index number was calculated by the following formula:

$$\text{Index} = \{\frac{\textit{Current year value}}{\textit{Base year value}} \times 100\}$$

Growth rate estimation. The growth rates of area, production and yield of cereal crops were worked out by fitting a semi-log function (exponential growth function) of the following type.

$$y = e^{\alpha+\beta t} \text{ or } l_n y = \alpha + \beta t$$

where, y=Area (thousand ha) or production (thousand metric ton) or yield (t/ha); β=Regression coefficient, ie, growth rate (in ratio scale); and t=time period (year)

Structural stability test was performed to verify the structural changes occurred in the area, production and yield in time series data. The following regression model was used for structural stability test:

$$LnY_i=\beta_1 + \beta_2D_1 + \beta_3X_i + \beta_4D_1*X_i + U_i$$

where, Y_i=Area (thousand ha) or production (thousand metric ton) or yield (t/ha) of different food grains in i^{th} year; D_1=Period dummy (1 for 2^{nd} period, otherwise 0); X_i=Time (i=1, 2, 3,---); β_1 is general intercept; β_2 is differential intercept; and β_4 is differential slope coefficient. β_2 indicates how much the slope coefficient of 2^{nd} period differs from the slope coefficient of 1^{st} period. The null hypothesis of the structural stability test is Ho; $\gamma_1 = \beta_1$ and $\gamma_2 = \beta_3$.

Trend of area, production and yield of food grains. The area indices constructed for different food grains showed overall increasing trend of Boro rice area, total rice and maize area from their respective base year. Wheat area increased in 2001-05 and decreased in 2006-10. Aus area sharply decreased in 2006-10 from its base period. But Aman area increased in 1981-85 and then reached a plateau in 2001-05. Again, it decreased steadily in 2006-10 period, the reasons for decreasing Aus, wheat, and Aman area was shifting to Boro rice and maize cultivation, Overall food grains like, Aman, Boro, total rice, and maize production increased in 2006-10 from their respective base period due to heavy state intervention in agriculture (Table 25). Moreover, wheat production decreased in 1986-90 and then increased sharply in 1996-2000. Overall yield of all food grains increased from their base period due to adopting modern technology.

Rate of change in area, production and productivity of food grains

In pre-establishment of BRRI (1947-48 to 1970-71), the overall growth rates of cereal production were higher than cereal area (Table 26). The area, production and productivity of all types of food grains appeared to have positive growth rates during pre adoption period of modern varieties. In early sixties, IR8 rice variety was first introduced in Boro season in Bangladesh. Area and production growth rate of Boro was higher than the other two seasons.

During 1984-85 to 2009-10, Aus, Aman and Boro rice area growth rates decreased but rice production growth rate increased due to adoption of BRRI developed high yielding rice varieties. Among food grains, wheat area and production growth rate was higher than total rice, maize areas and production. The overall food grain production growth rate was positive because, production growth rate is higher than area growth. Aus, Aman and wheat area growth rates were negative. Area of Aus, wheat, and Aman was shifting to Boro and maize production, only Boro and maize area

Table 25. Index of area, production and yield of cereal crops in Bangladesh.

Index	Aus	Aman	Boro	Total rice	Wheat	Maize
			Area ('000 ha)			
1971-1975	100					
(3128)	100					
(5611)	100					
(1080)	100					
(9819)	NA	NA				
1976-1980	101	105	99	103	NA	NA
1981-1985	97	106	134	106	100 (559)	NA
1986-1990	81	101	204	106	105	NA
1991-1995	54	102	244	102	113	100 (7)
1996-2000	46	101	308	106	143	270
2001-2005	37	99	365	108	112	782
2006-2010	31	96	423	111	70	2333
			Production ('000 ton)			
1971-1975	100					
(2695)	100					
(6205)	100					
(2113)	100					
(11013)	NA	NA				
1976-1980	115	119	103	115	NA	NA
1981-1985	113	126	167	130	100 (1167)	NA
1986-1990	102	133	255	149	87	NA
1991-1995	71	147	321	162	103	100 (17)
1996-2000	67	154	465	192	149	535
2001-2005	65	174	612	231	104	1636
2006-2010	61	179	812	271	71	5611
			Yield (t/ha)			
1971-1975	100					
(0.86)	100					
(1.11)	100					
(1.96)	100					
(1.12)	NA	NA				
1976-1980	115	114	103	112	NA	NA
1981-1985	116	119	124	123	100 (2.08)	NA
1986-1990	126	132	124	141	83	NA
1991-1995	131	144	131	158	91	100 (2.13)
1996-2000	145	153	149	181	104	218
2001-2005	178	176	167	214	92	236
2006-2010	201	185	191	244	82	276

Figure in the parentheses indicates base year of area, production and yield.

growth rate was positive. At present Boro rice and maize are competitive crops.

Structural stability test 1. There are significant difference in the area, production and yield of different food grains before establishment of BRRI in between (1947-48 to 1970-71 and after establishment of BRRI in between (1971-72 to 2009-10) and the nature of changes occurred in area, production and yield over time (Table 27). There were structural changes in area of different food grains during post establishment of BRRI. Aus production, total rice production and maize production are significant which indicates that there was structural changes in the production of different food grains after establishment of BRRI.

Structural stability test 2. There are difference in the area, production and yield level of different food grains between the two periods (1971-72 to 1983-84) and (1984-85 to 2009-10). The nature of changes occurred in the area production and yield level of food grains over time. There are structural changes in the area and production of different food grains during the period of 1984-85 to 2009-10 due to structural adjustment reforms initiated by the World Bank and the government continued input subsidies (Table 28).

Table 26. Annual growth rates of area, production and yield of cereal crops in Bangladesh, 1947-48 - 2009-10.

Period	Aus	Aman	Boro	Total rice	Wheat	Maize
			Area			
1947-48 - 1970-71	2.17***	0.23**	4.33***	1.03***	5.03***	0.01ns
1971-72 - 2009-10	3.80***	-0.16**	4.69***	0.23***	3.33***	11.80***
1971-72 - 1983-84	0.22ns	0.79***	2.83***	0.84***	15.91***	-1.14ns
1984-85 - 2009-10	-4.87***	-0.26***	4.25***	0.26***	-1.14*	18.24***
			Production			
1947-48 - 1970-71	3.35***	1.27***	8.01***	2.30***	6.95***	1.93ns
1971-72 - 2009-10	-1.96***	1.62***	6.48***	2.81***	4.84***	19.02***
1971-72 - 1983-84	2.38***	2.58***	4.82***	3.00***	25.08***	-5.11*
1984-85 - 2009-10	-2.44***	1.50***	6.28***	3.08***	-0.63ns	27.88***
			Yield			
1947-48 - 1970-71	1.17***	1.04***	3.68***	1.29***	1.92***	1.77***
1971-72 - 2009-10	1.84***	1.78***	1.78***	2.58***	1.50***	7.21***
1971-72 - 1983-84	2.17***	1.79***	1.99***	2.15***	9.19***	-3.99**
1984-85 - 2009-10	2.42***	1.76***	2.03***	2.83***	0.51*	9.64***

Source: Kurosaki, 2011 and various issues of BBS. *Note:* ***, ** and * indicate significant at the 1, 5 and 10% levels respectively.

Table 27. Test of structural stability in area, production and yield between pre establishment of BRRI period (1947-48 - 1970-71) and post establishment of BRRI period (1971-72 - 2009-10) for food grains.

Food grain	β_1 (t-value)	β_2 (t-value)	β_3 (t-value)	β_4 (t-value)	R^2 (F-value)	γ_1 $(\beta_1+\beta_2)$	γ_2 $(\beta_3+\beta_4)$	Ho: $\gamma_1=\beta_1$	Ho: $\gamma_2=\beta_3$
				Area					
Aus	7.5550***	1.7073***	0.0215***	-0.0595***	0.92	9.2623	-0.03800	Rejected	Rejected
	(161.56)	(19.94)	(6.58)	(-16.39)	(229.41)***				
Aman	8.62004***	0.0944***	0.00264**	-0.00424***	0.19	8.71444	-0.00160	Rejected	Accepted
	(516.56)	(3.09)	(2.26)	(-3.27)	(4.66)***				
Boro	5.5087***	0.1059	0.04123***	0.00569	0.97	5.6146	0.04692	Rejected	Accepted
	(87.98)	(0.92)	(9.41)	(1.17)	(808.19)***				
Total rice	8.9393***	0.20115***	0.01033***	-0.00801***	0.90	9.14045	0.00232	Rejected	Rejected
	(632.52)	(7.77)	(10.45)	(-7.30)	(177.51)***				
Wheat	3.3803***	1.2494***	0.04899***	-0.01566	0.89	4.6297	0.03333	Rejected	Rejected
	(20.73)	(4.19)	(4.29)	(-1.24)	(164.73)***				
Maize	1.2832***	-4.3319***	0.00502	0.11299***	0.81	-3.0487	0.11801	Rejected	Rejected
	(5.64)	(-10.39)	(0.32)	(6.39)	(89.43)***				
				Production					
Aus	7.2356***	1.3558***	0.03347***	-0.05308***	0.75	8.5914	-0.01961	Rejected	Rejected
	(127.01)	(13.00)	(8.40)	(-11.99)	(59.63)***				
Aman	8.5196***	-0.17797**	0.01293***	0.00323	0.87	8.34163	0.01616	Rejected	Accepted
	(215.99)	(-2.46)	(4.69)	(1.06)	(134.66)***				
Boro	5.2800***	0.50123***	0.07526***	-0.01049	0.97	5.78123	0.06477	Rejected	Accepted
	(57.82)	(3.00)	(11.78)	(-1.48)	(805.87)***				
Total rice	8.7729***	-0.2463***	0.02302***	0.005066***	0.97	8.5266	0.02809	Rejected	Accepted
	(292.68)	(-4.49)	(10.98)	(2.17)	(779.23)***				
Wheat	2.6781***	1.8621***	0.06649***	-0.01813	0.91	4.5402	0.04836	Rejected	Rejected
	(12.09)	(4.59)	(4.29)	(-1.05)	(198.97)***				
Maize	0.7968***	-6.4824***	0.01932	0.17083***	0.86	-5.6856	0.19015	Rejected	Rejected
	(2.47)	(-10.99)	(0.86)	(6.82)	(124.90)***				
				Yield					
Aus	-0.31939***	-0.3515***	0.01194***	0.00645**	0.89	-0.67089	0.01839	Rejected	Accepted
	(-9.39)	(-5.64)	(5.02)	(2.44)	(166.39)***				
Aman	-0.10042***	-0.27241***	0.01029***	0.00748***	0.92	-0.37283	0.01777	Rejected	Accepted
	(-3.37)	(-4.99)	(4.94)	(3.23)	(256.04)***				
Boro	-0.22868***	0.39526***	0.03403***	-0.01618***	0.94	0.16658	0.01785	Rejected	Rejected
	(-5.25)	(4.96)	(11.16)	(-4.78)	(354.81)***				

Table 27. Continued.

Food grain	β_1 (t-value)	β_2 (t-value)	β_3 (t-value)	β_4 (t-value)	R^2 (F-value)	γ_1 $(\beta_1+\beta_2)$	γ_2 $(\beta_3+\beta_4)$	Ho: $\gamma_1=\beta_1$	Ho: $\gamma_2=\beta_3$
Averege rice	-0.16638***	-0.44749***	0.01269***	0.01308***	0.97	-0.61387	0.02577	Rejected	Rejected
	(-7.37)	(-10.83)	(8.04)	(7.46)	(884.18)***				
Wheat	-0.7022***	0.6127***	0.01749***	-0.002475	0.89	-0.0895	0.01502	Rejected	Accepted
	(-8.75)	(4.17)	(3.12)	(-0.40)	(165.43)***				
Maize	-0.4863***	-2.1505***	0.01429	0.05783***	0.84	-2.6368	0.07212	Rejected	Rejected
	(-3.46)	(-8.37)	(1.46)	(5.30)	(109.66)***				

Note: ***, ** and * indicate significant at the 1, 5 and 10% levels respectively; Figure in the parentheses indicates t-value.

Table 28. Test of structural stability in area, production and yield between (1971-72 to 1983-84) and (1984-85 to 2009-10) for food grains in Bangladesh.

Food grain	β_1 (t-value)	β_2 (t-value)	β_3 (t-value)	β_4 (t-value)	R^2 (F-value)	γ_1 $(\beta_1+\beta_2)$	γ_2 $(\beta_3+\beta_4)$	Ho: $\gamma_1=\beta_1$	Ho: $\gamma_2=\beta_3$
				Area					
Aus	8.036***	0.6125***	0.00216	- 0.0508***	0.97	8.6485	-0.0487	Rejected	Rejected
	(201.50)	(9.72)	(0.43)	(-9.54)	(552.13)***				
Aman	8.6102***	0.0923**	0.0079***	-0.0106***	0.39	8.7025	-0.0027	Rejected	Rejected
	(402.75)	(2.73)	(2.94)	(-3.69)	(7.76)***				
Boro	6.8326***	0.0452	0.0282***	0.0142*	0.97	6.8778	0.0424	Rejected	Rejected
	(118.95)	(0.50)	(3.91)	(1.85)	(384.73)***				
Total rice	9.1595***	0.0253	0.0084***	-0.0058***	0.60	9.1848	0.0026	Rejected	Accepted
	(616.73)	(1.08)	(4.51)	(-2.93)	(17.93)***				
Wheat	4.3815***	2.3178***	0.1591***	-0.1705***	0.86	6.6993	-0.0114	Rejected	Rejected
	(32.99)	(11.04)	(9.51)	(-9.61)	(77.50)***				
Maize	0.9680***	-3.0287***	-0.0113	0.1937***	0.95	-2.0607	0.1824	Rejected	Rejected
	(5.34)	(-10.58)	(-0.50)	(8.01)	(279.33)***				
				Production					
Aus	7.8210***	0.4261***	0.0237***	-0.0481***	0.83	8.2471	-0.0244	Rejected	Rejected
	(118.56)	(4.09)	(2.86)	(-5.47)	(60.28)***				
Aman	8.6629***	0.0967	0.0257***	-0.0107	0.84	8.7596	0.0150	Rejected	Rejected
	(176.33)	(1.25)	(4.17)	(-1.64)	(62.70)***				
Boro	7.4284***	-0.0277	0.0482***	0.0145*	0.98	7.4007	0.0627	Rejected	Rejected
	(115.19)	(-0.27)	(5.93)	(1.69)	(576.94)***				
Total rice	9.2045***	-0.0851	0.0300***	0.0008	0.97	9.1194	0.0308	Rejected	Accepted
	(276.38)	(-1.62)	(7.16)	(0.18)	(407.50)***				
Wheat	4.1137***	3.1206***	0.2508***	-0.2571***	0.90	7.2343	-0.0063	Rejected	Rejected
	(25.84)	(12.40)	(12.50)	(-12.09)	(109.01)				
Maize	0.9048***	-4.5447***	-0.0510	0.3298***	0.96	-3.6399	0.2788	Rejected	Rejected
	(3.55)	(-11.28)	(-1.59)	(9.69)	(360.26)***				
				Yield					
Aus	-0.2157***	-0.1863***	0.0216***	0.0026	0.92	-0.402	0.0242	Rejected	Accepted
	(-5.91)	(-3.23)	(4.70)	(0.54)	(151.47)***				
Aman	0.0526	0.0043	0.0178***	-0.0001	0.92	0.0569	0.0177	Accepted	Accepted
	(1.47)	(0.08)	(3.96)	(-0.04)	(140.84)				
Boro	0.5957***	-0.0730	0.0199***	0.0003	0.93	0.5227	0.0202	Rejected	Accepted
	(18.09)	(-1.40)	(4.81)	(0.08)	(168.81)***				
Average rice	0.0450*	-0.1105***	0.0216***	0.0066**	0.98	-0.0655	0.0282	Rejected	Accepted
	(1.97)	(-3.05)	(7.49)	(2.16)	(725.59)***				
Wheat	-0.2677***	0.8028***	0.0916***	-0.0865***	0.80	0.5351	0.0051	Rejected	Rejected
	(-3.53)	(6.70)	(9.60)	(-8.55)	(46.72)***				
Maize	-0.0631	-1.5160***	-0.0396*	0.1361***	0.91	-1.5791	0.0965	Rejected	Rejected
	(-0.38)	(-5.73)	(-1.88)	(6.09)	(119.13)***				

Note: ***, ** and * indicate significant at the 1, 5 and 10% levels respectively; Figure in the parentheses indicates t-value.

Agricultural Statistics Division

SUMMARY

In the reporting period BRRI dhan32, BRRI dhan40, BRRI dhan41 and BR11 were found most stable in T. Aman season, while BR3, BRRI dhan51 and BRRI dhan52 appeared to be unstable among the non-aromatic rice. In case of aromatic rice, BRRI dhan38 appeared to be most stable followed by BRRI dhan37.

BRRI dhan28 and BRRI dhan29 were the most stable varieies and BR1, BR2, BR6, BR8 and BR18 appeared to be unstable in Boro season. In case of fine rice BRRI dhan50 appeared to be below average stable in Boro season.

BRRI variety contributes about 90% of total production of the country. It does not reflect in field label because of BRRI variety is being sold in different brand names. For example BRRI dhan28 is sold as Nizersail and BRRI dhan29 as Jhingasail and Miniket etc. Pure consumers were found to prefer rice varieties on the basis of taste, slenderness and availability.

Three mathematical models have been developed for consumer and producer preference to rice varieties by using four locations/districts farmers' data of Bangladesh in terms of rice deficit and rice surplus area. These three models are used to determine factors affecting producers' decision on varieties for rice cultivation and can provide an indication of the factors affecting consumers' preference to rice varieties.

The average As content in grain was 0.31 mg/kg at command area level and at upazila level it was 0.40 mg/kg, while groundwater As level was 178.6 ppb and 126.3 ppb, respectively. Out of 490 upazilas 68 are at high risk, 103 are at medium risk, 130 are at low risk and 189 upazilas are risk free. In about 46% of the total area of Bangladesh As concentration is below 10 µg l^{-1}. Approximately, in 72% area of Bangladesh arsenic concentrations is within 50 µg l^{-1}. About 14% area of Bangladesh appears as low As risk with arsenic concentrations in water between 50 µg l^{-1} to 100 µg l^{-1}. About 9% area falls under medium risk and about 6% under high risk.

Combining the total As of grain and water (drinking water and water for rice cooking) more than 800 and 700 ppb, respectively in command area level and upazila level consumed per person per day, which may accumulate at least a small amount of As in human body. Thus, consumption of rice containing a small amount of As per day may lead to accumulation of large amount of As in human body in the long run.

A total of 106 different analyses were performed during the reporting year. Besides, a number of maps were prepared using GIS and supplied to the scientists of other divisions whenever required.

STABILITY ANALYSIS OF BRRI VARIETIES

The newly developed stability model takes into account the performance of the genotypes across the geographical locations differing in land, soil and other biotic and abiotic factors and over the years characterizing fluctuation of weather variables, floods, and drought etc.

Experiments are being conducted in the T. Aman and Boro seasons with BRRI released rice varieties in Gazipur and different regional stations. The collaborative regional stations in the T. Aman season are Rajshahi, Rangpur, Comilla, Sonagazi, Barisal, Satkhira and Kushtia and in the Boro season Rajshahi, Rangpur, Comilla, Habiganj, Barisal, Bhanga, Satkhira and Kushtia.

In T. Aman, the number of varieties is 23 and in Boro it is 23. The design used is RCB with three replications and the effective plot size (harvest area) is 5- × 2-m^2 leaving the boarder. Recommended crop management practices are followed. The stability index of i^{th} genotype is defined as:

$$G_i = \left(F_i^I + P_i^I + S_i^I\right)$$

where, F_i^I = Fluctuation index of i^{th} variety, P_i^I = Performance index of i^{th} variety and S_i^I = Superiority index of i^{th} variety.

The value of G_i ranges from -1 to + 3 ie, $-1 \le G_i \le 3$. **The higher the value of G_i the more is the stability of the genotype across the environments. Stability of a variety is characterized as follows**:

Value of G_i	Nature of stability
≤ 0	Unstable
$0 < \mathbf{G_i} \leq 1$	Below average stability
$1 < G_i \leq 2$	Average stability
$2 < G_i \leq 3$	Stable

Tables 1 and 2 present the results. Among the non-aromatic T. Aman rice, BRRI dhan32 and BRRI dhan40 were found stable from year to year although their stability ranks interchange between 1 and 2. BR3 and BRRI dhan33 appeared to be unstable. BR4, BRRI dhan51 and BRRI dhan52 were found to have bellow average stability and all other aromatic T. Aman varieties appeared to show average stability. Among the aromatic T. Aman rice, BRRI dhan38 appeared to be the most stable followed by BRRI dhan37, while BR5 and BRRI dhan34 appeared to show bellow average stability.

In Boro, the stable varieties were BRRI dhan28 and BRRI dhan29. BR3, BR9, BR14, BR15, BR16, BR17, BR19 and BRRI dhan36 appeared to have average stability. All other Boro varieties appeared to have bellow average stability and of which BR6 was the most unstable variety followed by BR2 and BR8.

DEVELOPMENT AND VALIDATION OF PRODUCER AND CONSUMER PREFERENCE MODEL TO RICE VARIETIES

For this study four locations/districts of Bangladesh were selected. Dhaka and Gazipur was selected as 'Rice deficit'. Dinajpur and Bhola were selected as 'Rice surplus'. Fifty farmers were selected from each group of the locations and the selected farmers were categorized into three sub groups such as farmer as a producer, farmer as a producer-cum-consumer and pure consumer (Consume rice from market). Information was collected on the choice of varieties for production and consumption using a pre-designed questionnaire.

This study is an attempt to evaluate the factors affecting both producers' and consumers' preference to rice varieties, because no systematic

Table 1. Stability parameters of new model for grain yield for T. Aman.

Variety	Stability parameter		Stability index (G_i)		Stability rank (R_i)
	2002-11		2002-11		2002-11
	S_i	D_i	P_i	G_i	R_i
		Non-aromatic rice			
BR3	18.21	-15.32	14	-0.20	14
BR4	16.32	-5.83	18	0.81	12
BR10	19.93	7.97	32	1.61	8
BR11	15.01	5.51	29	2.01	4
BR22	17.33	5.28	28	1.67	8
BRRI dhan23	15.94	2.68	32	1.78	6
BRRI dhan25	22.49	-5.49	19	0.86	12
BRRI dhan30	18.11	4.10	33	1.58	9
BRRI dhan31	19.12	6.11	31	1.82	5
BRRI dhan32	18.95	10.89	34	2.62	2
BRRI dhan33	19.89	-14.63	12	0.15	14
BRRI dhan39	18.92	-12.20	15	0.42	13
BRRI dhan40	15.22	6.15	34	2.54	1
BRRI dhan41	16.56	6.52	33	2.10	3
BRRI dhan44	12.83	4.12	28	1.23	10
BRRI dhan46	15.75	4.60	26	1.02	11
BRRI dhan49	16.87	5.18	27	1.72	7
BRRI dhan51	11.58	-10.15	13	0.50	13
BRRI dhan52	11.29	-9.69	14	0.48	13
		Aromatic rice			
BR5	19.56	-5.86	11	0.25	4 (14)
BRRI dhan34	18.88	-3.98	14	0.98	3 (12)
BRRI dhan37	21.02	4.97	30	2.52	2 (1)
BRRI dhan38	16.72	4.56	33	2.70	1 (1)

Table 2. Stability parameters of new model for grain yield in Boro.

Variety	Stability parameter		Stability index (G_i)		Stability rank (R_i)
	2002-12		2002-12		2002-12
	S_i	D_i	P_i	G_i	R_i
BR1	12.10	-6.58	16	0.61	11
BR2	11.21	-9.12	6	0.36	13
BR3	8.53	2.80	28	1.42	4
BR6	11.94	-11.91	11	0.14	15
BR7	10.98	-4.85	12	0.62	10
BR8	14.57	-8.74	8	0.24	14
BR9	8.54	8.46	27	1.80	2
BR12	8.91	-5.63	20	1.11	7
BR14	8.99	6.49	30	1.72	3
BR15	8.55	0.98	25	1.26	6
BR16	8.76	6.85	32	1.76	2
BR17	10.02	3.59	35	1.41	4
BR18	11.52	-7.70	14	0.51	12
BR19	9.86	2.48	25	1.30	6
BR26	11.53	-3.23	18	0.83	9
BRRI dhan27	12.62	-2.81	16	0.62	10
BRRI dhan28	11.81	4.18	18	1.35	5
BRRI dhan29	8.49	21.54	35	2.89	1
BRRI dhan35	9.98	-2.02	17	0.89	9
BRRI dhan36	7.87	3.82	31	1.69	3
BRRI dhan45	8.99	3.90	26	1.10	8
BRRI dhan47	9.94	5.95	26	1.08	8
Fine rice					
BRRI dhan50	8.81	9.12	23	1.01	8

study has been conducted in identifying the factors that could influence or affect the preference to rice variety.

Analytical procedures

To explore the significant difference of preferring varieties among the group of people, chi-square (χ^2) tests (Gomez and Gomez 1983) were used according to a consumer preference study and survey on fast food conducted by Larry McMullen 2004.

The model of consumer demand for good characteristics is adapted from Ladd and Suvannunt (1976). Products and demand for the utility they provide, which in turn is a function of the characteristics of the product (Ladd and Suvannunt, p 505. Then Laurian J. Unnevehr (1986) has given a model of consumer demand for rice grain quality and return to research for quality improvement in Southeast Asia. Also Juliano, BO (1982), presented a paper at food conference of Singapore institute of food science and technology about consumer acceptance and processing characteristics of rice varieties. On the basis of above authors' ideas we have proposed two models for consumer preference and producer preference to rice varieties. These two models are given below:

Consumer preference model-

$$CP_i = f(PR_j, CI_k, RG_l, CRV_m, TRV, ARV)$$

where, CP_i = Preference of i-th consumers; $PR_{j(1,2,3...)}$ = Price of rice; $CI_{k(H,\ M,\ L)}$ = kth consumer income, RG_l = Rice grain quality characteristics; CRV_m = Category of rice variety; TRV = Taste characteristics of rice variety; ARV = Availability of rice variety.

Also

$$PR_j = \sum_{j=1}^{p} X_{Rj} R_{Cj} + U$$

here, X_{Rj} = Variance in the rice price; and

$$R_{Cj} = \sum_{j=1}^{p} PC_j + CC_l$$

$PC_{j(Whiteness,\ Brokens,\ Shape,\ Chalkiness)}$ = Physical characteristics
$PC_{j(Whiteness,\ Brokens,\ Shape,\ Chalkiness)}$ = Chemical characteristics
U = Constant variance (ie $E(U) = 0$)

Producer preference model-

$PP_i = f(CP_i, PRV, RGEAEZ, LEP, LD)$

where, PP_i = Preference of i-th producers; CP_i = Preference of i-th consumers
PRV = Production of rice variety (High production, Medium or average)
$RGEAEZ$ = Rice growing environment of AEZ
LFP = Local farmers practices; LD = Local demand

Producer cum consumer preference model-

$PC_i = PP_i + CP_1$

where, PP_i = Preference of i-th producers; CP_i = Preference of i-th consumers.

BR11, BR22 and BRRI dhan32, BR16, BRRI dhan28 and BRRI dhan29, BR9, BR16 and BR20 were found to be more preferable and cultivable varieties due to higher yield in T. Aman, Boro and Aus season respectively among the producers and producer cum consumers. Pure consumers were found to prefer rice varieties on the basis of taste (Table 3).

DISTRIBUTION OF ARSENIC IN GANGETIC FLOOD PLAIN

Arsenic risk assessment in ground water irrigated Boro rice area

Arsenic is getting into rice, Bangladesh's staple crop through irrigation water pumped from contaminated soils. But the available database was not adequate to represent arsenic situation in soils and rice grain for assessing possible contamination of soil and ground water arsenic in the food chain of Bangladeshi people through rice consumption. In previous chapter(s) we already got idea about As in food chain through contaminated As groundwater irrigation and soil. This will help to delineate the safe area for rice production and to develop appropriate mitigation plans for the arsenic affected areas of Bangladesh. Date of initiation, recession and depth of flood were analysed to determine the areas suitable for BRRI varieties. To authenticate the results ground truthing was done. ARCVIEW Spatial Analyst 3.2 were used for GIS analysis and constructing the maps. The main purpose of this work is to delineate arsenic risk and save areas for irrigated rice cultivation in Bangladesh.

Table 3. Pure consumers' reasons for liking varieties in Dhaka, Gazipur, Dinajpur and Bhola (%).

Reason	Gazipur	Dhaka	Dinajpur	Bhola
Tasty	28(56%)	26(52%)	29(58%)	24(48%)
Fine rice	10(20%)	12(24%)	11(22%)	9(18%)
Fine rice + tasty	9(18%)	7(14%)	1(2%)	10(20%)
Fine rice + non-sticky	3(6%)	5(10%)	9(18%)	7(14%)
Total	50	50	50	50

Determination of Boro suitable area

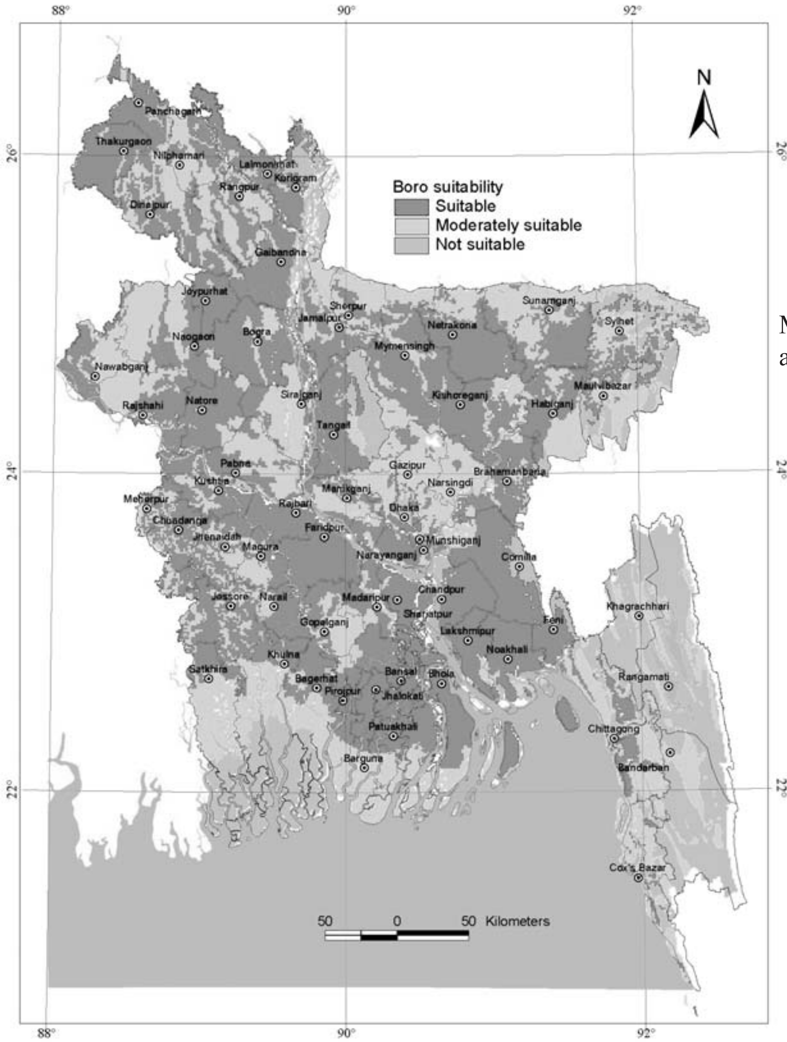
Five soil physical properties namely, Land type, top soil texture, slope, soil salinity, and soil permeability were considered to determine area suitable for growing rice in the Boro season. The resultant grid was classified into three suitability classes - suitable, moderately suitable and not suitable for Boro cultivation (Map 1).

Overlay of groundwater As surface with the Boro suitable area

Ground water As surface was converted into grid theme and was overlaid with Boro suitability grid theme to determine the As contaminated areas that are suitable for Boro cultivation. Overlaid resultant map was classified into four classes in terms of As risk in conjunction with Boro suitability, namely high risk, medium risk, low risk and no risk (Table 4 and Map 2).

Spatial sampling scheme from As risk area

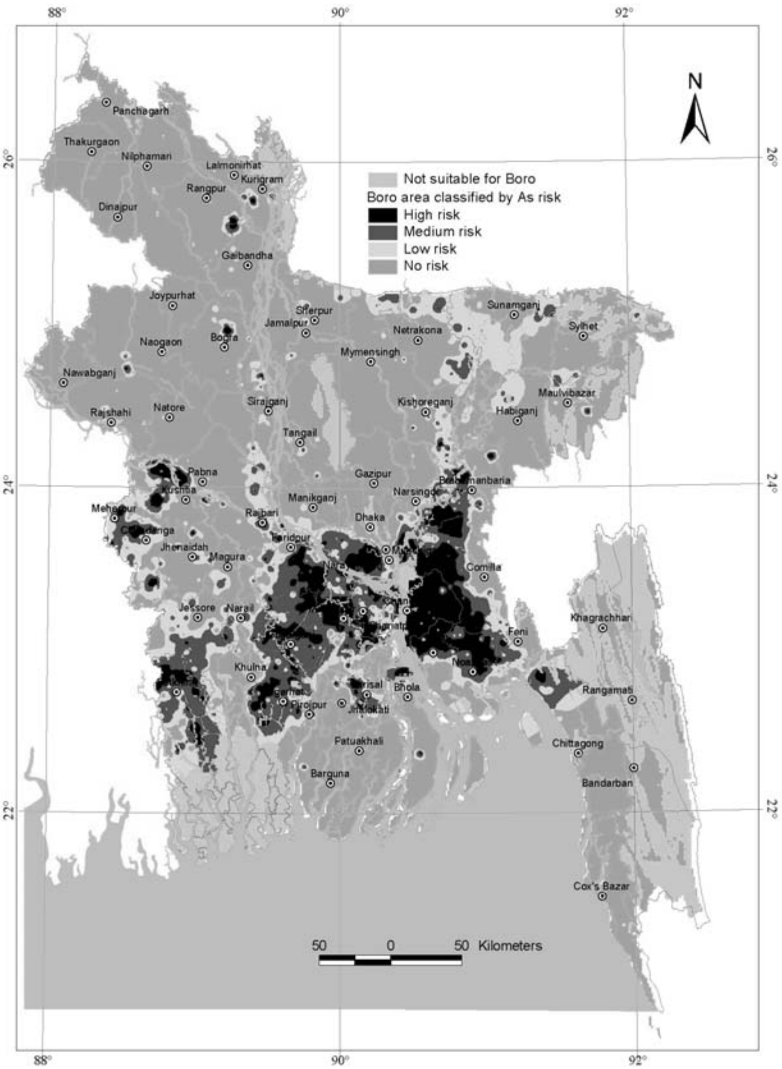
From the three classes of GW contaminated As risk areas, 100 unions (primary sampling units) were randomly selected, where more than 50% of the area falls within the risk level. These 100 primary sampling units (PSU) were distributed among three As risk classes, the number being proportional to their sizes (areas) to total As risk areas. The numbers of PSUs thus selected are 25 from high risk, 35 from medium risk and 40 from low risk classes (Table 5).



Map 1. Boro suitable area in Bangladesh.

Table 4. Classification of ground water As contaminated Boro area.

As class	As level µgm/1	Boro suitability	Boro suitability class	Over laid Id	As risk level
1	<50	No data	1	11	No risk
1	<50	Highly suitable	2	12	No risk
1	<50	Moderately suitable	3	13	No risk
1	<50	Not suitable	4	14	No risk
2	50-100	No data	1	21	No risk
2	50-100	Highly suitable	2	22	Low risk
2	50-100	Moderately suitable	3	23	Low risk
2	50-100	Not suitable	4	24	No risk
3	100-200	No data	1	31	No risk
3	100-200	Highly suitable	2	32	Medium risk
3	100-200	Moderately suitable	3	33	Medium risk
3	100-200	Not suitable	4	34	No risk
4	>200	No data	1	41	No risk
4	>200	Highly suitable	2	42	High risk
4	>200	Moderately suitable	3	43	High risk
4	>200	Not suitable	4	44	No risk



Map 2. Boro area classified by As risk.

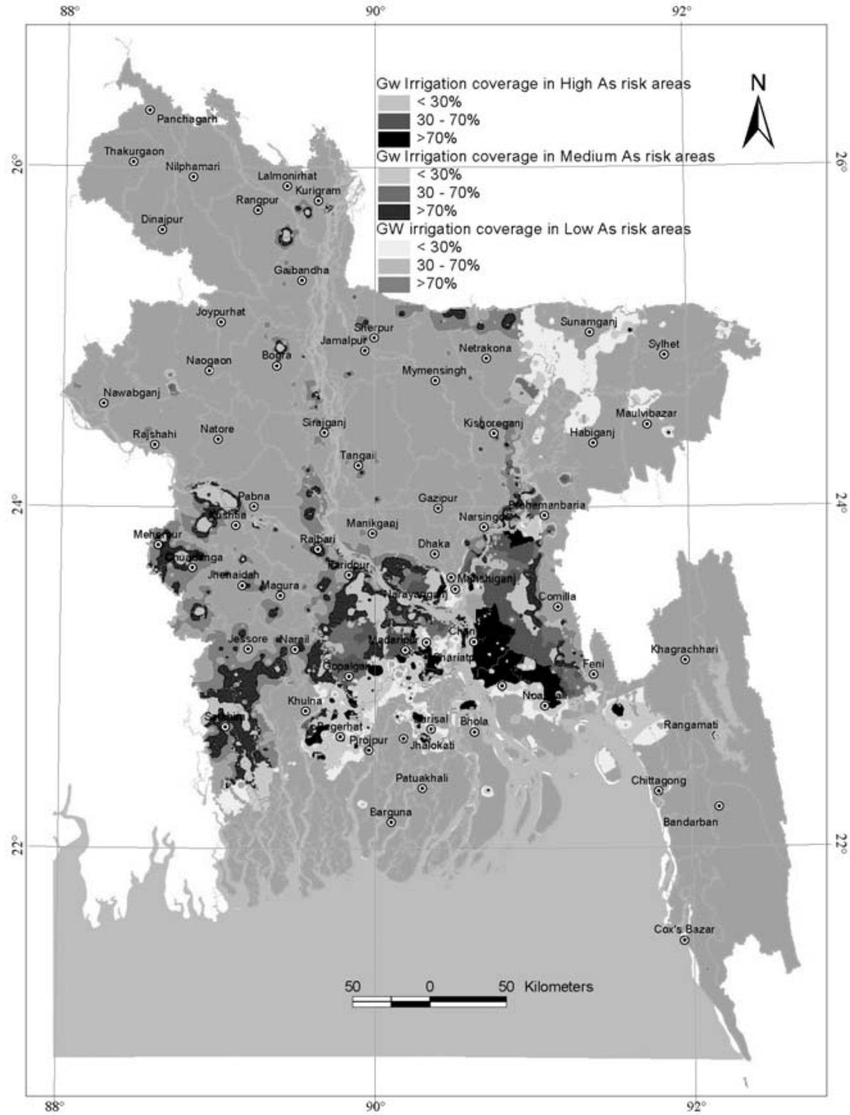
From each union, 10 sampling points (secondary sampling units: SSU) were selected. Map 3 shows the As risk areas due to As contaminated GW.

Map 1 presents suitability of Boro rice cultivation. Except eastern hill, reserve forest, Madhupur tract and some other pocket areas, Bangladesh is suitable for Boro rice cultivation with availability of irrigation water.

More than two third area of Bangladesh uses more than 70% ground water irrigation (Map 2). Intensity of irrigation gradually increased from the

Table 5. Size of PSUs and SSUs within As risk areas.

Risk level	PSU			SSU	
	PSU (no.)	Total area (km^2) of the unions	As affected area (km^2)	SSU per PSU	Total SSUs
High risk	25	7,233.00	5,145.00	10	250
Med risk	35	11,306.00	6,799.61	10	350
Low risk	40	13,837.00	7,303.00	10	400
No risk	40	84067.00	-	10	400



Map 3. As risk in Ground water irrigated Boro area.

south to the north and from east to west. Northern part of Bangladesh uses very intensive ground water irrigation than other parts, because of non-availability of surface water.

Finally, the risk of As-contaminated irrigation water to crop production has received little attention until now. To evaluate current and future As concentration in soils, data on As toxicity to crops are needed, both for flooded and non-flooded soil conditions. Therefore, field studies to test if As is one of the limiting factor for crop growth in the field should be emphasized. Further, it should become clear what soil parameters correlate with As uptake by plants and its toxicity. Based on that information, a toxicity database for different rice cultivars and other crops could be developed to set standards for As in flooded and non-flooded soils.

Risk may be assessed by two ways: firstly, the consumption of As contaminated drinking water and As contaminated rice by human being and secondly, shipment of As contaminated rice from contaminated area to non-contaminated (safe) areas for human consumption.

About 99% of the people eat huge amount of rice as their main food @ 455 gm/person per day and water about 800 ml/day perperson. The average As content in grain was 0.31 mg/kg at command area level and at upazila level. It was 0.40 mg/kg, while groundwater As level was 178.6 ppb and 126.3 ppb respectively.

- High As risk areas lie in the south-east to south-central regions in Bangladesh. Medium As risk areas spreads all over the country but more concentrated in south-west region to south-central and south-east regions. Low risk groundwater As contaminated areas spread all over the country as pockets.
- Combining the total As of grain and water (drinking water and water for rice cooking) more than 800 and 700 ppb, respectively in command area level and upazila level consumed per person per day. Out of it human body may accumulate at least a small amount of As. Thus, consumption of rice containing a small amount of As per day may lead to accumulation of large amount of As in human body in the long run.

SAMPLING PROTOCOL FOR SOIL AND WATER SAMPLING FOR ASSESSING AS STATUS IN SOUTH-WEST BANGLADESH

Arsenic is an obscure concept in the modern world. Arsenic pollution of the irrigation-water-soil systems is a major pathway through which As can make its way into the human body via food from crops grown in soils polluted by high-As irrigation water. This is especially true for Bangladesh because rice is the staple food crop and it is also the crop most vulnerable to As in irrigation water and soils because of its anaerobic growing conditions. Ground water is extensively used in irrigation of rice, the staple food of Bangladesh, with 83% of the total irrigated area under rice cultivation (Dey *et al.,* 1996) and more than 99% of the people eat huge amount of rice as their main food @416 gm/ person/day. Thus, consumption of rice containing a small amount of As may lead to accumulation of large amount of As in human body. In this study, arsenic contamination in ground water has been analyzed using BGS database in conjunction with ground water irrigation data and spatial database on the suitability of growing rice in the Boro season in order to develop a sampling scheme for collecting soil, water and plant samples from all over Bangladesh.

The main purpose of this work improve knowledge of the geographical distribution of contamination of soil and irrigation water with arsenic, in order to target arsenic management strategies to the most contaminated areas.

Sampling strategy

- From the command area of STW/DTW of the selected Mouza, three soil samples have been collected diagonally from the command area. One from near, one from middle and other from the tail end of the command area.
- Each sample was the composite of five sub-samples of 25 m^2 area and GPS value has been taken from the middle of the sub- samples.
- Soil samples have been collected from the top soil (0-15cm) depth.
- Water sample has been collected after 15-20 minutes pumping the STW/DTW and STW/DTW has been geo-referenced using GPS.
- Besides, other information such as depth and age of STW/DTW and the extent of its command area, cropping pattern, land type, etc of the sampling fields was also be recorded and all sampling points (fields) were geo-referenced using GPS.

Data collection

Latitude, longitude, date of collection, district, upazila, union, mouza, farmers name, farmer’s father's name, depth of soil sampling, number of sub sample, area of the sampling plot (in decimal), land type, irrigation system/canal (Kacha/Pucca/Pipe), past treatment, previous crop grown, next crop grown, irrigation facilities, source of irrigation, depth of STW/DTW, date of installation, area coverage, cropping pattern and water sample.

In total, 2517 soil samples and 839 water samples from 839 locations have been collected

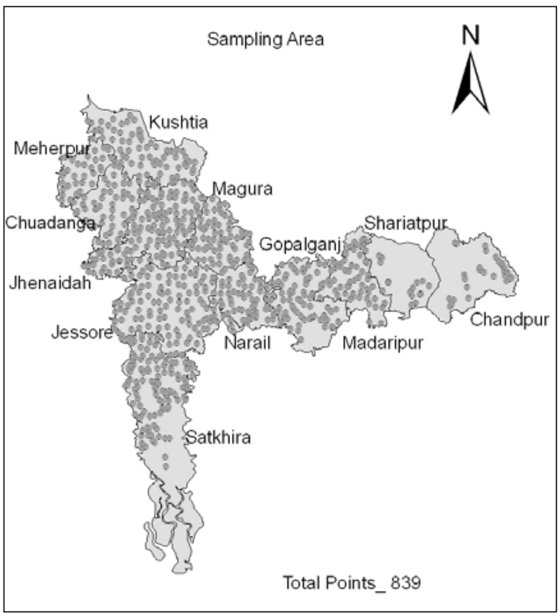
(Table 6 and Map 4) and about 1500 soil samples have been processed and digested, 839 water samples analysed for As (Map 5 and Map 6), Fe, Mn and P. Data entry of almost 65 upazilas have been completed by this time.

CUSTOMIZED SOFTWARE DEVELOPMENT

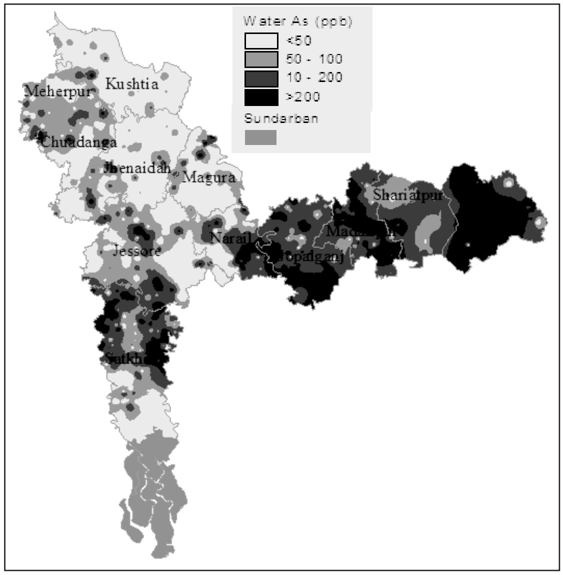
For administrative/accounting work the old payroll programme was MS-DOS environment. The main problem of this DOS software is that previously it was dependent on floppy disk and floppy drive, which is not available today and it is backdated. For pay bill the field of house-rent, medical allowance, charge allowance etc field digit was limited and there is no option for creation extra field, more over field digit was limited. So, in case of new pay scale and other official requirement it was problematic. On the basis of the above

Table 6. Sampling summary.

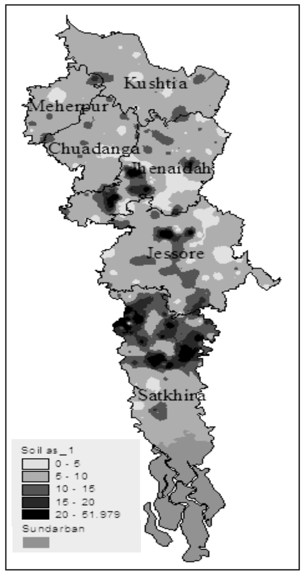
District	Points (no.)
Kushtia	69
Meherpur	32
Chuadanga	46
Jhenaidah	130
Jessore	115
Satkhira	116
Gopalganj	69
Madaripur	62
Narail	56
Magura	65
Shariatpur	16
Chandpur	27
B. Baria	35
Comilla	1
	839



Map 4. Sampling areas from south-east region of Bangladesh.



Map 5. Water Arsenic.



Map 6. Soil Arsenic.

problems we have taken a programme to modify and develop windows base Payroll software, which is free from all types of problems

The main purpose of this work is to develop software for administrative/accounting systems of BRRI and to develop a computer programme for maintaining and reporting the results.

Payroll software has been developed using C.NET programming language with the help of "IT Park Ltd" company. The Architecture of this software is Client-Server and structure is three tier application and data were managed by SQL Server2000. WindowsXP/2007 operating system was used to management and reporting the results for administrative/accounting systems of BRRI as per requirement of the accounts section with the help of "IT Park Ltd" company.

BRRI WEBSITE MANAGEMENT

The main purpose of this routine work is to complete the constructions of blank pages and modify the design of BRRI website and to manage and maintain it through regular updating the information and documents.

BRRI website: has been registered with BTCL. Agricultural Statistics Division maintains it uploading the information from concerned authority. BRRI website www.brri.gov.bd has been updated with latest information and some new pages have been added.

ICT NETWORK MANAGEMENT

The main purpose of this work is to manage and maintain ICT network of BRRI.
Agricultural Statistics Division manages and maintains the ICT network of BRRI with TRACER electocom, the Network developer company.

BRRI LAN is on work now. Seventy computers have been connected in this network. The LAN was connected through 1 Mbps DDN connectivity provided by BTCL. Fifty users have their own email address created through the web-mail of BRRI website. In the reporting period, we have increased to 4 Mbps DDN bandwidth connectivity. Now our internet speed is faster than previous one and we will be able to give internet connection to 250 computers. Hopefully, within short time all the BRRI scientists and officers will get internet accesses smoothly and they will be benefited to pass information internally as well as globally.

MAINTENANCE OF RICE AND RICE RELATED VARIABLE DATABASE

The main purpose of this work is maintaining up-to-date information on rice and related crops and inputs and to provide rice related information to other research divisions as well as interested persons.

Secondary data on rice and other important crops are collected periodically from BBS, Agricultural Marketing Directorate, Meteorological Department, Bangladesh Water Development Board, BADC and other databases have been updated.

SUPPORT SERVICES

The Agricultural Statistics Division provides statistical support services to other divisions and regional stations. In all, 106 different analyses were performed during the reporting year. Statisticians were also engaged in helping scientists of other disciplines in planning experiments, analyses of data and interpretation of results. This division also provided computer services to administration and accounts for maintaining personnel history and pay. Besides, a number of maps were prepared using GIS and supplied to the scientists of other divisions whenever required.

Farm Management Division

SUMMARY

An experiment was conducted at the West Byde of BRRI HQ farm, Gazipur during Boro 2011-12 season to determine the relative profitability of different sources of N (PU and USG) and weed control methods (herbicide Refit, herbicide Super Clean and hand weeding) in relation to labour utilization for rice cultivation. The treatments were arranged in a randomized complete block design with three replications. BRRI dhan29 was used for experimental purpose. In PU applied plots, hand weeding produced the highest number of tiller m^{-2} and grain $panicle^{-1}$. Super Clean produced the highest number of panicle m^{-2}. Weeding method had no significant effect on grain yield. All the variables were higher in USG applied plots than PU applied plots. USG applied plots required higher number (6%) of labour than PU applied plots. Application of Super Clean instead of Refit earned Tk 4,160 ha^{-1} more profit but application of Super Clean instead of hand weeding earned Tk 10,060 ha^{-1} more profit. However, application of Refit instead of hand weeding made more profit Tk 5,900 ha^{-1} and application of USG instead of PU made more profit Tk 6,209 ha^{-1}.

Another experiment was conducted during Aus 2011, T. Aman 2011 and Boro 2011-12 seasons at the West Byde of the BRRI HQ farm, Gazipur to determine the cost and return of HYV rice cultivation in present situation. The rice varieties BR26, BRRI dhan41 and BRRI dhan29 were tested in Aus, Aman and Boro seasons respectively. Labour requirement in Aus, Aman and Boro seasons was 269, 269 and 273 man days (md) ha^{-1} respectively. The total variable cost, gross return and gross margin for one hectare of land was the highest in Boro season followed by Aman and the lowest in Aus season, but the production cost of one kg rice was the highest in Aus season (Tk 14.9) followed by Aman (Tk 12.3) and Boro seasons (Tk 12.2). The BCR was 1.46, 1.71 and 1.64 in Aus, Aman and Boro seasons respectively.

An experiment was conducted during T. Aman 2011 season at the West Byde of BRRI HQ farm, Gazipur to find out the effect of different period of direct supervision on labour efficiency. The treatments were different level of direct supervision such as 100%, 80%, 60%, 40%, 20% and no direct supervision. Labour requirements for different operations such as seedling uprooting, transplanting, weeding, harvesting and postharvest operations were taken. Cent percent supervision required less number of labour and it was increased with decreasing of supervision period. Labour requirement was the highest under no supervision. Therefore, to increase the labour efficiency supervision must be confirmed.

Survey and monitoring labourers' wage rate were conducted throughout the year at Joydebpur, Chowrasta, Salna, Board Bazar, Konabari, Tongi. The average wage rate per day varies from Tk 300 to 330. The wage rate per day during the peak periods of the year was Tk 460 to 470 in May, Tk 275 to 330 in July-August and Tk 320 to 400 in December-January. The wage rate varied between Tk 200-225, 200-225, 200-230, 225-250, 250-300, 225-250, 250-300 and 300-350 at Habiganj, Rangpur, Rajshahi, Barisal, Sonagazi, Comilla Satkhira and Khulna, repectively.

About 17,003 kg of rice was produced consisting of 10,722 kg seed and 6,281 kg mixed rice. In addition 7,215 kg breeder seed and 1,574 kg TLS were also produced.

BRRI had 485 labourers (227 regular and 258 irregular). In BRRI HQ, total labourers were 289 of which 129 were regular and 160 were irregular. The institute has 274 ha of land including 163 ha cultivable land.

Total labour utilization in different divisions was 63,345.5 man days of which 59.57, 33.54 and 6.88% were utilized for research, support service and holidays respectively.

A total of Tk 75,83,587.12; Tk 42,70,232.88 and Tk 8,76,192.54 were paid to the labourers for research work, support service works and leaves respectively.

About 85.3 ha of land was utilized by different divisions in different seasons where 13.9 ha was used in Aus, 37 ha in Aman and 34.4 ha in Boro season.

In addition, this division is also responsible for the management of BRRI garden to maintain the aesthetic view of the campus with colourful flowers throughout the year.

Sources of N and methods of weed control in respect to labour use for rice cultivation

This experiment was conducted at the West Byde of BRRI HQ farm, Gazipur during Boro 2011-12 season in a randomized complete block (RCB) design with three replications to determine the relative profitability of different N sources and weed control method in relation to labour use for rice cultivation. BRRI dhan29 was used for experimental purpose. The treatments were different N sources (PU and USG) and weed control methods (herbicide Refit, herbicide Super Clean and hand weeding). The unit plot size was 10- × 10-m. Collected data were analyzed by following a standard statistical procedure and the mean differences were adjusted by LSD method.

Interaction effect. All the variables were significantly affected by the interaction effect of N fertilizers and weed control methods except 1000-grain weight and straw yield (Table 1).

Tiller number. In PU applied plots, hand weeding produced the highest number of tiller m^{-2}, followed by Super Clean but no significant difference between Super Clean and hand weeding was observed. In USG applied plots, weeding method had no significant effect. Irrespective of weed control method, USG applied plots produced the highest number of tiller m^{-2} than PU applied plots.

Panicle number. Regardless of N fertilizer, weed control method had no significant effect on panicle number m^{-2}. Irrespective of weed control method, USG applied plots produced higher number of panicle than PU applied plots.

Grain number. In PU applied plot, hand weeding plot produced the highest number of grain $panicle^{-1}$ and the lowest in Refit applied plot. In USG applied plots, Refit and Super Clean applied plot produced higher number of grain $panicle^{-1}$ than hand weeding plot. Irrespective of weeding method, USG produced higher number of grain $panicle^{-1}$ than PU applied plots.

Grain yield. Irrespective of N fertilizer, weed control methods had no significant effect on grain yield. Considering N fertilizers, the results shows that USG applied plots produced higher grain yield than PU applied plots.

Total labour requirement. Hand weeding required the highest number of labour followed by Refit and the lowest in Super clean applied plots. USG applied plots required higher (6%) number of labour than PU applied plots (Table 2).

Partial budgeting. Table 3 presents the cost and return and Table 4 presents the details of the partial budgeting. Application of Super Clean instead of Refit earned Tk 4,160 ha^{-1} profit but application of Super Clean instead of hand weeding earned Tk 10,060 ha^{-1} profit. However, application of Refit instead of hand weeding was profitable (Tk 5,900 ha^{-1}) and application of USG instead of PU earned profit of Tk 6,209 ha^{-1}.

It may be concluded that among the weed control methods application of Super Clean might be more profitable than Refit and hand weeding, and between N fertilizers, USG was more profitable than PU.

Table 1. Yield and yield components of rice as affected by the interaction effect of weed control and application method of N fertilizer in Boro 2011-12.

Treatment	Tiller m^{-2} (no.)	Panicle m^{-2} (no.)	Grain $panicle^{-1}$ (no.)	1000-grain wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
PU × Refit + HW	332bB	302aA	116bB	22.76	7.3aA	8.30
PU × Super Clean + HW	340aB	303aB	120aB	23.09	7.1aB	8.70
PU × HW	345aB	301aB	122aA	23.87	7.2aB	8.20
USG × Refit + HW	348aA	310aA	125aA	23.51	7.6aA	8.50
USG × Super Clean + HW	351aA	312aA	124aA	22.36	7.8aA	8.40
USG × HW	352aA	313aA	120bA	22.56	7.7aA	8.60
LSD at the 5% level	5.1	8.1	2.1	ns	0.5	ns

In a column, different small letters indicate the differences among methods under same N fertilizers and different capital letters indicate the difference among N fertilizers under same method, ns=Not significant.

Table 2. Labour requirement as affected by weed control and application method of N fertilizer in Boro 2011-12.

Treatment	Refit + HW	Super Clean + HW	Hand weeding	Mean
PU=Application of prilled urea as per recommended rate of N and applied 3 equal splits	230	212	265	236
USG=Application of USG as per recommended rate of N	246	230	280	252
Mean	238	221	273	

Table 3. Cost and return of weed control method and N fertilizer use for rice cultivation.

Treatment combination	Total variable cost (Tk ha^{-1})	Gross return (Tk ha^{-1})	Gross margin (Tk ha^{-1})
PU × Refit	49575	170900	121325
PU × Super clean	45665	168100	122435
PU × Hand weeding	55575	168600	113025
USG × Refit	53600	177500	123900
USG × Super clean	50090	181200	131110
USG × Hand weeding	59400	181800	122400

Price of rice and straw is Tk 25.0 kg^{-1} and Tk 3.0 kg^{-1} respectively. Labour cost is Tk 200 day^{-1}.

Table 4. Partial budgeting.

(a) Super Clean versus Refit

Debit		Credit	
Cost for using Super Clean	47878	Return from using Super Clean	174650
Revenue forgone for not using Refit	174200	Cost for using Refit	51588
Profit/Loss	+4160		
Total	226238		226238

(b) Super Clean versus hand weeding

Debit		Credit	
Cost for using Super Clean	47878	Return from using Super Clean	174650
Revenue forgone for not hand weeding	174200	Cost for hand weeding	57488
Profit/Loss	+10060		
Total	232138		232138

(c) Refit versus hand weeding

Debit		Credit	
Cost for using Refit	51588	Return from using Refit	174200
Revenue forgone for not hand weeding	174200	Cost for hand weeding	57488
Profit/Loss	+5900		
Total	231688		231688

(d) USG versus PU

Debit		Credit	
Cost for using USG	54363	Return from using USG	179500
Revenue forgone for not using PU	169200	Cost for using PU	50272
Profit/Loss	+6209		
Total	229772		229772

Cost and return of HYV rice cultivation in Aus, Aman and Boro seasons

This experiment was conducted during Aus 2011, T. Aman 2011 and Boro 2011-12 seasons at the West Byde of BRRI HQ farm, Gazipur to determine the cost of rice cultivation in existing situation and to generate primary data on the cost of HYV rice cultivation that can help for better planning. BR26, BRRI dhan41 and BRRI dhan29 were used in Aus, Aman and Boro seasons respectively. The plot size was 25- × 25-m irrespective of seasons. Labour requirements for different operations such as seedling uprooting, transplanting, weeding, harvesting, threshing and winnowing were done through direct supervision.

Total labour requirements for different operations of rice cultivation in one hectare of land were 269, 269 and 273 md ha^{-1} in Aus, Aman and Boro season respectively (Table 5). Boro season required the highest number of labour due to the higher requirement of labour for shorter type of seedling uprooting and transplanting as well as harvesting. Due to higher cost of irrigation, fertilizers and labourers, the total variable cost was the highest in Boro season (Tk 94,744) followed by Aman (Tk 76,186) and the lowest in Aus season (Tk 68,336). This cost includes the cost of labour, diesel and driver, seed, fertilizer, and irrigation (Table 6). The highest gross return was found in Boro season (Tk 1,55,300) followed by Aman (Tk 1,30,000) and Aus season (Tk 99,500). The gross margin was the highest in Boro season (Tk 60,556) followed by Aman (Tk 53,814) and Aus season (Tk 31,164). On the contrary, the cost of production of per kg rice was the highest in Aus season (Tk 14.9) followed by Aman (Tk 12.3) and Boro season (Tk 13.4). The BCR was 1.46, 1.71 and 1.64 in Aus, Aman and Boro seasons respectively (Table 7). Thus the highest gross margin was in Boro season and the lowest was in Aus season.

Table 6. Cost (Tk ha^{-1}) for rice cultivation in Aus, Aman and Boro seasons.

Item	Season		
	Aus	Aman	Boro
Labour	53800	53800	54600
Diesel, driver and labour	4400	4400	4400
Seed	650	650	650
Fertilizer	8936	8936	12469
Irrigation	550	8400	22625
Total variable cost	68336	76186	94744

Table 7. Yield, gross return, gross margin, cost of production of per kg rice and BCR for rice cultivation in Aus, Aman and Boro seasons.

Item	Season		
	Aus	T. Aman	Boro
Grain yield (t ha^{-1})	4.6	6.2	7.8
Straw yield (t ha^{-1})	7.1	8.2	8.7
Gross return (Tk ha^{-1})	99500	130000	155300
Total variable cost (Tk ha^{-1})	68336	76186	94744
Gross margin (Tk ha^{-1})	31164	53814	60556
Cost of production (Tk kg^{-1} rice)	14.9	12.3	12.2
BCR	1.46	1.71	1.64

Price of rice and straw is Tk 25.0 kg^{-1} and Tk 3.0 kg^{-1} respectively. Labour cost is Tk 200 day^{-1}.

Labour efficiency as affected by direct supervision for rice cultivation

This experiment was conducted during T. Aman season at the West Byde of BRRI HQ farm, Gazipur to find the effect of different period of direct supervision of labour on labour efficiency. The variety BRRI dhan41 was used. The plot size was 35- × 35-m. The treatments were T_1=100% direct supervision, T_2=80% direct supervision, T_3=60% direct supervision, T_4=40% direct supervision, T_5=20% direct supervision and T_6=No direct supervision. Labour requirements for different operations such as seedling uprooting, transplanting, weeding, harvesting and postharvest operation were taken. It was observed that 100% supervision required less number of labours but labour number increased with the decreasing of supervision period (Fig. 1). It was the highest under no supervision treatment. Therefore, to increase the labour efficiency supervision must be confirmed.

Monitoring labour wage rate at different locations

A survey was conducted to find out the labourers' wage rate at different locations such as Chowrasta, Joydebpur, Board Bazar, Salna, Konabari, Tongi etc (Table 8). The average wage rate per day was Tk 320-330. The highest wage rate was in May due to harvesting and postharvest operations of Boro rice and transplanting of Aus rice. Another higher

Table 5. Labour requirement (md ha^{-1}) for different operation of rice cultivation in Aus, Aman and Boro seasons.

Season	Seedbed preparation, seedling uprooting, etc	Transplanting	First weeding	Second weeding	Harvesting	Carrying, threshing, cleaning and drying	Total
Aus	25	56	46	30	44	68	269
Aman	26	57	46	29	44	67	269
Boro	28	60	41	28	47	69	273

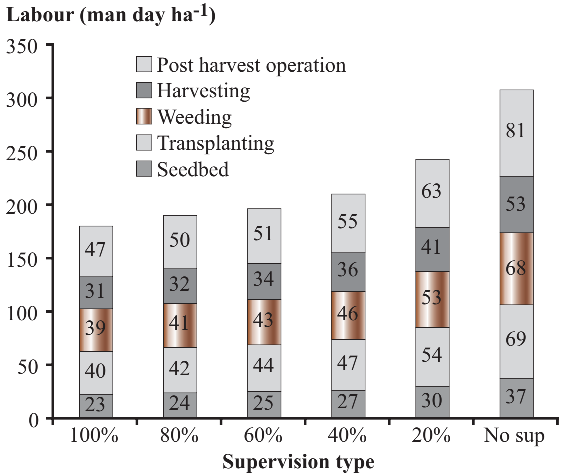


Fig. 1. Requirement of labour as affected by types of supervision.

rate was during July-August due to harvesting and postharvest operations of Aus and transplanting of Aman rice and the third higher wage rate was observed during December-January due to the peak period for harvesting and postharvest operation of Aman rice and transplanting of Boro rice. The wage rate during these peak months was Tk 460-470 in May, Tk 275-330 in July-August and Tk 320-400 in December-January. Another survey revealed that the wage rate varied from place to place and ranged in between Tk 200-225, 200-225, 200-230, 225-250, 250-300, 225-250, 250-300 and 300-350 at Habiganj, Rangpur, Rajshahi, Barisal, Sonagazi, Comilla Satkhira and Khulna respectively.

Rice seed production. This Division produced 17,003 kg rice of which 10,722 kg was seed and 6,281 kg was mixed rice.

Breeder seed and TLS. This Division produced 8,789 kg breeder seed and TLS. Three thousand nine hundred thirteen (3,913) kg breeder seed of BRRI dhan49 and 1,574 kg TLS of BRRI dhan51 was produced in T. Aman season and in Boro season 3,302 kg breeder seed of BRRI dhan28 was produced.

Land and labour management. BRRI has 485 labours. Among them 227 are regular and 258 are irregular (Table 9). BRRI HQ has 289 labours of which 129 are regular and 160 are irregular labours. BRRI has 274 ha of which 163 ha is cultivable.

Labour wages. It was observed that Tk 75,83,587.12 and Tk 42,70,232.88 and Tk 8,76,192.54 were paid to the labourers for research work, support service works and leaves respectively.

Labour use. Total labour use in different divisions for research purpose and research related works was 63,345.5 man days of which 59.57, 33.54 and 6.88% were used for research, support service and holiday purpose respectively.

Land use. A total of 85.3 ha of land were used by different divisions in different seasons of which 13.9 ha in Aus, 37 ha in Aman and 34.4 ha in Boro.

Irrigation. This division also responsible for irrigation of the cultivable land of BRRI throughout the year.

Table 8. Labourer's wage rate without stuff at different places around BRRI HQ, Gazipur during 2011-12.

Month	Wage rate (Tk)*	Remark
April	270-280	Normal period
May	460-470	Peak period- harvesting and postharvest operation of Boro rice and transplanting of Aus rice.
June	440-470	Normal period
July	275-280	Peak period- harvesting and postharvest operation of Aus rice and transplanting of Aman rice.
August	320-330	"
September	300-310	Normal period
October	280-290	"
November	270-280	"
December	320-330	Peak period- harvesting and postharvest operation of Aman rice and transplanting of Boro rice.
January	380-400	"
February	270-280	"
March	300-310	Normal period
Average	320-330	"

*Wage rate of each month is the average rate of different places such as Joydebpur, Chowrasta, Salna, Board Bazar, Konabari etc.

Table 9. Land and labour strength of BRRI in 2011-12.

Station	Total land (ha)	Cultivable land		Labour (no.)		
		Area (ha)	Total land (%)	Muster roll		Total
				Regular	Irregular	
HQ at Gazipur	76.83	44.45	57.9	129	160	289
Comilla	24.68	16.03	65.0	26	04	30
Habiganj	35.03	25.90	73.9	12	25	37
Sonagazi	45.77	35.90	78.4	23	4	27
Barisal	41.10	10.74	26.1	16	8	24
Rajshahi	13.24	8.92	67.4	13	12	25
Bhanga	11.46	9.55	83.3	03	11	14
Rangpur	6.07	4.05	66.7	05	20	25
Kushtia	0	0	0	-	6	6
Satkhira	20.00	8.10	40.5	-	8	8
Total	274.18	163.64	59.7	227	258	485

Garden management. This division always manages a visible flower garden to maintain an aesthetic view of the office area, some parts of the campus etc during summer and winter season.

Farm Machinery and Postharvest Technology Division

SUMMARY

Prime mover of the existing BRRI Winnower was replaced by a 4 hp diesel engine. The winnowing capacity of the modified winnower was increased to 550-600 kg/hr. Cleaning efficiency and operation costs of modified winnower was found same as previous version winnower.

BRRI USG applicator was re-designed as adjustable type considering line to line and plant to plant spacing of 18- × 20-cm, 20- × 20-cm and 22- × 20-cm. Adjustable mechanism of the re-designed applicator was also modified.

Mechanical transplanting of rice is the process of transplanting specifically raised seedling of rice. The seedlings were raised on polythene sheet and cut into slices of 28 × 58 cm size to feed into the seedling holding trays of the transplanter. A total of 14 (fourteen) treatments combining with different seed covering materials and dry and sprouted seed were used to conduct the study. Cow-dung mixed soil and without cow-dung mixed soil were also used as base soil treatment for this experiment.

Walking type mechanical rice transplanter was tested in NATP funded DUART project locations during Boro/2012 season. During test, flexible plastic tray (58 x 28 x 2.5 cm) was used to raise seedling for the transplanter. Yield performance of rice transplanting by mechanical rice transplanter were compared with hand transplanting method.

BRRI USG applicator was re-designed as adjustable one considering line to line spacing 18cm, 20cm and 22cm. During Boro 2012, the modified applicator performance test was evaluated in 10 locations under the NATP funded DUART project. In field operation, field capacity was found 0.15 ha/hr whereas, manual USG application capacity was 0.019 ha/hr. Yield variation was not observed in USG application by hand and applicator in studied ten locations. In all the cases, USG gave higher yield compared to hand broadcasting of prilled urea. USG also produced around 0.6 t/ha more yield than prilled urea.

Minimum tillage along with crop residue retention, after three years, slightly improved physical properties of soil such as bulk density and penetration resistance. In rice mazie cropping system, bulk density and penetration resistance under different tillage options along with residue retention are observed below the critical value which was regarded as sufficient to promote the growth and development of crops.

Energy input in conventional tillage, Single pass wet tillage in rice followed by zero tillage in maize, bed planting and Strip tillage was 49, 42, 42 and 41 GJ ha^{-1}, respectively in rice-maize cropping system. Maximum energy was consumed for chemical fertilizers. The lowest energy input was required for maize and highest for rice due to less irrigation water requirement in maize.

The physical and thermo chemical properties of rice husks were characterized to use as a feedstock for energy conversion process. As a source of biomass fuel, the characteristics of rice husk of four varieties are determined under this study.

In the reporting year 190 demonstration cum informal training programmes were conducted at different places under FMTD project. About 3800 participants including farmers, machine operators and Sub-Assistant Agricultural Officers (SAAO) attended the demonstration cum informal training programmers. As a result, awareness was created among the farmers on the benefit of using BRRI farm machinery and they also wanted to purchase the machine with 60% subsidised prices. Besides demonstration, BRRI machines were also displayed in the Agricultural Machinery Fair 2011-12 with the co-operation of Department of Agricultural Extension (DAE) of Kushtia and Gazipur office, BARI, Gazipur and RDA, Bogra.

We conducted 69 two-day-long training programmes during Aman and Boro seasons 2011-12 in different locations within the project areas. Altogether 1,380 participants mostly farm machinery operators attended the formal training programmes as trainee. A basic idea (how to operate new engine; when need to change air, oil and fuel filter etc) on operation, repair and maintenance of diesel engine has given to the participants. Trained operator was able to repair minor defects of the machine themselves. After training, the operators operated all machinery successfully.

A total of nine training programmes on ‘Seedling raising techniques for mechanical rice

transplanter and operation and maintenance of farm machinery' was conducted during Aman 2011 and Aus 2012. Different categories of farmers, manufacturer and traders participated in the training as trainee. Participants awarded about seedling raising techniques and operation of rice transplanter and USG Applicator. Soil collection, seedling tray preparation, rice transplanter and USG applicator operation was the parts of the training activities.

MACHINERY DEVELOPMENT AND TESTING

Development and modification of BRRI winnower

The BRRI winnower is operated by 0.5 hp electric motor and consists of grain hopper, blower, vibrating plate, eccentric linkage, grain screen assembly, dust sprout, wind board, sliding gate, grill etc. The power unit of existing winnower was replaced by 4 hp diesel engine and size and shape of winnower scaled up according to power adjustment. A new prototype was designed and fabricated in FMPHT divisional research workshop. The performance test of new developed and modified winnower was conducted and capacity was found 550-600 kg/hr (Table 1), which was higher than the existing BRRI winnower. The farmers can use this modified winnower in rural areas where electricity is not available.

Improvement of BRRI USG applicator

The existing fixed type BRRI USG applicator (20×20 cm) was modified and made it adjustable (Fig. 1) considering line to line and plant to plant spacing (18×20, 20×20 and 22×20 cm and depth of USG placing into soil 6-8 cm. The field capacity of the modified applicator was 32 decimal per hour which was quite similar with previous applicator. The average depths of USG placement were 5-6 cm for the applicator. In addition, the total weight of the modified applicator was reduced to 7.5 kg from 10 kg. The applicator should be operated by pushing force, whereas, pulling back might create blockage of granule dispensing channel by mud. During field operation, minimum standing water (0.5-1.0 cm) should be maintained for smooth operation. Standing water also have to maintained in the field after rice transplanting till the date of USG application to keep the soil soft that may help in opening and closing the furrow properly.

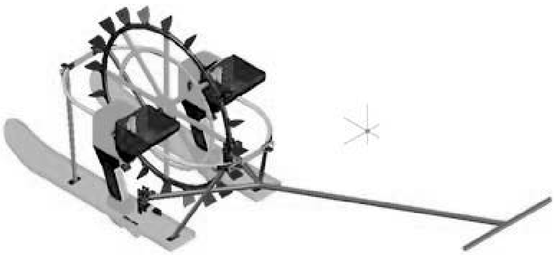


Fig. 1. Isometric view of BRRI USG Applicator.

Design and development of manual carrier

Manual carriers are extensively used as local transportation system in rural and urban areas to carry agricultural and non-agricultural goods. The existing traditional rickshaw-vans were used as a baseline to design and develop improved manual carrier enhancing the labour productivity and reduce the drudgery in farming work. The designed prototypes were four-speed change gear rickshaw-van and two speed change gear rickshaw-van. Manual carrier was designed with the help of CADRA engineering drawing tools (Software). Major parts involved were two-speed and four-speed changeable gears, modified hubs with enlarged width, two free wheel sprockets, UC pillow block bearing,

Table 1. Performance test of the modified winnower.

Trial no.	Revolution of driven pulley (rpm)	Capacity (kg/hr)	Cleaning efficiency (%)	Fuel consumption (liter)
1	670	550	95	0.9
2	690	600	90	1.0
3	685	580	92	1.0
Average	682	577	92.33	0.97

suspension springs, and wooden foot brake. The safe load of the developed prototype was found to be 350 kg. About 46% of safe loading capacity was increased in the developed prototype compared to the existing manual carrier. In emergency conditions, wooden foot brake can stop within a distance of 3-4 feet. This modified spoke span increased the carrying capacity of the prototype. The developed manual carrier can carry more than 500 kg load than the traditional rickshaw-van, stop instantly in any emergency conditions, pass any obstacle easily and make the drive and transportation easier and more comfortable.

Development of seedling raising technique for mechanical rice transplanter

Quality seedling is very important for successful operation of mechanical rice transplanter. Fourteen treatments combining with different seed covering materials, dry and sprouted seeds were used for this study. The treatments were as follows:

- T_1= Dry seed+ Soil+ Rice husk
- T_2= Dry seed+ Soil+ Sawdust
- T_3= Dry seed+ Soil+ Soil
- T_4=Dry seed+ (Soil+ Cowdung) + Rice husk
- T_5= Dry seed+ (Soil+ Cowdung) + Sawdust
- T_6= Dry seed+ (Soil+ Cowdung) + Soil
- T_7=Sprouted+ Soil + Rice husk
- T_8=Sprouted+ Soil + Sawdust
- T_9=Sprouted+ Soil + Soil
- T_{10}= Sprouted + (Soil+ Cowdung) + Rice husk
- T_{11}= Sprouted + (Soil+ Cowdung) + Sawdust
- T_{12}= Sprouted + (Soil+ Cowdung) + Soil
- T_{13}=Frame+ Sprouted+ Soil
- T_{14}=Frame+ Dry seed+ Soil + Rice husk

Seedling raised on polythene sheet was cut into slices of 28 × 58 cm size to feed into the seedling holding trays of the transplanter. However, the seedling raised in the tray can directly used to the transplanter holding tray because of similar size of seedling and transplanter tray. A piece of perforated polythene sheet was placed on a levelled dry/wet bed and wood strips of 2.0-3.0 cm wide and 2.0 cm thick was used to control the thickness of seedbed and separate seedling block according to transplanter tray size. Plastic tray of 28 × 58 × 2.5 cm size was used for raising seedling on the tray. The highest number of seedling per square centimeter was found for T_9 (4.25) treatment followed by T_{13} and T_7 treatments respectively. The lowest number of seedling was found for T_{14} (2.24) treatments followed by T_{10}, and T_1 respectively. Treatment T_9 seedling was found more suitable for machine transplanting.

Test and evaluation of mechanical rice transplanter

The experiment was conducted under the Development and Validation of USG Applicator and Rice Transplanter (DUART) Project at the project area during Aman 2011 and Boro 2012. During the test, flexible plastic tray (58 × 28 × 2.5 cm) was used to raise seedling for the transplanter. About 14-15-day-old seedling with 3-4 leaves was used in Aman transplanting and 30-day-old seedling with 3-4 leaves was used in Boro transplanting. After land preparation, the field was kept two days for soil settlement. 0.5-1.0 cm standing water was maintained during field operation.

A total of 21 field trails out of 10 trials in Aman 2011 and 11 trials in Boro 2012 were conducted in different locations to observe the field performance of the applicator. The locations were Kumarkhali, Kushtia; Sadar, Kushtia; Rajendrapur, Sadar, Netrakona; Challisha, Sadar, Netrakona; Laksam, Comilla; Purbadhala, Netrakona; Burichang, Comilla; Sadar, Rangpur; Paba, Rajshahi and Mithapukur, Rangpur.

Yield performance of rice transplanting by mechanical rice transplanter were compared with hand transplanting method. In hand transplanting plot, farmer's seedling of the same variety was used. Average yield of the machine transplanting plot and hand transplanting plot were 4.95 and 4.85 t/ha.

During evaluation, data on average speed (m/sec), field capacity (decimal/hr), fuel consumption (l/hr), number of plants per hill, number of hill per m^2, missing hill per m^2, floating hill per m^2, buried hill per m^2 and damaged hill per m^2 found 0.8, 68.3, 0.88, 3-6, 20, 1.8, 0.8, 0.5 and 1.1 respectively in Aman season whereas 0.82, 66.27, 0.92, 3-5, 20, 1.36 0.73, 0.45 and 0.82 respectively found in Boro season.

Performance evaluation of BRRI USG applicator

The experiment was conducted under the NATP funded project 'Development and Validation of USG Applicator and Rice Transplanter (DUART)' during Boro 2012. A total of 10 field trials were conducted in different locations to observe the field performance of the applicator. The locations were Kumarkhali, Kushtia; Sadar, Netrakona; Laksam, Comilla; Purbadhala, Netrakona; Burichang, Comilla; Sadar, Habiganj; Sadar, Rangpur; Paba, Rajshahi; Godagari, Rajshahi; Mithapukur, Rangpur. During performance study in different locations, the following treatments were applied:

- T_1 = USG application in the field by USG applicator
- T_2 = USG application in the field manually
- T_3 = Prilled urea application by hand broadcasting.

BRRI dhan29 and BRRI dhan28 were cultivated in all locations. To evaluate the applicator 2.7 gm size granule was applied in the field. The calculated dose of USG was about 168 kg/ha whereas recommended dose of prilled urea, 270 kg/ha for BRRI dhan29 and 250 kg/ha for BRRI dhan28, was applied. Average depth of granule placement was around 7 cm.

Yield variation was not observed in USG application by hand and applicator in studied ten locations. During field operation, field capacity was found 0.15 ha/hr whereas manual USG application capacity was found 0.019 ha/hr. In some locations, USG applying by applicator produced higher yield than hand application or vis-à-vis. But USG produced around 0.6 t/ha more yield than prilled urea. It might be due to the USG produced higher effective tiller/m^2 as well as higher grains/m^2 that resulted in higher yield.

Effect of tillage and residue retention on soil physical and chemical properties in Rice-Maize cropping system

This experiment was conducted in the BRRI RS farm, Rajshahi during 2009 to 2012 in Rice-Maize cropping systems. The experiment was laid out in a strip plot design with different tillage options as main plot and crop residue retention as subplot with three replications. The sequence of treatment imposition is given below-

For rice

A. Tillage options

Puddled

CT=Conventional tillage

SPWT=Single pass wet tillage

Unpuddled

BP=Bed formed by versatile multi planter (VMP)

ST= Strip tillage by VMP

B. Residue incorporation

C_1 = 100% crop residue retention

C_2 = 50% crop residue retention

C_3 = 0% crop residue retention

For maize

A. Tillage options

CT = Conventional tillage

ZT = Zero tillage by VMP

BP = Bed formed by VMP

ST = Strip tillage by VMP

Bulk density (After rice harvest). Tillage conditions showed significant effect on bulk density after second rice crop at 0-7.5 cm layer only. The non-significant effect of tillage methods on soil bulk density may be attributed to low soil organic matter. Soil bulk density increased with increasing depth for all tillage systems in maize cultivation. Residue management had not statistical significant effect on soil bulk density. Irrespective of tillage and residue management, bulk density at the 0-7.5 cm depth was lower than that of 7.5-15 cm depth.

Soil penetration resistance. Tillage practices demonstrated insignificant effect on penetration resistance (PR) in all the three rice seasons up to 15 cm depth except 5, 7.5, 12.5 cm depth after second rice crop and 5, 7.5 and 10 cm depth after third rice crop. In three years study, tillage and residue retention showed insignificant effect on bulk density and penetration resistance in Rice-Maize cropping systems.

Energy consumptions in Rice-Maize cropping systems under conservation tillage. The inputs used in different stages of crop production and outputs obtained in terms of yield were used for calculating energy of the systems. All the inputs in the form of the labour, diesel, seed, chemical fertilizer, plant protection (insecticides /pesticides/ herbicides) used in all different operations were taken into consideration with the use of energy conversion factor. The different field operations performed for completion of each activity in the experiment was measured in terms of time taken for human, machinery and fuel consumption and expressed as energy input in mega joules (MJ). The farm production (grain yield) was also converted in terms of energy output (MJ) under Rice-Maize cropping systems. Energy use for the operations of (i) land preparation (ii) puddling (iii) seedling raising and transplanting (iv) sowing/planting (v) interculture/weeding (vi) irrigation (vii) crop management (viii) harvesting and threshing was calculated. Energy input was also classified on the basis of source and use as direct and indirect energy. Fuel and human labour was considered as direct energy. Direct energy was the highest in CT and the lowest in SPWT due to difference in fuel use. Fuel was the main contributor of direct energy. Seed, machinery use, fertilizing, plant protection and irrigation was considered as indirect energy. Indirect energy contributed maximum energy compared to direct energy in rice production. The largest source of indirect energy consumption was contributed from fertilizer. Seed energy was the highest in ST compared to other tillage operation due to closer spacing of seedling which required more seeds. Machinery energy was the highest in CT followed by SPWT, BP and ST.

Energy output-input relationship. In Rice-Maize cropping systems, energy output as a function of tillage treatment was highest in SPWT followed by ZT and lowest in CT. The minimum tillage (SPWT followed by ZT, BP and ST) saved 14-16% energy input compared to CT in rice-maize cropping systems. Energy use ratio was 25%, 19% and 26% in SPWT followed by ZT, BP and ST respectively compared to CT (Table 2).

RENEWABLE ENERGY

Physical and thermochemical properties of rice husk

Physical characteristics. Physical properties of rice husk such as moisture content and bulk density was evaluated in this study. The moisture content

Table 2. Energy output-input relationship under different tillage options in Rice-Maize cropping systems (average over three seasons).

Tillage practice	Rice-Maize cropping systems		
	Energy input, GJ ha^{-1}	Energy output, GJ ha^{-1}	Energy ratio
CT	49	408	8.3
SPWT/ZT	42	432	10.4
BP	42	416	9.9
ST	41	431	10.5

of the rice husk ranged from 8.68 (BRRI dhan46) to 9.75% (BR22) and the bulk density of the husk varied from 108 kg/m^3 (BRRI dhan46) to 116 kg/m^3 (BRRI dhan47).

Proximate analysis. Rice husk contain relatively high volatile matter, high ash and low fixed carbon. Figure 2 shows that ash content ranged from 13.69-18.76% depending on biomass type. Rice husk content volatile matter ranged from 68.11 (BRRI dhan47) to 72.22% (BRRI dhan46). The fixed carbon content in the four varieties of rice husk samples remains in the range 11.29 to 16.10%.

Thermochemical characteristics

Higher heating values. The higher heat value (expressed in MJ/kg) of biomass samples, which is the maximum amount of energy that could be potentially recovered on complete combustion was determined under adiabatic conditions. Figure 3 presents the results.

The higher heating value of rice husk determined in this study ranged of 13.31 MJ/kg (BR22) to 14.42 MJ/kg (BRRI dhan46). The

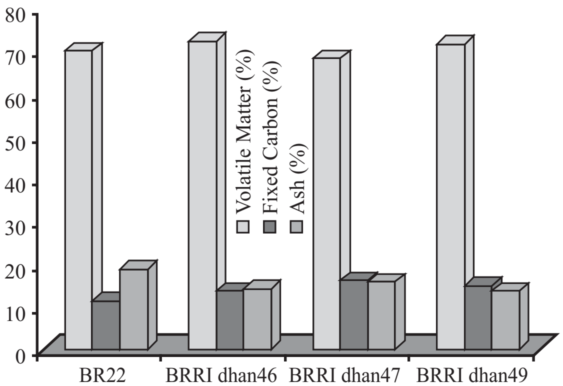


Fig. 2. Contents of volatile matter, fixed carbon and ash in the agricultural residues.

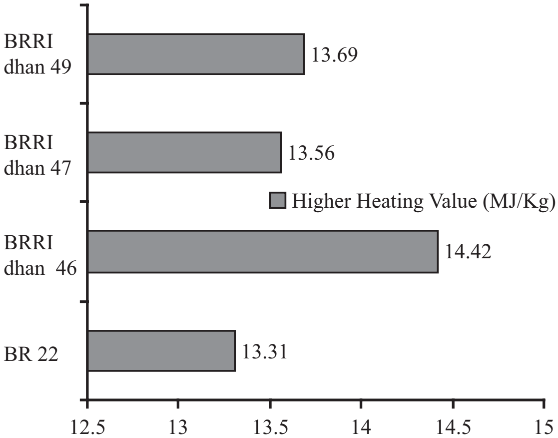


Fig. 3. Higher heating values of selected rice husk sample.

highest calorific values were found from BRRI dhan46 14.42 MJ/Kg followed by other studied rice husk.

Elemental analysis

Ash-forming elements such as Ca, Fe, K, Mg and P in rice husk are important to be documented for any thermo-chemical conversion process. Rice husk from studied varieties of interest display lower (less than 1%) concentration in K, Mg, P except Ca. Rice husk is a renewable source of biomass energy.

EXTENSION OF AGRICULTURAL MACHINERY

Demonstration cum training of BRRI developed machinery at farmer's field

Demonstrations cum training programmers were conducted under Farm Machinery Technology Development and Dissemination (FMTD) project. BRRI thresher (Open drum, TH7), Power tiller mounted reaper, Winnower and manual weeder were demonstrated to the farmers' field during T. Aman, Boro and Aus seasons. At each programme, altogether 20 participants mostly farmers including male and female were participants as trainee in the day long demonstration cum training programme. During Aus, Aman and Boro 2011-12 seasons, 190 demonstrations cum informal trainings were conducted in the project areas. About 3,800 participants including farmers, machine operators and Sub-Assistant Agricultural Officers (SAAO) attended the demonstration cum informal training programmes. Functions of these machines and advantages and disadvantages were displayed to the spectators by posters, display cards and leaflets. Awareness about the benefit of using machinery in farm operation was created among the farmers and other stakeholders.

Participation in the agricultural machinery fair 2011-12

BRRI machines were displayed in the Agricultural Machinery Fair 2011-12 with the cooperation of DAE, Kushtia and Gazipur, BARI and RDA, Bogra. Drum seeder, BRRI weeder, BRRI rice-wheat reaper, BRRI rice-wheat thresher (TH-7), BRRI open drum thresher, BRRI winnower, BRRI USG applicator and BRRI chula were also displayed in the fairs. Functions of these machines, advantages and disadvantages were displayed to the spectators by posters, display cards and leaflets. Awareness about the benefit of using machinery in farm operation was created among the farmers and other stakeholders. Nowadays, more farmers have been using BRRI machines including weeder, thresher and winnower. As a result, the use of agricultural machinery has been increasing day by day.

Training on operation, repair and maintenance of BRRI farm machinery

Training programmes on operation, repair and maintenance of BRRI farm machinery were conducted under FMTD project. Farmers and farm machinery operators of the project areas participated in the training programmes. The trainings were arranged with the help of DAE personnel at Upzila Agriculture Offices. In each of the two-day long training programmes, altogether 20 participants mostly farm machinery operators were participants as trainee. In practical session, participants operated different agricultural machinery including closed drum thresher (TH7), open drum thresher, reaper and winnower. Eighteen farm machinery operators including farmers and two Sub-Assistant Agriculture Officers (SAAO) participated in the training programme. A total of 69 training programmes were conducted during Aman and Boro seasons 2011-12 in different location within the project areas. Altogether 1,380 participants mostly farm machinery operators attended in the programmes as trainee. This type of training was found useful for the operators.

Training on seedling raising techniques and operation and maintenance of rice transplanter and USG Applicator

Training programmes were conducted under NATP funded project titled as 'Development and Validation of USG Applicator and Rice Transplanter (DUART)' within the project locations. Farmers and farm machinery operators of the project areas were the participants. The trainings were arranged with the help of DAE personnel. In each of the day-long training programmes, altogether 20 participants mostly farm machinery operators were participants as trainee. Training programmes were consist of both the orientation lecture and the hand on practical session. They also prepared seedling tray for rice transplanter. Arrangement was made to demonstrate the operation of BRRI developed USG applicator among the farmers. Proper operation of machinery, safety measures, and assessment of repair and maintenance of these machines were also included in the practical session. Nine training programmes were conducted during Aman and Boro seasons 2011-12 in different locations within the project areas. Altogether 180 participants were trained under these training programmes.

Workshop Machinery and Maintenance Division

SUMMARY

The imported self-propelled reaper and existing BRRI developed self-propelled reaper were tested in BRRI RS, Rajshahi in Boro 2011-12 and T. Aman 2010-11 seasons. During the field operation of the reaper with 1.2 m head, average field capacity of imported reaper were found 0.236 ha/hr (58.29 decimal/hr) and 0.232 ha/hr (57.24 decimal/hr) in Boro 2011-12 and T. Aman 2010-11 seasons respectively. On the other hand, average field capacity of the existing BRRI developed self-propelled reaper with the same head in Boro 2011-12 and T. Aman 2010-11 seasons were found 0.278 ha/hr (68.66 decimal/hr) and 0.267 ha/hr (65.84 decimal/hr) respectively. The average fuel consumption of imported reaper and BRRI developed reaper were 0.827 l/hr and 0.765 l/hr respectively. The purchase price of imported reaper is almost double of BRRI self-propelled reaper. According to the analysis it is clear that the overall performance of the BRRI developed reaper was better than that of the imported reaper. All the information regarding repair and maintenance are still recorded manually. It is really a burdensome work when some queries have to be faced. Therefore, last year, using access built-in features and wizard, a simple data base programme (version: 01) was developed . But it had some limitations. To overcome these limitations 2nd version of database programme has been developed.

DEVELOPMENT OF AGRICULTURAL MACHINERY

Design, development, modification and introduction of self-propelled reaper and mini-power tiller

The complete design of self-propelled reaper has been done with the help of AutoCAD tools (Fig. 1). In this machine for easy power transmission, a gearbox with mechanism of two forward and a backward speed have been introduced. Fabrication of the reaper has been going on in full suing at BRRI Research Workshop by the direct supervision of the principal investigator (PI) and co-principal investigators. On the other hand, using the AutoCAD tool, the design of a mini-power tiller has been completed, which will be operated by the same power unit of the reaper. Simultaneously, fabrication of mini power tiller is also going on at BRRI research workshop. The following series of fabrication work have been carried out step by step to fulfil the objectives of the proposed research project.

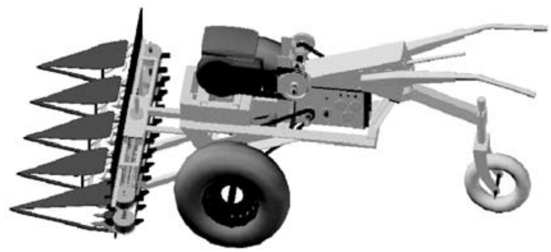


Fig. 1. AutoCAD drawing of complete BRRI self-propelled reaper.

Design of the self-propelled reaper

The self-propelled reaper consists of two major components:

- Power transmitting unit (Fig. 2) and
- Windrower type reaping unit (Fig. 3).

Power transmitting unit

The power transmission unit of self-propelled reaper consists of different components, such as:

- Chassis of the power unit.
- Power transmission system
- Prime mover
- Control accessories etc.

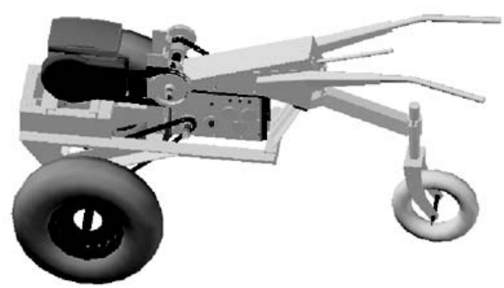


Fig. 2 Power unit of self-propelled reaper.

Windrower type reaping unit

This system consists of :

- Crop conveying and supporting unit
- Crop cutting unit
- Crop dividing and lifting unit

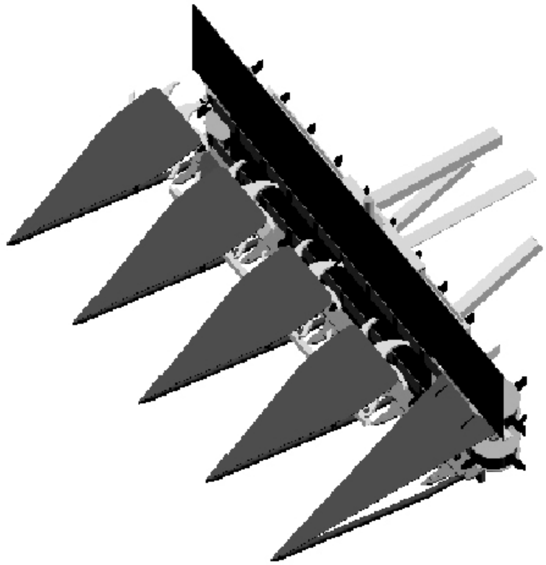


Fig. 3. Windrower type reaping unit of self-propelled reaper.

Chassis of self-propelled reaper unit

The chassis of the self-propelled reaper unit consists of the following items:

Rectangular shape mainframe

The main frame is made of 6.0 mm thickness 38.1 × 38.1 mm m/s angle bar. It is vertically placed up to 50 cm from top and then it is bent 15° from vertical towards forward up to 25 cm. The main power transmission shaft is placed 5 cm apart from the upper end of the frame. Two ball bearings along with casings are used for connecting the shaft to the main frame. The gearbox along with the shaft is placed 26 cm below the main power transmission shaft by the ball bearings with casings. Figure 4 shows the details.

Rectangular shape engine base frame

The engine base frame is made of 5 mm thickness m/s angle bar (Fig. 5). It is fitted horizontally to the ground and perpendicular joined to the main frame at a point 46 cm from its top by electric arc welding.

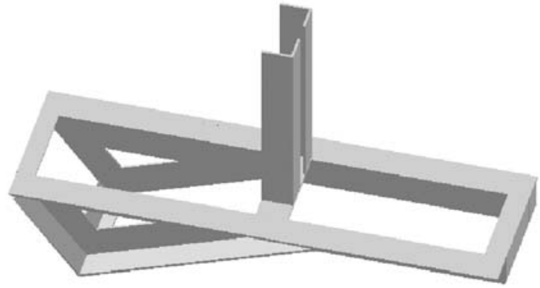


Fig. 4. Mainframe of self-propelled reaper.

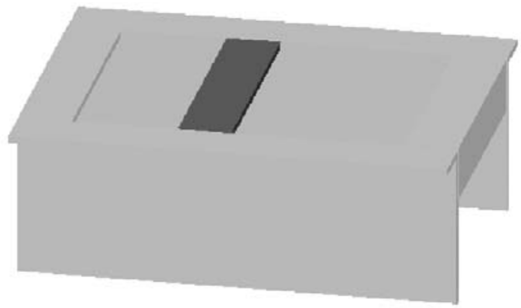


Fig. 5. Engine base frame of self-propelled reaper.

Gearbox along with shaft and a large sprocket

The gearbox is a power-transmitting unit. It should be simple in construction with forward and backward speed and a neutral gear position. The gearbox used in this project is therefore, very simple but the design is unique in its functions (Fig. 6). In this gearbox, for neutral gear position and forward speed of the reaper, gears are moving along with shaft without carrying any load. The gearing action is only activated when the reaper needs to move backward. The gearbox consists of different parts as listed below:

Gearbox casing

Casing is a primary part of a gearbox. It mainly works as a cover and main support of the pinions and shafts of the gearbox. In this study, a casing of a gearbox has been designed with the 6.0 mm thickness m/s plane sheet. The size of the

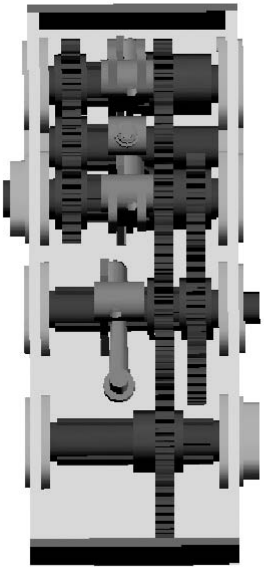


Fig. 6. Gearbox of self-propelled reaper.

gearbox casing is 160×160 mm and 128 mm height (Fig. 7).

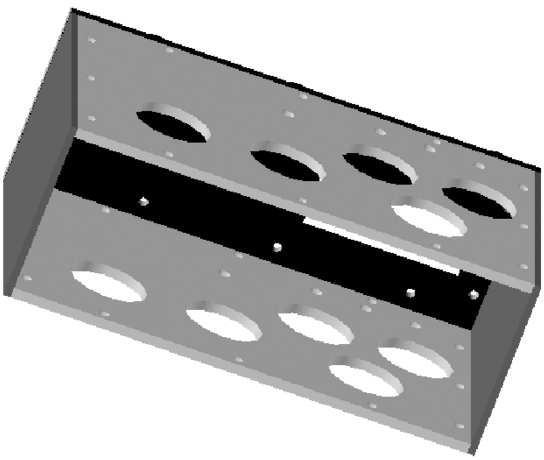


Fig. 7. Gearbox casing of self-propelled reaper.

Gear shaft with key

As the term usually used, a shaft is a rotating member transmitting power. Shafts are used in all kinds of machinery and mechanical equipments. In this study, material selected for making shafts is medium carbon m/s rods. The diameter of the shafts depends on the total load carried by the shafts with different load carrying elements such as pulleys and gears etc. In the gearbox, two shafts of minimum diameter 20 mm and the other one of diameter 14.2 mm have been chosen. Figure 8 shows the drawing of the gearbox shaft.

Fig. 8. Gearbox shaft of self-propelled reaper.

Gear pinion

The spur gears are toothed wheels whose tooth elements are straight and parallel to the shaft axis. They transmit motion and power between parallel shafts. Five spur gears are used for transmitting power through a pair of sprocket and a roller chain from main power shaft, which convey power from engine through v-belt and pulley (Fig. 9).

Fig. 9. Gear and pinion of self-propelled reaper.

Ball bearing and journal bearing

Three shafts are mounted to the sidewall of the gearbox by three pairs of ball bearing. Also, use a pair of journal bearing of two mm film width to the gears so that they move around the shaft independently. Figure 10 shows the bearing of self-propelled reaper.

Positive clutch slider

Two common forms of clutches are the square–jaw clutch and the spiral-jaw clutch (Fig. 11). One of the members must always slide axially on feather

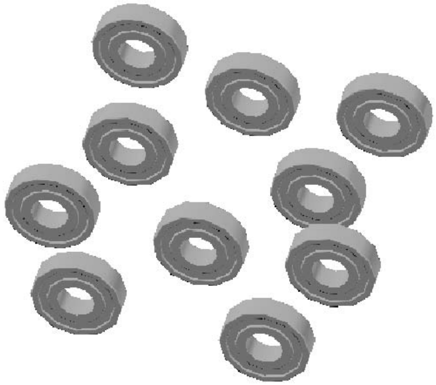


Fig. 10. Bearings of self-propelled reaper.

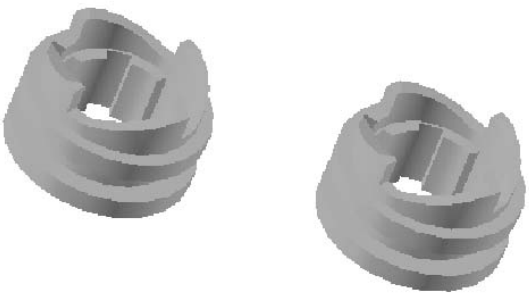


Fig. 11. Positive clutch slider of self-propelled reaper.

keys or spines to engage and disengage the clutch. The square-jaw clutch is the simplest form and can theoretically transmit torque in either direction without introducing a component of force. The spiral-jaw clutch can be engaged at somewhat higher speeds without serious clashing, but it can transmit torque in only one direction without requiring an external axial force to maintain the engagement. Straight spines are also widely used to give positive engagement with no tendency to develop an axial force.

Two driving wheels with axle

A 32.0 mm diameter m/s shaft is used for driving wheel axle (Fig. 12). Two ball bearings with pillow type casing are used to fit the wheel axle to the inclined trusses. A 20.5 cm diameter sprocket is used in this axle to transmit power from the gearbox by a roller chain.

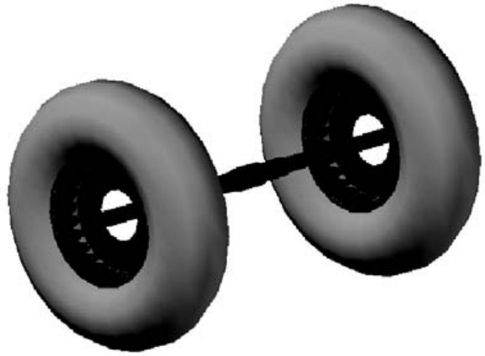


Fig. 12. Two driving wheels of self-propelled reaper.

Two driving handles

The driving handles are made of 20 mm diameter m/s pipe. It is fitted to the upper end of the main frame by electric arc welding. Two 15.5 mm diameter m/s rods are used to connect the other ends of the engine base frame to driving handles by electric arc welding. Another 12.5 mm diameter m/s rod is used to connect two handles by electric arc welding (Fig. 13).

Fig. 13. Two driving handles with tail wheel.

Gear shifting lever along with accessories

Clutches are used to connect or disconnect shafts at will. The principal types are positive, friction, hydraulic, and electromagnetic clutches. In this study, the positive spiral jaw clutches have been used (Fig. 14).

Fig. 14. Gear shifting lever with accessories.

Main power transmission shaft with two pulleys and a small sprocket

Continuous mechanical power is usually transmitted along and between rotating shafts. The transfer between shafts is accomplished by gears, belts, chains or other similar means for matching the torque/speed characteristics of the interconnected shafts (Fig. 15). Shafts are supported in two bearings (sliding or rolling) which allow the shafts to turn freely - there is no appreciable torque exerted by the bearings. A sliding bearing needs a lubricant film in the clearance space between shaft and bearing bush. In the fully hydrodynamic bearing illustrating the oil is dragged into the wedge-shaped gap causing a pressure build-up (similar to that in hydroplaning) which supports the shaft without metal-to-metal contact and little friction.

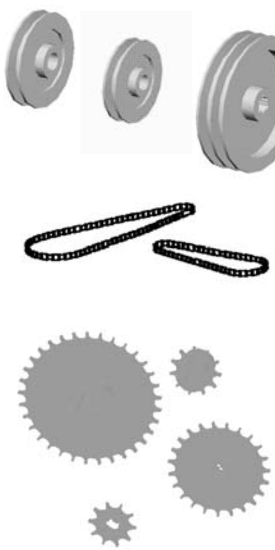


Fig. 15. Pulleys, chain and sprocket of self-propelled reaper.

Power transmission system of self-propelled reaper

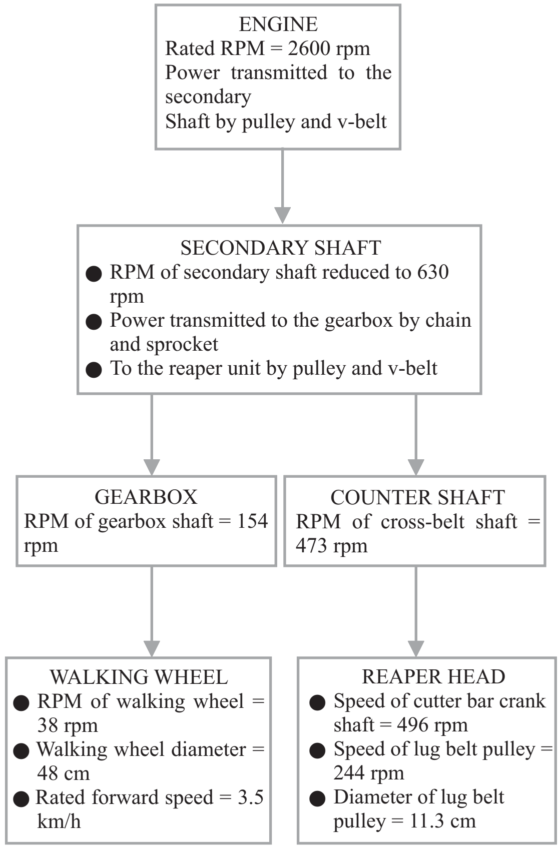


Fig. 16. Schematic diagram of power transmission system of self-propelled reaper.

Windrower type reaping unit

Crop supporting unit. The limitation of working length of cutter bar was kept at 120 cm. The length of conveyer belt is 266 cm passing over 11.4 cm diameter pullies, which conveyed the cut crop to one end of the machine with the help of star wheels. Figure 17 shows the crop supporting unit.

Crop cutting unit

A standard reciprocating type cutter bar of 120 cm length was selected with a stroke of 76.2 mm length. The cutter bar consists of a single action cutter bar, which has 16 knifes triangular in shape located in above fixed one has the same number of guards. Figure 18 shows the crop cutting unit of self-propelled reaper.

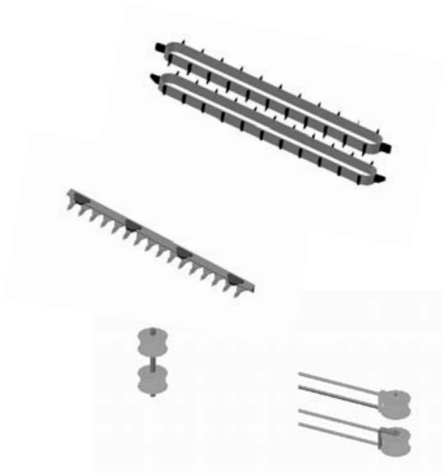


Fig. 17. Cutter bar, conveyer belt and pulley of self-propelled reaper.

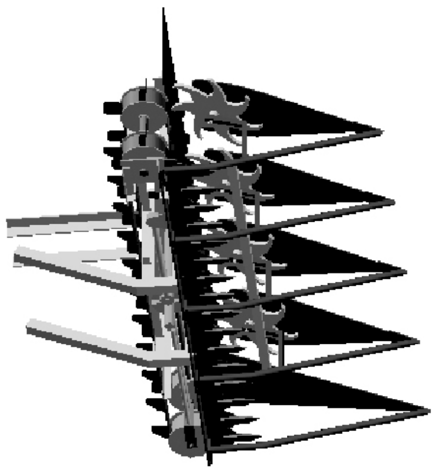


Fig. 18. Crop cutting unit of self-propelled reaper (Back view).

The cutter bar shaft is driven by the crank mechanism directly from the secondary shaft of the chassis through v-belt and pulley. The recommended speed ratio of average cutter bar speed to the forward speed of the machine is 1.3 to 1.4 at a forward speed of 3.5 km/h (0.972 m/s).

Crop dividing unit

The crop dividing unit is to divide the crop and to guide the crop towards the cutter bar. The machine consists of five such units (Fig. 19). Each unit is 51.10 cm long spaced at 22 cm apart. At the upper end of each unit plastic star wheels are mounted, which convey the cut crop to one end of the machine.

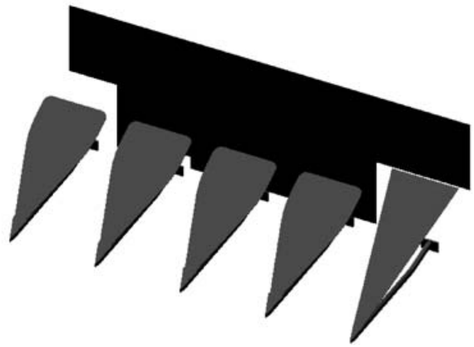


Fig. 19. Crop dividing unit of self-propelled.

Analysis of the information/data

In the last Boro 2011-12 and T. Aman seasons 2010-11, BR11 were harvested in BRRI RS, Rajshahi to test the overall performance of the imported self-propelled reaper and BRRI developed self-propelled reaper under DDMISRMT project. The PI and CI of the project, scientists, scientific assistant, farm manager, labourers and others of BRRI RS, Rajshahi were present during the field trial of the existing BRRI self-propelled reaper and imported self propelled reaper (Fig. 20). The following factors were considered to evaluate the performance of both the reapers.

Factor to be considered

- Crop cutting area and cutting time
- Walking speed
- Purchase price
- Fuel consumption
- Field capacity

Crop cutting area and cutting time

A total area of 53.43 decimal and 52.24 decimal paddy field were harvested in 55.0 minutes in 2011-12 and 2010-11 seasons respectively by the imported self-propelled reaper (Table 1). On the other hand, 62.92 decimal and 60.35 decimal paddy fields were harvested in 55.0 minutes in 2011-12 Boro and 2010-11 T. Aman seasons respectively by the existing BRRI developed self-

Fig. 20. Imported reaper was field tested at BRRI RS, Rajshahi.

propelled reaper (Table 1). On the basis of the above discussion, the cutting speed and cutting area of the BRRI developed self-propelled reaper is higher than that of imported reaper.

Walking speed

During the field operation of the reaper with 1.2 m head walking speed of imported reaper and BRRI developed self-propelled reaper were found 2.33 km/hr and 3.78 km/hr respectively (Table 1). Here, the working speed of BRRI reaper is higher than the imported reaper. But this higher speed is not a problem to operate the reaper during field operation for an operator. Although the walking speed of imported reaper is low, it creates a problem for operators due to the lower magnitude of its handle from the ground level. So, the operator is to bend his body during harvesting paddy by the imported reaper. The operator is also to give the extra downward pressure on the handle during harvesting paddy due to imbalanced weight of the reaper. Those are the major problems of the imported reaper, which may create a serious health hazard in the long run. On the other hand, BRRI reaper has no such kinds of problem due to balanced weight. As a result, the operator can cut paddy easily and continuously without health hazard.

Fuel consumption

Before starting the harvesting operation in the test plot, the fuel tank of the reaper was filled up to its top. The quantity of fuel required to fill the tank fully after harvesting the plot was measured to determine the quantity of fuel consumed for reaping the test plot. Fuel consumption of imported reaper and BRRI developed self-propelled reaper were 0.834 l/hr and 0.771 l/hr in 2011-12 Boro season and 0.820 l/hr and 0.760 l/hr in 2011 T. Aman seasons respectively (Table 1). In this year fuel consumption is slightly higher than that of the previous year.

Field capacity

The average field capacity of imported reaper were found 0.236 ha/hr (58.29 decimal/hr) and 0.232 ha/hr (52.47 decimal/hr) in 2011-12 Boro and 2010-11 T. Aman seasons respectively (Table 1). On the other hand, average field capacity of BRRI developed self-propelled reaper were 0.0.278 ha/hr (68.66 decimal/hr) and 0.267 ha/hr (65.84 decimal/hr) in 2011-12 Boro and 2010-11 T. Aman

Table 1. Comparison between BRRI developed reaper and imported reaper.

Item	Imported reaper		BRRI developed reaper	
	2011-12 season	2010-11 season	2011-12 season	2010-11 season
Total operation time (min)	55.0	55.0	55.0	55.0
Effective width of cut (m)	1.2	1.2	1.2	1.2
Walking speed (km/hr)	2.33	2.33	3.78	3.78
Fuel consumption (l/hr)	0.834	0.820	0.771	0.760
Purchase price (taka)	1,40,000	1,40,000	70,000	70,000
Area covered (m^2)	2163 (53.43 deci)	2123.3 (52.24 deci)	2547 (62.92 deci)	2443.5 (60.35 deci)
Field capacity (ha/hr)	0.236 (58.29 deci/hr)	0.232 (57.24 deci/hr)	0.278 (68.66 deci/hr)	0.267 (65.84 deci/hr)

seasons respectively (Table 1). Besides the average field capacities of imported reaper and BRRI reaper were 62 decimal/hr and 95 decimal/hr respectively when turning time was not considered.

DATA BASE DEVELOPMENT

Workshop Machinery and Maintenance Division of BRRI consists of two workshops. One is research workshop and another is auto workshop. Research workshop is used only for research works and the auto workshop is used for repair and maintenance of all the vehicles as well as agricultural machinery of BRRI. A lot of money is spent for these purposes. But all the information regarding repair and maintenance are still recorded manually. It is really a burdensome work when some queries have to be faced. Therefore, last year, using access built-in features and wizard, a simple data base programme (version: 01) was developed . But it had some limitations. To overcome these limitations 2nd version of database programme has been developed. With this database programme we can do the following:

- Record information on related to automobiles and farm machinery;
- Preserve information regarding works done everyday ie, repair, charge of spare parts under major and minor repair and maintenance work;
- Note down detailed expenditure of the yearly maintenance work;
- Prepare maintenance related query reports within a very short time;
- Presentation report with different suitable chart/graph.

Adaptive Research Division

SUMMARY

In ALART 2011, OM1490 was found suitable for proposed variety trial (PVT) in both T. Aus and B. Aus. Among the genotypes for ALART (PQR and RLR) in T. Aman 2011, BR7465-1-4-1 and BR7875-*5 (NIL)-52-HRI as PQR and BR7465-1-2-4 as RLR were considered for PVT. As PQR in Boro 2012, BR7358-5-3-2-1 and BR7358-30-3-1 from tested genotypes were considered for PVT, if disease reaction of those lines is accepted by the pathologist. Micronutrient dense BR7840-54-1-2-5 was also considered for PVT in Boro 2012.

During Aus and Aman 2011 and Boro 2012, SPDPs were conducted by using different BRRI technologies at different locations of Bangladesh under different programmes like SRRPP, BRRI core, AFACI, climate change etc. Under these programmes, 468 demonstrations were conducted from which about 265 tons of quality seeds were produced and 80 tons seeds were retained by the farmers for next year cultivation.

Under the Minimizing Rice Yield Gap Project (BRRI part), research activities were carried out in 75 upazilas under 25 districts of Bangladesh. In Aman 2011, it was seen that on average 26.44% yield was increased by BRRI recommended practice and in Boro 2012, yield increase was 18.24% over traditional farmers' practice.

On-farm farmers' participatory adaptive research trials were conducted under yield gap minimization in rice using integrated crop and resource management (ICRM) practices in nine upazilas of five districts during T. Aman 2011 and Boro 2012. It was found that yield increased in ICRM practices was 0.8-1.2 t/ha over farmers' practice during Aman season and 0.9-1.7 t/ha during Boro season.

During the reporting period, the Adaptive Research Division (ARD) conducted 153 farmers' training at differnt locations of the country in which 5,355 trainees (4,590 farmers and 765 SAAOs of DAE) participated. ARD conducted 54 field days at different locations of the country. A total of about 10,397 persons participated in those occasions.

A total of 5785 kg quality seeds of the current rice varieties were produced at BRRI HQ farm, Gazipur for adaptive trials in different locations of the country in Aus, Aman and Boro seasons.

TECHNOLOGY VALIDATION

Advanced line adaptive research trial (ALART), T. Aus 2011

One advanced line OM1490 along with BR26 and BRRI dhan48 as checks were tested in Barisal (Bakerganj), Khulna (Dumuria), Gazipur (Sreepur), Tangail (Sadar), Chittagong (Hathazari), Chapainawabganj (Sadar), Comilla (Chandina) and Kushtia (Sadar) during T. Aus 2011. The tested genotype produced good yield ranging from 3.8 to 5.2 t/ha in different locations except Khulna due to some management problems at that location (Table 1). On average, OM1490 produced yield (4.1 t/ha) higher than the check variety BR26 (3.9 t/ha) but lower than another check variety BRRI dhan48 (4.8 t/ha). On the other hand, the average growth duration of OM1490 and BRRI dhan48 were 102 and 107 days respectively. That means OM1490 is five days earlier than the check variety BRRI dhan48, although the yield of OM1490 is slightly lower than that of BRRI dhan48. So, if we want short duration variety with reasonabely good yield in Aus season, OM1490 may be a suitable one. The 1000-grain weight of OM1490 was 22.75g which was the lowest among the tested entries. The tested line including check varieties were lodging tolerant. Based on shorter growth duration, grain yield and farmers' opinion, OM1490 may be considered for PVT.

Advanced line adaptive research trial (ALART), B. Aus 2011

Three advanced lines- OM1490, BR7383-2B-23, BR7385-2B-13 along with a standard check BRRI dhan43 and a local check were tested at Gazipur (BRRI farm and Kapasia), Zhinaidah (Sadar), Faridpur (Sadar) and Kushtia (Sadar) during B. Aus, 2011. But unfortunately, the trials at Zhinaidah and Faridpur were damaged due to some local unfavourable situation. Although the genotype OM1490 produced slightly higher yield than the other genotypes including standard check but this variation (0.1-0.3 t/ha) was insignificant (Table 2).

Table 1. Grain yield (t/ha), growth duration, 1000-grain weight and plant height of some advanced lines under ALART in T. Aus 2011.

Entry	Grain yield (t/ha)									Growth duration (day)	1000-grain wt (g)	Plant ht (cm)
	Chapainawabganj	Chittagong	Tangail	Sripur	Comilla	Khulna	Kushtia	Barisal	Mean	Mean	Mean	Mean
OM1490	4.3	4.5	4.0	3.8	4.3	2.5	5.2	4.5	4.1	102	22.75	94
BR26 (ck)	3.5	3.9	3.9	3.9	4.2	3.0	4.9	3.9	3.9	111	23.20	110
BRRI dhan48 (ck)	4.6	4.5	5.2	4.8	5.6	3.6	5.4	4.6	4.8	107	23.37	103
LSD (0.05)				0.38					0.13	0.10	0.23	1.33

Table 2. Grain yield (t/ha), growth duration, 1000-grain weight and plant height of some advanced lines under ALART during B. Aus 2011.

Entry	Grain yield (t/ha)				Growth duration (day)	1000-grain wt (g)	Plant ht (cm)
	Gazipur	Kapasia	Kushtia	Mean	Mean	Mean	Mean
OM1490	2.6	2.4	3.9	3.0	101	23.60	88
BR7383-2B-23	2.6	2.3	3.6	2.9	106	24.20	107
BR7385-2B-13	2.7	2.5	3.3	2.9	106	24.50	106
BRRI dhan43 (ck)	2.5	2.3	3.2	2.7	105	23.96	104
Local (ck)	1.4	1.4	2.5	1.8	99	22.33	123
LSD (0.05)		0.30		0.50	4.51	2.78	5.63

However, the tested genotypes and standard check produced higher yield than the local check. Among the tested entries, OM1490 matured in the shortest period (101 days) whereas other two entries matured in 106 days. That means, OM1490 is five days earlier with a slightly higher yield than the other two advanced lines. OM1490 is also four days earlier than the standard check variety BRRI dhan43. Although the local varieties in different locations matured in 99 days, on average, the yield of those varieties was very low (1.8 t/ha). Except BR7385-2B-13, the tested entries including standard check BRRI dhan43 were lodging tolerant. The local checks were totally (100%) lodged. Based on shorter growth duration (101 days) and reasonable yield, OM1490 may be considered for PVT in B. Aus.

Advanced line adaptive research trial (ALART), PQR, T. Aman 2011

Three advanced lines: BR7465-1-4-1, BR7875-*5 (NIL)-52-HR1 and BR7878-*5 (NIL)-72-HR6 along with BRRI dhan37 and BRRI dhan38 as checks were tested in West byde, BRRI HQ Gazipur, Satkhira (Kaliganj), Gazipur (Kapasia), Jessore (Monirampur), Mymensingh (Bhaluka), Rangpur (Pirganj), Dinajpur (Sadar), Rajshahi (Godagari), Kushtia (Sadar) and Comilla (Sadar) during T. Aman 2011. The tested lines produced significantly higher yields than the standard check varieties in almost all locations (Table 3). Ranging from 4.26 to 5.67 t/ha in different locations except Mymensingh (3.70 t/ha), the average grain yield of BR7465-1-4-1 was the highest (4.65 t/ha) among the tested genotypes including check varieties, BRRI dhan37 (3.26 t/ha) and BRRI dhan38 (3.42 t/ha). At Mymensingh, all genotypes produced comparatively poor yields (3.29-3.82 t/ha) due to some management problems. Besides, sheath blight infection and stem borer attack were also higher especially in advanced lines at Mymensingh, which was one of the reasons for lower yield of advanced lines at that location. BR7465-1-4-1 yielded the highest (5.67 t/ha) at BRRI HQ followed by 5.03 t/ha at Satkhira. The second highest yield (4.44 t/ha) was achieved by BR7875-*5 (NIL)-52-HRI. Among the tested genotypes, BR7878-*5 (NIL)-72-HR6 produced the lowest yield (3.81 t/ha), although this yield was also higher than the check varieties.

Growth durations of the genotypes were also varied among the locations due to different reasons. On average, the second highest yielder BR7875-*5 (NIL)-52-HRI matured in the lowest growth duration (130 days), which was about 15 days earlier than both the check varieties. However, the highest grain yielder BR7465-1-4-1 matured in 139 days, which is also 6-8 days earlier than the check varieties. The 1000-grain weight of first and second highest yielder lines (ranged from 18.03 to 18.22) was very similar to that of check variety BRRI dhan38. All the entries except check varieties were lodging tolerant. Based on growth duration, grain yield and farmers' opinion, two advanced lines BR7465-1-4-1 and BR7875-*5 (NIL)-52-HRI may be considered for PVT, if disease reaction of those lines is accepted by the pathologist.

Advanced line adaptive research trial (ALART), RLR, T. Aman 2011

Two advanced lines: BR7465-1-2-4 and BR7474-60-5-3 along with BR11 and Guti Swarna as checks were tested in West byde, BRRI HQ Gazipur, Satkhira (Kaliganj), Gazipur (Kapasia), Jessore (Monirampur), Mymensingh (Bhaluka), Rangpur (Pirganj), Dinajpur (Sadar), Rajshahi (Godagari), Kushtia (Sadar) and Comilla (Sadar) during T. Aman 2011.

The tested genotypes produced different grain yields in different locations. The advanced lines could not produce higher yields than the standard check varieties in almost all locations (Table 4). On average, none of the advanced lines over yielded the check varieties BR11 (5.15 t/ha) and Guti Swarna (4.94 t/ha). BR11 and Guti Swarna required longer growth duration (143-144 days) than the advanced lines (128-139 days). Although the yield performance of BR7465-1-2-4 is lower than the other entries, it matured within a shortest period of time (128 days), which is about 15 days earlier than the check varieties BR11 and Guti Swarna. However, the other advanced line BR7465-1-2-4 matured in 139 days. All the entries including check varieties were lodging tolerant. Based on growth duration, grain yield and farmers' opinion, BR7465-1-2-4 may be considered for

Table 3. Grain yield (t/ha), growth duration, 1000-grain weight and plant height of some advanced lines under ALART (PQR) in T. Aman 2011.

Entry	Grain yield (t/ha)											Growth duration (day)	1000-grain wt (g)	Plant ht (cm)
	Mymensingh	Rangpur	Dinajpur	Rajshahi	Kushtia	Comilla	Gazipur BRRI HQ	Sathkhira	Kapasia	Jessor	Mean	Mean	Mean	Mean
BR7465-1-4-1	3.70	4.26	4.63	4.77	4.8	4.76	5.67	5.03	4.30	4.60	4.65	139	18.22	109
BR7875-*5 (NIL)-52-HR1	3.51	3.61	4.83	4.70	4.70	4.70	4.57	3.93	5.13	4.73	4.44	130	18.03	113
BR7878-5* (NIL)-72-HR6	3.82	3.69	2.97	3.20	3.20	3.2	4.22	4.00	5.33	4.50	3.81	133	16.82	113
BRRI dhan37 (ck)	3.29	3.26	3.30	3.07	3.06	3.07	3.17	3.08	3.17	4.23	3.26	147	17.39	125
BRRI dhan38 (ck)	3.41	3.51	3.70	3.50	3.50	3.50	3.16	2.87	3.16	3.90	3.42	145	18.77	123
LSD (0.05)					0.60						0.18	0.17	0.62	1.31

Table 4. Grain yield (t/ha), growth duration, 1000-grain weight and plant height of some advanced lines under ALART (RLR) in T. Aman 2011.

Entry	Grain yield (t/ha)											Growth duration (day)	1000-grain wt (g)	Plant ht (cm)
	Mymensingh	Rangpur	Dinajpur	Rajshahi	Kushtia	Comilla	Gazipur BRRI HQ	Sathkhira	Jessore	Kapasia	Mean	Mean	Mean	Mean
BR7465-1-2-4	4.30	4.25	4.76	4.76	4.31	4.31	3.94	3.60	4.33	4.10	4.27	128	21.67	97
BR7474-60-5-3	4.23	4.23	5.36	5.36	4.29	4.29	4.00	3.77	4.77	5.77	4.61	139	22.88	103
BR11 (ck)	4.44	4.32	5.53	5.96	5.01	5.02	5.06	4.27	5.47	6.40	5.15	144	22.74	108
Guti Swarna (ck)	4.08	4.21	5.96	5.73	5.01	5.00	4.52	3.97	5.30	5.63	4.94	143	19.94	105
LSD (0.05)					0.49						0.15	0.00	0.35	1.09

PVT, if disease reaction of the line is accepted by the pathologist.

Advanced line adaptive research trial (ALART), PQR, Boro 2012

Three advanced lines- BR7358-5-3-2-1, BR7358-30-3-1 and BR7372-18-3-3 along with BRRI dhan50 as check were tested in West byde, BRRI HQ Gazipur, Jessore (Sadar), Rangpur (Pirganj), Comilla (Debiddar), Dinajpur (Sadar), Rajshahi (Godagari), Mymensingh (Bhaluka), Habiganj (Sadar), Faridpur (Bhanga) and Barisal (Sadar) in Boro 2012. The tested entry BR7358-5-3-2-1 produced the highest grain yield (7.77 t/ha) in Dinajpur followed by Habiganj (7.60 t/ha) and it was the lowest (5.61 t/ha) in Rangpur (Table 5). Another tested entry BR7358-30-3-1 produced the highest grain yield (7.93 t/ha) in Rajshahi and the lowest (5.35 t/ha) in Rangpur. Among the tested genotypes, the yield performance of BR7372-18-3-3 was also good, although it was lower than the other genotypes. The overall yield performance of the tested genotypes was very good in Dinajpur and Rajshshi, but it was comparatively poor in Rangpur and Faridpur. On average, the tested entry BR7358-5-3-2-1 produced the highest grain yield (6.58 t/ha), which was similar (6.53 t/ha) to that of BR7358-30-3-1. The tested entry BR7372-18-3-3 produced the lowest average yield (5.90 t/ha) among the tested entries and it was similar (6.00 t/ha) to that of the check variety BRRI dhan50. On average 0.5 t/ha more yield was obtained by the tested entries BR7358-5-3-2-1 and BR7358-30-3-1 than the check variety BRRI dhan50.

On average, the highest yielder BR7358-5-3-2-1 matured in the shortest growth duration (144 days) followed by BR7358-30-3-1and BR7372-18-3-3 which matured in 148 and 149 days respectively. The average growth duration of check variety BRRI dhan50 was 151 days. That means BR7358-5-3-2-1 and BR7358-30-3-1 were 3-7 days earlier with about half ton more yield than the check variety BRRI dhan50. Irrespective of location, the check variety BRRI dhan50 produced the lowest 1000-grain weight (19.67 g) followed by BR7358-30-3-1 (21.82 g), which was similar to that of the highest yielder BR7358-5-3-2-1 (21.86 g) and it indicates the fineness of the tested entries. All the tested entries including check were lodging tolerant. Based on growth duration, grain yield and farmers' opinion, two advanced lines BR7358-5-3-2-1 and BR7358-30-3-1 may be considered for PVT, if disease reaction of those lines is accepted by the pathologist.

Advanced line adaptive research trial (ALART), micronutrient, Boro 2012

Four micronutrient dense advanced lines- BR7976-11-11-3-1, BR7840-54-3-1, BR7840-54-2-5-1 and BR7840-54-1-2-5 along with BRRI dhan28 and BRRI dhan29 as checks were tested in West byde, BRRI HQ Gazipur, Jessore (Sadar), Rangpur (Pirganj), Comilla (Debiddar), Dinajpur (Sadar), Rajshahi (Godagari), Mymensingh (Bhaluka), Habiganj (Sadar), Faridpur (Bhanga) and Barisal (Sadar) during Boro 2012. The tested entry BR7976-11-11-3-1 produced the highest yield (7.17 t/ha) in Habiganj followed by Rajshahi (7.03 t/ha) and Mymensingh (6.70 t/ha) and it produced the lowest yield (5.09 t/ha) in Barisal (Table 6). The yield performance of other tested genotypes like BR7840-54-3-1, BR7840-54-2-5-1 and BR7840-54-1-2-5 was also good and location effect in grain yield of those genotypes was very clear. Within the location, grain yield was also differed due to the effect of different advanced lines. Among the tested genotypes, BR7840-54-1-2-5 produced the highest mean grain yield (6.42 t/ha) followed by BR7840-54-3-1 (6.32 t/ha) and BR7840-54-2-5-1 (6.31 t/ha). The yield of BR7976-11-11-3-1 was 6.13 t/ha, which was the lowest in the tested genotypes. The mean yield of all the tested genotypes was lower (6.13-6.42 t/ha) than that of the check variety BRRI dhan29 (7.04 t/ha) but it was higher or similar to that of the other check variety BRRI dhan28 (6.21 t/ha).

The mean growth duration of the tested genotypes varied from 146 to 149 days, whereas it was 144 days and 163 days for the check varieties BRRI dhan28 and BRRI dhan29 respectively. On average, the entry BR7840-54-1-2-5 produced the highest 1000-grain weight (25.67 g) followed by BR7976-11-11-3-1 (23.65 g), BR7840-54-3-1 (23.48 g) and BR7840-54-2-5-1 (20.95 g). All the entries were lodging tolerant, but the check variety BRRI dhan28 lodged about 80-100% in Faridpur

Table 5. Grain yield (t/ha), growth duration, 1000-grain weight and plant height of some advanced lines in different locations of Bangladesh under ALART (PQR) during Boro 2012.

Entry	Grain yield (t/ha)											Growth duration (day)	1000-grain wt (g)	Plant ht (cm)
	Gazipur	Jessore	Rangpur	Comilla	Dinajpur	Rajshahi	Mymensingh	Habiganj	Faridpur	Barisal	Mean	Mean	Mean	Mean
BR7358-5-3-2-1	6.58	6.89	5.61	6.09	7.77	7.40	6.32	7.60	5.86	5.71	6.58	144	21.86	95
BR7358-30-3-1	6.28	6.66	5.35	5.95	7.03	7.93	6.17	7.37	6.48	6.11	6.53	148	21.82	86
BR7372-18-3-3	5.25	5.37	4.93	5.68	6.83	6.70	5.94	6.47	5.93	5.84	5.90	149	22.04	97
BRRI dhan50 (ck)	5.93	5.90	5.68	6.16	5.70	6.33	6.15	6.03	5.98	6.17	6.00	151	19.67	83
LSD (0.05)					0.61						0.19	0.15	0.56	0.92

Table 6. Grain yield (t/ha), growth duration, 1000-grain weight and plant height of some advanced lines in different locations of Bangladesh under ALART (Micronutrient) during Boro 2012.

Entry	Grain yield (t/ha)											Growth duration (day)	1000-grain wt (g)	Plant ht (cm)
	Gazipur	Jessore	Rangpur	Comilla	Dinajpur	Rajshahi	Mymensingh	Habiganj	Faridpur	Barisal	Mean	Mean	Mean	Mean
BR7976-11-11-3-1	5.37	6.14	6.47	5.80	5.73	7.03	6.70	7.17	5.80	5.09	6.13	146	23.65	101
BR7840-54-3-1	7.35	5.82	6.27	6.16	5.67	6.73	6.70	6.90	6.07	5.51	6.32	147	23.48	105
BR7840-54-2-5-1	6.55	6.72	5.80	6.18	5.60	7.13	6.60	6.80	6.34	5.39	6.31	148	20.95	102
BR7840-54-1-2-5	6.65	6.45	5.90	6.34	5.27	6.77	6.80	7.30	6.47	6.27	6.42	149	25.67	110
BRRI dhan28 (ck)	6.45	5.99	4.91	5.25	5.80	7.73	5.77	7.27	6.53	6.45	6.21	144	22.37	106
BRRI dhan29 (ck)	7.91	6.95	6.49	6.50	6.20	7.20	6.78	7.50	7.66	7.22	7.04	163	21.32	102
LSD (0.05)					0.57						0.18	0.00	0.51	0.99

and Barisal. Based on growth duration, grain yield and farmers' opinion, micronutrient dense BR7840-54-1-2-5 may be considered for PVT.

TECHNOLOGY DISSEMINATION

Seed production and dissemination programme (SPDP)

For rapid dissemination of newly released BRRI varieties among the farmers, ARD used to conduct seed production and dissemination programme (SPDP) in every season of the year. This is an effective programme for the adoption of BRRI varieties through quality seed production. During the reported period, the SPDP has been conducted in different locations of the country in Aus, Aman and Boro seasons under different funding sources. In this programme, mainly BRRI varieties are demonstrated in farmers' field, but in Aman and Boro seasons, some other technologies like USG, LCC and AWD have been superimposed on the BRRI varieties for efficient N and water management. Therefore, the overall objectives of this programme were to disseminate newly released BRRI varieties rapidly among the farmers of the country along with USG, LCC, AWD technologies and motivate farmers for adopting these technologies.

Southern coastal regional rice cultivation and production increase programme (SRRPP)

SPDP, T. Aus 2011. During T. Aus, 2011, SPDP was conducted in 18 upazilas of seven districts under SRRPP. BRRI dhan27 and BRRI dhan48 were selected for each upazila. The growth duration of BRRI dhan27 and BRRI dhan48 varied from 110 to 120 days in different locations. The average growth duration of BRRI dhan27 and BRRI dhan48 was 116 and 112 days respectively. Grain yield of those varieties varied from 3.0-5.5 t/ha. The average grain yield of BRRI dhan27 and BRRI dhan48 were 3.70 and 4.37 t/ha respectively. Total production of BRRI dhan27 and BRRI dhan48 were 8,257 and 13,100 kg and retained seeds by the farmers were 910 and 1,050 kg respectively for further use and for distribution to other interested farmers. A total of 360 farmers were motivated to cultivate BRRI dhan27 and 650 farmers to cultivate BRRI dhan48 in the next years.

SPDP with USG, T. Aman 2011. SPDP with USG demonstrations were conducted in nine tidal coastal districts (Barisal, Patuakhali, Jhlokathi, Pirojpur, Borguna, Bhola, Khulna, Shatkhira and Bagerhat) both in saline and non-saline ecosystem during T. Aman 2011. BRRI dhan41, BRRI dhan44 and BRRI dhan49 were used as cultivar in different upazilas of Barisal, Patuakhali, Jhalokathi, Pirojpur, Borguna and Bhola districts, where BRRI dhan41, BRRI dhan46 and BRRI dhan49 were used as cultivar in different upazilas of Khulna, Shatkhira and Bagerhat districts. On average grain yield of BRRI dhan41, BRRI dhan44, BRRI dhan46 and BRRI dhan49 were 4.2, 4.4, 4.3 and 4.9 t/ha respectively. BRRI dhan44 performed well in Barisal, Patuakhali, Jhalokathi, Pirojpur, Borguna and Bhola districts. The retained seeds by the farmers of BRRI dhan41, BRRI dhan44, BRRI dhan46 and BRRI dhan49 were 4,597, 2,362, 1,825 and 7,672 kg respectively for next Aman season cultivation. A total of 2,844 farmers/people learned about these varieties and benefits of USG application through field visits, discussion and knowledge sharing. Among them 887 farmers were motivated about the technologies and showed interest to use the technologies in next year.

SPDP with LCC, T. Aman 2011. SPDP with LCC demonstrations were conducted in nine tidal coastal districts (Barisal, Patuakhali, Jhalokathi, Pirojpur, Borguna, Bhola, Khulna, Shatkhira and Bagerhat) both in saline and non-saline ecosystems during T. Aman 2011. BRRI dhan41and BRRI dhan44 were used as cultivar in different upazilas of Barisal, Patuakhali, Jhalokathi, Pirojpur, Borguna and Bhola districts, where as BRRI dhan41, BRRI dhan46 and BRRI dhan49 were used as cultivar in different upazilas of Khulna, Shatkhira and Bagerhat districts. Average grain yield of BRRI dhan41, BRRI dhan44, BRRI dhan46 and BRRI dhan49 were 4.0, 4.2, 4.1 and 4.7 t/ha respectively. BRRI dhan44 performed well in Barisal, Patuakhali, Jhalokathi, Pirojpur, Borguna and Bhola districts. The retained seeds by the farmers of BRRI dhan41, BRRI dhan44, BRRI dhan46 and BRRI dhan49 were 3,838, 2,622, 1,263, and 3,390 kg respectively for next Aman season cultivation. A total of 6,751 farmers/people gained knowledge about these varieties and benefits of LCC application through field visits, discussion and knowledge sharing. Among them 2,545 farmers were motivated about the technologies and showed interest to use the technologies in next year.

SPDP with USG, Boro 2012. SPDP with USG demonstration trials were conducted in 41 upazilas of nine southern coastal districts under SRRPP. BRRI dhan45 and BRRI hybrid dhan3 were selected as varieties for each upazila. The growth duration of BRRI dhan45 varied from 141-1148 days in different locations. The average growth duration of BRRI dhan45 was 146 days. Grain yield of that variety varied from 5.4-6.0 t/ha. The average production of BRRI dhan45 was 5.7 t/ha. Total production of BRRI dhan45 was 31,580 kg and retained seeds by the farmers was 8,910 kg for further use and for distribution to other interested farmers. A total of 2,815 farmers learned about BRRI dhan45 and USG. The motivated farmers were 1,644. The average growth duration of BRRI hybrid dhan3 was 146 days and average grain yield was 7.63 t/ha. A total of 3,075 farmers learned about BRRI hybrid dhan3 of which 1385 farmers motivated to cultivate this variety in the next year.

SPDP with LCC, Boro 2012. SPDP with LCC was conducted in 41 upazilas of nine districts under SRRPP. BRRI dhan28 or BRRI dhan47 as inbreed and BRRI hybrid dhan3 were selected for each upazila. BRRI dhan28 produced average grain yields 5.5 t/ha by using LCC with average growth duration of 142 days. BRRI dhan47 produced average grain yield 5.3 t/ha with average growth duration 153 days. Farmers were very much interested about LCC as a urea saving device. The use of LCC could reduce rice production cost to some extent and save the environment by reducing the use of N fertilizers. Total production of BRRI dhan28 and BRRI dhan47 were 19,335 and 10,885 kg respectively. Retained seeds by the farmers of BRRI dhan28 and BRRI dhan47 were 5,885 and 3,440 kg respectively for further use. The farmers who learned about BRRI dhan28 and BRRI dhan47 were 1,580 and 1,045 respectively. The motivated farmers of BRRI dhan28 and BRRI dhan47 were 950 and 470 respectively. A total of 2,610 farmers learned about BRRI hybrid dhan3 of which 1,440 farmers motivated to cultivate this variety in the next year.

SPDP with AWD, Boro 2012. SPDP with AWD was conducted in 41 upazilas of nine districts under SRRPP. BRRI dhan29 and BRRI hybrid dhan3 were selected for each upazila. The growth duration of BRRI dhan29 varied from 158-164 days in different locations. The average growth duration of BRRI dhan29 was 160 days. Grain yield of that variety varied from 6.3-7.0 t/ha. The average production of BRRI dhan29 was 6.5 t/ha. Total production of BRRI dhan29 was 35,814 kg and retained seeds by the farmers was 9,295 kg for further use and for distribution to other interested farmers. A total of 2,975 farmers gained knowledge about BRRI dhan29 and AWD. The motivated farmers were 1,225. The average growth duration of BRRI hybrid dhan3 was 147 days and average grain yield was 7.6 t/ha. A total of 3,125 farmers learned about BRRI hybrid dhan3 of which 1,375 farmers motivated to cultivate this variety in the next year.

BRRI core programme

SPDP with LCC, T. Aman 2011. A total of 10 SPDP with LCC were conducted in 10 upzilas of seven districts (Gazipur, Gaibandha, Bogra, Panchagor, Rangpur, Rajshahi and Sylhet). BRRI dhan37, BRRI dhan46 and BRRI dhan49 were used as cultivar in that up-scaling programme. A total of 565 kg quality seeds of BRRI dhan37, 1440 kg of BRRI dhan46 and 4580 kg of BRRI dhan49 were retained by the farmers for next Aman season. Thus 6.58 tons quality seeds of three BRRI varieties were retained due to execution of SPDP. The average grain yield of BRRI dhan37, BRRI dhan46 and BRRI dhan49 were 3.02 t/ha, 3.7 t/ha and 4.5 t/ha respectively and more farmers showed their interest about BRRI dhan49. A total of 195 farmers showed interest to cultivate BRRI dhan37 and 245 for BRRI dhan46 whereas 270 farmers showed interest to cultivate BRRI dhan49 in the next season. The yield advantage was associated with lodging resistance of the varieties, less disease and insect infestations because of LCC based urea application. The farmers could save urea by using LCC. The technology should therefore, be popularized further for greater national interest.

SPDP with USG, T. Aman 2011. A total of 13 SPDP with USG were conducted in 13 upzilas of 10 districts (Jamalpur, Sherpur, Norsingdi, Tangail, Faridpur, Chittagong, Cox's Bazar, Comilla, B. Baria, and Feni). BRRI dhan37, BRRI dhan46 and BRRI dhan49 were used as cultivars in that programme. Averaged over 15 locations, BRRI dhan37 yielded 3.1 t/ha, BRRI dhan46 yielded 4 t/ha and BRRI dhan49 yielded 4.6 t/ha. The demonstrated farmers retained 12.52 tons quality seeds for next year use. A total of 3,177 farmers/people learned about these varieties and benefits of USG application through field visits, discussion and knowledge sharing. Among them 1,334 farmers were motivated about the technologies and showed interest to use the technologies in next year.

SPDP with USG, Boro 2012. A total of 17 SPDP with USG were conducted in 16 upzilas of 11 districts during Boro 2012. BRRI dhan45 and BRRI dhan50 were used as variety in those Demonstrations. BRRI dhan45, BRRI dhan50 and BRRI hybrid dhan3 produced yield on average, 6.2, 5.6 and 8.2 t/ha respectively. About 14,057, 13,414 and 6,586 kg quality grains were produced and farmers retained 3,400 and 3,451 kg of BRRI dhan45 and BRRI dhan50 for next season use. A total of 581, 712 and 674 farmers were motivated and 1,363, 1,441 and 1,476 farmers learned about USG and rice varieties respectively from the demonstrations.

SPDP with LCC, Boro 2012. A total of 17 SPDP with LCC were conducted in 17 upzilas of 13 districts during Boro 2012. Averaged over 17 locations, among the plots where LCC was used BRRI dhan45 produced grain yield of 6.1 t/ha and BRRI dhan50 produced average grain yield of 5.5 t/ha. About 13,697 and 13,171 kg quality grains were produced and farmers retained respectively 3,040 and 2,625 kg seeds for next season use. A total of 495 and 631 farmers were motivated and 1,155 and 1,396 farmers learned about LCC and rice varieties respectively from the demonstrations.

Use of poultry manure as an alternate phosphorus source

During Boro 2012 eight demonstrations using poultry manure in rice cultivation were conducted in eight upazilas of five districts. BRRI dhan50 were used in those trials. The plot size was one bigha for each of poultry manure and TSP. Thirty days decomposed poultry manure was applied @ 1.5 t/ha in one bigha per variety and recommended amount of TSP @120 kg/ha was applied in another one bigha to demonstrate the benifits of using poultry manure. Other management practices were same for two plots. Data on growth duration, grain yield, farmers' opinion and interested farmers were recorded.

Growth duration of BRRI dhan50 in poultry manure applied and P applied plots were same for a particular location but some variations were found in different locations. Grain yield in poultry manure applied and P applied plots were very similar. The highest grain yield was found in Kapasia for its fertile land under single Boro rice area. Farmers observed that full dose of P fertilizer could be substituted by poultry manure application. A total of 302 farmers showed interest to apply poultry manure in their rice field in next season.

AFACI FOOD SECURITY PROJECT IN BANGLADESH

Rice production by using USG applicator and LCC in T. Aman 2011. Progressive farmers were selected in collaboration with DAE in Chandina, Comilla and Satkhira Sadar. The farmers were provided with seeds of BRRI dhan34, BRRI dhan37 and BRRI dhan49 in Chandina, Comilla, one bigha area for each variety and BR23 in Satkhira Sadar in two bighas. About 30-day-old seedlings were transplanted at Comilla while 52-day-old seedlings of BR23 were transplanted at Satkhira. Required fertilizers, signboards, insecticides, fungicides etc were supplied to the farmers. LCC was used for urea application in BRRI dhan34 and BRRI dhan37 as well as USG using applicator machine in BRRI dhan49 at Comilla. However at Satkhira only USG was applied manually (because of stagnant water and very tall seedlings). Field days were conducted for building awareness, interest among the farmers for rapid adoption and dissemination of potential technologies. Farmers' training was conducted on modern rice production technologies to update their knowledge and skill so that they can increase their rice production by using good quality seeds of promising varieties along with other production technologies.

BRRI dhan49 produced higher grain yield (4.8 t/ha) than the other varieties (BRRI dhan34 and BRRI dhan37) in Comilla. Growth duration of the varieties grown in Comilla was more or less similar (134-137 days). In Satkhira BR23 produced grain yield of 5.1 t/ha with growth duration of 144 days. Major portion of seeds produced by the farmers in the demonstrated plots were retained by themselves for next year (season) cultivation. Majority farmers at Comilla were interested to grow BRRI dhan49 for higher yield along with fine grain. Farmers at Satkhira preferred BR23 for adaptability at that situation.

Rice production by using USG applicator during Boro 2012. Progressive farmers were selected in collaboration with DAE in Daudkandi, Comilla and Satkhira Sadar. The farmers were provided with seeds of BRRI dhan55 and BRRI hybrid dhan3 in Daudkandi, Comilla, two bighas area for each variety. BRRI dhan47, BRRI dhan55, BRRI hybrid dhan3 and BINA dhan8 were supplied in Satkhira Sadar to be used in one bigha area for each of BRRI varieties and two bighas for BINA dhan8. About 35-day-old seedlings were transplanted at both the locations. Required fertilizers, signboards, insecticides, fungicides etc were supplied to the farmers. USG applicator machine was used in both the locations. Field days were conducted for building awareness, interest among the farmers for rapid adoption and dissemination of technologies. Farmers training were conducted on modern rice production technologies to update their knowledge and skill so that they can increase their rice production by using good quality seeds of promising varieties along with other production technologies.

BRRI hybrid dhan3 produced higher grain yield (8.3 t/ha) than BRRI dhan55 (7.8 t/ha) in Comilla. However in Satkhira Sadar yield performances of four varieties (BRRI dhan47, BRRI dhan55, BRRI hybrid dhan3 and BINA dhan8) were very similar (7.9-8.1 t/ha). Growth duration of BRRI dhan55 was 2-3 days longer than BRRI hybrid dhan3 (145-148 days) in both the locations. Growth duration of BRRI dhan47 and BINA dhan8 was similar (152 days). A portion of seeds produced by the farmers in the production plots were retained by themselves for next year (season) cultivation. Majority farmers at trial sites of Comilla and Satkhira were interested to grow BRRI dhan55 for very attractive yield and grain size with reasonably shorter growth duration. They also preferred BRRI hybrid dhan3 for higher yield, however they raised question about the availability of seeds of BRRI hybrid dhan3 in next season as per their needs. Farmers at Satkhira showed mixed reactions about BRRI dhan47 and BINA dhan8 as these two varieties were very similar in respect of grain size, plant height and other morphological characters. Farmers were confused to identify which one is BRRI dhan47 or BINA dhan8 if two hills from two varieties were randomly placed in front of them. However some farmers mentioned about the lesser shattering habit of BINA dhan8 compared to that of BRRI dhan47. But the general observation from scientists conducting the trials and some of the farmers' view was that the shattering habit of BRRI dhan47 and BINA dhan8 was almost similar. The yield advantage of 0.2 t/ha by BINA dhan8 than BRRI dhan47 was due to variation of the fertility level of farmers plots. Farmers used to cultivate a HYV named Jamaibabu at Satkhira. Farmers are more interested to grow BRRI dhan55 instead of Jamaibabu in the next season.

Rice-based technology development and dissemination for changing climate SPDP along with LCC, USG and poultry manure application, T. Aman 2011

One SPDP was conducted at Nockla, Sherpur for rapid dissemination of BRRI varieties. Progressive farmers and rented land were selected in collaboration with DAE. The farmers were provided with seeds of BRRI dhan49. Required fertilizers, signboards were supplied to the farmers. LCC for urea application, USG and Poulty Manure were also supplied. Field days were conducted for building awareness, interest among the farmers for rapid adoption and technology dissemination. Using USG BRRI dhan49 produced higher grain yield. Using Poulty manure BRRI dhan49 produced medium grain yield and using LCC BRRI dhan49 produced lower grain. In this area, BRRI dhan49 showed low yield potential than its yield capacity because at the beginning of this season heavy rainfall had been occurred for two to three weeks. As a result, transplanted seddlings were fully submerged in the water. In that time, seedlings of poultry manure programme were fully died as seedlings were submerged into water up to ten days. Then seedlings of poultry manure programme were retransplated.

SPDP along with LCC, USG and AWD, Boro 2012

SPDP along with LCC, USG and AWD was conducted at Nockla, Sherpur for rapid dissemination of BRRI varieties. One acre land was taken as rent and progressive farmer were selected in collaboration with DAE. The farmers were provided with seeds of BRRI dhan50 and BRRI dhan55. Required fertilizers and signboards were supplied to the farmers. LCC and USG were supplied for urea application. BRRI dhan50 was used for USG, LCC and BRRI dhan55 was used for AWD. Field days were conducted for building awareness and interest among the farmers for rapid adoption and dissemination of technologies. BRRI dhan50 produced grain yield of 2.80 and 2.85 t/ha under USG and LCC respectively having growth duration of 156 days. BRRI dhan55 produced lower yield (2.08 t/ha) under AWD condition. The varieties produced lower yields at that location due to problem of irrigation at flowering stage as the irrigation pump was out of order at that time. All seeds produced by the farmers from the rented land were retained and stored in farmer's house, which will be distributed among neighbouring farmers in the next season.

One field day was conducted during Boro 2012. Number of participants in that field day was about 200 including farmers, scientists, DAE personnel, local leaders. Another field day was conducted for Aman seed distribution. A total of 595 kg seeds were distributed among the faemers. Scientists, DAE personnel, local leaders participated in the occasion of seed distribution. Two farmers trainings were conducted in the demonstration area. In each training there were 30 farmers and five SAAOs. Farmers were trained on modern rice production technologies.

MINIMIZING RICE YIELD GAP PROJECT (BRRI PART)

Identification of location specific rice cultivation problem and maximizing rice yield through BRRI technologies in Aman 2011

Under the Minimizing Rice Yield Gap Project (BRRI part), research activities were carried out in 25 districts (Rangpur, Dinajpur, Rajshahi, Naogaon, Bogra, Pabna, Sylhet, Sunamganj, Habiganj, Gazipur, Faridpur, Gopalganj, Mymensingh, Sherpur, Netrokona, Kishoreganj, Tangail, Jessore, Jhinaidah, Barisal, Pirojpur, Patuakhali, Lakshmipur, Comilla, Chandpur) covering 75 upazilas to minimize yield gap between researcher managed and farmers practice at farmer's field level in T. Aman 2011. Progressive farmers were selected in collaboration with DAE. The farmers were provided with seeds of BR11, BRRI dhan33, BRRI dhan45, BRRI dhan49, BRRI dhan51 and BRRI dhan52. Based on the present research findings it comes to light that improved practice ie BRRI recommended practice increased 7.37 to 39% and increased 26.44% yield on average over traditional farmers practice at field condition. If BRRI recommended practices would followed, a total of twenty lac and fourteen thousand tons yield gap could be minimized in T. Aman 2011 by on going activities at 25 districts, which covers 75 upazilas. If this kind of research activities is explored throughout the country then fifty lac and fifty thousand tons extra yield may be added to our national production only in T. Aman season, which not only boost our national production but also ensure our food security in the long run.

Identification of location specific rice cultivation problem and maximizing rice yield through BRRI technologies in Boro 2012

Under the Minimizing Rice Yield Gap Project (BRRI part), research activities were carried out in 25 districts covering 75 upazilas (Rangpur, Dinajpur, Rajshahi, Naogaon, Bogra, Pabna, Sylhet, Sunamganj, Habiganj, Gazipur, Faridpur, Gopalganj, Mymensingh, Serpur, Netrokona, Kisoreganj, Tangail, Jessore, Jhinaidah, Barisal, Pirojpur, Patuakhali, Lakshmipur, Comilla, Chandpur) to minimize yield gap between researcher managed and farmers practice at farmer's field level in Boro 2012. Progressive farmers were selected in collaboration with DAE. The farmers were provided with seeds of BRRI dhan28, BRRI dhan29 and BRRI dhan47. Based on the present research findings it comes to light that improved practice ie BRRI recommended practice increased yield ranges from 7.09 to 95.0% and the average increased yield was 18.24% over traditional farmers practice at farmer's field condition. A total of 41 lac (41,00,000) tons extra rice can be produced throughout the country if this programme is implemented.

Seventy-five field days were executed in 25 districts during T. Aman 2011 and Boro 2012. About 15,000 farmers, DAE personnel and NGO representatives participated in those field days. All the farmers showed interest to apply BRRI management packages with BRRI varieties, which were used in those field trials.

Five batches (25 trainees in each) of residential training has been executed in BRRI HQ, Gazipur by the project's BRRI part. Under this programme, 75 Upazila Agriculture Officers (UAO) participated in two days residential training and 50 Agriculture Extension Officers (AEO) participated in three days residential training in July-August 2011.

Breeder/foundation seed. BRRI part has provided about 18 MT foundation seeds in T. Aman 2011, 32 MT foundation and 90 kg breeder seeds in Boro 2012 and 19 MT foundation and 200 kg breeder seeds in Aman 2012 as an important input for demonstrations implemented by DAE and BRRI research part. BRRI part has also provided technological back up in establishing the demonstration plots in the farmers' field.

Procurement and distribution of machinery. BRRI part of the project procured 13 moisture meter, 10 computer and laptop, 10 digital camera, one video camera, one photocopier, one multimedia projector, one meeting amplifier, one seed counter, one PH meter, one EC meter, one electric oven, one electric balance. These equipments were distriduted in seven regional stations of BRRI (BRRI RS- Rangpur, Rajshahi, Kushtia, Bhanga, Barisal, Comilla and Habiganj).

Printing and publication. Two thousand copies of Adhunik Dhaner Cash book have been published and distributed among the extension personnel and farmers of the project area

Yield gap minimization in rice using Integrated Crop and Resource Management (ICRM) practices (under KGF)

On-farm farmers' participatory adaptive research trials were conducted using Integrated Crop and Resource Management (ICRM) practices in nine upazilas of five districts during Aman 2011 and Boro 2012. BRRI implemented the project programme in five upazilas- Kapasia (Gazipur), Pakundia, Kotiadi (Kishoreganj), Monohordi and Polash (Norshingdi) where as Social Progress Services (SPS), an NGO at Sherpur, implemented in four upazilas- Madarganj (Jamalpur), Sadar, Nockla and Nalitabari (Sherpur). Three villages were selected in each upazila with ten farmers in each village with a land area of one bigha of each farmer. Each farmer's field was divided into two parts to assign two treatments- a) Farmers' management practice and b) ICRM practices. All resources needed for farmer's practice (FP) were managed and applied by the farmers themselves. In remaining half bigha, the ICRM practices were applied from project fund. BRRI dhan49 was used as cultivar in all trials during Aman 2011. BRRI dhan49 was not available in the farmer's fields. So that same quality seeds for FP and ICRM were supplied from project fund. But in Boro 2012, BRRI dhan28 or BRRI dhan29 was used depending on farmer's use and locality. The component technologies of ICRM package are the best available recommended rice production technologies- like quality seed, healthy seedlings, planting optimum aged seedling in proper time, balanced nutrition, improved water and pest management etc. Data on input uses, production costs, grain yield and straw yield were collected. Training on ICRM practices were arranged for the participating and associated farmers and DAE staffs. Expert scientists from BRRI provided training to the farmers on selection of varieties, quality seeds, healthy seedlings, optimum planting time, optimum aged seedlings, balanced fertilization, improved water, weed, insects and disease management, quality seed production, storage and processing. Field days were also arranged by BRRI and SPS in their respective locations to show the overall performance of on-farm adaptive research trials conducted during the reporting period.

Yield gap minimization of T. Aman 2011. In all upazilas farmers used 13-20 days overaged old seedlings than optimum aged seedlings of BRRI dhan49 during Aman 2011. The optimum seedling age of BRRI dhan49 was 30-35 days which was followed in ICRM practices where as in FP 45- to 54-day-old seedlings were used. Farmers transplanted maximum aged 54-day-old seedlings in one village of Madarganj upazila. One village of Nalitabari upazila in Sherpur district was affected by flood after 2-3 days of transplanting and experiment could not be established. Growth duration of ICRM and FP was not widely varied due to seedling age. It varied from 134 days to 145 days in different locations. Sometimes crops were 2-4 days delayed in farmer's practice due to use of overaged seedlings. In FP, only urea was applied in overdose (40-45 kg/bigha) and sometimes non-urea was also applied at insufficient dose. Weeds were not controlled properly in FP plots and insecticides were applied at low dose. Optimum aged seedlings, use of healthy seedlings, balanced fertilization, proper weeds, insects and diseases management were adopted in ICRM production package which resulted to 0.8-1.2 t/ha increased yield over FP. Supplemental irrigation was applied only in Kapasia at maximum tillering and PI stage so that higher grain yield was found both in ICRM and FP than that of other locations. Grain yield was 4.5-5.4 t/ha in ICRM and 3.6-4.3 t/ha in FP in different locations.

Crop growth and tillering were better in ICRM than FP and straw yield was also higher in ICRM plots. Farmers were impressed by the newly released variety BRRI dhan49, which was one week earlier than BR11 with a good yield. They retained seeds for themselves and distributed seeds among the neighbouring farmers for next year. A total of nearly 45 tons seeds were produced in project implemented areas from which farmers retained nearly 16 tons in T. Aman 2011.

Yield gap minimization of Boro 2012. Farmers used 10-17 days over aged seedlings than optimum aged seedlings of BRRI dhan28 in Monohordi, Kotiadi, Pakundia, Sherpur sadar and Nalitabari upazila. Similarly they used 10-18 days over aged seedlings than optimum aged seedling of BRRI dhan29 in Kapasia, Polash, Nockla and Madarganj upazila. On average, farmer used two weeks over aged seedlings of BRRI dhan28 and BRRI dhan29 in all upazilas. The ideal seed bed was prepared where irrigation was provided in ICRM practices and seedlings growth was good and optimum aged seedlings could be transplanted. On the other hand in FP ideal seed bed was not prepared and they did not apply irrigation. Seedling growth was slow and this is why transplanting was delayed.

Growth durations of ICRM and FP were very close in both BRRI dhan28 and BRRI dhan29 with few exceptions. Growth durations of ICRM practices varied from 138 days to 145 days in BRRI dhan28 and that was 158 to 162 in BRRI dhan29. In some locations crops (BRRI dhan28 and BRRI dhan29) were 7-8 days delayed in FP due to use of over aged seedlings. In FP, urea was applied in over dose (50-55 kg/bigha) and non-urea such as TSP, MP, gypsum and $ZnSO_4$ were applied in under dose. Weeds were not controlled properly in FP plots and insecticides were applied at low dose. Optimum aged seedlings, use of healthy seedlings, balanced fertilization, proper weeds, insects and diseases management were adopted in ICRM production package, which resulted 0.9-1.6 t/ha increased yield over FP in BRRI dhan28 and it was 1.2-1.7 t/ha in BRRI dhan29. Average increased yield was 1.31 and 1.48 t/ha in BRRI dhan28 and BRRI dhan29 respectively.

FARMERS' OPINION ABOUT BRRI VARIETIES AND OTHER TECHNOLOGIES

During the reported period, ARD has conducted a lot of demonstrations using different BRRI varieties with some other associated technologies in different seasons under different projects and BRRI core programme. Farmers expressed their opinions about the technologies. Farmers' opinions were collected by ARD personnel by direct interview and report (data sheet) was collected from the DAE personnel. These opinions are very important for BRRI scientists, especially for the breeders, to rectify the problems by different means.

Farmers' opinion about Aus varieties

BRRI dhan27 and BRRI dhan48. Farmers preferred both the varieties for higher yield with a shorter growth duration. In addition to that farmers prefer BRRI dhan27 especially for taller plant type as they can use the straw to feed the cattle. BRRI dhan27 is very much suitable in tidal prone area of Barisal region. In tide free areas farmers preperred BRRI dhan48 specially for its higher yield and grain size.

Farmers' opinion about Aman varieties

BRRI dhan40 and BRRI dhan41. These varieties are popular especially in coastal areas of Bangladesh. The farmers of those areas expressed their liking due to some characteristics of the varieties like salt tolerance, lodging tolerance, tall plant type, bold grain, more straw and higher market price. Some farmers also expressed their disliking for grain spots especially in BRRI dhan40.

BRRI dhan44. BRRI dhan44 is highly preferred by the farmers in non-saline tidal area of southern region of Bangladesh due to its lesser insect disease attack, tall plant type, strong culm and lodging tolerance, higher market price and coarse grain.

BRRI dhan46. Farmers preferred this photosensitive late planting variety in flood prone areas of Bangladesh because of its better yield and bold grain type. Yield is not so much hamperred due to late planting. Some farmers expressed their disliking for its shattering habit at maturity and brown spot disease.

BRRI dhan49. Most of the farmers expressed their liking for this variety due to its higher grain yield as like as BR11. Rice is palatable and grain quality is very near to Nizershail. However, false smut disease affected this variety in some areas.

Farmers' opinion about Boro varieties

BRRI dhan45. Considering growth duration and yield, BRRI dhan45 is good but irregular flowering is a big problem of this variety. Some farmers expressed their unwillingness to accept this variety because of this problem.

BRRI dhan47. This salt tolerant variety is highly preferred by the farmers in saline areas of coastal districts of Bangladesh. It is lodging tolerant and bold grain type and it has high market value. However, the variety has some shattering problem at the maturity stage.

BRRI dhan50. Farmers were impressed with the yield performance of BRRI dhan50. However they showed mixed reactions about the variety. Some farmers interested to grow it for its very long slender grains along with aroma and satisfactory yield. They opined that though BRRI dhan50 produced lower yield than that of BRRI dhan28 and BRRI dhan29, it can be sold at higher price in the market. Hence it will be profitable for them. They opined that it will be problem in milling in normal mills because it may be broken during milling due to its longer slender grain. Still most farmers were interested to the variety for higher grain yield along with aroma and very long slender attractive grains.

BRRI dhan55. Majority farmers were interested to grow BRRI dhan55 for very attractive yield and grain size with reasonably shorter growth duration. However, some farmers mentioned about uneven flowering of this variety.

BRRI hybrid dhan3. Farmers preferred BRRI hybrid dhan3 for its attractive panicle size, higher grains per panicle than other varieties and also for higher yield. However the farmers raised question about the availability of seeds of BRRI hybrid dhan3 for the next season as per their needs.

TRAINING AND PROMOTIONAL ACTIVITIES

Farmers' training

It is an important tool to train up farmers on updated modern rice cultivation technologies and to encourage them to adopt modern rice varieties and associated technologies for increasing rice yield at reduced cost of production. It is a one-day programme where 30 farmers and five SAAOs participated. It was conducted in different upzilas of Bangladesh with the collaboration of DAE. Modern rice varieties and associated technologies were discussed with the help of colorful transparencies/slides and sometimes videos using multimedia projector for the farmers' easy understanding.

During the reporting period, ARD conducted a total of 153 farmers' training at differnt locations of the country in which 5,355 trainees (4,590 farmers and 765 SAAOs of DAE) participated.

Field day/farmer's rally

These events are very useful tools for generating awareness and interests among the farmers and concerned extension agents about the modern rice production technologies. It helps to get publicity and familiarity of the institute, our technologies and BRRI's contribution towards national economy. Field days were conducted mainly in demonstration sites in collaboration with DAE and local farmers at different locations of Bangladesh. Farmers, researchers, extension service providers, GO personnel, administrative people, public leaders etc are invited in a field day. Field visit followed by discussion is carried out. ARD conducted two categories of field day. About 200-250 persons were invited in big field day and 50-100 persons were invited in small field day. ARD conducted 54 field days at different locations of the country. A total of about 10,397 persons participated in those occasions. These programmes also generated much enthusiasm about modern rice production technologies for increased production.

Seed production at BRRI farm

As a whole, during the reporting period, 5,785 kg quality seeds of the current rice varieties were produced at BRRI HQ farm, Gazipur for adaptive trials in different locations of the country in Aus, Aman and Boro seasons. During Aus 2011, a total of 650 kg seeds were produced and the major amount of seeds was used in demonstration programme conducted by ARD. Parts of seeds were distributed to other divisions for research purpose and partly to the central store. Finally the whole amount of Aus seeds was distributed. Similarly, during T. Aman 2011, a total of 2,330 kg seeds were produced and 1,850 kg were distributed for the purposes as mentioned above and the excess seeds were sent to the BRRI central store. During Boro 2012, a total of 2,805 kg seeds were produced and the whole seeds were retained for conducting research and demonstration programme for Boro 2013.

Training Division

SUMMARY

The Training Division has conducted 87 training programmes in the reporting period with a course duration from 1-day to 1-week depending on their nature and requirement. A total of 2,853 participants from different government and non-government organizations and farmers were trained through these courses. The highest number of participants was from the Department of Agricultural Extension (DAE) followed by farmers. The overall improvement of knowledge for extension personnel of 1-week rice production training (RPT) varied widely and it was 153% for AEO of DAE, 204-314% for SAAO of DAE from different region and 149% for special programme (Junior Agronomist and officers of different NGO). From 1974 to June 2012, BRRI completed 2,398 training programmes through which 67,539 participants were trained on different aspects of rice production technologies. The trainees expressed positive views about the course content and training method. Most of the BRRI's speakers' performance was very good to excellent. Training Division also organized three 3-day workshops on development and utilization of Bangladesh Rice Knowledge Bank (BRKB).

TRAINING NEED ASSESSMENT

A survey was conducted at the beginning of each batch to know the expectation of the participants about the training. A total of 2,262 responses on different issues were received from the trainees of which 668 from climate change, 628 from regular batch, 382 from Mujibnagar project, 192 from IAPP, 74 from BRRI scientists and 54 from NGO officers of the country (Table 1). They were very much interested to know details of diseases (19.58%), insect pest management (19.19%) and modern rice variety (15.38%), which were followed by fertilizer management, rice growth and crop management (Agronomy).

CAPACITY BUILDING AND TECHNOLOGY TRANSFER THROUGH TRAINING

One-week rice production training for SAAO (Regular)

The main objective of the course is to train the grass root level extension workers of DAE. The course curriculum was designed based on the priority of field problems related to rice production and rice based technologies. A total of 1064 extension providers of which 399 AEO and SAAO (15 batches) from all over Bangladesh, 334 SAAO (14 batches) from climate change project area, 191 SAAO from Mujibnagar project area (Kushtia, Meherpur, Jhinadha, Chuadanga), 96 from IAPP project area and 44 officers (2 batches) BRRI and different NGOs were present (Table 2).

Knowledge improvement was assessed based on the marks obtained in benchmark and final evaluation of individual participant. On average, improvement of the participants from regular, climate change, Mujibnagar, IAPP and Special batches was 153, 221, 223, 204 314 and 149 respectively (Table 3). Table 4 presents the performance status of 1-week rice production for different categories of participants.

Quality rice seed production, processing and storage

Five 2-day and two 3-day training programmes on seed production, processing and storage for the UAO and SAAO of DAE were conducted using the fund of 'Integrated Agricultural Productivity Project (IAPP) and National Agricultural Technology Project-DAE part. Table 5 shows the details about the training.

Rice yield gap minimization

A 2-day training course was designed to train up the upazila agriculture officers (UAO) of the DAE on rice production technologies for minimizing rice yield gap. Table 6 shows the particulars of the training.

Special training course

Boro rice production. A 3-day training on Boro rice production was organized for 20 Agronomist for IRRI coordinated NGOs. A total of 21 trainees

Table 1. Expectations by the trainees on different subjects in need during 2011-12.

Subject/issue	Expectation (%)								
	AEO (ToT)	SAAO				NGO (ToT)	SO	All	Rank
		Regular	Climate change	Mujibnagar	IAPP				
Disease	22.59	21.04	19.61	16.49	17.19	20.37	17.95	19.58	1
Insect	21.11	17.96	20.81	19.63	16.15	16.67	15.38	19.19	2
Variety	14.81	16.34	16.02	14.40	13.02	18.52	12.82	15.38	3
Rice growth	10.37	4.05	4.94	3.14	5.21	9.26	17.95	5.61	5
Fertilizer	3.70	10.52	12.72	6.02	9.38	12.96	10.26	9.55	4
Hybrid	3.70	7.28	5.84	2.88	2.60	1.85	3.85	5.04	6
Soil	4.81	3.07	3.89	4.97	5.73	3.70	1.28	4.02	8
Agronomy	4.44	2.43	6.74	8.64	9.38	1.85	3.85	5.61	5
IWM	2.59	5.02	1.80	9.16	7.29	5.56	3.85	4.64	7
Seed	1.85	3.56	2.40	3.40	4.69	5.56	2.56	3.09	9
Weed	0.74	1.29	0.75	3.66	0.00	0.00	0.00	1.28	10
Others	9.26	7.44	4.49	7.59	9.38	3.70	10.26	6.98	-
Total	100	100	100	100	100	100	100	100	
Response (no.)	270	618	668	382	192	54	78	2262	

Table 2. One week rice production training conducted by BRRI in 2011-12.

Project	Batch (no.)	Participant (no.)			Designation	Organization
		Total	Male	Female		
Regular	5	90	80	10	AEO	DAE
	10	309	280	29	SAAO	DAE
Climate change	14	339	303	31	SAAO	DAE
Mujibnagar	8	191	192	19	SAAO	DAE
IAPP	4	96	84	12	SAAO	DAE
Special	2	44	36	8	SO, of	BRRI, NGO
Total	43	1064	955	109		

Table 3. Knowledge improvement through one week rice production training during 2011-12.

Project	Batch (no.)	Evaluation (average mark %)		Improvement (%)
		Benchmark	Final	
Regular	5	31.60	79.80	153
	10	23.00	73.90	221
Climate change	14	24.11	76.38	223
Mujibnagar	8	23.60	71.90	204
IAPP	4	16.40	67.90	314
Special	2	31.50	78.50	149
Total	43	30.04	89.67	252.8

Table 4. Performance status of one week rice production trainees in 2011-12.

Project	Batch (no.)	Categories of results/certificates 9%)		
		Distinction	Satisfactory	Participatory
Regular	5	63.3	32.3	4.40
	10	43	51	9.00
Climate change	14	50.9	45.20	3.89
Mujibnagar	8	32.46	61.25	6.28
IAPP	4	21.87	61.45	16.66
Special	2	50	45.45	4.54
Total	43	43.08	49.44	7.46

Table 5. Particulars of seed production, processing and storage training during 2011-12.

Project	Batch (no.)	Participant (no.)			Designation	Organization
		Total	Male	Female		
DAE	5	132	126	6	UAO	DAE
IAPP	4	96	90	6	SAAO	DAE
Total	9	228	216	12		

Table 6. Particulars of rice yield gap minimization training, BRRI, 2011-12.

Duration	Participant (no.)			Participant
	Total	Male	Female	
23-24 Jul 11	18	17	1	UAO, AEO
25-26 Jul 11	21	20	1	UAO, AEO
27-28 Jul 11	23	23	0	UAO, AEO
Total	62	60	2	

from different NGOs were attended this course (Table 7).

BRRI developed technologies. A 3-day training on BRRI developed technologies was organized for UAO of DAE using the fund of NATP, DAE. A total of 30 trainees from different upazilas participated in this course (Table 7).

Farmers' training. Twenty-eight 1-day rice production training programmes were conducted in different regions of Bangladesh in collaboration with DAE under CRRP, climate change and IAPP projects. In total 1400 trainees were trained through this course (Table 8).

Up-dated training information of BRRI. During the reporting period, 143 training courses have been conducted by the different divisions and regional stations of BRRI, of which 87 were conducted by the Training Divisions (Table 9). Until June 2012, 2,398 training courses including 25 international ones have been conducted for 67,539 participants of different organizations (Table 10). Table 11 presents the categories of participants under long and short courses from 1974 to June 2012.

EFFECTIVENESS OF IMPARTED RICE PRODUCTION TRAINING

Performance of course works related activities

It is very important to determine the impact of different aspects of imparted rice production training for its better planning and execution in future. This study was conducted at the end of each batch to collect the relevant information. After the completion of data collection, information were compiled and analyzed. This study reveals that one week RPT course is very much helpful for the trainees to build up their capacity for modern rice production activates.

Performance of BRRI speakers

Ten batches of one week RPT were considered for this evaluation. At first, batch wise analysis was done on the basis of five criteria for each speaker. The five criteria were as follows: a. style of presentation; b. question handling; c. use of training materials; d. time management and e. quality and relevance of handout and its timely supply. Average of the five criteria was used to determine the performance of individual speaker in each batch. The overall performance of BRRI's speakers was very good.

BANGLADESH RICE KNOWLEDGE BANK (BRKB)

Development and Utilization of Bangladesh Rice Knowledge Bank (BRKB) sub-project funded by SPGR-NATP is performing under Training Division of BRRI since April 2010 for three years to digitalize the BRRI technologies. A six-member BRKB management committee headed by Director (Research), BRRI is formed in the first year for better management of BRKB, which is being remained active. The number of members of the BRKB working group was increased from 10 to 17 by co-opting the scientists from relevant disciplines for improvement and development of BRKB materials. Fifteen BRKB user groups with 20 members existing at union level in every selected pilot upazilas under 15 districts all over the country. Two 3-day training on BRKB and two workshops were organized during the reporting period (Tables 12 and 13).

Table 7. Particulars of two-day special training courses, 2011-12.

Title	Duration	Participant (no.)			Participant	Fund
		Total	M	F		
Boro rice production	13-15 Nov 11	21	20	1	Junior Agronomist, NGO	SUSFER, IRRI
BRRI developed technologies	18-20 Feb 12	30	28	2	UAO, DAE	NATP, BARC
Total		51	48	3		

Table 8. One-day rice production training courses for farmers' different project/fund during 2011-12.

Project/fund	Training (no.)	Participant (no.)		
		Total	Male	Female
CRRP	8	240	176	64
Climate change project	18	1100	1095	5
IAPP	2	60	60	0
Total	28	1400	1331	69

Table 9. Total training conducted by training division during 2011-12.

Name of the training	Training (no.)	Duration	Participant (no.)			Designation	Organization
			M	F	Total		
Rice production training (ToT)	5	1-week	80	10	90	AEO	DAE
Rice production training (Regular)	10	1-week	280	29	309	SAAO	DAE
Modern rice and quality seed production training (Climate change)	14	1-week	303	31	334	SAAO	DAE
Integrated rice production (Mujibnagar)	8	1-week	172	19	191	SAAO	DAE
Integrated rice production (IAPP)	4	1-week	84	12	96	SAAO	DAE
Rice production training (Project Scientists)	1	1-week	25	1	26	SO	BRRI
Rice production training (NGO)	1	1-week	11	7	18	Junior Agronomist	NGO
Quality rice seed production, processing and storage (IAPP)	4	3-day	90	6	96	SAAO	DAE
Boro rice production	1	3-day	20	1	21	Junior Agronomist	NGO
BRRI developed technologies	1	3-day	28	2	30	UAO	DAE
Utilization of BRKB	2	3-day	42	6	48	SAAO and Computer operator	DAE and UP
Rice yield gap minimization	3	2-day	60	2	62	UAO	DAE
Seed production, processing and storage	5	2-day	126	6	132	UAO	DAE
Farmers training	28	1-day	1331	69	1400	Farmers	
Total	87		2,652	201	2,853		

Table 10. Training conducted by BRRI from 1974 to June 2012.

Division	Name of training	Duration	Training (no.)	Participant (no.)
Training division	Rice Production Training (RPT)	1-4 months	93	2442
	RPT and others	1-3 weeks	371	9407
	RPT and others	1-5 days	437	13426
		Sub total	901	25,275
Other divisions	RPT and others	1-2 weeks	9	103
	RPT and others	1-5 days	1144	30346
		Sub total	1,153	30,449
Regional stations	RPT and others	1-3 days	344	11815
		Sub total	344	11,815
		Grand total	2,398	67,539

Other than RPT were water management, fertilizer management, seed production and preservation, hybrid rice seed production, farm machinery, IPM, BRKB etc.

Table 11. Categories of participants under long and short courses from1974 to June 2012.

Types and no. of training	Categories of participant												Total
	Scientist		DAE/other officer		BS[1]/SAAO/SA/SSA		Others[2]		NGO		Farmer		
	M	F	M	F	M	F	M	F	M	F	M	F	
Long course (93)	383	65	1729	18	112	-	98	-	36	-	-	-	2,442
Short course (2305)	1612	189	5142	311	12724	1224	1525	345	1046	84	38114	2781	65,097
Grand total													67,539

[1]BS = Block Supervisor. SSAO = Sub Assistant Agriculture Officer, SA = Scientific Assistant, [2]Others = (Teacher, Fertilizer dealer, Seed dealer, Local representative, BRRI staff). M = Male, F = Female.

Table 12. Three day training on Utilization of Bangladesh Rice Knowledge Bank.

Duration	Participant (no.)			Designation	Organization
	Total	Male	Female		
10-20 Feb 12	20	19	1	Scientist	BRRI
27-29 Mar 12	18	15	3	Computer operator	Union parisad
Total	38	34	3		

Table 13. Particulars of workshop on development and utilization of BRKB.

Duration	Participant (no.)			Participant
	Total	Male	Female	
18-20 Feb 12	20	19	1	Scientists, BRRI
27-29 Mar 12	20	19	1	Scientists, BRRI
Total	40	38	2	

BRRI RS, Barisal

SUMMARY

A total of 397 progenies and 22 fixed lines were selected from F_4 and F_5 generations from the pedigree nursery (F_4-F_6 generation) with emphasis on height, tolerance to tidal submergence, earliness, plant type, grain type and high yield potential. From long-term missing element trial, it may be concluded that BRRI RS, Barisal farm needed complete (NPKSZn) fertilization to obtain maximum yield. Omission of any one nutrient element from complete treatment decrease yield and the extend of yield decrease depends on each nutrient missing. IRBB60, IRBB65 and IRBB66 performed best against BB Apathogen in Barisal regions. About 4-5 number of irrigation could be saved by using AWD technology, which was also increased water productivity in Barisal regions.

VARIETAL DEVELOPMENT

Hybridization for the development of tidal submergence tolerant rice varieties. Three set of parents were grown at BRRI RS farm, Barisal starting from 30 June with an interval of 7 days to synchronize flowering. Thirty-day-old seedlings were transplanted using single seedling with a spacing of 25- × 15-cm in a 5.4 m × 2 rows plot. A total of 12 crosses were made in this programme with achieving objectives of taller seedling height, tidal submergence tolerance, bold grain high yield potential and earliness.

Pedigree nursery (F_4-F_6 generation). A total of 1123 progenies from F_4 (296), F_5 (561) and F_6 (266) generations were grown in BRRI RS farm, Barisal. Each progeny were in a 5.4 m single row using single seedling for transplanting at a spacing of 30- × 20-cm. A total of 397 progenies and 22 fixed lines were selected from F_4 and F_5 generations.

CROP-SOIL-WATER MANAGEMENT

Long-term missing element trial. The experiment was initiated on a permanent layout at the BRRI RS farm, Barisal in 2009 Boro season viewing missing element approach using six treatments in RCB design with four replications (Table 1). In Boro season NPKSZn @ 150-15-50-10-1 kg/ha was used but in T. Aman season it was 60-25-35-20-5 kg/ha. Urea N was applied in three equal splits ie 1/3 at final land preparation, 1/3 at active tillering stage and 1/3 at 5-7 days before PI stage. The rest of the fertilizers was applied at final land preparation. The unit plot size was 6- × 3-m. Forty-five- and 30-day-old 2-3 seedlings/hill was transplanted in Boro and T. Aman seasons respectively. For grain yield the crop was harvested form 5 m^2 areas at the center part of each plot and 16 hills were collected for tiller and panicle counting and straw yield. The grain yield was recorded at 14% moisture content and straw yield as oven dry basis.

Results reveal that BRRI RS, Barisal farm need complete (NPKSZn) fertilization for obtaining maximum yield. Omission of any one nutrient element from complete treatment decrease yield and the amount of yield decrease depends on each nutrient missing.

PEST MANAGEMENT

Performance of BB resistant genotypes (pyramid lines) at different AEZs of Bangladesh during T.Aman 2011 and Boro seasons. The experiment was conducted in T. Aman 2011 and Boro 2011-12 season at BRRI farm Barisal to see the performance of BB resistant genotypes (pyramid lines). In this study, ten pyramid lines with standard checks were evaluated under natural condition. Thirty- to thirty-five-day-old seedlings were transplanted with the spacing 20- × 20-cm having 2-3 seedlings/hill. Plot size was 3- × 2-m with three replications. Cultivation procedure and

Table 1. Treatment details of the long-term missing element experiments, 2009-2012.

Treatment	Fertilizers
T_1	NPKSZn
T_2	NPSZn (-N)
T_3	NKSZn (-P)
T_4	PKSZn (-K)
T_5	NSZn (-S)
T_6	NPKS (-Zn)

fertilizers were used as BRRI recommended dose. Cultural management was done as and when necessary. Data of yield components and percent leaf area damage by BB pathogen were taken at dough to maturity. Finally disease data of leaf area damage were converted to disease severity scale (0-9) following SES (1996).

Pyramid lines IRBB60, IRBB65 and IRBB66 performed best against BB pathogen. At BRRI RS, Barisal farm, none of the tested pyramid lines showed resistant reaction under natural condition in T. Aman season. This trial submerged several times by the tidal flash after crop establishment. There is a possibility of not to work BB resistant gene under submergence condition. The yield performances of the tested materials were low in T. Aman season compared to Boro season. Especially in T. Aman at Barisal, yield performance was very low due to tidal flash.

TECHNOLOGY TRANSFER

Advanced line adaptive research trial (ALART). Seven advanced lines like BR7372-117-3-4-3, BR7358-5-3-2-1, BR7358-56-2-2-1, BRRI dhan29-SC3-28-16-10-6, BRRI dhan29-SC3-28-16-10-2, BRRI dhan29-SC3-28-16-10-8, BR7372-18-2-1-HR1 along with three standard check viz BRRI dhan47, BRRI dhan28 and BRRI dhan29 were tested at BRRI farm Barisal during Boro, 2011-12. The unit plot size for each entry was 15 m^2. Seedlings were transplanted in 20 x 20 cm spacing. All the tested genotypes produced lower grain yield than the standard checks.

Adoption and demonstration of water saving technologies at farmer's fields. Field demonstrations were conducted at farmer's field to create awareness among the farmers about the benefits of AWD technology. Farmers were selected under STW/DTW according to the project areas. Demonstrations were executed by using perforated PVC tool. Flexible polythene pipe were distributed among the farmers to encourage them saving conveyance loss. Field tube (PVC pipe) water level, number of irrigation, irrigation time and irrigation water amount, fuel consumption, discharge at inlet and outlet of flexible polythene pipe, yield and yield component data were collected.

AWD technology was found cost effective resource conserving technology to the farmers. About 4-5 number of irrigation could be saved by using AWD technology, which was also increased water productivity. AWD method was found to be suitable for water and fuel saving technology during dry season (Boro) water scarce period. It saved about 20 to 26% water by which farmers can save about Tk 2,800-3,600/ha fuel cost. AWD method was applied in the farmer's field without any yield reduction. This technology is environment friendly for reducing groundwater use in the irrigated ecosystem in the climate change situation.

Field day. Two field days were conducted during T. Aman 2011 season. About 450 real farmers, local elected representatives, DAE personnel, BRRI scientists, staff and other participant participated in these field days. The farmers who participated in those field days showed their high interest to cultivate the demonstrated varieties in the next season if the seeds are available. Besides this, the farmers and other personnel's knew about BRRI and its other technology packages in relation to rice production.

Farmers training. During the reporting periods nine farmers training were conducted in different locations of Barisal regions. A total of 331 male and 89 female farmers participated in these training programmes.

Seed production. During the reporting period five and 17 tons breeder seeds were produced in T. Aman and Boro seasons respectively.

BRRI RS, Comilla

grown in T. Aman season. Out of them 19 crosses were confirmed and registered in BRRI cross list with station code BRC368 to BRC386. In Boro, 30 crosses and their respective parents were grown. Out of them 28 crosses were confirmed and registered in BRRI cross list with station code BRC387 to BRC413.

Growing of F_2 population

F_2 seeds of 17 crosses along with their parents were grown for selection of progenies with emphasis on earliness, plant and grain types, number of effective tiller and high yield potential than the standard varieties in T. Aman. A total of 279 plant progenies were selected from the population of 17 crosses. F_2 seeds of three crosses along with their parents were grown for selection of progenies with desirable plant type and high yield potential in Boro season. Fifty-six plant progenies were selected from the population of three crosses.

Pedigree nursery (F_3, F_4 and F_5 generations)

A total of 211 F_3 and 27 F_4 progenies were grown for selection of desirable progenies from the segregating populations with emphasis on plant type, earliness, grain type, grain colour, lodging tolerance and better phenotypic acceptance over the standard varieties in T. Aman. Ninety-nine and nine plant progenies were selected from F_4 and F_5 generations respectively and five breeding lines were bulked from F_5 generation. A total of 484 progenies (164 F_3, 17 F_4, 303 F_5) were grown for selection of desirable segregates with emphasis on earliness, strong culm, high yield potential as well as disease and insect resistance at field condition in Boro season. A total of 215, 15 and 122 plant progenies were selected from F_3, F_4 and F_5 generations respectively.

Preliminary yield trial (PYT) in T. Aman

In total, 26 genotypes from RLR # HQ were evaluated in PYT-E and PYT-L at BRRI, Comilla against standard checks viz BR4, BR11, BRRI dhan30, BRRI dhan32, BRRI dhan33, BRRI dhan39, BRRI dhan49, BINA dhan7 and BRRI dhan57 for initial yield evaluation and selection of desirable lines compared to standard checks. Also seven genotypes from PQR # HQ were evaluated against standard checks BRRI dhan37 and BRRI dhan38. Thirty-day-old seedlings of each genotype were transplanted @ single seedling with 25- × 15-cm spacing. The unit plot size was 5.4 m × 8 rows. The field lay out were RCBD with two replications. Recommended fertilizer doses were applied with a usual split application of urea in three times at 15, 30 and 45 days after transplanting. Other cultural operations were done as and when necessary. In PYT-E, only genotype BR7472-16-2-1-2-3 showed better yield performance than all the standard checks but one week later than all check varieties. This genotype could be comparable with PYT # L group in next T. Aman season (Table 1). In PYT-L, none of the genotypes yielded better than standard checks BRRI dhan32 and BRRI dhan49. This field was submerged for 10 days but two standard checks mentioned above showed satisfactory yield performance although some of the test entries showed slightly better yield performance than the other two standard checks (Table 1). Therefore, it could be concluded that genotypes from PYT-L were not suitable for Comilla region. In PYT # PQR, test entries were long slender premium grade but without aroma. Since any long slender aromatic rice variety has not been developed, BRRI dhan37 and BRRI dhan38 were used as standard checks. Genotypes BR7369-52-3-2-1-1, BR7357-6-2-1-1 and BR7647-16-2-2-2-1-1 showed one ton yield advantage per ha with one week earlier growth duration than the standard checks (Table 2). These test entries could be exportable in the international market.

Secondary yield trial (SYT) in T. Aman

Thirteen genotypes from RLR # HQ were evaluated in SYT # 1 and SYT # 2 at Comilla against standard checks viz BR11, BRRI dhan31, BRRI dhan33, BRRI dhan39 and BRRI dhan49 for yield evaluation in a replicated trial and selection of desirable lines compared with standard checks. Also five genotypes from PQR # HQ were evaluated against standard checks viz BRRI dhan37 and BRRI dhan38. Thirty-day-old seedlings of each genotype were transplanted @ single seedling with 25- × 15-cm spacing. The unit

Table 1. Yield and agronomic performance of breeding materials of preliminary yield trial, RLR # HQ, T. Aman 2011-12.

Designation	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	Yield (t/ha)
		PYT # E		
BR7617-7-1-3-1	104	134	236	3.3
BR7468-12-1-1-1-1	108	127	276	3.3
BR7472-16-2-1-2-1	108	129	292	3.2
BR7472-16-2-1-2-2	107	128	262	3.4
BR7472-16-2-1-2-3	116	128	248	4.2
BR7474-5-1-1-5-2	105	126	244	3.5
BRRI dhan33 (ck)	104	120	268	3.4
BRRI dhan39 (ck)	102	121	240	3.9
BINA dhan7 (ck)	86	120	250	3.5
		PYT # L		
BR7952-1-3-3	119	127	257	3.5
BR7952-1-3-4	121	138	256	3.2
BR7952-15-1-1	103	132	243	3.2
BR7952-17-2-2	108	132	252	4.0
BR7966-9-2-3	114	122	252	3.4
BR7966-16-2-2	117	123	235	3.5
BR7966-25-2-1	107	122	240	3.1
BR7966-33-1-1	125	130	272	3.8
BR7966-33-2-1	117	122	242	3.2
BR7966-2-2	127	127	236	3.0
BR7966-33-2-3	120	125	234	3.2
BR7473-12-2-2-1	106	124	230	2.5
BR7678-7-2-5-2	110	136	250	3.2
BR7638-7-2-5-3	121	137	238	3.4
BR7638-25-2-1-3	103	140	271	2.9
BR7638-25-2-1-6	115	140	276	2.9
BR7638-33-1-2-2	113	140	282	3.4
BR7465-7-2-3-1	116	130	278	3.3
BR7465-7-2-3-1	104	130	246	3.4
BR7474-2-4-5-1-1	105	130	238	3.1
BR4 (ck)	112	142	214	2.4
BR11 (ck)	104	140	222	3.3
BRRI dhan30 (ck)	109	140	230	3.1
BRRI dhan32 (ck)	125	130	274	4.8
BRRI dhan49 (ck)	104	134	290	4.5

Seeding date: 10 Jul 2011, Transplanting date: 7 Aug 2011.

Table 2. Yield agronomic performance of breeding materials of preliminary yield trial (PYT) PQR # HQ, T. Aman 2011-12.

Designation	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	Yield (t/ha)
BR7697-15-4-42-1	118	131	242	3.7
BR7697-15-4-4-2-2	114	132	262	3.7
BR7647-16-2-2-2-1-1	118	132	250	4.4
BR7357-7-1-5-2-1 116	129	236	3.2	
BR7357-11-2-4-1-1-HR3	128	131	236	3.3
BR7357-6-2-1-1	117	125	230	4.5
BR7369-52-3-2-1-1	116	124	232	4.5
BRRI dhan37 (ck)	119	135	262	3.3
BRRI dhan38 (ck)	124	138	272	3.5

Seeding date: 11 Jul 2011, Transplanting date: 6 Aug 2011.

plot size was 5.4 m × 10 rows. The field layout was RCB design with two replications. Recommended fertilizer doses were applied with a usual split application of urea in three times at 15, 30 and 45 days after transplanting. Other cultural operations were done as and when necessary. In SYT # 1 (RLR) two genotypes (Entry # 5 and 7) were selected as compared with standard check BRRI dhan31 for yield and earlier growth duration (Table 3). In SYT # 2, although all the genotypes showed better yield performance than mega variety BR11 but none of the entries yielded better than BRRI dhan49. Genotype BR7638-19-1-2-1 and BR7638-35-2-2-1 showed similar yield performance of BRRI dhan31 but 3- 9 days late growth duration. Therefore none of the genotypes were selected from SYT # 2 for Comilla region. In SYT, PQR all the test entries were long slender except genotype BR7044-1-5-1, which was medium slender and premium grade with less shattering. Genotype BR7357-11-2-4-1-1 was selected for its better yield and earliness (Table 3). On the other hand genotype BR7044-1-5-1 was selected for similar yield potential of BRRI dhan37 and BRRI dhan38 along with strong plant stature and one week earlier than standard checks (Table 4).

Observational trial (OT) in Boro

Four observational trial containing 80 genotypes were grown along with standard checks viz BR16, BRRI dhan45 and BRRI dhan28 for selection of genetically fixed lines with uniform plant height, heading, plant and grain type along with high yield potential. Each genotype was grown in a 5.4 m × 4 rows plot with 25- × 15-cm spacing using single seedling for transplanting. Forty-day-old seedlings were used for transplanting. Recommended fertilizer doses were applied with a usual split application of urea in three times at 15, 30 and 45 days after transplanting. Other cultural operations were done as and when necessary. Twenty-six genotypes were selected from OT (Table 5).

International rice observational nursery (IRON) in T. Aman

Seventy-eight genetically diverse test entries with international and two local checks were grown for selection of genotypes from the diverse genetic background having earliness, good grain type, compact panicle, lodging resistance, disease and insect resistance and high yield potential at rainfed condition. The experiment was conducted as per INGER nursery management. Nine genotypes (Entry # 1, 3, 4, 6, 8, 10, 11, 12, 13) were selected based on better phenotypic performance as compared with standard check (Table 6).

Regional yield trial (RYT), PQR in Boro

Two RYTs consisting of three and five genotypes were evaluated at BRRI RS, Comilla farm against the standard checks for evaluation of specific and general adaptability of the genotypes in on-station

Table 3.Yield and agronomic performance of breeding materials of secondary yield trial (SYT) RLR #HQ, T. Aman 2011-12.

Designation	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	Yield (t/ha)
		SYT # 1		
BR7472-16-2-1-2-3	113	133	254	3.5
BR7622-5-1-1-1	117	133	236	2.7
BR7639-68-2-1-1	100	129	238	3.8
BR7620-2-2-2-1	123	250	128	3.5
BR7473-12-2-2-6	113	131	272	4.7
BR7472-16-2-1-2-2	107	131	236	3.4
BR7044-1-5-1 116	128	282	4.1	
BRRIdhan31 (ck)	111	135	270	4.2
BRRIdhan33 (ck)	100	115	226	3.3
BRRIdhan39 (ck)	105	122	236	4.0
		SYT # 2		
BR7624-43-1-2-3	118	143	248	3.3
BR7474-5-1-5-2	110	128	279	3.7
BR7638-19-1-2-1	99	143	282	4.1
BR7638-35-2-2-1	117	137	278	4.3
BR7617-15-3-1-3	102	136	237	2.7
BR7638-2-1-2	116	143	244	3.7
BR11 (ck)	94	143	231	2.8
BRRIdhan31 (ck)	117	134	257	4.1
BRRIdhan49 (ck)	103	133	282	4.7

Seeding date: 11 Jul 2011, Transplanting date: 5 Aug 2011.

Table 4. Yield agronomic performance of breeding materials of secondary yield trial (SYT) PQR # HQ, T. Aman 2011-12.

Designation	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	Yield (t/ha)
BR7357-11-2-4-1-1	129	131	234	4.6
BR7357-6-2-1-1	118	125	334	3.3
BR7369-52-3-2-1-1	128	126	245	3.5
BR7369-16-5-2-3-1	124	133	255	3.4
BR7044-1-5-1	129	125	240	4.1
BRRI dhan34 (ck)	133	133	264	3.4
BRRI dhan37 (ck)	129	135	268	4.0
BRRI dhan38 (ck)	133	136	276	4.1

Seeding date: 11 Jul 2011, Transplanting date: 6 Aug 2011.

Table 5. List of selected materials from observational trial (OT), Boro 2011-12, BRRI, Comilla.

Designation	Parentage	Designation	Parentage
BRC266-1-1-3-2	BR16/90060-TR1252-8-2-1	BRC269-3-1-2-2	BR16/90060-TR1252-8-2-1
BRC266-1-1-3-7	"	BRC269-15-1-1-3	"
BRC266-5-1-1-4	"	BRC270-2-1-1-2	"
BRC266-1-2-1-6	"	BRC271-31-3-1-2	"
BRC266-1-2-1-7	"	BRC274-34-1-2-2	"
BRC266-5-1-1-1	"	BRC278-1-1-1-2	"
BRC266-5-1-2-1	"	BRC278-1-1-1-4	"
BRC266-5-1-2-6	"	BRC278-8-1-1-3	"
BRC266-6-1-3-3	"	BRC279-19-1-2-2	"
BRC266-5-2-2-2	"	BRC280-49-4-3-2	"
BRC266-6-1-4-2	"	BRC281-4-1-2-3	"
BRC266-35-3-1-2	"	BRC281-16-1-2-2	"
BRC267-17-1-1-2	"	BRC285-31-1-4-1	"

Seeding date: 2 Jan 2012, Transplanting date: 29 Feb 2012.

Table 6. List of selected genotypes from IRON, BRRI RS, Comilla, T. Aman 2011-12.

Designation	Plant ht (cm)	Growth duration (day)
IR80431-B-44-4	102	93
PSBRC80	87	94
PSBRC68	96	101
IR09Fi75 (IR85088-Sub3-2-1-1)	96	106
IR84196-32	83	90
BR7870-5(NIL)-10-HR3	90	90
923	69	108
IR09F162(IR85086-Sub-8-3-2-3)	92	111
IR09F185 (IR85288-Sub-38-1-1-2)	89	116
IR09F260(IR85272-166-2-2-3)	93	98
CN 1039-9	88	95
IR09F176(IR85088-Sub-6-2-1-2)	102	108
BR7155-20-1-3	91	105
IR09F183(IR85088-Sub-57-2-3-2)	104	114
IR09F159(IR85083-Sub9-1-1-3)	99	115
IR09F214(IR85309-Sub-188-1-2-3)	97	116
BRRI dhan49 (ck)	89	110
BINA dhan7 (ck)	*	

*Fully damaged by rice tungro virus. Seeding date: 3 Aug 2011, Transplanting date: 12 Sep 2011.

condition. Thirty-five-day-old seedlings of each genotype was transplanted @ 2-3 seedlings with 25- × 15 cm spacing. The unit plot size was 5.4 m × 12 rows. The field layout was RCB with two replications. Fertilizers @ 135-20-60 kg NPK/ha with all amount of P and K were applied at the time of final land preparation. Nitrogen was applied in three equal splits at 15 DATs, maximum tillering and before PI stage. Gypsum and zinc sulphate @ 100 and 10 kg/ha were applied during land preparation. Crop management such as weeding, controlling disease and insect pests were done in time. In RYT # 1 (PQR) genotype BR7358-36-2-2-1 was selected for 0.5 t/ha yields advantage than Minikit (Local check) and standard checks BRRI dhan28. Genotype BR7372-18-2-1-HR1 has mild aroma, which is comparable with BRRI dhan50. This genotype is one week earlier than BRRI dhan50 with little yield advantage. Therefore, considering yield and growth duration, these two genotypes were selected from RYT # 1 (PQR)

(Table 7). In RYT # 2 (PQR), none of the genotypes showed earliness than BRRI fhan28. It should be mentioned that all tested entries were extra long type. If we consider yield, entry # 1 and entry # 2 is selected. On the other hand, considering earliness, all tested genotypes were 3-4 days earlier than BRRI dhan50 with similar to 1 t/ha yield advantage. Therefore, all genotypes were selected for further evaluation in BRRI RS, Comilla farm (Table 7).

Regional yield trial (RYT), micronutrient in Boro

Eight genotypes were evaluated along with two standard checks- BRRI dhan28 and BRRI dhan29 in different regional stations for determination of general and specific adaptability of the selected genotypes. Thirty-five-day-old seedlings of each genotype was transplanted @ 2-3 seedlings with 25- × 15-cm spacing. The unit plot size was 5.4 m × 12 rows. The field layout was RCB with three replications. Fertilizers @ 135-20-60 kg NPK/ha with all amount of P and K were applied at the time of final land preparation. Nitrogen was applied in three equal splits at 15 DATs, maximum tillering and before PI stage. Gypsum and zinc sulphate @ 100 and 10 kg/ha were applied during land preparation. Crop management such as weeding, controlling disease and insect pests were done in time. In RYT (Micronutrient) genotype BR7830-16-1-5-3 was selected for better yield performance as compared with BRRI dhan28 and for earliness as compared with BRRI dhan29 (Table 8).

Multilocation trial of long slender and premium grade genotypes under CSISA funded project in Boro

Eight genotypes were evaluated at Comilla, Barisal, Gazipur, Habiganj, Rajshahi, Kushtia and Satkhira against the standard check BRRI dhan28 for evaluation of yield and other agronomic characters in different region of Bangladesh in a replicated trial and selection of desirable lines compared with standard checks. Forty-day-old seedlings of each genotypes was transplanted @ 2-3 seedlings with 25- × 15-cm spacing. The unit plot size was 5 m × 10 rows with three replications. Fertilizer doses @ 200-84-100-100-10 kg of urea, TSP, MP, gypsum and zinc sulphate per hectare were applied in the field. All fertilizers except urea and half dose of MOP were used as basal. Urea was applied in three splits at 15, 30 and 45 days after transplanting and ½ doze of MOP was used in two splits with second and third splits of urea. In this trial, five genotypes (Entty # 1, 2, 3, 6 and 7) were selected as compared to BRRI dhan28 in terms of yield potential, growth duration and plant height (Table 9).

Multilocation trial of promising hybrids for Boro season

Eight test entries and two check varieties were

Table 7. Result of regional yield trial (RYT), PQR, Boro 2011-12.

Designation	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	Yield (t/ha)
		*RYT # 1**		
BR7358-36-2-2-1	103	144	361	6.6
BR7358-19-3-1-1	85	142	373	6.2
BR7372-18-2-1-HR1	106	150	259	6.1
BRRI dhan28 (ck)	106	141	353	6.1
BRRI dhan50 (ck)	82	156	445	5.7
Minikit (L. ck)	103	146	407	5.3
		*RYT # 2***		
BR7358-35-2-1-1	85	152	384	6.8
BR7358-35-3-2-1	83	152	358	6.5
BR7358-35-3-3	107	152	305	5.8
BR7372-22-1-4-4	102	153	331	5.8
BR7372-30-1-1	104	151	319	6.1
BRRI dhan28 (ck)	102	142	389	6.2
BRRI dhan50 (ck)	75	156	415	5.8

*Seeding date: 6 Dec 2011, Transplanting date: 29 Jan 2012. **Seeding date: 6 Dec 2011, Transplanting date: 30 Jan 2012.

Table 8. Result of regional yield trial (RYT) micronutrient, Boro 2011-12.

Designation	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	Yield (t/ha)
BR7976-11-11-3-1	97	146	295	5.6
BR7840-54-3-1	104	147	285	5.1
BR7840-54-2-5-1	102	142	315	5.1
BR7830-16-1-5-3	86	146	346	6.3
BR7831-74-1-5-2	106	157	343	5.2
IR83294-9-1-3-2-3-Gaz1	94	145	455	5.6
BR7881-25-1-1-5	95	155	385	5.2
BR7840-54-1-2-5	109	149	277	5.0
BRRI dhan28 (ck)	99	141	384	6.1
BRRI dhan29 (ck)	103	158	427	6.4

Seeding date: 7 Dec 2011, Transplanting date: 1 Feb 2012.

Table 9. Results of multilocation trials of CSISA genotype for Boro 2011-12.

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)*
BR7372-117-3-4-3	96	143	5.4
BR7358-5-3-2-1	96	142	5.3
BR7358-56-2-2-1	101	144	5.5
BRRI dhan29-SC3-28-16-10-6-HR3 (Com)	89	136	4.5
BRRI dhan29-SC3-28-16-10-2-HR2 (Com)	88	136	4.1
BRRI dhan29-SC3-28-16-10-8-HR1 (Com)	91	144	5.4
BR7372-18-2-1-HR1 (Com)	101	147	5.2
BRRI dhan28(ck)	97	143	5.7

*Average yield of seven locations.

evaluated in BRRI RS, Comilla for testing the yield potential of the hybrid entries in different locations. Thirty-five-day-old seedlings were transplanted using single seedling per hill with 25- × 15-cm spacing in 5.4 m × 10 rows plot in three replications. Fertilizer doses were 120-60-40 kg/ha NPK. All fertilizers except N were used as basal. N was applied in three splits at 15, 30 and 45 days after transplanting. In this trial, among ten entries including checks, the highest yield (6.97 t/ha) was obtained from entry BIO 452 as compared with check varieties showing growth duration 137 days, which was almost similar to the checks (Table 10). But all entries were highly susceptible to lodging problem. So, it would be better to go for further evaluation.

Advanced yield trial (AYT) in Boro

Seven genotypes selected from SYT of BRRI RS, Comilla were evaluated in this experiment against the standard checks for evaluation of advanced breeding lines to develop variety suitable for Comilla region. Forty-day-old seedlings were transplanted in a 5.4 m × 12 rows following RCB design with three replications using single seedling per hill at 25- × 15-cm spacing. BRRI dhan28 and BRRI dhan45 were used as the standard checks. Fertilizer and other cultural management were same as of the experiment 3. In AYT, all the tested genotypes were two weeks earlier than both the standard checks BRRI dhan28 and BRRI dhan45. Although these genotypes showed 0.5 t/ha lower yield performance but earliness is most critical factor for late Boro, salinity, cold and haor areas. Considering these factors, these genotypes would be further evaluated in next Boro and T. Aus seasons (Table 11).

Breeder seed production

BRRI dhan33, BRRI dhan32, BRRI dhan49 and BRRI dhan51 were grown in 2.50 ha land for breeder seed production in T. Aman following the standard management practices. In total, 500kg BRRI dhan33 and 892 kg BRRI dhan49 breeder seeds were produced. BRRI dhan28, BRRI dhan29 and BRRI dhan50 were grown in 4.50 ha land for breeder seed production in Boro following the standard management practices. In total, 12,283 kg BRRI dhan28, 3,060 kg BRRI dhan29 and 2,620 kg BRRI dhan50 breeder seeds were

Table 10. Results of multilocation trial of promising hybrids for Boro 2011-12.

Designation	Plant ht (cm)	Growth duration (day)	Filled grain (no./panicle)	Yield (t/ha)	Lodging score (%)	Remarks
BIO404	100	135	200	6.2	80	Uneven flowering
BIO4311BH	100	139	159	6.4	75	Uneven flowering
BIO452	119	137	277	7.0	100	Tall
BIO459	116	136	224	6.1	100	Tall
BIO543	104	134	166	5.9	100	
BIO598	104	139	191	5.7	100	SB* score 1
BIO605	10	139	127	6.1	85	SB* score 1
BIO610	106	140	263	5.8	100	
BRRI dhan28 (ck)	99	135	132	6.4	100	
BRRI hybrid dhan2 (ck)	105	138	170	6.8	45	

Seeding date: 28 Dec 2011, Transplanting date: 2 Feb 2012. SB* = Stem Borer.

Table 11. List of selected materials grown in advanced yield trial (AYT), irrigated rice (Boro) 2011-12, BRRI RS, Comilla.

Designation/Treatment	Growth duration (day)	Yield (t/ha)
BRRI dhan29-SC3-28-16-10-2-HR2 (Com)	112	4.2
BRRI dhan29-SC3-28-16-10- 6-HR3 (Com)	111	4.0
BRRI dhan29-SC3-28-16-10-4-HR5 (Com)	112	3.9
BRRI dhan29-SC3-28-16-10-4-HR3 (Com)	113	4.2
BRRI dhan28 (ck)	129	4.7
BRRI dhan45 (ck)	125	4.6

Seeding date: 15 Jan 2012, Transplanting date: 26 Feb 2012.

produced and were sent to GRS Division, BRRI HQ, Gazipur.

Note: *In T. Aman after transplanting flooding ocurred and some fields were stagnant with water for 20 days. So, fields of BRRI dhan32 and BRRI dhan51 were totally damaged but fields of BRRI dhan33 and BRRI dhan49 were partially damaged due to flooding.*

SOCIO-ECONOMICS AND POLICY

Stability analysis of BRRI developed Aman varieties

Twenty-four varieties were evaluated at BRRI RS, Comilla farm for Evaluation of BRRI developed T. Aman varieties to determine the stability index. The experiment was laid out in RCB design with three replications. Thirty-day-old seedlings were transplanted with 20- × 20-cm spacing. Each plot size was 4- × 3-m. Recommended fertilizer doses were applied with as usual split application of urea in three times at 15, 30 and 45 days after transplanting.

Among the 24 varieties, five produced yield more than or equal to 4.50 t/ha and showed growth duration ranged from 135-149 days. On the other hand, two varieties BR10 and BR11 produced yield less than 2 t/ha and some of the varieties produced yield less than 3 t/ha due to sheath blight and tungro disease infestation. BRRI dhan41 produced the highest grain yield (5.7 t/ha) and BR10 produced the lowest grain yield (1.7 t/ha) (Table 12). Considering yield performance the top five varieties were BRRI dhan41, BRRI dhan49, BRRI dhan44, BRRI dhan46 and BRRI dhan31.

Stability analysis of BRRI developed Boro varieties

Twenty-four varieties were evaluated at BRRI RS, Comilla farm for evaluation of BRRI developed Boro varieties to determine the stability index. The experiment was laid out in RCB design with three replications. Forty-day-old seedlings were transplanted with 20- × 20-cm spacing. Each plot size was 4- × 3-m. Recommended fertilizer doses were applied with as usual split application of urea in three times at 15, 30 and 45 days after transplanting.

Among the 24 varieties, five produced yield ranged from 6.8 to 5.9 t/ha and showed growth duration ranged from 140 to 161 days. BRRI dhan29 produced the highest grain yield (6.8 t/ha) and BR17 produced the lowest grain yield (3.3 t/ha) (Table 13). Rest of the varieties produced yield ranged from 4.2 to 5.7 t/ha and showed

Table 12. Result of stability analysis of BRRI varieties, T. Aman 2011-2012, BRRI RS, Comilla.

Variety	Growth duration (day)	Sheath blight (score)	Tungro (Score)	Yield (t/ha)
BR3	144	7	1	3.7
BR4	145	7	3	3.2
BR5	147	7	3	3.3
BR10	141	9	9	1.7
BR11	141	9	9	1.8
BR22	149	5	0	3.7
BR23	149	3	9	4.4
BR25	131	5	9	2.6
BRRI dhan30	141	3	9	2.4
BRRI dhan31	138	5	9	4.5
BRRI dhan32	131	7	9	4.4
BRRI dhan33	118	3	9	3.0
BRRI dhan34	133	7	9	2.9
BRRI dhan37	139	7	9	3.0
BRRI dhan38	139	7	3	3.4
BRRI dhan39	124	3	9	2.2
BRRI dhan40	145	7	0	4.5
BRRI dhan41	149	9	0	5.7
BRRI dhan44	145	7	0	4.7
BRRI dhan46	149	7	3	4.5
BRRI dhan49	135	5	0	4.8
BRRI dhan51	147	7	5	3.5
BRRI dhan52	144	7	9	3.6
IR64	131	3	3	3.0

Seeding date: 3 Jul 2011, Transplanting date: 26 Jul 2011.

Table 13. Result of stability analysis of BRRI varieties, Boro 2011-12, BRRI RS, Comilla.

Variety	Growth duration (day)	Yield (t/ha)
BR1	144	5.3
BR2	152	4.6
BR3	161	6.0
BR6	139	4.3
BR7	153	4.3
BR8	156	6.0
BR9	154	5.9
BR12	159	5.0
BR14	147	5.7
BR15	160	5.1
BR16	160	5.7
BR17	149	3.3
BR18	163	5.2
BR19	165	5.2
BR26	139	5.4
BRRI dhan27	153	5.5
BRRI dhan28	140	5.9
BRRI dhan29	157	6.8
BRRI dhan35	153	4.5
BRRI dhan36	139	4.5
BRRI dhan45	143	5.7
BRRI dhan47	144	5.5
BRRI dhan50	152	5.5
IR64	139	4.2

Seeding date: 9 Dec 2011, D/T: 19 Jan 2012.

growth duration ranged from 139 to 163 days. So, considering the yield performance the top five varieties were BRRI dhan29, BR8, BR3, BRRI dhan28 and BR9.

TECHNOLOGY TRANSFER

Evaluation of yield and other agronomic characters of newly BRRI released varieties in BRRI RS, Comilla farm, Boro 2011-2012

Three newly released Boro varieties were evaluated in this exrperiment against the standard checks- BRRI dhan28 and BRRI dhan29 at BRRI RS, Comilla farm to determine the yield and other agronomic characters and to determine milling yield after parboiled rice. The experiment was laid out in RCB design with three replications. Forty-day-old seedlings were transplanted with 20- × 20-cm spacing. Each plot size was 3.6- × 6.6-m. Recommended fertilizer doses were applied with a usual split application of urea in three times at 15, 30 and 45 days after transplanting.

In this experiment, BRRI dhan55, BRRI dhan57 and BRRI dhan58 produced higher yield than BRRI dhan28 and were two weeks earlier than BRRI dhan29 in terms of growth duration (Table 14). BRRI dhan28 is lodging susceptible at hard dough stage, which is lacking in three new varieties. Table 15 shows the amount of polished rice per 40 kg paddy.

Training/Agricultural fair

Thirty farmers (23 male and seven female) of Daudkandi of Comilla district were trained by day long one training programme on rice production technologies during the reporting year. Besides,

Table 14. Yield and other agronomic characters of newly BRRI released varieties in BRRI RS, Comilla farm, Boro 2011-12.

Variety	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BRRI dhan55	95	141	6.2
BRRI dhan57	92	145	5.4
BRRI dhan58	89	142	6.2
BRRI dhan28 (ck)	90	138	5.2
BRRI dhan29 (ck)	102	159	6.6

Seeding date: 5 Dec 2011, Transplanting date: 13 Jan 2012.

Table 15. Milling yield of polished rice of newly released variety after parboiling.

Variety	Polished rice/40 kg paddy (kg)	Broken rice/40 kg paddy (kg)
BRRI dhan55	23	3
BRRI dhan57	24	2.5
BRRI dhan58	25	1.8
BRRI dhan28 (ck)	25	1.7
BRRI dhan29 (ck)	25	1.5

twenty UAO and ten DAE, BARI, BADC personnel of Comilla region were trained by day long one training programme on recently released Boro variety BRRI dhan58 and T. Aman variety BRRI dhan49 during the reporting year. BRRI Comilla also participated in one agricultural fair of Daudkandi upazila.

SUMMARY

Twenty-nine crosses were made and 47 crosses were confirmed and 326, 213, 116 and 312 plant progenies with desirable plant type and high yield potential were selected from F_2, F_3, F_4 and F_5 generations, respectively and five plant progenies were selected for bulk under the varietal development programme. Twenty-six genotypes were selected from OT for uniformity in desirable characters and high yield potential in Boro season.

In PYT-E (T. Aman), one genotype BR7472-16-2-1-2-3 was selected for better yield. None of the genotypes were selected from PYT-L. In PYT # PQR, genotypes BR7369-52-3-2-1-1, BR7357-6-2-1-1 and BR7647-16-2-2-2-1-1 were selected for higher yield advantage. For T. Aman, in SYT # 1 (RLR) two genotypes (BR7044-1-5-1and BR7473-12-2-2-6) were selected as compared with standard check BRRI dhan31 for yield and earlier growth duration. In SYT # 2, none of the genotypes were selected from SYT # 2 for Comilla region. In SYT, PQR genotype BR7357-11-2-4-1-1 was selected for its better yield and earliness.

In RYT # 1 (PQR, Boro) two genotypes (BR7358-36-2-2-1 and BR7372-18-2-1-HR1) were selected as compared with standard checks BRRI dhan28, BRRI dhan50 and Minikit for yield and earliness. In RYT # 2 (PQR, Boro) BR7358-35-2-1-1 and BR7372-30-1-1 were selected for better yield performance and earliness but genotype BR7358-35-3-2-1 was selected only for better yield performance as compared to standard checks. In RYT Boro (Micronutrient) genotype BR7830-16-1-5-3 was selected for better yield performance as compared to BRRI dhan28 and for earliness as compared to BRRI dhan29.

In Boro season, from multilocation trials of CSISA genotypes, five genotypes BR7372-117-3-4-3, BR7358-5-3-2-1, BR7358-56-2-2-1, BR7372-18-2-1-HR1 and BRRI dhan29-SC3-28-16-10-8 were selected as compared with BRRI dhan28 in terms of yield and growth duration. In Boro, multilocation trials of hybrid rice, genotype BIO 452 was selected for its highest yield as compared with checks BRRI dhan28 and BRRI hybrid dhan2 and showed growth duration 137 days, which was similar to checks. But all the entries were highly susceptible to lodging except BRRI hybrid dhan2.

In AYT (Boro) trials, four genotypes were selected for earliness as compared to BRRI dhan28 and BRRI dhan45. From IRON, nine genotypes were selected considering better phenotypic performance as compared to standard checks.

In T. Aman, 500kg BRRI dhan33 and 892 kg BRRI dhan49 and in Boro, 12283 kg BRRI dhan28, 3060 kg BRRI dhan29 and 2620 kg BRRI dhan50 breeder seeds were produced.

Twenty-four T. Aman and 24 Boro rice varieties were evaluated at BRRI RS, Comilla farm to identify stability index. Considering yield performance, the top five varieties were BRRI dhan41, BRRI dhan49, BRRI dhan44, BRRI dhan46 and BRRI dhan31 in T. Aman and BRRI dhan29, BR8, BR3, BRRI dhan28 and BR9 in Boro.

Thirty farmers (23 male and seven female) of Daudkandi of Comilla district were trained by day long one training programme on rice production technologies during the reporting year. Besides, twenty UAO and ten DAE, BARI, BADC personnel of Comilla region were trained by day long one training programme on recently released Boro variety BRRI dhan58 and T. Aman variety BRRI dhan49 during the reporting year.

BRRI RS, Comilla also participated in one agricultural fair of Daudkandi upazila.

VARIETAL DEVELOPMENT

Hybridization

In T. Aman, ten crosses were made using 12 parents for development of improved genotypes with high yield potential along with earliness, photoperiod sensitivity, acceptable grain quality and resistance to diseases and insect pests. In Boro, 19 crosses were made using 11 parents for development of improved rice varieties with high yield potential along with earliness, resistance to diseases and insect pests and suitable for Comilla region.

F_1 confirmation

Twenty crosses and their respective parents were

BRRI RS, Habiganj

SUMMARY

In B. Aman season, 73 desirable homozygous plants of DWR were selected. In RYT, all the tested entries yielded higher than check Hbj AmanIV. In Boro season, 85 F_7 plants from 18 F_6 populations, 98 F_7 plants from 10 F_6 populations and 48 F_5 plants from five F_4 populations were selected with desirable characters for the development of varieties suitable for *haor* areas. Four tested entries yielded higher than BRRI dhan28 (6.5 tha^{-1}) with similar growth duration in PYT. In RYT#1, BR7325-4B-1 and BR7226-19-1-3 yielded higher than BRRI dhan29 (6.5 tha^{-1}). One of the tested lines BR7742-79-24L4-10 (6.12 tha^{-1}) out yielded BR19 (5.97 tha^{-1}) in RYT#2**.** But in RYT#3, all the lines out yielded BRRI dhan45 (5.2 tha^{-1}) and IR83140-B-32-B-B, IR83141-B-18-B-B, IR80416-B-32-3, PSBRC82 yielded higher than BRRI dhan28 (5.7 tha^{-1}) with almost similar growth duration. Tested entries (BR7840-54-2-5-1, BR7830-16-1-5-3, BR83294-9-1-3-2-3 and BR7840-54-1-2-5) yielded higher than BRRI dhan28 (4.9 tha^{-1}) in RYT#4, but none of the entries out yielded BRRI dhan29 (6.1 tha^{-1}). In MLT#1, none of the line out yielded BRRI dhan28 (5.3 tha^{-1}) but two entries (BR7372-117-3-4-3 and BR7873-5*(NIL)-51-HR6) yielded closed to BRRI dhan28 with similar growth duration**.** Among the advanced breeding lines in MLT#2, three entries viz BIO 452 (6.44 tha^{-1}), BIO 459 (6.32 tha^{-1}), and BIO 605 (6.29 tha^{-1}) yielded higher than BRRI dhan28 (5.70 tha^{-1}) and BRRI Hybrid dhan2 (6.05 tha^{-1}) with almost similar growth duration. Out of 84, only three entries viz PK 8601-1-10-3 (6.75 tha^{-1}), PR33993-B-15-2-1-4-5-3-2-2 (6.42 tha^{-1}) and IR 09A102 (7.21 tha^{-1}) were selected from IIRON-2011 according to their yield performance, phenotypic acceptance and growth duration.

Balanced fertilization with complete treatment significantly increased the rice grain yield. The highest rice yield (5.2 tha^{-1}) was obtained with complete fertilizer dose of NPKS and the lowest rice yield (2.3 tha^{-1}) was obtained with all missing treatment.

The recommended patterns (BRRI dhan46-BRRI dhan29-Fallow) produced 14% higher grain yield and gross margin over existing farmers' patterns (BR22-BRRI dhan28-Fallow). The recommended cropping pattern produced 12.15 tha^{-1} yield that earned gross margin of Tk 1,94,400/ha. In Boro season, normal transplanting and double transplanting (DT) produced significantly higher grain yield than the delayed planting.

VARIETAL DEVELOPMENT

Deep water rice improvement

Regional yield trial. Six advanced genotypes with check HbjAIV were in a 5 m × 10 row plot with 25 cm spacing between rows. One meter spacing was maintained between each entry (Table 1). All the tested entries yielded higher than HbjAIV (2.4 tha^{-1}) that also showed consistent yield for the last three years trial with higher survival rate.

Table 1. List of the DWR lines with yield (t/ha) selected from yield trial, DWR 2011.

Designation	Survival (%)	Yield 2011 (tha^{-1})	Yield 2010 (tha^{-1})	Yield 2009 (tha^{-1})
BR224-2B-2-5	95	3.1	3.2	2.5
BR5925-B-2	92	2.8	2.9	2.4
BR5915-B-34	95	2.5	3.0	2.4
Bazail-65	95	2.6	3.1	2.5
Gabura	92	2.6	3.2	2.6
Lalkhama	95	3.0	2.7	2.4
HbjAIV (ck)	90	2.4	2.7	1.9

D/S: 26 May 2011.

IRRIGATED RICE (BORO)

Preliminary yield trial (PYT)

Eleven advanced breeding lines along with BRRI dhan28 and BRRI dhan29 as checks were planted in a 5.4 m × 10 row plot with 25 cm spacing between rows. Four tested entries, PR26703-3B-PJ25 (6.2 tha^{-1}), NSIC RC134 (6.2 tha^{-1}), OM4668 (5.7 tha^{-1}) and BI4 (5.9 tha^{-1}) yielded higher than BRRI dhan28 (6.5 tha^{-1}) with similar growth duration.

Regional yield trial (RYT# 1)

Six advanced breeding lines along with BR14 and BRRI dhan29 as check were planted in a 5.4 m × 10 row plot with 25 cm spacing between rows. Two tested entries, BR7325-4B-1(7.4 tha^{-1}) and

BR7226-19-1-3 (7.1 tha^{-1}) yielded higher than BRRI dhan29 (6.5 tha^{-1}) with similar growth duration.

Regional yield trial (RYT#2)
Four advanced breeding lines along with BR19 as check were planted in a 5.4 m × 10 row plot with 25 cm spacing between rows. One of the tested lines BR7742-79-24L4-10 (6.12 tha^{-1}) out yielded BR19 (5.97 tha^{-1})

Regional yield trial (RYT#3)
Eight advanced breeding lines along with BRRI dhan28 and BRRI dhan45 as check were planted in a 5.4 m × 10 row plot with 25 cm spacing between rows.

All of the lines out yielded BRRI dhan45 (5.2 tha^{-1}) and IR83140-B-32-B-B, IR83141-B-18-B-B, IR80416-B-32-3 and PSBRC82 yielded higher than BRRI dhan28 (5.7 tha^{-1}) with almost similar growth duration.

Regional yield trial (RYT#4)
Eight advanced breeding lines along with BRRI dhan28 and BRRI dhan29 as check were planted in a 5.4 m × 10 row plot with 25 cm spacing between rows. None of the lines out yielded BRRI dhan29 (6.1 tha^{-1}) but tested entries (BR7840-54-2-5-1, BR7830-16-1-5-3, BR83294-9-1-3-2-3 and BR7840-54-1-2-5) yielded higher than BRRI dhan28 (4.9 tha^{-1}).

Multi-location trial on hybrid rice (MLT#2)
Eight advanced breeding lines along with BRRI dhan28 and BRRI hybrid dhan2 as check were planted in a 5.4 m × 10 row plot with 25 cm spacing between rows

Among the advanced breeding lines, three entries viz BIO 452 (6.44 tha^{-1}), BIO 459 (6.32 tha^{-1}), and BIO 605 (6.29 tha^{-1}) yielded higher than BRRI dhan28 (5.70 tha^{-1}) and BRRI hybrid dhan2 (6.05 tha^{-1}) with almost similar growth duration to BRRI dhan28.

International Irrigated Rice Observational Nursery (IIRON-2011)
Eighty-four advanced breeding lines/varieties with one local HYV (BRRI dhan28) check were planted in a 5.4 m × 4 row plot with 25 cm spacing between rows. Out of them only three entries viz PK 8601-1-10-3 (6.75 tha^{-1}), PR33993-B-15-2-1-4-5-3-2-2 (6.42 tha^{-1}) and IR 09A102 (7.21 tha^{-1}) were selected according to their yield performance, phenotypic acceptance and growth duration. These materials will be re-tested in the next season.

CROP-SOIL-WATER MANAGEMENT

Long-term missing element trial for diagnosing the limiting nutrient in soil
The experiment was initiated in a permanent layout at the BRRI RS farm, Habiganj in 2007-08 Boro season viewing missing element approach using eight treatments in RCB design with three replications. Boro 2011-12 is the 5th year continuation of this experiment. There was a complete treatment consisting of the application of soil test based (STB) N, P, K and S fertilizer and other treatments 'missing' the nutrient elements such as -N, -P, -K, -S. In Boro season NPKS @ 85-38-50-9 kg ha^{-1} was used

Balanced fertilization with complete treatment significantly increased the grain yield and other agronomic characters of rice. The highest rice yield of 5.2 tha^{-1} was obtained with complete fertilizer dose of NPKS and the lowest rice yield of 2.3 tha^{-1} was obtained with all the missing treatments.

RICE FARMING SYSTEMS

Multilocation testing of BRRI dhan46-BRRIdhan29-Fallow cropping pattern
Multilocation trial of BRRI dhan46-BRRIdhan29-Fallow cropping pattern in medium highland phase II was undertaken at Madhabpur upazila of Habiganj district.

The recommended patterns (RM) produced 14% higher grain yield and gross margin over existing farmers' patterns (FP BR22-BRRI dhan28-Fallow). The recommended cropping pattern produced the yield of 12.15 t/ha and gross margin of Tk 1,94,400/ha. It was because of higher yield gap between recommended and farmers' practice in both T. Aman and Boro season.

Evaluation of double transplanting at low lying area under T. Aman-Boro cropping pattern

The study was conducted during Boro season in RCB design with three replications with BRRI dhan29. The treatments were- T_1-Normal transplanting (45-day-old seedling); T_2-Double transplanting (first transplanting of 45-day-old seedlings and 2nd transplanting with tillers of 30-day-old crop of 1st planting); T_3-Delayed transplanting (75-day-old seedlings).

Normal transplanting and DT produced significantly higher grain yield than the delayed planting. Crop duration of delayed planting was higher than the normal and DT.

BRRI RS, Kushtia

SUMMARY

Six lines were tested in RYT, upland rice (Aus) 2011. The yield of the tested lines were ranged from 3.3 to 4.0 t/ha. The line BR6855-2B-11-3-5 was the highest yielder (4 t/ha) followed by BR7181-2B-2-6, BR7384-2B-5 and BR6976-2B-11-1. The rest two lines namely, BR7178-2B-19 and BR7976-2B-15 produced lower yield (3.3 t/ha) among the tested lines.

Three lines were tested in ALART, upland rice (Aus) 2011. The yield of the tested lines ranged from 3.4 to 3.9 t/ha and were similar that of the standard check BRRI dhan43 but 0.8-1.3 t/ha higher yield than the local check Hashikalmi. The line OM1490 produced the highest yield (3.9 t/ha) with the highest number of panicles/m^2 (278.3) and the shortest plant height (80.5 cm).

In RYT, T. Aus 2011, the tested materials produced similar yield to the check BRRI dhan48, but 0.2-0.9 t/ha higher than BR26 except Zirasail. Zirasail showed the lowest yield (4.0 t/ha) as well as the longest growth duration (120 days) and the tallest plant height (122.4 cm).

The yield of the tested line, OM1490 (5.3 t/ha) was similar to the checks, BR26 and BRRI dhan48 in the ALART, T. Aus 2011. Growth duration, plant height and thousand grain weights were also similar to the checks.

The highest yield (3.7 t/ha) was found with BR7642-11-2-2 in the trial against rice gall midge. Yield advantage for this line was 0.6 and1.7 t/ha over the susceptible and resistant checks respectively. Higher number of panicles/m^2 with a few number of onion shoot was observed in the lines, BR7640-42-3-3, BR7640-44-2-1 and BR7642-11-2-2. Therefore, these BRRI developed lines may be resistant against rice gall midge.

The highest yield (3.8 t/ha) was found in the tested line IR83377-B-B-93-3 followed by IR83873-B-B-47-4 (3.6 t/ha) and IR82635-B-B-145-1 (3.6 t/ha) in the PVS in T. Aman 2011 season. Yield of the other eleven lines ranged from 2.0 to 3.4 t/ha. Among the lines, IR83377-B-B-93-3, BR IR83376-B-B-130-2, IR83383-B-B-129-4 was ranked in the first, second and third position respectively in the farmers' opinion.

The highest yield (5.9 t/ha) was found in the tested line BR7358-5-3-2-1 followed by BR7358-56-2-2-1 (5.7 t/ha), BR7372-117-3-4-3 (5.6 t/ha) and BRRI dhan29-Sc3-28-16-10-8 (5.6 t/ha) in MLT, CSISA, Boro 2011-12. The lowest yield having the lowest panicles/m^2 was observed in the tested line BRRI dhan29-Sc3-28-16-10-2 (4.1 t/ha) and BRRI dhan29-Sc3-28-16-10-6 (4.2 t/ha).

The early transplanting of T. Aman through supplemental irrigation ensured that T. Aman effectively mitigated the terminal drought occurred at reproductive stage and at vegetative stage during T. Aman 2011. Both the short and long duration T. Aman varieties suffered less drought and showed good yield performance if they were transplanted on 24 to 31 July. In T. Aman 2011, suitable transplanting dates were between 24 July and 31 July for BRRI dhan33 and BR11 respectively.

Application of supplemental irrigation at three water levels below ground surface showed that there was no considerable yield difference among the treatments. The highest yield was found in T_3 (5.6 t/ha) and the lowest was found in T_2 (5.3 t/ha) and yield difference was only 6%. However, further trials are needed to draw a conclusion.

Efficiency of natural enemies was studied at Kushtia sadar upazila in T. Aman 2011. Two parasitoids- one *Elasmus* sp. (Elasmidae) and one *Eulophid* were found to parasitize the leaf folder larvae. *Elasmus* sp. parasitized 8.3 to 14.3% in different occasions. The *Eulophid* parasitoid was found in one occasion only and its parasitism rate was only 5%.

Yield and growth duration of 23 BRRI varieties were studied in T. Aman 2011. Among the 23 varieties 18 were found to give higher yield than the standard yield determined for them. The other varieties yielded similar or lower than the standard yield. Growth duration of some of the test varieties decreased (up to 12 days as in the case of BR10), whereas in some varities it increased up to 28 days as in the case of BRRI dhan46. On the other hand, four were found to give higher yield and the other varieties yielded lower than the standard yield among the 23 varieties in Boro 2011-12. In this season, growth duration of some of the test varieties decreased up to 9 days as in the case of BRRI dhan18, whereas in some varities it increased up to 35 days as in the case of BRRI dhan26.

Yield of BRRI dhan49, BR10 in T. Aman and BRRI dhan28 in Boro season under farmers managed and BRRI managed conditions were compared in Shailkupa, Sadar and Kotchandpur upazilas of Jhenaidah. The yield of the fields having BRRI recommended practices was higher than those having farmer's practices in all of three locations. Overall, yield was increased by 25% in the T. Aman and 11% in the Boro season.

In total, five farmer's trainings were conducted in which around 150 farmers participated. Four field day programme were organized to demonstrate BRRI developed technologies. BRRI RS, Kushtia also participated in the agricultural fair.

VARIETAL DEVELOPMENT

Regional yield trial (RYT), upland rice (Aus) 2011

Six lines namely, BR7178-2B-19, BR7181-2B-2-6, BR6855-2B-11-3-5, BR6976-2B-11-1, BR7384-2B-5 and BR7976-2B-15 were tested in this trial. The yield of the tested lines ranged from 3.3 to to 4.0 t/ha. The line BR6855-2B-11-3-5 produced the highest yield (4.0 t/ha) followed by BR7181-2B-2-6, BR6976-2B-11-1, BR7384-2B-5. Growth duration of the lines was more or less similar to the standard check BRRI dhan42 and BRRI dhan43 but one week longer than the local check Hashikalmi except BR7178-2B-19 (110 days) (Table 1). Plant height of the tested lines was 14.9-48.5 cm shorter than the local check Hashikalmi (124.5 cm). Due to this, the tested entries didn't lodge but the local check Hashikalmi lodged completely.

Advanced lines adaptive research trial (ALART), upland rice (Aus) 2011

Three lines namely, OM1490, BR7383-2B-23 and BR7385-2B-13 were tested at Kushtia in upland rice (Aus) 2011. BRRI dhan43 and Hashikalmi were used as standard and local check respectively. The yield of the tested lines ranged from 3.4 to 3.9 t/ha and was similar to the yield of standard check BRRI dhan43, but 0.8-1.3 t/ha higher than the local check Hashikalmi. The line OM1490 produced the highest yield (3.9 t/ha) with the highest number of panicles/m^2 (278.3) and shortest plant height (80.5 cm). Growth duration of the lines was more or less similar to that of the standard check BRRI dhan43 but one week longer than the local check Hashikalmi (Table 2).

Regional yield trial (RYT), T. Aus 2011

Eight materials were tested in T. Aus 2011. The materials were BR7566-4-4-1, BR7566-39-6-1, BR7569-107-1-3, BR7577-9-1-2, BR7413-14-3-3, BR7417-6-1-1, BR7417-6-1-2 and Zirasail. BR26 and BRRI dhan48 were used as standard checks. The yield of the test lines ranged from 4.0 to 5.6 t/ha. The tested materials produced similar yield to the check BRRI dhan48 but 0.2-0.9 t/ha higher than BR26 except Zirasail. Zirasail showed the lowest yield (4.0 t/ha) with the longest growth duration (120 days) and the tallest plant height (122.4 cm). Most of the entries showed similar growth duration and similar plant height to the check varieties (Table 3).

Advanced lines adaptive research trial (ALART), T. Aus 2011

OM1490 was tested along with the standard checks

Table 1. Performance of some RYT lines, upland rice (Aus) in 2011.

Designation	Plant ht (cm)	Panicle (no./m^2)	Growth duration (day)*	Yield (t/ha)
BR7178-2B-19	101.8	229	110	3.3
BR7181-2B-2-6	103.0	248	113	3.9
BR6855-2B-11-3-5	107.4	226	119	4.0
BR6976-2B-11-1	85.1	221	115	3.7
BR7384-2B-5	109.6	247	114	3.8
BR7976-2B-15	76.0	259	114	3.3
BRRR dhan42 (ck)	106.6	185	116	2.9
BRRR dhan43 (ck)	102.8	273	117	3.3
Hashi Kalmi (Local ck)	124.5	280	108	2.7
LSD (0.5)	3.1	30.6	1.07	0.4

*Growth duration was longer due to lack of soil moisture after seeding and also delayed germination. Seeding: 14 Apr 2011.

Table 2. Performance of some ALART lines, upland rice (Aus) in 2011.

Designation	Growth duration* (day)	Plant ht (cm)	Panicle (no./m^2)	Filled grain (no./panicle)	Unfilled grain (no./panicle)	Yield (t/ha)
OM1490	116	80.5	278	87	09	3.9
BR7383-2B-23	117	100.3	227	89	10	3.6
BR7385-2B-13	117	110.8	192	79	19	3.4
BRRI dhan43 (Std ck)	118	102.1	181	84	15	3.3
Hashikalmi (Local ck)	108	122.5	271	45	13	2.6
LSD (0.5)	1.0	4.8	57.1	-	-	0.4

*Growth duration was longer due to lack of soil moisture after seeding and also delayed germination. Seeding: 14 Apr 2011.

Table 3. Performance of some RYT lines, T. Aus 2011.

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BR7566-4-4-1	99.0	101	5.0
BR7566-39-6-1	93.1	104	4.9
BR7569-107-1-3	93.3	101	5.3
BR7577-9-1-2	101.0	100	5.3
BR7413-14-3-3	105.0	117	5.2
BR7417-6-1-1	96.3	103	5.6
BR7417-6-1-2	99.1	101	5.3
Zirasail	122.4	120	4.0
BR26 (ck)	103.0	98	4.7
BRRI dhan48 (ck)	98.8	98	5.4

Seeding: 21 Apr 2011, Transplanting: 16 May 2011.

BR26 and BRRI dhan48 in T. Aus 2011. The yield of the test line, OM1490 (5.3 t/ha) was similar to the checks, BR26 and BRRI dhan48. Growth duration, plant height and 1000-grain weight were also similar to those of the checks (Table 4).

Regional yield trial (RYT) against rice gall midge, T. Aman 2011

Five materials were tested in T. Aman 2011. The materials were BR7640-31-3-2, BR7640-35-2-1, BR7640-44-2-1, BR7640-42-3-3 and BR7642-3-3. BR11 (susceptible), RD4 (resistant) and BG400-1 (resistant) were used as checks. The yield of the tested lines ranged from 3.1 to 3.7 t/ha. The highest yield (3.7 t/ha) was observed in BR7642-11-2-2. Most of the entries showed similar growth duration and seven to ten days earlier than both the susceptible and resistant checks (Table 5). Higher onion shoot formation was observed in BR7640-31-3-2, BR7640-35-2-1 which was similar to that of the susceptible check (BR11) and resistant checks (RD4 and BG400-1). Higher number of panicles/m^2 with negligible onion shoot formation was observed in the lines, BR7640-44-2-1, BR7640-42-3-3 and BR7642-11-2-2. Therefore, BRRI developed these lines might be resistant against gall midge.

Participatory variety selection (PVS), T. Aman 2011

Fourteen lines/varieties were evaluated against the checks IR64, BINA dhan7, BRRI dhan49 and Guti Swarna in T. Aman 2011. The highest yield (3.8 t/ha) was found in the test line IR83377-B-B-93-3

Table 4. Performance of some ALART lines in T. Aus 2011.

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	Filled grain (no./panicle)	Unfilled grain (no./panicle)	1000-grain wt (gm)	Yield (t/ha)
OM1490	102	90.5	417	83.2	10.9	25.3	5.3
BR26 (ck)	102	103.6	354	78.9	6.7	24.9	5.0
BRRI dhan48 (ck)	102	101.1	259	110.3	14.8	26.8	5.4
LSD (0.5)	-	5.3	77.8	-	-	2.4	0.4

Seeding: 20 Apr 2011, Transplanting: 15 May 2011.

Table 5. Performance of some RYT lines against rice gall midge, T. Aman 2011.

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	Yield (t/ha)	% onion shoot		
					30 DAT	45 DAT	60 DAT
BR7640-31-3-2	128	118.2	165	3.2	7.76	28.35	32.28
BR7640-35-2-1	129	114.5	177	3.1	6.33	31.94	30.40
BR7640-44-2-1	126	116.1	224	3.5	0.02	0.07	0.01
BR7640-42-3-3	124	116.2	236	3.5	0.02	0.05	0.00
BR7642-11-2-2	128	113.5	220	3.7	0.17	1.22	0.38
BR 11 (Sus ck)	138	97.9	228	3.1	7.97	20.97	21.00
RD 4 (Res ck)	134	85.8	197	2.0	11.09	19.32	22.89
BG 400-1 (Res ck)	134	88.8	192	2.3	11.35	22.02	26.17
LSD (0.5)	-	4.23	31.36	0.38	-	-	-

Seeding: 2 Aug 2011, Transplanting: 24 Aug 2011.

followed by IR83873-B-B-47-4 (3.6 t/ha) and IR82635-B-B-145-1 (3.6 t/ha). The yield of other eleven lines ranged from 2.0 to 3.4 t/ha. Among the eleven lines, yield of three lines was similar to that of the check variety BINA dhan7 (3.3 t/ha) and yield of seven lines was similar to those of BRRI dhan49 (2.7 t/ha), IR64 (2.7 t/ha) and Guti Swarna (2.5 t/ha). The lowest yield was observed in IR80461-B-79-3 (2.0 t/ha) (Table 6). Growth duration of some materials (IR83376-B-B-71-1, IR83873-B-B-47-4, IR82589-B-B-84-3, IR83383-B-B-141-2, IR83381-B-B-137-1 and IR80461-B-79-3) was similar to the check IR64 (106 days). Among the lines, IR83377-B-B-93-3, BR IR83376-B-B-130-2, IR83383-B-B-129-4 was selected as the first, second and third ranking lines respectively through farmers' participation.

Multi location trial (MLT) of some rice genotypes, Boro 2011-12

Nine lines along with the check BRRI dhan28 was in Boro 2011-12. The highest yield (5.9 t/ha) was found in the test line BR7358-5-3-2-1 followed by BR7358-56-2-2-1 (5.7 t/ha), BR7372-117-3-4-3 (5.6 t/ha) and BRRI dhan29-Sc3-28-16-10-8 (5.6 t/ha). The lowest yield having the lowest panicles/m^2 was observed in the test line BRRI dhan29-Sc3-28-16-10-2 (4.1 t/ha) and BRRI dhan29-Sc3-28-16-10-6 (4.2 t/ha). Growth duration of the tested materials was similar to those of the

Table 6. Participatory variety selection (PVS), T. Aman 2011.

Designation	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	1000-grain wt (gm)	Yield (t/ha)*
IR83388-B-B-108-3	74.8	112	251	22.3	2.9
IR83383-B-B-129-3	78.7	113	304	22.7	2.7
IR83376-B-B-71-1	80.1	105	292	24.4	3.4
IR83383-B-B-129-4	83.1	115	256	23.2	3.1 (3^{rd})
IR83873-B-B-47-4	84.1	107	277	25.2	3.6
IR83376-B-B-130-2	93.4	112	255	24.1	3.3 (2^{nd})
IR83377-B-B-93-3	88.3	113	288	25.3	3.8 (1^{st})
IR82589-B-B-84-3	92.0	106	188	22.2	2.7
IR82635-B-B-75-2	102.5	114	160	22.1	2.8
IR82635-B-B-145-1	99.0	112	202	22.0	3.6
IR80411-B-49-1	77.3	126	271	22.5	2.5
IR83383-B-B-141-2	82.9	108	316	25.8	3.0
IR83381-B-B-137-1	84.9	109	277	21.5	3.2
IR80461-B-79-3	81.5	104	221	23.1	2.0
BINA dhan7 (ck)	76.3	117	355	33.1	3.3
IR64 (ck)	76.0	106	299	23.7	2.7
BRRI dhan49 (ck)	75.1	127	355	17.8	2.7
Guti Swarna (ck)	77.8	130	385	19.0	2.5

*Yield was reduced due to gall midge infestation. Seeding: 2 Aug 2011, Transplanting: 25 Aug 2011.

check variety BRRI dhan28 except BRRI dhan29-Sc3-28-16-10-2, BRRI dhan29-Sc3-28-16-10-6, BRRI dhan29-Sc3-28-L16-4-HR2 and BR7873-5(NIL)-51-HR6. Growth duration of BRRI dhan29-Sc3-28-16-10-8 and BRRI dhan29-Sc3-28-16-10-6 was two weeks shorter and BRRI dhan29-Sc3-28-L16-4-HR2 as well as BR7873-5(NIL)-51-HR6 was one week longer than BRRI dhan28 (Table 7).

CROP-SOIL-WATER MANAGEMENT

Terminal drought mitigation through integrated approaches

Approach 1. The experiment was conducted at IETC, BWDB, Kushtia commonly known as Baradi farm in T. Aman 2011. The experimental design was RCB with three replications. BR11 was used for the experiment with two treatments. The treatments were- W_1=Supplemental irrigated, W_2=Rainfed condition. Thirty-day-old rice seedlings were transplanted with 60 cm buffer zones. Individual plot size was 5- × 3-m with 20- × 20-cm spacing. In the treatment W_1 crop was established applying supplemental irrigation on 17 July. In the treatment W_2, transplanting was done when sufficient rainfall occurred and it was on 31 July. Supplemental irrigation was applied when water level in PVC pipe placed at a corner of each plot went down 25 cm from the top. A USWB Class A evaporation pan and a rain gauge were installed near the experimental field for determining rainfall and evaporation amounts during the growing season of rice.

Approach 2. A long duration variety (BR11) and a short duration variety (BRRI dhan33) were tested during T. Aman season. There were four treatments with three replications in the experiment and the treatments were- T_1=Transplanting date July 10, T_2=Transplanting date July 17, T_3=Transplanting date July 24, T_4=Transplanting date July 31. Thirty-day-old rice seedlings were transplanted after proper land preparation with 20- × 20-cm spacing. The drought amount (water deficit in soil) was calculated using drought model (developed by Dr. Towfiqul Islam). Figure 1 shows the annual rainfall amount from 2002 to 2011, which was analyzed. In 2011, total annual rainfall was 1128 mm, which is considerably less than average annual rainfall of this region (1478 mm). The rainfall occurrence situation is so alarming that

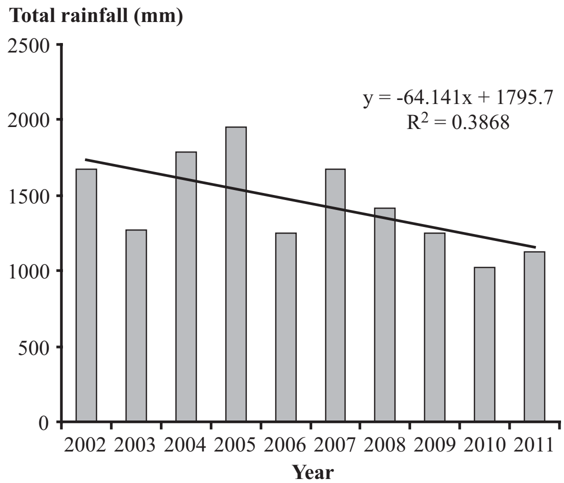


Fig. 1. Annual rainfall (2002-11).

Table 7. Multi location trial of some rice genotypes, CSISA, Boro 2011-12.

Designation	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	1000-grain wt (gm)	Yield (t/ha)
BR7372-117-3-4-3	83.5	149	313	18.8	5.6
BR7358-5-3-2-1	94.3	148	261	22.1	5.9
BR7358-56-2-2-1	104.5	152	347	21.5	5.7
BRRI dhan29-Sc3-28-16-10-6	78.3	135	223	21.9	4.2
BRRI dhan29-Sc3-28-16-10-2	84.9	136	213	22.3	4.1
BRRI dhan29-Sc3-28-16-10-8	83.7	151	305	20.1	5.6
BR7372-18-2-1-HR1	95.7	150	232	27.7	4.9
BR7873-5(NIL)-51-HR6	91.2	155	356	17.6	5.3
BRRI dhan29-Sc3-28-L16- 4-HR2	88.6	157	301	21.4	4.8
BRRIdhan28 (ck)	101.4	149	305	21.6	5.4
LSD (0.5)	1.9	1.7	28.2	1.10	0.26

Seeding: 7 Dec 2011, Transplanting: 22 Jan 2012.

the crop is not getting rain water in time and is suffering from terminal drought.

Result

Approach 1 (Water management). Table 8 presents water requirement and water applied at different stages of rice growing period. The total amount of evapotranspiration (ET) and seepage and percolation (S and P) was considered as water requirement. W_1 was transplanted on 17 July (timely transplanting applying supplemental irrigation) and W_2 on 31 July (rainfed condition). In the treatment W_1, water requirement (excluding land preparation water) was 625.9 mm during the vegetative stage and 888.8 mm of water was applied including land preparation water with rainfall (638.8 mm) to meet that water requirement. But in the treatment W_2, water was not supplied and only rainfall (836.9 mm) met 557.1 mm of water requirement excluding water required for land preparation. Two supplemental irrigations (200 mm) for land preparation at vegetative stage and one supplemental irrigation (50 mm) at reproductive stage were applied to mitigate water requirement in the treatment W_1. On the contrary, treatment W_2 depended only on rainfall. Treatment W_2 suffered from terminal drought due to late transplanting and shortage of rainfall. The yield performances of both the treatments showed the impact of terminal drought at the reproductive stage on yield (Table 9). In treatment W_1 (supplemental irrigation) yield was increased by1.3 t/ha compared to W_2, which was about 29% of the yield. The early transplanting of T. Aman through supplemental irrigation ensured that T. Aman effectively mitigated the terminal drought occurred at reproductive stage and at vegetative stage during T. Aman 2011.

Approach 2 (Transplanting dates). Table 10 shows drought amount at different growth stages of rice for different transplanting dates. For BRRI dhan33, the highest drought amount was observed for transplanting date 10 July and the lowest for transplanting date 31 July in T. Aman 2011. Table 10 also shows that the variety faced drought in the vegetative stage for different transplanting dates except 31 July. In ripening stage drought occurred for all transplanting dates. In case of BR11, the highest and the lowest drought amount were observed for transplanting dates 10 July (117.5 mm) and 31 July (97.8 mm) respectively. The highest drought amount was observed in the vegetative stage for 10 July transplanting date, but drought was not observed for 31 July transplanting. The drought amount was highest at the reproductive stage for the rice transplanted on 31 July (34.0 mm), though drought was not observed for that transplanting date at the vegetative stage. Figure 2 and 3 presents the drought patterns during the rice growing period for all transplanting dates for BRRI dhan33 and BR11 respectively. BRRI dhan33 transplanted on 31 July yielded higher (5.1 t/ha) than the other treatments (Table 11). 31 July transplanting did not suffer from drought during its vegetative and reproductive stages. It only faced drought in the ripening stage and total drought amount throughout the growing season was the lowest (57.0 mm) for

Table 8. Growth stage-wise water requirement and water application in T. Aman 2011.

Treatment	Water requirement			Water applied			
	ET (mm)	S and P (mm)	Total (mm)	Rainfall (mm)	Irrigation (no.)	Irrigation (mm)	Total (mm)
				Vegetative stage			
W_1	215.9	410	625.9	638.8	2*	250	888.8
W_2	186.1	371	557.1	836.9	0	0	836.9
				Reproductive stage			
W_1	113.1	210	323.1	240.3	1	50	290.3
W_2	103.9	210	313.9	41.9	0	0	41.9
				Ripening stage			
W_1	72.0	210	282	0.0	0	0	0.00
W_2	72.0	210	282	0.0	0	0	0.00

*Water required for land preparation considered as supplemental irrigation. W_1=Supplemental irrigation, W_2=Rainfed condition, ET=Evapo-transpiration, S and P=Seepage and percolation.

Table 9. Yield performance for supplemental irrigation application and rainfed condition, T. Aman 2011.

Treatment	Plant ht (cm)	Panicle (no./m^2)	Yield (t/ha)	Yield loss in rainfed condition (t/ha)	Yield loss (%)
W_1	119	256	5.9	1.3	29.4
W_2	112	244	4.5		

W_1=Supplemental irrigation, W_2=Rainfed condition.

Table 10. Drought amount at different growth stages of rice in T. Aman 2011.

Treatment	Vegetative stage (mm)	Reproductive stage (mm)	Ripening stage (mm)	Total (mm)
		BRRI dhan33		
T_1=10 Jul	49.8	0	27.0	76.8
T_2=17 Jul	35.0	0	39.0	74.0
T_3=24 Jul	13.0	0	51.0	64.0
T_4=31 Jul	0	0	57.0	57.0
		BR11		
T_1=10 Jul	49.8	8.0	59.8	117.5
T_2=17 Jul	35.0	14.0	65.8	114.8
T_3=24 Jul	13.0	24.0	64.8	101.8
T_4=31 Jul	0	34.0	63.8	97.8

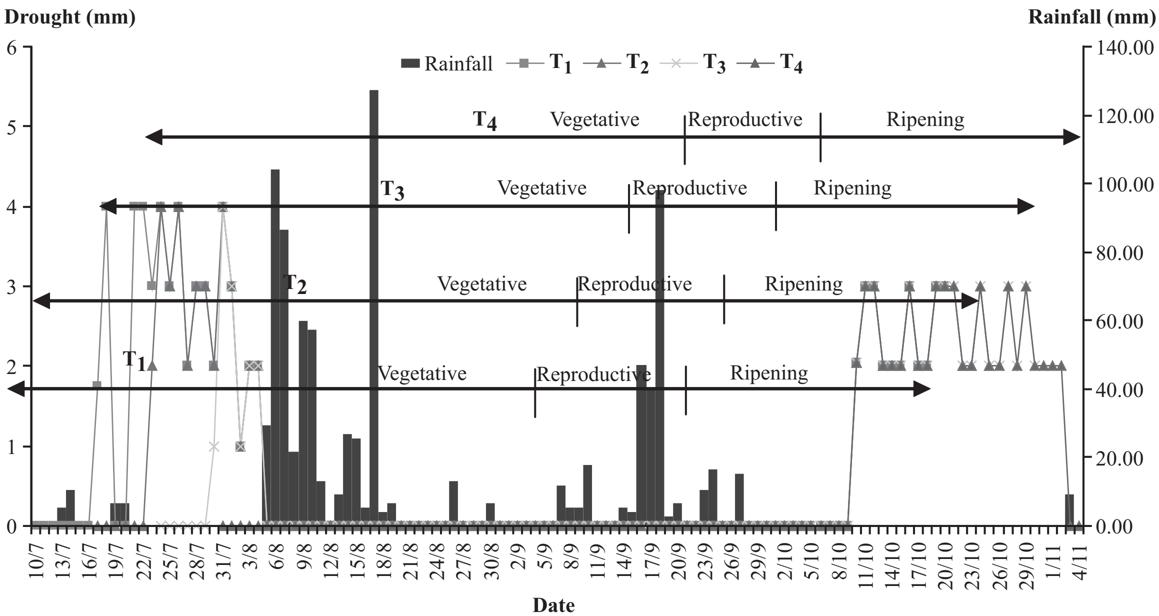


Fig. 2. Drought patterns for BRRI dhan33.

the rice transplanted on 31 July. For BR11, the highest yield was found for 24 July transplanting (5.3 t/ha) and this was followed by 10 July transplanting (5.0 t/ha). The lowest yield was observed in case of 17 July (4.5 t/ha) transplanting which suffered drought (14.0 mm) at the reproductive stage (Tables 10 and 11).

The early transplanting of T. Aman through supplemental irrigation ensured that T. Aman effectively mitigated the terminal drought occurred at the reproductive stage and at the vegetative stage in T. Aman 2011. Both the short and long duration T. Aman rice varieties suffered less drought and showed good yield performance when they were transplanted on 24 July to 31 July. In T. Aman 2011, suitable transplanting dates were between 24 July and 31 July for BRRI dhan33 and BR11 respectively.

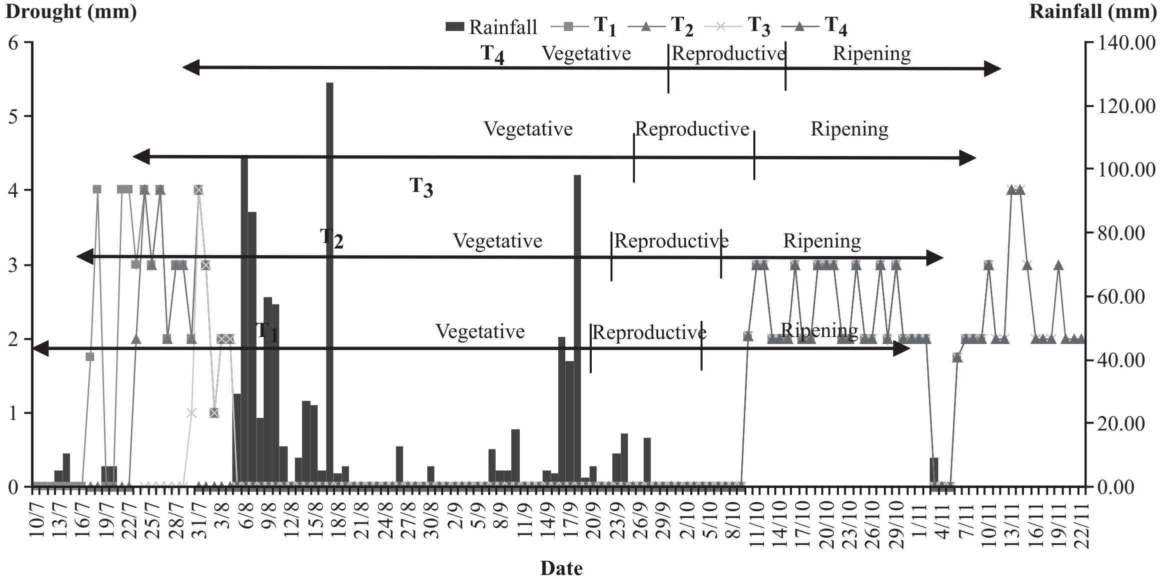


Fig. 3. Drought patterns for BR11.

Table 11. Yield and yield components for different transplanting dates, T. Aman 2011.

Treatment	Plant ht (cm)	Panicle (no./m^2)	Yield (t/ha)
	BRRI dhan33		
T_1=10 Jul	112	218	3.6
T_2=17 Jul	107	220	3.7
T_3=24 Jul	106	225	4.4
T_4=31 Jul	104	244	5.1
	BR11		
T_1=10 Jul	113	252	5.0
T_2=17 Jul	113	244	4.5
T_3=24 Jul	111	254	5.3
T_4=31 Jul	109	209	4.6

Determination of suitable time for application of supplemental irrigation

BRRI dhan49 was used in this experiment during T. Aman 2011 season. There were three treatments with three replications in the experiment and the treatments were; T_1=Supplemental irrigation applied when water level reaches at 5 cm below ground surface, T_2=Supplemental irrigation applied when water level reaches at 10 cm below ground surface, T_3=Supplemental irrigation applied when water level reaches at 15 cm below ground surface. BRRI recommended cultural and fertilizer management practices were followed in growing the crop. Thirty-day-old seedlings were transplanted after proper land preparation with 20- × 20-cm spacing. Individual plot size was 5- × 3-m, separated by 60 cm buffer zone. Supplemental irrigation was applied according to different treatment (T_1, T_2 and T_3). A USWB Class A evaporation pan and a rain gauge were installed near the experimental field for determining rainfall and evaporation amounts during the rice growing season.

Figure 4 represents water level, rainfall occurrence and supplemental irrigaiton during the rice growth stages. In this graphical presentation, only critical stages (mainly reproductive stage and some parts of vegetative and ripening stages) were considered. Because, crop suffered from water stresses during these periods. Figure 4 shows supplemental irrigation application times and depths. So, one supplemental irrigation was applied in vegetative stage. Then irrigation was applied in most critical stages, ie, reproductive stage and in early part of ripening stage (Fig. 4). The number of supplemental irrigation application was one in each stage for all the treatments. The depth of irrigation water was 5 cm above the ground surface in all irrigation applications. Though the water level depth of each treatment was taken care properly, interval of irrigation application among the treatments was very short. So, it was observed that

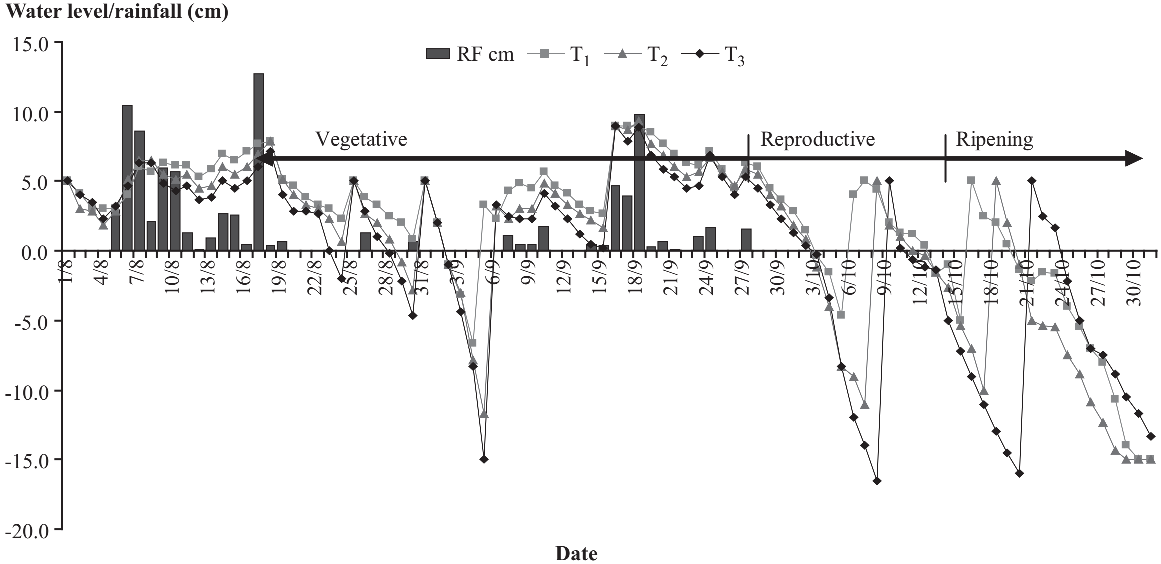


Fig. 4. Water level and irrigation application in critical stages for different treatment.

comparatively greater amount of irrigation water was required in T_3 than that of the other two treatments. There was no considerable yield difference among the treatments (Table 12). The highest yield was found in T_3 (5.6 t/ha) and the lowest in T_2 (5.3 t/ha); and yield difference was only six percent. In terms of yield performances, T_3 performed slightly better than the other two treatments but interval of irrigation application in all the treatments was very short. So, these results do not indicate any suitable time of irrigation application (suitable water depth below ground surface). Therefore, more trials are needed to reach a final conclusion.

PEST MANAGEMENT

Parasitism rate of rice leaf folder

Rice leaves with the symptoms of leaf folder infestation were collected from three locations of Kushtia sadar upazilla during T. Aman 2011. The leaves were kept individually in test tubes. The open ends of the test tubes were closed by cotton wads with a few drops of water inside the tube to keep the leaves moistened. Thus the leaf folder larvae were reared for 20-25 days until completion of parasite emergence.

Two parasitoids - one *Elasmus* sp. (Elasmidae) and one *Eulophid* were found to parasitize the leaf folder larvae. *Elasmus* sp. parasitized 8.3 to 14.3% in different occasions. The *Eulophid* parasitoid was found in one occasion only and parasitism rate by it was only 5% (Table 13).

SOCIO ECONOMICS AND POLICY

Stability analysis of BRRI varieties

An experiment on the yield performance of BRRI varieties was conducted at the Baradi farm of BWDB, Kushtia in T. Aman 2011 and another in farmer's field at Kushtia sadar in Boro, 2011-12 season. Twenty-three BRRI developed rice varieties were taken into consideration in each season.

Table 14 presents the yields and growth duration of the test varieties of the T. Aman season. Among the varieties the highest yield was obtained with the BRRI dhan31 and BRRI dhan41 (5.7 t/ha) and the lowest with the BR5 (3.7 t/ha). Of the 23 varieties, 18 were found to give higher yield than the standard yield determined for them. The other varieties yielded similar or lower than the standard yield. The highest increase in yield was obtained with BRRI dhan41 (increase by 1.2 t/ha), where as

Table 12. Yield and yield components for supplemental irrigation depth, T. Aman 2011.

Treatment	Plant ht (cm)	Tiller (no./m^2)	Panicle (no./m^2)	1000-grain wt (gm)	Yield (t/ha)
T_1	110.5	581	275	20.3	5.4
T_2	111.1	526	282	19.7	5.3
T_3	112.8	539	299	20.4	5.6

T_1=Supplemental irrigation applied when water level reaches at 5 cm below ground surface, T_2=Supplemental irrigation applied when water level reaches at 10 cm below ground surface, T_3=Supplemental irrigation applied when water level reaches at 15 cm below ground surface. Seeding: 17 Jun 2011, Transplanting: 17 Jul 2011.

Table 13. Rate of parasitism of rice leaf folder, Kushtia sadar in T. Aman 2011.

Collection date	Larvae collection (no.)	Larvae infested (no.)		% parasitism	
		Elasmus sp.	*Eulophid*	*Elasmus* sp.	*Eulophid*
11 Sept 2011	60	5	3	8.3	5.00
17 Oct 2011	141	18	0	12.8	0.00
3 Nov 2011	49	7	0	14.3	0.00

Table 14. Yield and growth durations of some BRRI varieties in T. Aman 2011.

Variety	Growth duration (day)	Standard growth duration (day)	Yield (t/ha)	Standard yield (t/ha)	Rank
BR3	134	145	5.0	4.0	13
BR4	145	145	5.3	5.0	09
BR5	153	150	3.7	3.0	23
BR10	138	150	4.6	5.5	19
BR11	139	145	4.8	5.5	15
BR22	157	150	5.4	5.0	07
BR23	158	150	5.2	5.5	11
BR25	135	135	4.8	4.5	16
BRRI dhan30	141	145	5.6	5.0	03
BRRI dhan31	140	140	5.7	5.0	01
BRRI dhan32	136	130	5.6	5.0	04
BRRI dhan33	119	118	5.0	4.5	14
BRRI dhan34	144	135	3.9	3.5	21
BRRI dhan37	148	140	3.9	3.5	22
BRRI dhan38	150	140	4.0	3.5	20
BRRI dhan39	126	122	4.7	4.5	18
BRRI dhan40	146	145	5.4	4.5	08
BRRI dhan41	153	148	5.7	4.5	02
BRRI dhan44	145	145	5.5	5.5	05
BRRI dhan46	152	124	4.8	4.7	17
BRRI dhan49	139	135	5.5	5.5	06
BRRI dhan51	141	142	5.3	4.5	10
BRRI dhan52	142	145	5.2	5.0	12

Seeding: 29 Jun 2011, Transplanting: 26 Jul 2011.

the highest reduction was found in case of BR10 (0.9 t/ha reduction). Growth duration of some of the test varieties decreased (up to 12 days as in the case of BR10), whereas in some varities it increased (up to 28 days as in the case of BRRI dhan46). Lodging at different magnitudes (30-60%) was observed in case of five test varieties viz BR5, BR25, BRRI dhan32, BRRI dhan34 and BRRI dhan38.

Table 15 presents the yields and growth duration of the test varieties of the Boro season. Among the varieties the highest yield was obtained with the BRRI dhan36 (5.9 t/ha) and the lowest with the BR3 (3.1 t/ha). Of the 23 varieties, four were found to give higher yields than the standard yield determined for them. The other varieties yielded lower than the standard yield. The highest increase in yield was obtained with BR6 and BR26

Table 15. Yield and growth durations of some BRRI varieties in Boro 2011-12.

Variety	Growth duration (day)	Standard growth duration (day)	Yield (t/ha)	Standard yield (t/ha)	Rank
BR1	157	150	4.7	5.5	07
BR2	156	160	4.7	5.0	08
BR3	167	170	3.1	6.5	23
BR6	148	140	5.8	4.5	02
BR7	161	155	4.1	4.5	16
BR8	158	160	4.5	6.0	15
BR9	157	155	4.6	6.0	12
BR12	167	170	3.5	5.5	20
BR14	155	160	4.6	6.0	13
BR15	161	165	4.6	5.5	14
BR16	161	165	3.2	6.0	22
BR17	156	155	4.7	6.0	09
BR18	161	170	4.0	6.0	17
BR19	166	170	3.3	6.0	21
BR26	150	115	5.3	4.0	05
BRRI dhan27	156	115	4.7	4.0	10
BRRI dhan28	144	140	5.7	6.0	03
BRRI dhan29	160	160	4.7	7.5	11
BRRI dhan35	160	155	4.0	5.0	18
BRRI dhan36	149	140	5.9	5.0	01
BRRI dhan45	142	145	5.6	6.5	04
BRRI dhan47	152	152	4.0	6.0	19
BRRI dhan50	157	155	4.8	6.0	06

Seeding: 15 Dec 2011, Transplanting: 3 Feb 2012.

(increase by 1.3 t/ha), where as the highest reduction was found in case of BR3 (3.4 t/ha reduction). Growth duration of some of the test varieties decreased (up to 9 days as in the case of BR18), where as in some varieties it increased (up to 35 days as in the case of BR26). Lodging tendency was not found in the BRRI varieties during Boro season.

TECHNOLOGY TRANSFER

Yield gap minimization of rice (MRYG)

BRRI dhan49 was used for two locations viz Shailkupa, Jhenaidah sadar and BR10 was used in Kotchandpur under Jhenaidah district in T. Aman 2011. On the other hand BRRI dhan28 was used for all of these three locations during Boro 2011-12. There were two treatments in this demonstration. One was BRRI recommended practice, which covered in 66 decimals area; another was farmer's practice had a coverage in 33 decimal area. Twenty-three to 35-day-old seedlings in T. Aman and 35-40-day-old seedlings in Boro were planted in 66 decimal area following BRRI recommended practices. The other 33 decimal areas were cultivated following farmer's own practices. Data were taken on the yield and some agronomic characteristics.

Field that was cultivated following BRRI recommended practices produced higher yield than that were following farmer's practices in all the three locations during T. Aman season. Yield advantage was 0.86, 1.9 and 1.21 t/ha in Shailkupa, Jhenaidah sadar and Kotchandpur respectively. Overall, 32.3% yield was increased by BRRI recommended practices (Table 16). In Boro season, yield advantage was 1.2, 0.8 and 0.7 t/ha in Shailkupa, Jhenaidah sadar and Kotchandpur respectively. Overall, 13.3% yield increase was found in BRRI recommended practices (Table 17) during this season.

Farmers' training

In total, five farmers' training programmes were conducted with the cooperation of the Department of Agricultural Extension (DAE) in different upazila's of Kushtia sadar and Meherpur district. The numbers of participants ranged between 25 and 35 in the programmes. Modern rice varieties

Table 16. Yield and some agronomic characteristics, yield gap minimization of rice (MRYG), T. Aman 2011.

Variety	Treatment	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	Yield (t/ha)	Increased over FP	Yield advantage (%)
			Shailkupa				
BRRI dhan49	RP	105.7	131	375	4.7	0.86 (22.6)	
	FP	103.2	132	320	3.8		
			Jhenidah sadar				
BRRI dhan49	RP	110.4	137	311	6.2	1.9 (44.2)	32.3
	FP	91.4	139	306	4.3		
			Kotchandpur				
BR10	RP	117.6	141	370	5.2	1.21 (30.0)	
	FP	111.2	141	300	4.0		

RP-BRRI recommended practices, FP-Farmer’s practices.

Table 17. Yield and some agronomic characteristics, yield gap minimization of rice (MRYG), Boro 2011-12.

Variety	Treatment	Plant ht (cm)	Growth duration (day)	Panicle (no./m^2)	Yield (t/ha)	Increased over FP	Yield advantage (%)
			Shailkupa				
BRRI dhan28	RP	104.9	138	354	7.3	1.2 (19.7)	
	FP	95.7	140	337	6.1		
			Jhenidah sadar				
BRRI dhan28	RP	111.0	142	438	8.5	0.8 (10.5)	13.3
	FP	109.5	141	415	7.6		
			Kotchandpur				
BRRI dhan28	RP	105.8	139	390	7.9	0.7 (9.7)	
	FP	99.3	139	372	7.2		

RP-BRRI recommended practices, FP-Farmer’s practices.

and associated technologies were discussed with the help of colourful transparencies and slides for easy understanding of the farmers.

Field day and agricultural fair

Three field day programme were conducted at Shailkupa, Jhenaidah sadar and Kotchandpur upazila in Jhenaidah district under yield gap minimization project. Another one field day programme was conducted at Boria, Kushtia under CURE WG1 project on BRRI developed technologies where about 550 farmers attended.

We participated in one agricultural fair arranged by DAE, Kushtia district in which BRRI developed technologies were demonstrated. This programme generated much enthusiasm about modern rice production technologies among the visitors.

BRRI RS, Rajshahi

SUMMARY

The selected 50 genotypes in OYT yielded from 1.2 to 3.5 t/ha under reproductive stage stress compared to check varieties 0.7-2.1 t/ha. The genotype IR87656-21-1-1-4 produced the highest yield (3.5 t/ha) and showed about 100 days growth duration for stress conditions and 110 days for control.

Nineteen genotypes out of 39 from AYT stress were selected. IR83377-B-B-93-3 and IR83376-B-B-86-3 produced the highest yield (3.1 t/ha) with harvest index (0.45).

IR83377-B-B-42-3 and IR83383-B-B-140-2 both produced the highest yield (3.1 t/ha) at stress condition and was a little lower than moderately drought tolerant check variety Apo and BRRI dhan33 (3.3 t/ha).

IR87707-446-B-B-B produced the highest yield (1.9 t/ha) in stress condition compared to BINA dhan7 (1.2 t/ha) from NIL. The growth duration was 12-16 days shorter than the control condition.

IR82635-B-B-145-1, IR82635-B-B-75-2 and IR82589-B-B-84-3 stood 1st, 2nd and 3rd drought stress in PVS trial and IR83383-B-B-141-2, IR83383-B-B-129-4 and IR82635-B-B-145-1 in control condition. IR82635-B-B-145-1 showed the preference for both rain-fed drought stress and control.

Only 15 of 58 hybrids yielded more than 8 t/ha. The entry H-791 produced the highest yield (9.02 t/ha) with a growth duration of 160 days.

All the test genotypes for RYT T. Aus gave better yield compared to the standard check BR26 (2.48 t/ha) and BRRIdhan48 (2.55t/ha). BR7413-14-3-3 produced the highest yield (3.37 t/ha) followed by BR7417-6-1-2 (3.07 t/ha).

All the genotypes from RYT T. Aman showed tolerance to lodging. Yield was the highest (5.16t/ha) for the check BRRI dhan49 followed by IR51491-AC5-4-SC3-20-3-15 (4.91 t/ha).

Among the tested entries from RYT 1 Boro, BR7372-18-2-1-HR1 produced the highest yield (5.56 t/ha) followed by BR7358-19-3-1-1 (5.29 t/ha) but none found better than the check Minikit (5.62 t/ha).

BR7358-35-2-1-1 produced the highest yield (5.96 t/ha) from RYT 2 Boro, followed by BR7358-35-3-2-1 (5.54t/ha) which produced 1.0-1.5 t/ha more yield advantage than the check varieties BRRI dhan28 (4.49 t/ha) and BRRI dhan50 (4.36 t/ha).

BR7831-74-1-5-2 (5.44 t/ha) and BR7840-54-2-5-1 (5.22 t/ha) yielded better than the standard check BRRI dhan28 (4.16 t/ha) and BRRI dhan29 (5.17 t/ha) from micro-nutrient dense rice.

Grain yield amazingly declined with increased seedling age. Irrespective of genotype, the highest mean grain yield (4.74 t/ha) was obtained with 25-day-old seedlings transplanted. IR83377-B-B-93-3 produced the highest mean grain yield (4.67 t/ha) that was at par with IRRI 123 (4.66 t/ha). In general, grain yield reduced with increased seedling age conceivably due to less vegetative growth and less effective tillers.

Irrespective of genotype and planting date, the highest mean grain yield (4.82 t/ha) was obtained that transplanted on 16 July and was at par with 1 August planting (4.71 t/ha). Among rice genotypes, IR83377-B-B-93-3 produced the highest yield (4.74 t/ ha) followed by IRRI 123 (4.65 t/ha) in rain-fed environment. It turned out from the experiments that 16 July to 1 August is the suitable time for transplanting of the promising drought tolerant rice genotypes.

Most of the pyramid lines showed resistant reaction against the bacterial blight pathogen under artificial inoculation. The susceptible check Purbachi and TN1 showed very sensitive reaction. IRBB54, IRBB55 and IRBB57 exhibited most resistant reactions against BB in Rajshahi region.

Only Power blast was found effective in controlling (89.48%) sheath blight disease.

The fungicide 'Controller' reduced 57% disease over control plot but was not up to the mark (80%).

Fungal infection level in the silage at divisional and local district storage was similar. A total of 46 samples of rice tested for the presence of aflatoxins. None of the samples contained aflatoxin B_1 above the UNICF/WHO/FAO maximum permissible level of 30 µg/kg (ppb) in foods for human consumption. Aflatoxin B_1 was not detected in the tested samples.

Stem borer (SB), green leaf hopper (GLH), brown plant hopper (BPH) and white leaf hopper

(WLH) were the most prevalent insect pests. Among the natural enemies, staphylinid beetles were the most prevalent predator followed by carabid beetles, earwig, ladybird beetles and damsel fly. Most of the insect pests had one peak of occurrence in October and natural enemies had two peaks of occurrence in November and April.

The highest panicle/m^2 (194) was recorded in conservation tillage. There were significant variation of grain yield due to the treatments. Conventional transplanting method produced the highest mean yield (4.28 t/ha) and permanent bed showed the highest gross margin (Tk 25,879).

In Aman season, 400, 160 and 160 kg seeds of BRRI dhan49, BRRI dha53 and BRRI dhan54, respectively were produced and 2390, 445 and 455 kg seeds of BRRI dhan28, BRRI dhan29 and BRRI dhan50 respectively in Boro. Five one-day farmers training on rice technologies were conducted under climate change project in which 175 farmers including 10 female farmers and four SAAO participated.

VARIETAL DEVELOPMENT

Observational yield trial (OYT) at reproductive stage in drought stress environment

One hundred and ninety-five genotypes along with four checks (International; IRRI 119, IR64 and MTU 1010, local; Guti Swarna) were sown on 28 July 2011 to select genetically fixed lines with uniform plant height, uniformity in heading and grain type along with grain yield under reproductive stress condition. Twenty-four-day-old seedlings were transplanted following Augmented design on 22 August 2011 in a 3.75 m × 3 rows plot with 25- × 15-cm spacing using single seedling for transplanting. Fertilizers as N, P, K, S and Zn @ 83, 15, 38, 10.6 and 1.5 kg/ha from urea, TSP, MOP, gypsum and zinc sulphate @ 180, 75, 75, 60 and 7.5 kg/ha were used. TSP, MOP, gypsum, zinc sulphate and one-third urea was applied as basal during final land preparation. Rest of the urea was top dressed in two equal splits at early tillering (10 DAT) and mid tillering stages (25 DAT). Crop management were done as and when necessary. Drought stress was initiated by cutting levee after four weeks of transplanting through proper draining of water from the field up to maturity. Same set of genotypes along with the checks with same seedling age were grown under control condition. Experimental design, plot size, spacing, crop management, fertilizer doses and application were same as stress field condition except standing water was retained in the field from transplanting up to two weeks after flowering. Data on water table depth, rainfall, phenotypic acceptance at vegetative and maturity, plant height, days to 80% maturity and grain yield (t/ha) were recorded.

The selected 50 genotypes yielded from 1.2 to 3.5 t/ha under reproductive stage stress whereas check varieties yielded 0.7-2.1 t/ha under same condition. The genotype IR87656-21-1-1-4 produced the highest yield (3.5 t/ha) and showed about 100 days growth duration for stress conditions and 110 days for control. The tested genotypes started (50%) flowering from 12 October and continued until 9 November. During the rainless period water table depth was 80-85cm from the surface. Soil moisture remained 12-14% in initial flowering period and gradually decreased up to 4-5% on 5 November which indicated that crop experienced severe drought stress during flowering stage. During reproductive stage crop also received some drought stress indicated by leaf rolling and leaf drying. Results indicates that the grain yield of all the genotypes was higher under control condition than in stress except very few cases. The higher yield in control condition expressed the yield potential under normal field condition of those genotypes.

Advanced yield trial (AYT) for breeding lines with 100-120 days

Fifty genotypes including six checks (International, IR64 and local, BRRI dhan39, BRRI dhan49, BRRI dhan56, BINA dhan7 and Guti Swarna) were sown on 29 July 2011 to select desirable genotypes with high yield under drought stress at reproductive stage. Twenty-six-day-old seedlings were transplanted on 25 August 2011 in a 4.05 m × 4 rows plot with 25- × 15-cm spacing using single seedling. The trial was set in Aplha Lattice design with two replications. Fertilizers as N, P, K, S and

Zn @ 83, 15, 38, 10.6 and 1.5 kg/ha from urea, TSP, MOP, gypsum and zinc sulphate were used. TSP, MOP, gypsum, zinc sulphate and one-third urea was applied as basal during final land preparation. Rest of the urea was top dressed in two equal splits at early tillering (10 DAT) and mid tillering stage (25 DAT). Crop management were done as and when necessary. Same set of genotypes along with the checks with same seedling were grown under control condition. Experimental design, plot size, spacing, crop management, fertilizer doses and application of fertilizers were same as stress field condition except standing water was retained in the field from transplanting up to two weeks after flowering. Water table depth, rainfall, phenotypic acceptance at vegetative and maturity, leaf rolling at vegetative stage, plant height, days to 80% maturity, grain yield (t/ha) and harvest index (HI) in stress condition were recorded.

Nineteen genotypes out of 39 genotypes were selected based on yield, agronomic characteristics and drought stress. The genotypes along with checks started flowering from 3rd week of October and continued up to 13 November. During the flowering period water table depth was 20-80 cm below from the surface. Water table depth was gradually decreased until flowering period. Results indicates that crop experienced severe drought stress. Soil moisture gradually decreased from15 to 11%. Severe leaf rolling and leaf drying was also occurred.

In stress condition, the highest yield was observed for genotype IR83377-B-B-93-3 and IR83376-B-B-86-3 (3.1 t/ha) followed by IR83383-B-B-141-4 (2.8 t/ha), IR83383-B-B-129-4 (2.6 t/ha) and IR83894-B-B-46-4 (2.6 t/ha). Some of the genotypes showed 1.7-2.1 t/ha yield advantage over the check varieties. The highest yielding genotype showed optimum harvest index (0.45) under stress condition. Almost all the genotypes produced higher yield under stress condition than in control. This result indicates the potential of drought tolerant genotypes under normal field condition. Growth duration varied from 6-10 days between stress and control condition. It also indicates that growth duration may be shorter or longer for specific genotype because of drought stress.

Advanced yield trial (AYT Gazipur) 100-120 days at reproductive stage drought stress and control conditions

Twenty-two genotypes including five checks-BRRI dhan33, BRRI dhan39, BINA dhan7, IR64 and Apo were evaluated in both the drought stress and control conditions in Aman 2011 at Alimganj, Paba and BRRI RS, Rajshahi to select desirable genotypes with high yield under drought stress at reproductive stage. Thirty-day-old seedlings were transplanted on 4 September 2011 in a 4.05 m × 4 rows plot with 25- × 15-cm spacing using single seedling for transplanting. The trial was set in Aplha Lattice design with two replications. Fertilizers as N, P, K, S and Zn @ 83, 15, 38, 10.6 and 1.5 kg/ha from urea, TSP, MOP, gypsum and zinc sulphate @ 180, 75, 75, 60 and 7.5 kg/ha were used. TSP, MOP, gypsum, zinc sulphate and one-third urea was applied as basal during final land preparation. Rest of the urea was top dressed in two equal splits at early tillering (10 DAT) and mid tillering stage (25 DAT). Crop management were done as and when necessary. Same set of genotypes were grown under control condition. Experimental design, plot size, spacing, crop management, fertilizer doses and application of fertilizers were same as stress field condition except standing water was retained in the field from transplanting up to two weeks after flowering. Data on water table depth, rainfall, phenotypic acceptance at vegetative and maturity, leaf rolling at vegetative stage, plant height, days to 80% maturity, grain yield (t/ha) and HI in stress condition were recorded.

The genotypes along with checks flowered at the 3rd week of October to the last week of October in stress condition. Soil moisture was 11% and after rainfall on 23 October and again decreased to 4%. Leaf rolling and leaf drying was observed for the tested and check varieties. Among the test entries IR83377-B-B-42-3 and IR83383-B-B-140-2 both of them produced the highest yield (3.1 t/ha) at stress condition and was little lower than moderately drought tolerant check variety Apo and BRRI dhan33 those produced 3.3 t/ha.

Evaluation of IR64 NILs at reproductive stage in drought stress condition, Aman 2011

Three genotypes- IR77707-446-B-B-B, IR77707-

445-B-B-B, IR77707-182-B-B-B genotypes along with two checks (International, IR64 and local, BINA dhan7) were sown on 31 July 2011 to select desirable genotypes with high yield under drought stress at reproductive stage. Twenty-five-day-old seedlings were transplanted on 23 August 2011 in a 3.90 m × 4 rows plot with 25- × 15-cm spacing using single seedling for transplanting. The trial was set in Aplha Lattice design with two replications. Fertilizers as N, P, K, S and Zn @ 83, 15, 38, 10.6 and 1.5 kg/ha from urea, TSP, MOP, gypsum and zinc sulphate @ 180, 75, 75, 60 and 7.5 kg/ha were used. TSP, MOP, gypsum, zinc sulphate and one-third urea was applied as basal during final land preparation. Rest of the urea was top dressed in two equal splits at early tillering (10 DAT) and mid tillering stage (25 DAT). Crop management were done as and when necessary. Same set of genotypes along with the checks with same seedling age were grown under control field condition. Experimental design, plot size, spacing, crop management, fertilizer doses and application of fertilizers were same as stress field condition except standing water was retained in the field from transplanting up to two weeks after flowering. Data on water table depth, rainfall, phenotypic acceptance at vegetative and maturity, leaf rolling at vegetative stage, plant height, days to 80% maturity, grain yield (t/ha) and HI in stress condition were recorded.

All the genotypes along with checks flowered at 3rd week of October in stress conditions. During the flowering period water table depth was 80 cm below the surface. Leaf rolling and leaf drying was observed for the tested and check varieties. IR87707-446-B-B-B produced the highest yield (1.9 t/ha) in stress condition compared to BINA dhan7 (1.2 t/ha). Growth duration was 12-16 days shorter than the control condition.

Evaluation of drought tolerant donors at reproductive stage in drought stress condition

Fourteen genotypes including two checks- IR64 and Swarna were sown on 28 July 2011 to select desirable genotypes with high drought tolerance at reproductive stage. Twenty-five day-old seedlings were transplanted on 23 August 2011 in a 3.75 m × 6 rows plot with 25- × 15-cm spacing using single seedling for transplanting. The trial was set up in Aplha Lattice design with two replications. Data on water table depth, rainfall, phenotypic acceptance at vegetative and maturity, leaf rolling at vegetative stage, plant height, days to 80% maturity, grain yield (t/ha) and HI in stress condition were recorded.

The tested genotypes along with checks flowered at the 3rd week of October. During the flowering period water table depth was 80 cm below the surface. Leaf rolling and leaf drying were observed for the tested and check varieties. The highest yield (1.5 t/ha) was found from PIN KAEO in stress condition.

Evaluation of F_2 population under drought stress

Nineteen F_2 populations were evaluated under drought stress to select suitable progenies for drought prone rain-fed environment. Approximately, 2500-3000 plants were grown from each cross. Thirty-day-old seedlings were transplanted @ 1 seedlings/hill with 25- × 15-cm spacing. Fertilizer as N, P, K, S and Zn were applied @ 83, 15, 38, 10.6 and 1.5 kg/ha from urea, TSP, MOP, gypsum and zinc sulphate. One third N and full amount of P, K, S and Zn were applied at the time of final land preparation. Rest of the N was applied in two equal splits at 10 and 25 DAT. Selection of desirable progenies at maturity and preservation of F_2 seeds with proper labels for handling segregating population was done.

About 264 desirable progeny populations were preserved for Aman 2012. From panicle initiation to maturity period (25 September to 21 October) crop faced severe drought stress.

Participatory variety selection (PVS) under drought stress and control environment in Aman 2011

Two field trials were conducted under drought prone rain-fed environment at Paba, Rajshahi and controlled condition at BRRI RS, Rajshahi during July-November 2011 to evaluate and select drought tolerant rice germplasm suitable for the northwest Bangladesh where rice yield drastically reduced due to drought. Eighteen rice genotypes including four check varieties BRRI dhan49, BINA dhan7, IR64 and Guti Swarna were evaluated. Twenty-two day-old seedlings were transplanted on 21 August 2011 with 20- × 15-cm spacing in Alpha Lattice design. Fertilizers P, K, S and Zn @ 15, 38, 10.6 and 1.5 kg/ha from TSP, MOP, gypsum, zinc sulphate and one-third urea were applied during final land preparation. Rest of the urea was top-dressed at 20 and 40 DAT. Insecticides and other management practices were done uniformly for all the entries in each location. Forty-five participants including male and female farmers, researchers, extension and NGO personnel were invited to evaluate the genotypes at maturity stage. The genotypes were labelled with codes and hanged a box for vote. The farmers were briefed about the activity. Three positive and three negative ballot papers were supplied to each participant. Also, the farmers were encouraged to put vote fairly. At first, the participants moved around the plots, observed and voted in their own judgments.

Crop of Paba, Rajshahi site faced severe drought at reproductive stage while the BRRI RS, Rajshahi site did not as it was in controlled condition. In drought, the highest grain yield (2.24 t/ha) was found for IR82635-B-B-145-1 followed by IR82589-B-B-84-3 (2.06 t/ha) while the check varieties BRRI dhan49 and Guti Swarna did not produce any yield. Yield of all entries at Paba reduced drastically due to severe drought. In control condition, almost all the germplasm performed well and yield ranged from 4.09 to 5.54 t/ha.

Growth duration of the promising entries was much shorter (about 115 days) than the existing long duration varieties (140 days). Among the entries, IR82635-B-B-145-1, IR82635-B-B-75-2 and IR82589-B-B-84-3 stood 1st, 2nd and 3rd obtaining the preference score 0.149, 0.125 and 0.073 respectively under drought stress. However, the entries IR83383-B-B-141-2, IR83383-B-B-129-4 and IR82635-B-B-145-1 stood 1st, 2nd and 3rd respectively. IR82635-B-B-145-1 showed the preference for both rain-fed drought stress and controlled environment. The selected promising genotypes would be needed to upscale through baby trials. In addition, some entries could not get place but those performed at par with the selected ones. So those entries should be included in the 'Mother' trial along with new lines. It has been committed to supply 2 kg seeds of these lines to respective PVS farmers for growing in their fields under own management as 'Baby' trial in the following Aman season. Regarding drought stress, the germplasm IR82635-B-B-145-1 and IR82635-B-B-75-2 showed enormous prospect in drought prone rain-fed environment to improve farmers' livelihood.

Evaluation of hybrid rice varieties/lines, Boro 2011-12

A total of 58 hybrid rice varieties/lines including check were evaluated at BRRI RS, Rajshahi in collaboration with SCA during Boro 2011-12 to select hybrid rice variety suitable for Boro season. Thirty-two-day-old seedlings were transplanted on 3-5 January 2012 in a spacing of 20- × 15-cm using single seedling/hill in RCB design with three replications. The unit plot size was 5- × 6-m. Fertilizers as urea, TSP, MP, gypsum and $ZnSO_4$ were applied @ 270, 130, 120, 70 and 10 kg/ha. Standard crop management practices were followed for all the entries as and when necessary.

Among the 58 entries, only 15 entries yielded more than 8 t/ha. The entry H-791 produced the highest grain yield (9.02 t/ha) with a growth duration of 160 days followed by H-799 (8.82 t/ha) with a growth duration of 156 days.

Regional yield trial (Upland Aus) 2011-12

Nine genotypes including three checks; BRRI dhan42, BRRI dhan43 and Varia vadya were direct seeded on 23 April 2011 for confirmatory yield evaluation and regional adaptability of promising genotypes. The trial was set in RCB design with three replications. Fertilizers @ 60, 40, 40 kg NPK/ha from urea, TSP, MOP, gypsum and zinc sulphate @ 100 and 10 kg/ha, respectively were applied. The whole amounts of P, K, S and Zn were applied at the time of final land preparation. Nitrogen was applied in three equal splits at 15, 30 and 45 DAS. Crop management practices were done as and when necessary. Data on date of seeding, flowering, 80% maturity, phenotypic acceptance at vegetative and maturity, plant height, grain yield (t/ha) were recorded.

The local variety Varia vadya flowered and matured early among the tested entries, but yield was very low due to tungro infestation. None of the tested genotypes out yielded the check variety BRRI dhan43 (2.50t/ha) but BR7181-2B-2-6 produced comparable yield (2.45 t/ha) and higher than BRRI dhan42 (2.05 t/ha).

Regional yield trial (T. Aus), 2011-12

The genotypes- BR7566-4-4-2, BR7566-39-6-1, BR7569-107-1-3, BR7577-9-1-2, BR7413-14-3-3, BR7417-6-1-1, BR7417-6-1-2 and three checks- B26, BRRI dhan48 and Zirasail were sown on 20 April 2011 to evaluate them in different yield potentials in different regions. Twenty-seven-day-old seedlings were transplanted on 16 May in 5.4 m × 10 rows plot with 20- × 15-cm spacing using 2-3 seedlings per hill. The experimental design was RCB with three replications. Fertilizer doses were 60, 40, 40, 10 kg NPKS/ha form urea, TSP, MOP and gypsum. The whole amount of PKS were applied at the time of final land preparation. Nitrogen was applied in two equal splits at 13 and 29 DAT. Crop management practices were done as and when necessary. Data on date of seeding, transplanting, flowering and maturity, phenotypic acceptance at maturity stages, seedling height, plant height, lodging tolerance and yield/plot were collected.

All the test genotypes produced better yield compared to the standard check BR26 (2.48 t/ha) and BRRI dhan48 (2.55 t/ha). Among them BR7413-14-3-3 produced the highest yield (3.37 t/ha) followed by BR7417-6-1-2 (3.07 t/ha).

Regional yield trial (T. Aman), 2011-12

Two genotypes; IR51491-AC5-4-SC3-20-3-15, IR51491-AC5-4-SC3-20-3-5 and two checks; BR11 and BRRI dhan49 were sown on 4 July 2011 to evaluate specific and general adaptability of the genotypes. Twenty-nine-day-old seedlings were transplanted on 2 August in 5.4 m × 12 rows plot with 25- × 15-cm spacing using 2-3 seedlings per hill. The experimental design was RCB with two replications. Fertilizer doses were 80, 10, 60 kg NPK/ha from urea, TSP, MOP and gypsum and zinc sulphate @ 100 and 10 kg/ha respectively were applied. The whole amounts of P, K, S and Zn were applied at the time of final land preparation. Nitrogen was applied in three equal splits at 10-15 DAT, maximum tillering and before PI stage. Crop management practices were done as and when necessary. Data on date of flowering and maturity, phenotypic acceptance at vegetative and reproductive phases, seedling height, plant height, lodging tolerance and yield per plot were collected.

All the tested genotypes started flowering from second to last week of October. Maturity completed within second and third week of November. All the genotypes showed tolerance to lodging. Yield was the highest (5.16t/ha) for the check BRRI dhan49 followed by IR51491-AC5-4-SC3-20-3-15 (4.91 t/ha).

IRRIGATED ECOSYSTEM

Regional yield trial (RYT-1), Boro 2011-12

The experiment was conducted in Boro season at the BRRI RS, Rajshahi to evaluate general and specific adaptability of the selected genotypes- BR7358-36-2-2-1, BR7358-19-3-1-1 and the standard checks- BRRI dhan28, BRRI dhan50 and Minikit. The unit plot size was 5.4 m × 12 rows. Two to three seedlings were transplanted with 25- × 15-cm spacing. The experiment was laid out in RCB design with three replications. Fertilizer doses were 135, 20, 60 kg NPK/ha from urea, TSP, MOP and gypsum and zinc sulphate @ 20 and 4 kg/ha. The whole amounts of P, K, S and Zn were applied at the time of final land preparation. Nitrogen in three equal splits at 10-15 DAT, maximum tillering and before PI stage respectively, was applied during land preparation. Crop management practices were done as and when necessary. Data on date of flowering and maturity, phenotypic acceptance at vegetative and reproductive phases, seedling height, plant height, lodging tolerance and yield per plot were collected.

Among the tested entries, BR7372-18-2-1-HR1 produced the highest yield (5.56 t/ha) followed by BR7358-19-3-1-1 (5.29 t/ha). However, none of the entries found better than the check variety Minikit (5.62 t/ha).

Regional yield trial (RYT-2), Boro 2011-12

The experiment was conducted in Boro season at the BRRI RS, Rajshahi to evaluate general and specific adaptability of the selected genotypes; BR7358-35-2-1-1, BR7358-35-3-2-1, BR7358-35-3-3, BR7372-22-1-4-4, BR7372-30-1-1 in comparison with standard checks BRRI dhan28 and BRRI dhan50. The unit plot size was 5.4 m × 12 rows. Two to three seedlings were transplanted with 25- × 15-cm spacing. The experiment was laid out in RCB design with three replications. Fertilizer doses were 135, 20, 60 kg NPK/ha from urea, TSP, MOP and gypsum and zinc sulphate @ 20 and 4 kg/ha. The whole amount of P, K, S and Zn were applied at the time of final land preparation. Nitrogen was applied in three equal splits at 10-15 DAT, maximum tillering and before PI stage. Crop management practices were done as and when necessary. Data on date of flowering and maturity, phenotypic acceptance at vegetative and reproductive phases, plant height, lodging tolerance and yield per plot were collected.

All the tested entries gave better yield than the standard checks except BR7372-30-1-1. Among the tested entries, BR7358-35-2-1-1 produced the highest yield (5.96 t/ha) followed by BR7358-35-3-2-1 (5.54t/ha) which produced 1.0-1.5 t/ha more yield advantage than the check varieties- BRRI dhan28 (4.49 t/ha) and BRRI dhan50 (4.36 t/ha).

Evaluation of micronutrient dense breeding lines in RYT

The experiment was conducted in Boro season at the BRRI RS, Rajshahi to evaluate general and specific adaptability of the selected genotypes. Ten genotypes along with two check BRRI dhan28 and BRRI dhan29 were sown on 1 December 2011 and transplanted on 7 January 2012. The unit plot size was 5.4 m × 12 rows. Two to three seedlings were transplanted with 25- × 15-cm spacing. The experiment was laid out in RCB design with three replications. Fertilizer doses 92, 17, 50 NPK kg/ha from urea, TSP, MOP, S and Zn from gypsum and zinc sulphate @ 100 and 10 kg/ha respectively were applied. P, S, Zn and ½ doses of K were applied at the time of final land preparation. Nitrogen was applied in three equal splits at 15 DAT, 30 DAT and 5 Days before PI stage. Rest of ½ K was applied at second and third splits of urea. Crop management practices were done as and when necessary. Data on date of seeding, transplanting, flowering and maturity, phenotypic acceptance at vegetative and reproductive phases, plant height, lodging tolerance and yield/plot were collected.

Among the tested entries, BR7831-74-1-5-2 (5.44 t/ha) and BR7840-54-2-5-1 (5.22 t/ha) produced better yield than the standard check BRRI dhan28 (4.16 t/ha) and BRRI dhan29 (5.17 t/ha). Most of the entries produced better yield than BRRI dhan28.

CROP-SOIL-WATER MANAGEMENT

Effect of nutrient rates on the performance of promising rice genotypes

The experiment was conducted at the BRRI RS, Rajshahi during July to December 2011 to evaluate promising rice genotypes under a range of nutrient supplies and to determine optimum dose of nutrients for better performance of the rice genotypes in rain-fed environment. The experimental field was in High Gangetic River Floodplain under AEZ 11, having silty loam soil with pH range from 8.0 to 8.5. Four levels of fertilizer were used in the experiment. The genotypes IR83377-B-B-93-3, IRRI123, IR83381-B-B-6-1 and check varieties BRRI dhan56, BRRI dhan57 and BINA dhan7 were used in the experiment. The experiment was laid out in strip-plot design with three replications. Fertilizer treatments were- F_1=No fertilizer, F_2=66.7% of STB, F_3=STB, F_4=133.4% of STB were in main plot and genotypes- BRRI dhan56, BRRI dhan57, IR83377-B-B-93-3, IRRI123, IR83381-B-B-6-1 and BINA dhan7 were in sub-plot with unit plot size 3- × 4-m. Twenty-two-day-old seedlings were transplanted on 26 July 2011 with 20- × 15-cm spacing. Fertilizers were applied from TSP, MOP, gypsum and zinc sulphate. Urea was top dressed in three equal splits on 6 August, 22 August and 7 September 2011. Proper crop protection measures were taken as and when necessary. The experiment was conducted under rain fed condition, however the crop was irrigated a bit to synchronize urea fertilizer top dressing. Data were analyzed using the statistical package CROPSTAT.

Grain yield, yield components and vegetative characteristics were significantly influenced by different levels of nutrient rates. Fertilizer responses of genotypes indicates that increased level of fertilizer for F_1 to F_4 increased yield. However, the increasing trend was sharp from F_1 to F_3 level and then it was slow from F_3 to F_4. Irrespective of rice genotype, the highest mean grain yield (5.17 t/ha) was obtained in F_4 where 33.3% higher amount of fertilizers applied over the soil test based (STB) rates (F_3) while the lowest yield was obtained in (F_1). Yield increased 34.4, 47.2 and 50.1% in F_2, F_3 and F_4 respectively over the control (F_1) treatment. Response of the genotypes to yield and agronomical characteristics was significantly affected by the nutrients rates. Among the rice genotypes, the highest mean grain yield (4.53 t/ha) was found from IR83377-B-B-93-3, which was at par with IRRI123 (4.38 t/ha). The results indicates that the genotypes IR83377-B-B-93-3, IRRI123 and BINA dhan7 were more efficient to utilize applied nutrient up to the highest dose while the other three genotypes responded up to STB (F_3) dose. Mean growth duration increased 3, 5 and 6 days in F_2, F_3 and F_4 respectively compared to F_1. Generally, higher growth duration was found in the treatments where higher amount of nutrients was applied compared to lower dose.

Response of rice genotypes to late planting in rain fed environment

The experiment was conducted at the BRRI RS, Rajshahi during July to December 2011 to investigate the effect of late planting and seedling age on growth and yield of the genotypes and determine the factors affecting the ability of genotypes to cope with late planting. The experimental field was in AEZ 11, silty loam soil with pH range 8.0-8.5. Three levels of seedling age for transplanting-

- T_1=25-day-old seedlings,
- T_2=35-day-old seedlings and
- T_3=45-day-old seedlings were used in the experiment.

The genotypes were IR83377-B-B-93-3, IRRI 123, IR83381-B-B-6-1 and check varieties BRRI dhan56, BRRI dhan57 and BINA dhan7. The seedlings for T_1 transplanted when its age was 25 days, 35 days and 45 days. Strip-plot design was followed with three replications. Seedlings of all the treatments were sown on 6 July 2011 and transplanted on 1, 11 and 21 August 2011 respectively. Seedlings were transplanted in 20- × 15-cm spacing @ 3 seedlings per hill. Unit plot size was 3- × 5-m. Fertilizers N, P, K, S and Zn @ 83, 15, 30, 11 and 2.7 kg/ha from urea, TSP, MOP, gypsum and zinc sulphate were used. TSP, MOP, gypsum and zinc sulphate were applied as basal during final land preparation. Urea was applied in three equal splits at early tillering (10 DAT), mid tillering (25 DAT) and panicle initiation stage (40 DAT) respectively in each treatment. Uniform crop protection measures were taken as and when necessary for all the planting dates. Crop from center 6 m^2 area of each plot was harvested at the maturity stage. After threshing grains were cleaned, sun-dried to record grain weight/6m^2, adjusted to 14% moisture and grain yield calculated.

Yield and agronomic attributes were significantly affected by the treatments. Grain yield amazingly declined with increased seedling age. Irrespective of genotype, the highest mean grain yield (4.74 t/ha) was obtained in T_1 while transplanted 25-day-old seedlings followed by 35-day-old seedlings (4.14 t/ha). Grain yield reduced by 14.4% in the treatment T_2 by using 35-day-old seedlings while it was 37.2% in T_3 planted 45-day-old seedlings. Generally, yield reduced in treatments that was transplanted with older seedlings. Except the growth duration, all other parameters like HI and sterility, reduced with the increased seedling age. Growth duration was statistically affected by seedling age and genotypes. In general, growth duration sharply increased with increased seedling age.

Among the tested genotypes, IR83377-B-B-93-3 produced the highest mean grain yield (4.67 t/ha) that was at par with IRRI 123 (4.66 t/ha). In general, grain yield reduced with increased seedling age conceivably due to less vegetative growth and less effective tillers. Moreover, pest infestation was higher in the late-planted plots. The highest mean sterility (25.06%) was found in BRRI dhan57 followed by IR83381-B-B-6-1 (24.75%). BRRI dhan57 produced significantly finer grain (19.54 g).

Effect of planting date on the performance of the promising rice genotypes at drought prone northwest Bangladesh

The experiment was conducted at the BRRI RS, Rajshahi during June to December 2011 to find out the optimum planting date of the rice genotypes for better performance and to investigate the climatic effect on crop establishment, growth and yield. The experimental field was in AEZ 11 having silty loam soil with pH ranges from 8.0 to 8.5. Five planting dates were-

- T_1=1 July,
- T_2=16 July,
- T_3=1 August,
- T_4=16 August and
- T_5=1 September followed in the experiment.

The test entries IR74371-70-1-1, IR83377-B-B-93-3, IRRI123 and check varieties- BRRI dhan56, BRRI dhan57 and BINA dhan7 were used in the trial. The experiment was laid out in strip-plot design with three replications. Transplanting dates were in main plots and genotypes in sub-plots. Unit plot size was 3- × 5-m. Twenty-two-day-old seedlings were transplanted for every transplanting time as per treatments with 20- × 15-cm spacing. Fertilizers as N, P, K, S and Zn @ 83, 15, 38, 10.6 and 1.5 kg/ha from urea, TSP, MOP, gypsum and zinc sulphate were used in the experiment. TSP, MOP, gypsum and zinc sulphate were applied as basal during final land preparation. Urea top dressed in three equal splits at early tillering (10 DAT), mid tillering (25 DAT) and panicle initiation stage (40 DAT) for each planting. Uniform crop protection measures were taken as and when necessary for all the planting dates. Crop from center 6-m^2 area of each plot was harvested at the maturity stage for yield data. After threshing grains were cleaned, sun-dried to record grain weight/6m^2. Grain yield was adjusted with ton per hectare at 14% moisture content. The data were analyzed using the statistical package CROPSTAT.

Yield and agronomic characteristics were significantly affected by transplanting dates. Irrespective of genotypes the planting dates, the highest mean grain yield (4.82 t/ha) was obtained in the treatment T_2 transplanted on 16 July that was at par with 1 August planting (4.71 t/ha). Significant grain yield reduction was observed for rice planted in delayed planting started on 16 August and thereafter, while substantial reduction occurred at early planting on 1 July. It was significantly lower than rice planted in 16 July and 1 August planting. Grain yield drastically reduced in delay planting started on 16 August and on ward might be due to weather factors like less rainfall and lower temperature at vegetative and reproductive stage. The lowest mean grain yield (2.96 t/ha) was found in 1 September planting as the crop suffered by terminal drought as well as low temperature followed by 16 August planting (3.90 t/ha). Yield of the 1 July planting was also higher, however the crop faced more biotic and abiotic stresses (rat damage, insect pest infestation, more rain, lodging etc.) at reproductive stage so that the yield reduced compared to the 16th July and 1 August planting. Moreover, the low grain yield was associated with shortened growth period, lower panicle density, lower biomass accumulation at heading, lesser grains per panicle than early planted rice. Harvest index was also significantly affected by treatments and followed the similar trend of grain yield. It was the highest in 16th July planting and the lowest was in 1th September planting, perhaps due to the vegetative growth as well as yield was dramatically declined. Sterility increased in delayed planting. Panicles/m^2, 1000 grain weight and plant height of 1 July to 16 August planting were statistically similar, however it was reduced thereafter.

Genotypes had significant effect on yield and yield contributing characteristics. Irrespective of treatment among rice genotypes, IR83377-B-B-93-3 produced the highest yield (4.74 t/ ha) followed by IRRI 123 (4.65 t/ha). Genotypes IR83377-B-B-93-3, BRRI dhan56 and IRRI123 having lower sterile spikelet performed well even under drought stress in the late planting. Panicles per unit area was the highest for IRRI 123 (304.82) followed by BINA dhan7 (297.22). Finally, it could be concluded that 16 July to 1 August is the suitable time for transplanting of the promising drought tolerant rice genotypes to attain better yield.

Disease management

Performance of bacterial blight resistant pyramid lines in different AEZs of Bangladesh, Boro 2011-12. Fourteen genotypes of bacterial blight (BB) resistant pyramid lines were collected from IRRI and evaluated in Rajshahi against BB under artificial inoculation conditions to find out the genotypes suitable for Rajshahi region condition/specific locations against BB of rice. Seeds were sown on 11 December 2011. The seedlings were transplanted in the field on 22 January 2012. The unit plot size was 1 m^2. The experiment was laid out in RCB design with three replications. Inoculation was done 7 May 2012 with 7-day-old culture of bacterial suspension. The isolate was BXo9. The data were collected after 14 days of inoculation from 10 hills of each entry

Most of the pyramid lines showed resistant reaction against the BB pathogen under artificial inoculation. The susceptible check Purbachi and TN1 showed very sensitive reaction. Among the tested materials IRBB54, IRBB55 and IRBB57 exhibited most resistant reactions against BB in Rajshahi region.

Chemical control of sheath blight disease. Nineteen fungicides were tested against sheath blight disease using BR11 as test materials in T. Aman 2011 at BRRI Rajshahi station to find out the efficacy of new fungicides against sheath blight disease. Thirty-day-old seedlings were transplanted in 20- × 15-cm spacing. Recommended fertilizer and other agronomic management were done as and when necessary. Artificial inoculation was done at the maximum tillering stage by inserting growing mycelial PDA plug of *Rhizoctonia solani* inside the base of hill (just above water line). Two consecutive sprays at 6 and 17 days after inoculation were done when clear sheath blight symptoms appeared.

Only Power blast was found effective in controlling (89.48%) sheath blight disease.

Chemical control of false smut disease. Seven fungicides were tested against false smut disease using BRRI dhan49 as test materials in T. Aman 2011 at BRRI RS, Rajshahi to find out effective fungicides in controlling false smut disease of rice. Thirty-one-day-old seedlings were transplanted in 20- × 20-cm spacing. Recommended fertilizer and other agronomic management were done as and when necessary. Two consecutive sprays were done at PI and flowering stages. The experiment was conducted under natural incidence of false smut disease. There was severe incidence of false smut disease in the experimental field.

The fungicide 'Controller' reduced 57% disease over control plot but was not up to the mark (80%). Percent hill infection of control plot was higher than treated plot, although number of infected florets per panicle was the highest in 'Cuprofix' treated plot.

Bacterial blight resistant variety. The experiment was conducted to iIntrogress BB resistance genes into BRRI dhan28 and BRRI dhan29. In this experiment, BRRI dhan28 and BRRI dhan29 were used as recipient and IRBB65 and IRBB66 as donor. IRBB65 and IRBB66 are pyramid lines and have combination of resistant gene against bacterial blight. For synchronization of male and female parents we arranged five set of sowing and transplanting dates. Thirty-eight-day-old seedlings were transplanted at five days interval starting from 5 January 2012. Plot size was 1.20- × 1.20-m and spacing was 20- × 15-cm. Both hand emasculation and hot water treatment were done for hybridization.

F_1 seeds available for the crosses between-

- BRRI dhan28×IRBB65=17,
- BRRI dhan28×IRBB66=17 panicles,
- BRRI dhan29×IRBB65=11 panicles and
- BRRI dhan29×IRBB66=19 panicles.

The obtained seeds would be sown in following Boro season to confirm F_1 using molecular techniques and backcrosses would be done with recipient parents. Subsequent backcross would be done to obtain BB resistant variety.

Detection of fungi and mycotoxin production. Brown rice samples were collected from different silage and examined under microscope following ISTA rules to detect fungi, to identify the fungus associated in stored grain and to detect the mycotoxin. Seed associated fungi including toxin producing fungi were detected. The moisture content in the rice (wet weight basis) was estimated using a Kett PBTK moisture meter. The grain samples in sealed polythene bags were stored at -58°C for aflatoxin estimations. Estimation of aflatoxin was done in the following process.

Rice grains were ground to a fine powered Udy cyclone mill. The samples were extracted by the modified 70% aqueous acetone procedure; (i) Solid-liquid extraction with acetone and water, (ii) Clean up with SPE cartridges (Phenyl), (iii) Elution with chloroform and (iv) Dry and reconstitute to 1 m L with mobile phase for HPLC analysis.

Sample analysis. HPLC system Agilent-1100 series with Flourosence detector, HPLC column was C_{18}. Mobile phase was 630 m L water, 220 m L methanol, 150 m L acetonitrile in isocratic mode with 1 m L flow rate. Total run time was 15 minutes and injection volume 20 µL. Column oven temperature was 30°C.

Quality control of the analysis. (i) Recovery was calculated of aflatoxins (B_1, B_2, G_1 and G_2) fortified at 2 µg/kg, 10 µg/kg, 20 µg/kg, 100 µg/kg and 200 µg/kg levels using peak area of chromatograms was found 90-92%. (ii) Suitable seven point calibration curve was done, preferably on matrix at 0.5 ng/mL, 2 ng/mL, 10 ng/mL, 25 ng/m L, 50 ng/mL, 100 ng/mL, and 250 ng/mL (µg/kg) level. Linear regression was 0.99. (iii) The method was validated as per European Commission decision (2002). The detection limit was 0.5 µg/kg, decision limit (CC_α) was 4.34 µg/kg and detection capacity (CC_β) was 4.64 µg/kg.

Fungal infection level in the silage at divisional and local district storage was also determined and it was similar for both at silage and local storage. A total of 46 samples of rice were tested for the presence of aflatoxins. None of the samples contained aflatoxins B_1 not above the UNICEF/WHO/FAO maximum permissible level of 30 µg/kg (ppb) in foods for human consumption. Aflatoxin B_1 was not detected in 41 among the tested samples. Among the 46 samples which contained below 30 µg/kg collected from different silage. Five samples are more likely to be colonized by the fungi may be due to high moisture levels in them caused by improper drying or higher humidity. But when with self-sufficiency in rice, we may face problems of aflatoxin accumulation associated with longer periods of storage and higher moisture levels as observed with prolonged storage of improperly dried rough rice.

Insect management

Monitoring of rice insect pests and natural enemies. Light trap was operated regularly and rice insect pests and their natural enemies were monitored in light trap at BRRI RS, Rajshahi during July 2011 to June 2012 to study the pest and their natural enemy incidence pattern in rice fields and to create a database.

Stem borer (SB), green leaf hopper (GLH), brown plant hopper (BPH) and white leaf hopper (WLH) were the most prevalent insect pests. Among the natural enemies, staphylinid beetles were the most prevalent predator followed by carabid beetles, earwig, ladybird beetles and damsel fly. *Nephotettix nigropictus* dominated over *Nephotettix virescens*. Yellow stem borer was the most prevalent stem borer species followed by pink borer. Most of the insect pests had one peak of occurrence in October and natural enemies had two peaks of occurrence in November and April.

Evaluation of botanicals against yellow stem borer. Two botanical, neem *(Azadirachta indica)* oil and mahogany *(Swietenia macrophylla)* seed extract, were evaluated against yellow stem borer (YSB) in T. Aman at field of BRRI RS, Rajshahi and two in Boro to verify efficacy of some botanicals against stem borer. The trials were conducted in 60 m^2 plots with BRRI dhan49. The experiment was laid out in a CRD with six replications. Virtako, a registered and popular insecticide was included as standard check in evaluation trial. This trial was conducted at the maximum tillering stage. YSB egg masses were placed in six hills (one egg mass/hill) when the egg masses were at hatching initiation stage and each hill was confined by mylar film cage. Botanicals and insecticide were sprayed two to three hours before egg mass placing in the field. Five percent crude neem oil collected from the local market of Chapai Nawabganj district was used for spraying purpose. Few drops of nonidet were used in spray volume as emulsifying agent.

Mahogani seed extract were collected by boiling in water and used @ 0.5kg/Bigha. Number of white head was counted 25-30 days after spraying.

Both neem oil and mahogany seed exracts were effective as compared to the insecticide Virtako against yellow stem borer reducing dead heart 71.23, 74.89 and 84.08% respectively over control.

Farmers' participatory insecticidal management of yellow stem borer. On-station (BRRI RS, Rajshahi field) and On-farm (at Palashi, Godagari, Rajshahi) experiments were conducted in RCBD with three replications to evaluate the farmers' practice of controlling yellow stem borer by commonly used granular insecticide. BRRI dhan49 was used in both the locations. There were six different treatments in the experiment; Total control (prophylactic, 10 days interval granular application), Untreated control (no insecticide), insecticide at 1st top dress (after mid tillering, 30-35 DAT), insecticide at 2nd top dress (50-55 DAT), ETL based control and mechanical control (eg hand picking of egg mass). Dead heart (DH) and white head (WH) numbers were counted twice, at mid tillering stage and flowering stage.

ETL was not crossed by the insect damage in both the locations. In BRRI, Rajshahi, stem borer infestation ranged between 0.16% to 0.58% dead hearts (DH) and 0.58 to 1.27% white head (WH). Dead hearts were lower (0.16%) in total control plot but WH were not significantly different in all the treatment plots. Untreated control plot had lower infestation than all treated plots. Total control plots produced significantly ($p=0.05$) higher yield than the other treatment plots. Stem borer infestation (DH/WH) had no effect on these higher yields). In Palashi, Godagari, DH ranged from 0.96 to 1.56% at vegetative stage but after flowering WH were visible 2.09 to 2.76%. There were no significant difference in yield though stem borer infestation varied among the treatment plots. The preventive applications of granular insecticide (Carbofuran) are not effective even when applied at the recommended dose, or applied more than once per season. It is important to apply insecticide on the basis of economic return or an economic threshold level. Thus we can conclude that there is no need of using preventive insecticide against stem borer in rice.

RICE FARMING SYSTEMS

Effect of conservative tillage on the productivity of Aman tice under Rice-Maize-Mungbean systems

The experiment was conducted in farmers' fields in kharif 1 season to evaluate effect of conservation tillage on Aman rice cultivation under Rice-Maize-Mungbean system and to find out the extent of resource conservation through conservation tillage. Conventional tillage (Farmers' practice) was compared with five type of conservation tillage systems. The treatments were-

- T_1=Conventional tillage (CT),
- T_2=Zero tillage (ZT),
- T_3=strip tillage (ST),
- T_4=minimum tillage (MT) using PTOS,
- T_5=Fresh bed and
- T_6=Permanent bed.

BRRI dhan49 was established by DSR in case of conservation tillage practices and conventional transplanting as check. Strip and Minimum tillage was done by PTOS machine through one-pass, seed dropping was done simultaneously. Bed was formed by bed planter as well as seed was sown with this planter. Zero tillage was done by lithao and the seed was sown manually. Except conventional tillage, Glyphosate (Round up) was applied in conservation tillage treatments seven days before seeding in the land for weed control. Another pre-emergence herbicide, Pendamethalin was used at 2 DAS. In case of transplanting, seeds were sown in seed bed on the same day. Thirty-day-old seedlings were transplanted with a spacing of 20- × 15-cm with 2-3 seedlings per hill. Total amount of P, K, S and Zn were applied as basal fertilizers. Half of the N fertilizer was applied at 15 DAT and the rest at 35 DAT. One hand weeding was done to the bed planting and PTOS plots within 30 DAS. Transplanted plot were usually weeded twice.

The results indicate that the tiller/m^2 and the panicle/m^2 were unaffected under different cultivation techniques. The highest panicle/m^2

(194) was recorded in CT treatment followed by ST (191). There were significant variation of grain yield due to the treatments and conventional transplanting method produced the highest mean yield (4.28 t/ha) followed by FB (4.00 t/ha). It was also found that highest gross margin was in the PB treatment (Tk 25,879) and that the lowest in ZT treatment (Tk 16,866).

BRRI RS, Rangpur

SUMMARY

An on station experiment was conducted with four entries to evaluate submergence tolerant varieties under submerged condition. Among them IR64-Sub1 showed higher survival rate (90%).

PVS function was arranged as on-station PVS mother trial of Sub1 entries at Rangpur. Participating farmers selected PVS-2 (Ceharang-Sub1) and PVS-3 (IR64-Sub1) as the best material.

In pedigree experiment 291 tolerant progenies and 61 bulk populations were selected with desirable agronomic characters at maturity in 18 days submergence.

Seventeen genotypes of IRRI origin selected from OT along with one check variety were evaluated under controlled stagnant water stress condition. The yield performances of the test entries for medium stagnant water ranged from 2.74 to 3.3 t/ha and the range of growth duration was 168 to 177 days. Based on overall performances, it might not be possible to promote any entries to further yield trials due to very long growth duration.

Three mother trials were conducted through GO/NGO collaboration in three different locations of northern district of Bangladesh. PVS function was arranged as on-farm PVS mother trial of Sub1 entries at Alambiditor, (Gongachora, Rangpur) for preference analysis during Aman 2011. Participating farmers selected PVS-3 (IR64-Sub1) as the best material.

Both in Aman and Boro seasons soil test based (STB) fertilizer recommendation produced the highest yield among all treatments followed by fresh poultry litter (applied at 6 t/ha).

Twelve hours water layered at night time appeared to better compared to the other treatments for quality seedlings against cold weather in winter season.

In Rice-Maize-Mungbean system, maize grown under conventional tillage after puddle transplanted rice produced significantly lowest yield (7.4 t/ha) compared to the rest of the treatments (8.0-8.5 t/ha). In case of rice the highest rice yield (4.77 t/ha) was found in ZTDSR plots (after ZT maize).

The effect of plant population on yield and yield components of maize in 2011-12 was studied. Grain yield was significantly the highest (8.7-9.2 t/ha) for 75000 plants/ha (60 × 22 cm) and 82000 plants/ha (55 × 22 cm).

Dry direct seeded rice with short duration variety and crop diversification is a suitable technology for northern part of Bangladesh to overcome climate change situation. Dry DSR by PTOS produced the highest grain yield (4.56 t/ha).

The trial was conducted in control condition (inside tank) during T. Aman with different nutrient management in nursery bed and seedling age was used as treatments. $N_2D_2T_2$ (N_2=N-P_2O_5-K_2O : 75-40-40 (25 kg N through 5 t/ha of FYM and remaining 50 kg N, D_2=25 g/m^2, T_2=40-day-old seedlings) found the best treatment of all parameters studied.

From the spacing management trial the output of the experimental observation showed, 15- × 20-cm plant spacing is suitable for BRRI dhan51 and BRRI dhan52 showed the best result with 20- × 20-cm spacing. Two seedlings per hill appeared as the best option for both varieties.

In nitrogen management after de-submergence for quick recovery experiment showed that 10 days after flood water recession was the best for recovery, survivality and yield. N_3 fertilizers option showed better performance for yield and survivality.

A total of 12,541 kg breeder seeds of six varieties and 7,519 kg TLS of fifteen varieties were produced and disseminated during 2010-11.

VARIETAL DEVELOPMENT

Mother trial with Sub1 genotypes under participatory variety selection (PVS) in northern Bangladesh

The experiment was conducted in Rangpur to evaluate submergence tolerant varieties under control submergence condition. Three submergence tolerant genotypes along with a check variety BRRI dhan33 were evaluated in three different planting conditions- completely submergence for 18 days (T_1), rainfed (T_2) and Bolan (double transplanting) (T_3). PVS-1 (PSBRC82-Sub1) and PVS-4 (BRRI dhan33) were damaged in 18 days submergence condition and maximum plant survived with PVS-2

(Ceharang-Sub1) (80%) and PVS-3 (IR64-Sub1) (90%). However PSBRC82-Sub1 performed better and produced higher yield in rainfed and Bolan practice though damaged in submergence condition. Ceharang-Sub1 and IR64-Sub1 showed better in three conditions (Table 1).

Growing and screening of pedigree generation

In pedigree experiment 291 tolerant progenies and 61 bulk populations were selected with desirable agronomic characters at maturity in 18 days submergence.

Evaluation of stagnant flood tolerant (Medium stagnant water tolerance) entries under preliminary and observation yield trial

Seventeen genotypes of IRRI origin selected from OT along with one check variety were evaluated under controlled stagnant water stress condition. The yield performances of the test entries ranged from 2.74 to 3.3 t/ha and the range of growth duration was 168 to 177 days. Based on overall performances of the test entries both under controlled and rainfed conditions, it could be concluded that it might not be possible to promote any entries to further yield trials due to very long growth duration, though the entries possess very good tolerances against both complete submergence and stagnant water stresses. However, some of the entries could be used as parental materials in the breeding programme.

Mother trial under participatory variety selection (PVS) in northern Bangladesh (On farm)

Three mother trials were conducted through GO/NGO collaboration in three locations of northern district of Bangladesh at Alambiditor (Gongachora, Rangpur), Charbudaru (Sadar, Lalmonirhat) and Hathya (Ulipur, Kurigram). PVS function were arranged at Alambiditor, for preference analysis during Aman 2011. In total, 30 farmers, including male 20 and female 10 were participated in the voting activities. Participating farmers selected PVS-3 (IR64-Sub1) as the best material and PVS-4 (BRRI dhan33) as the worst genotypes.

All locations Sub1 lines showed their plant height, tiller and hill more or less same. The highest yield was observed in PSBRC82-Sub1 (4.85) at Charbudaru. Ceharang-Sub1 produced satisfactory yield. Early maturing Sub1 line IR64-Sub1 and modern short duration variety BRRI dhan33 (ck) showed similar yield.

Participatory variety selection (PVS)-Baby trial

Three submergence tolerance high yielding genotypes, having highest votes in PVS function of the previous year, are evaluated in this trial in the submergence prone areas of farmers' field.

CROP-SOIL-WATER MANAGEMENT

Integrated fertilizer management practice for premium quality rice in Aman season 2011

Depletion of soil organic matter and imbalance use of inorganic fertilizer is considered as one of the major threats to sustainability of agriculture of Bangladesh. Here fuel for cooking purposes is limited and cow dung and crop residues are largely used as fuel. That's why the researchers drive to search another organic fertilizer like fresh poultry litter. To find out the suitable ratio of inorganic and organic fertilizer for higher grain yield, an experiment was established in BRRI, RS Rangpur.

Table 1. Performance of Sub1 genotypes in submergence, rainfed, and the practice of Bolan on station mother trial under PVS, BRRI RS, Rangpur, T. Aman 2011.

Entry #	Plant ht (cm)			Tiller (no./hill)			Panicle (no./hill)			Grain yield (t/ha)		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
PVS-1	*	111.3	94.5	*	8.6	9.5	*	8.3	8.6	*	4.1	4.3
PVS-2	96.1	114.0	100.8	9.4	7.3	8.2	8.8	7.3	7.4	3.1	3.8	3.8
PVS-3	91.1	101.6	90.9	9.2	9.0	8.8	8.3	8.1	7.9	3.2	3.1	2.9
PVS-4	*	102.3	100.2	*	6.0	6.5	*	5.2	5.9	*	3.7	3.5
LSD (5%)	6.7	4.6	3.6	1.5	2.9	1.1	1.8	2.8	1.2	0.5	0.5	0.5
CV%	7.2	2.1	1.9	16.2	18.9	7.0	22.0	19.6	8.6	16.0	7.1	7.2

* = Damage.

The experiment was set up in split-split plot design with three replications. Treatments were-

- A. Fertilizer : T_1=STB. T_2=FPL 2.5 t/ha, T_3=FPL 6 t/ha, T_4=STB-N t/ha and T_5=No fertilizer.
- B. Variety : V_1= BRRI dhan34, V_2=BRRI dhan38, V_3= Kataribhog.

In this trial STB produced the highest yield (4.5 t/ha) among all treatments followed by fresh poultry litter (Table 2). No fertilizer or control plot produced the lowest yield (2.1 t/ha). BRRI dhan38 (V_2) yielded the highest.

Integrated fertilizer management practice for premium quality rice in Boro 2011-12

The experiment was conducted during Boro season with three replications to find out the optimum doses of organic and inorganic fertilizers on three different popular rice varieties with the combination of five different fertilizer treatments. Treatments were-

- A. Fertilizer : T_1=STB (yield goal: 6.0-6.5 t/ha; recommended), T_2=Fresh PL @ 2.5 t/ha + 1/2 of N, T_3=Fresh PL @ 6.0 t/ha + 1/3 of N (if necessary), T_4=STB-N (control) and T_5=Absolute control (no fertilizer).
- B. Variety : V_1=BRRI dhan28, V_2=BRRI dhan29, V_3= BRRI dhan50.

T_1V_2 (STB + BRRI dhan29) combination produced the highest grain yield (6.5 t/ha). T_3V_1 combination (Fresh PL @ 6.0 t/ha + 1/3 of N [if necessary] + BRRI dhan28) also produced better yield (5.5 t/ha) than other treatments (Table 3). No fertilizer with three different varieties produced the lowest yield.

Water management for quality rice seedling production in winter

BRRI established an experiment to find out a suitable technology to protect the seedlings from cold weather by using irrigation water treatment in Boro 2011-12 with six different treatments with two sets such as- T_1=12 hour water layered at day time, T_2=Eight hour water layered at day time, T_3=12 hour water layered at night time, T_4=Without water layer (Control), T_5=Polythene box cover and T_6=Flat polythene cover. T_3 (12 hour water layered at night time) produced the highest dry weight in both time of sowing treatments. The control treatment T_4 produced the lowest dry weight (1.1 gm) and (0.7 gm) in both treatments (Table 4). Twelve hours of irrigation water in night time produced the quality seedling, which is followed by 12 hours day time irrigation.

Study on tillage/crop establishment and weed management options on maize in rice-maize-mungbean system

After the harvest of rice in October 2011, maize was grown with two treatments, zero tillage (ZT) and conventional tillage (CT) in each of the ZTDSR, CTDSR, and CTTPR treatments used for rice. The

Table 2. Integrated fertilizer management for three-premium quality rice in Aman 2011, Rangpur.

Treatment	Yield (t/ha)
T_1V_1	3.4
T_1V_2	4.5
T_1V_3	3.9
T_2V_1	3.2
T_2V_2	4.4
T_2V_3	3.2
T_3V_1	3.3
T_3V_2	4.5
T_3V_3	3.1
T_4V_1	2.4
T_4V_2	3.9
T_4V3	2.6
T_5V_1	2.1
T_5V_2	3.8
T_5V_3	2.4
LSD (0.05)	0.4
CV (%)	7.9

Table 3. Integrated fertilizer management for three-premium quality rice in Boro 2011-12, Rangpur.

Treatment	Yield (t/ha)
T_1V_1	6.1
T_1V_2	6.5
T_1V_3	4.1
T_2V_1	4.7
T_2V_2	5.4
T_2V_3	3.7
T_3V_1	5.5
T_3V_2	5.4
T_3V_3	4.2
T_4V_1	2.4
T_4V_2	3.1
T_4V3	2.9
T_5V_1	1.5
T_5V_2	2.3
T_5V_3	1.2
LSD (0.05)	0.7
CV (%)	11.2

Table 4. Effect of water treatment on seedlings (Set 1 and set 2), Boro 2011-12.

Treatment	Set 1			Set 2		
	Seedling ht (cm)	Seedling density (no.)	Dry wt (gm)	Seedling ht (cm)	Seedling density (no.)	Dry wt (gm)
T_1	17.0	76.0	1.2	19.5	94.0	1.6
T_2	13.6	56.3	0.8	18.4	86.3	1.3
T_3	16.4	74.6	1.4	19.6	100.3	2.2
T_4	8.7	70.3	1.1	12.6	69.3	0.7
T_5	14.5	84.6	1.4	19.2	74.6	1.3
T_6	19.2	76.6	1.4	24.2	86.6	1.4
LSD (0.05)	2.5	24.7	0.6	2.2	31.5	0.5

result shows the effect of tillage and crop establishment on rice followed by tillage options in maize on the yield and yield components of maize in 2011-12. There was highly significant effect of tillage on yield ($p<0.01$) and on HI ($p<0.05$). Maize grown under conventional tillage after puddle transplanted rice produced significantly the lowest yield (7.4 t ha^{-1}) compared to the rest of the treatments (8.0-8.5 t ha^{-1}). Maize grown under either conventional tillage or zero tillage after DSR grown under either conventional tillage or zero tillage and maize grown under zero tillage after puddle transplanted rice produced significantly similar yields. The lowest yield under conventional tillage after transplanted rice was due to low HI and fewer cobs per plant. The highest rice yield (4.77 t/ha) was found in ZTDSR plots (after ZT maize).

Effect of plant geometry and population on Rabi maize in 2010-11

The effect of plant geometry and population on yield and yield components of maize in 2011-12 was studied. There were significant differences between plant populations on grain and stover yield and 1000-grain weight (TGW) but not on cobs per plant and grains per cob. Grain yield was significantly the highest (8.7-9.2 t/ha) for 75000 plants/ha (60 × 22 cm) and 82000 plants/ha (55 × 22 cm) and the lowest for 65000 plants/ha (70 × 22 cm) mainly due to greater stover and hence greater biomass yield (Table 5).

Weed growth in minimum tillage condition and control of weed by herbicide sources under conservation agriculture (CA) based dry direct seeded rice followed by Rice-Wheat-Mungbeen cropping systems

Dry direct seeded rice with short duration variety and crop diversification is a suitable technology for northern part of Bangladesh to overcome climate change situation. Conventional tillage with Topster weed control options produced the highest grain yield (5.0 t/ha) followed by conventional with hand weeding (Table 6). Farmers choosed both the sites of dry DSR by PTOS for easy seed sowing and labour save. Maximum farmers executed crop diversification and get benefited.

Nursery management for enhanced survival of SUB1 introgressed genotypes of rice for submergence-prone areas

The trial was conducted in control condition (inside tank) in T. Aman 2011 with different nutrient management in nursery bed and seedling age were used as treatments. $N_2D_2T_2$ (N_2=N-P_2O_5-K_2O : 75-40-40 (25 kg N through 5 t/ha of FYM and remaining 50 kg N, D_2=25 g/m^2, T_2=40-day-old seedlings) was found as the best treatment of all the parameters studied followed by $N_2D_2T_1$ (N_2=N-P_2O_5-K_2O : 75-40-40 (25 kg N through 5 t/ha of FYM and the remaining 50 kg N, D_2=25 g/m^2, T_1=25-day-old seedlings). Percent survival was found around 80% and grains filling percentage was more than 70.

Optimizing number of seedlings/hill and spacing for transplanting to enhance the productivity of stress tolerant rice genotypes for submergence prone areas

The trial was conducted in control condition with BRRI dhan51 and BRRI dhan52, number of seedlings/hill and different plant spacing were used as treatments. The output of this experimental observation, 15- × 20-cm is the suitable spacing for BRRI dhan51. And for BRRI dhan52 showed

Table 5. Effect of plant geometry and plant population on yield and yield components in 2011-12.

Plant population (ha^{-1})	Cobs/plant	Grain/cob	1000-grain wt (g)	Grain yield (t/ ha)	Stover yield (t/ ha)
70×22 cm (65,000)	0.99a	420a	429a	7.96c	8.83d
65×22 cm (70,000)	1.01a	420a	410b	8.30bc	9.65c
60×22 cm (75,000)	0.96a	407a	400b	8.71ab	10.32b
55×22 cm (82,000)	0.98a	408a	384c	9.22a	11.40ab
50×22 cm (90,000)	0.96a	380a	374c	8.65b	11.85a

Table 6. Grain yield of different tillage practices and herbicide source in Aman, 2011.

Weed control option	Conventional tillage		Strip tillage	
	Panicle (no./m^2)	Grain yield (t/ha)	Panicle (no./m^2)	Grain yield (t/ha)
Topster	311	5.00	280	4.00
Sirious	260	4.46	287	3.88
Pre+Post	303	3.86	296	3.51
2 HW	264	4.73	285	4.35
No weeded	198	0.66	203	1.27

20- × 20-cm. However, two seedlings per hill was best option for both the varieties.

Nitrogen management after submergence for quick recovery

In nitrogen management after de-submergence for quick recovery experiment showed that 10 days after flood water recession was the best for recovery, survival and yield. Use of 30 kg N/ha produced better yield and survival rate (Table 7).

Comparison between Aus variety BRRI dhan48 and local variety Parija in Aus 2011

BRRI popular Aus variety BRRI dhan48 was evaluated with local variety Parija with two different transplanting dates in BRRI RS, Rangpur with two replications. The first transplanting date (set 1) was 29 April 2011 and second one (set 2) was 9 May 2011.

Early transplanted (29 April 2011) BRRI dhan48 produced the highest grain yield 4.6 t/ha (Table 8). Late transplanted BRRI dhan48 produced lower yield. Thus it is very clear that BRRI dhan48 produced better yield than Parija.

Evaluation of modern T. Aman varieties (On station)

Two advanced line Shabagi-6 and Shabagi-7 with check- BRRI dhan53, BRRI dhan54 and BU-1 were evaluated for selection of better lines for Aman season. BRRI dhan54 produced the highest yield (4.5 t/ha) (Table 9).

Table 7. Effect of nitrogen management after de-submergence on survival, yield and yield components of BRRI dhan51 (Swarna-Sub1) subjected to 16 days of submergence during seedling stage in T. Aman 2011.

Treatment	Spikelet (no./panicle)	Grain filling (%)	1000-grain wt (g)	Survival (%) after de-sub	Maturity (day)	Grain yield (t/ha)
			N_1 (10 kg N/ha)			
T_1=10 days	144.8	77.0	15.6	70.7	168	4.02
T_2=20 days	142.2	81.9	16.4	70.7	167	4.13
T_3=30 days	145.4	76.8	15.9	68.7	169	4.11
			N_2 (20 kg N/ha)			
T_1=10 days	139.7	76.5	16.5	70.3	167	4.14
T_2=20 days	151.5	75.8	16.2	70.4	170	4.03
T_3=30 days	141.6	78.6	16.7	71.0	171	4.05
			N_3 (30 kg N/ha)			
T_1=10 days	156.9	75.2	15.8	70.6	172	4.18
T_2=20 days	150.2	77.1	16.9	70.6	172	4.13
T_3=30 days	139.7	73.0	16.4	69.6	173	4.10
LSD (5%)	21.0	6.0	1.4	3.0	NS	0.2
CV %	12.1	3.4	5.0	1.7	NS	3.8

Table 8. Comparison between popular varieties in T. Aus 2011.

Variety	Plant ht (cm)	Panicle (no./m^2)	Tiller (no./m^2)	Yield (t/ha)	Maturity (day)
		Planting time: 29 April 2011			
BRRI dhan48	101	225	250	4.6	105
Parija	91	225	255	1.9	96
		Planting time: 9 May 2011			
BRRI dhan48	101	200	225	4.3	106
Parija	94	225	250	2.4	98

Table 9. Performance of modern T. Aman varieties, BRRI RS, Rangpur.

Variety	Yield (t/ha)	Maturity (day)
BRRI dhan53	3.0	117
BRRI dhan54	4.5	121
BU-1	2.0	116
Shahbagi-6	3.7	113
Shahbagi-7	2.3	113

Seed production in T. Aman 2011 and Boro 2011-12

Supply of quality seeds to farm level is essential for high yield. So, BRRI RS, Rangpur participated in the activities regarding breeder seed production along with supply of truthfully levelled seed (TLS). A total of 12,541 kg breeder seeds of six varieties and 7,519 kg TLS of fifteen varieties both in T. Aman and Boro were produced and disseminated during 2010-11.

BRRI RS, Satkhira

SUMMARY

In T. Aman season, soil and water salinity is reduced due to heavy rainfall as rice cultivation depends on rain fed condition. Heavy rainfal, washes out soil and water salinity from of July to September.

The quality of the irrigation water used to leak salts below the root zone is an important factor in managing the soil salinity.

Maintaining the soil near field capacity with frequent watering dilutes. Light leeching before planting or light irrigation after planting moves salt below the planting and early rooting zone.

Cultivating potato, onion and jute along with BRRI dhan34, BRRI dhan46 and BRRI dhan37 helped to obtain higher economic return than a system without T. Aman Rice.

Better production and net profit per hectare was found in Boro (BRRI dhan50-Jute-BRRI dhan39) and followed by Boro (BRRI dhan28)-Jute-(BRRI dhan33) T. Aman cropping pattern. The results imply that short duration Aman varieties BRRI dhan33 and BRRI dhan39 helped to obtain higher economic return than a system without Aman rice.

BRRI dhan28 in Boro season and BRRI dhan48 in T. Aus helped to obtain higher economic return than a system without T. Aus rice and it also increased cropping intensity.

BRRI dhan28 in Boro season and the advanced lines and Laxmidigha local Aman variety helped to obtain higher economic return than a system without B. Aman rice and also increased cropping intensity.

Yield gap minimization programme was conducted to increase rice yield and disseminate the technologies including varieties among the farmers.

Sharputi, Salmn, Carp and Tablet Fish could be raised successfully in DWR field without any hampering of rice yield. The rice, fish systems provide a great source of protein and additional income to the farmers. This technology can be helpful, if the farmers are provided with necessary training to adopt the Rice + Fish culture systems.

At farmer's level, it is necessary to facilitate seed production technology that can be helpful for the spread of a variety at the grass root level. A seed producing farmer will not only be able to know about a new variety but also to use it profitably. Furthermore, the seed production plot serves as a demonstration plot through which farmers get motivated and inspired to accept a variety.

BREEDER SEED PRODUCTION

A total of 11.15 tons of breeder seeds of BRRI dhan28 in Boro season and BRRI dhan34 in T. Aman were produced in BRRI RS, Satkhira and the total amount of the seeds was sent GRS Division, BRRI, Gazipur for suppli to different, GOs, NGOs and private seed producing organizations as per demand.

Breeder seed plots were rouged out thoroughly during the growing season to ensure the varietal purity. All the varieties were grown using nucleus stock seeds to row methods during Boro-2012 seasons in transplanting conditions. Fertilizers were applied @ 120-80-80kg NPK/ha in Boro season and gypsum 100kg/ha was applied at the time of land preparation. Necessary control measures were taken against disease, weed and insects pest infestation. Rouging was done when necessary with proper record keeping. Urea was applied as to dress in four splits depending on the crop conditions. Panicles from standard plants for each variety were harvested, separately for growing breeder seeds in the next year. Rest of the plot was mass harvested, which was considered as breeder seeds after getting field certificate from SCA. After harvest, the seeds of each variety were threshed, dried, cleaned individually and to the total amount of the seed was sent the GRS Division, BRRI HQ, Gazipur. Under this condition, the seed remains viable at last for one year. The harvested seed then offered as a lot of getting the laboratory certificate from SCA for breeder seed with tag.

QUALITY SEED PRODUCTION

An experiment was conducted at Debhata and sadar Upazila in Satkhira district during Boro 2012 and Aman 2011 to expedite the delivery systems of good quality seeds among the farm community. The objectives were to determine the performance of newly released BRRI varieties and to motivate the farmers through quality seeds production. Farmers' produced 8.05 ton seeds of BRRI dhan34, BRRI dhan37, BRRI dhan39, BRRI dhan41, BRRI dhan46 and BRRI dhan49 in T. Aman season and they retained 5.57 ton seeds for further cultivation and it was about 68.95% of the total production. Most of farmers showed positive response about the BRRI varieties due to earliness, higher yield, presence of aroma (BRRI dhan34, BRRI dhan37), fine grain and higher market price. In Boro season, selected 20 farmers produced 10.75 ton seeds of BRRI dhan28, BRRI dhan29 and BRRI dhan50 and they retained 6.95 ton seeds for further cultivation, which was about 64.65% of the total production. Most of the farmers choice showed positive response and they preferred BRRI dhan28, BRRI dhan29 and BRRI dhan50.

BRRI dhan46, BRRI dhan39, BRRI dhan34, BRRI dhan37, BRRI dhan46 and BRRI dhan41 were selected for seed production in T.Aman season. Each variety was cultivated in 33 decimal area. Seeds of the selected varieties were supplied to the respective farmers with production technologies .The samples were harvested from 10 m2 area for yield estimation. This programme was conducted in two upazilas; Debhata and sadar Satkhira and 10 farmers were selected in each upazila.

All the farmers showed their interest about the varieties. Yield variation of same variety was observed in two locations. On average, yields of the aromatic and slender grain varieties BRRI dhan46, BRRI dhan34, BRRI dhan37, BRRI dhan39, BRRI dhan41, and BRRI dhan49 was 4.15, 3.80, 5.70, 3.85, 5.55 and 4.95 t/ha respectively (Table 1).

Most of the farmers showed positive response about the BRRI varieties due to their earliness, higher yield and presence of aroma, fine grain and higher market price.

A wide variation in the yields of some variety was found across the locations. However, on average, BRRI dhan28 and BRRI dhan50 yielded 6.45 t/ha and 7.25 t/ha respectively (Table 2). Farmers preferred BRRI dhan28 and BRRI dhan50 for short duration and BRRI dhan29 for higher grain yield. Farmers liked BRRI dhan50 for its higher grain yield and fine rice with aroma.

EVALUATION OF RICE VARIETIES IN NON-SALINE ECOSYSTEM

A demonstration programme of rice varieties were conducted during Boro 2012 at BRRI RS, Satkhira farm to find out the suitable rice varieties in Boro season and its economic importance. Thirty rice varieties in RCB design with three replications were used in the experiment. One to two seedlings were transplanted per hill with 15cm 20cm spacing with 30-day-old seedlings on 20 December 2012. Recommended fertilizer doses were applied and all other management practices were followed as and when necessary. Table 3 presents the rice yield.

In Rice garden, results indicate that BRRI dhan29 produced the highest grain yield 9.256t/ha followed by BRRI dhan50 (7.85 t/ha). The satisfactory yield was also found in BR3, BR14, BR16, BR17, BR18, Hybrid HIRA and BRRI dhan28 (Table 3). It can be concluded from the result that BRRI dhan29 BRRI dhan50 and BRRI dhan28 are suitable variety in Boro season in Satkhira region.

During the reporting period we conducted six field days at sadar-Satkhira, Debhata and Shyamnagar. A total of 1,680 persons (Farmers, researchers, extension providers, NGO personnel, administrative people, public leaders, electronic media and media personnel etc) participated in three rallies organized on the occasion (Table 4). BRRI developed varieties, technologies and farm machinery were demonstrated. These programmes also generated much enthusiasm about modern rice production technologies among the farmers.

BRRI RS, Satkhira participated in agricultural fairs during the reporting period, where BRRI developed farm machinery were exhibited.

Table 1.Variety wise area, grain yield, seed production and number of interested farmers during T. Aman 2011.

Varity	Average yield (t/ha)	Dmonstration area (decimal)	Seed production (ton)	Retained seed (ton)	Interested farmers
BRRI dhan46	4.15	66	1.55	1.05	50
BRRI dhan34	3.80	66	1.15	0.95	45
BRRI dhan37	3.70	66	1.0	0.65	65
BRRI dhan39	3.85	66	1.20	0.85	50
BRRI dhan41	5.55	66	1.75	1.05	58
BRRI dhan49	4.95	66	1.25	1.00	54
Total	26.00	396	7.95	5.55	322

Table 2. Variety wise area, grain yield, total seed production and retention farmers' and number of interested farmers under seed production and dissemination during Boro 2012.

Varity	Average yield (t/ha)	Total dmonstration area (decimal)	Total seed production (ton)	Retained seed (ton)	Interested farmers
BRRI dhan28	6.45	350	3.15	2.40	225
BRRI dhan29	8.45	350	4.25	2.35	125
BRRI dhan50	7.25	350	3.35	2.20	220
Total		1050	10.75	6.95	570

Table 3. Rice yield varieties in single Boro season at BRRI Regional Station, Satkhira during Boro-2010.

Variety	Yield	Variety	Yield (t/ha)
BR3	7.50	BRRI dhan28	7.28
BR6	5.25	BRRI dhan29	9.20
BR7	5.45	BRRI dhan35	5.65
BR8	6.55	BRRI dhan36	5.38
BR9	6.58	BRRI dhan45	7.59
BR14	7.26	BRRI dhan47	6.75
BR15	6.38	BRRI dhan50	7.85
BR16	7.05	BRRI hybrid1	7.15
BR17	7.065	HIRA	7.66
BR18	7.18	Sonar Bangla	6.55
BR19	7.56		

Table 4. Field day conducted and number of participant at different locations during July 2011 to June 2012.

Location	Farmer	Participant (no.)		Total
		SAAO	DAE/BRRI/NGO/officers/ leaders and media personals	
Sadar-Satkhira	480	60	150	690
Debhata	485	60	140	685
Shyamnagar	480	60	60	600

BRRI RS, Sonagazi

SUMMARY

The highest grain yield (4.60 t/ha) was recorded when 25% additional N fertilizer was added with STB during T. Aman season at BRRI RS, Sonagazi.

A good water bearing aquifer exists at a depth from 155 m to 180 m in BRRI RS, Sonagazi farm having 0.30- 0.57 dS/m salinity. Rainwater harvesting in a reservoir with 25 cm high embankment conserved more water than without embankment, which could increase irrigated area of Rabi crops profitably in coastal area.

Eight salt tolerant genetically fixed Aus lines were selected for further trial. Fourteen salt tolerant genotypes from OT were selected during Aus season. Genotypes OMCS 2000 and AS996 produced 0.3-0.9 t/ha higher grain yield compared to BRRI dhan27 and Binnatoa.

IRBB66 produced 3.52 t/ha grain yield with 4% leaf damage caused by BB as T. Aman crop followed by IRBB21 (3.27 t/ha, 3% leaf damage, which are better than IR24, Purbachi and TN1. Dizole 300EC, Emiscore and Fiscal 10 EC reduced growth of *Rhizoctonia solani* by 70.63-87.31 %. Five major diseases viz brown spot (BS), bacterial leaf blight (BLB), false smut, narrow brown spot (NBS) and sheath blight (ShB) were recorded during T. Aman season.

A total of 120 farmers were trained on modern rice production techniques. About 11.5 ton breeder seed and 11 ton TLS were produced.

CROP-SOIL-WATER MANAGEMENT

Fertilizer package for saline and charland

This experiment was conducted at BRRI RS, Sonagazi, Feni (AEZ-18) during T. Aman 2011 to identify fertilizer management packages for Rice-Fallow-Rice cropping systems under saline and charland ecosystem. The experiment was conducted in clay loam textured soil having pH (1:2.5) 7.42, organic C 0.93%, total N 0.09%, available P, S and Zn are 10.76, 82.83 and 0.44 ppm respectively along with exchangeable K 0.17 cmol/kg. Treatments tested were- N_{90}-P_{11}-K_{30}-S_4-$Zn_{1.5}$ (T_1, 100% dose), N_{113}-P_{11}-K_{30}-S_4-$Zn_{1.5}$ (T_2, 25% N), N_{113}-P_{14}-K_{30}-S_4-$Zn_{1.5}$ (T_3, 25% NP), N_{113}-P_{11}-K_{38}-S_4-$Zn_{1.5}$ (T_4, 25% NK), N_{90}-P_{14}-K_{38}-S_4-$Zn_{1.5}$ (T_5, 25% PK), N_{113}-P_{14}-K_{38}-S_4-$Zn_{1.5}$ (T_6, 25% NPK), N_{68}-P_8-K_{23}-S_3-$Zn_{1.1}$ (T_7, 75% of T_1) and zero fertilizers (T_8). RCB design was used with three replications. Indicator variety was BRRI dhan41. Two-three seedlings/hill were transplanted with 20- × 20-cm spacing. One third urea and all other fertilizers were applied at final land preparation. Rest of the urea was applied at 25 DAT and 50 DAT in equal splits. Other intercultural operations were done at per BRRI recommendation. Crop was harvested from 5 m^2 area and grain yield was adjusted to 14% moisture. Tiller and panicle number, grain and straw yields were recorded and analyzed statistically.

The highest grain yield (4.60 t/ha) was recorded when 25% additional N fertilizer was added with STB (Table 1). However, this yield was statistically similar with all treatments except T_4 and T_8. Tiller production varied significantly but it was not reflected in panicle production. Higher straw yields were recorded in T_2 and T_4 treatments.

Exploration of fresh ground water

Fresh water availability in dry season hinders crop production in coastal areas. So, efforts were made to assess the availability of fresh ground water, the performance and cost-effectiveness of tubewell irrigation and to monitor the long-term effect of ground water extraction in coastal saline areas. About 62-day-old seedlings of BRRI dhan28, BRRI dhan47 and BRRI dhan55 were transplanted on 7 February 2012. BRRI recommended cultural practices were followed for growing crop.

A good water bearing aquifer exists at a depth from 155 m to 180 m (510 ft - 590 ft) in BRRI RS, Sonagazi farm. The pump was discharging ground water with salinity level of 0.30- 0.57 dS/m, which was below permissible maximum limit (<4 dS/m). BRRI dhan28, BRRI dhan47 and BRRI dhan55 were grown during Boro 2012. Grain yield of BRRI dhan28, BRRI dhan47 and BRRI dhan55 were 5.52 t/ha, 5.27 t/ha and 5.70 t/ha respectively. All the varieties performed well under irrigated conditions. But long-term effects of groundwater extraction in coastal saline areas need to be monitored.

Table 1. Effect of fertilizer combinations on some plant parameters of BRRI dhan41, T. Aman 2011, BRRI RS, Sonagazi.

Treatment	Tiller (no./m^2)	Panicle (no./m^2)	Grain yield (t/ha)	Straw yield (t/ha)
T_1 = 100 NPKSZn (STB)	235ab	189	4.43ab	5.73ab
T_2 = T_1+25% N	215ab	183	4.60a	6.19a
T_3 =T_1+ 25 5 NP	238ab	197	4.29ab	5.32ab
T_4 = T_1+ 25% NK	260a	188	3.85b	6.10a
T_5 = T_1+ 25% PK	231ab	195	4.07ab	5.52ab
T_6 = T_1 + 25% NPK	213ab	183	4.24ab	5.87ab
T_7 = 75% of T_1	209ab	177	4.07ab	4.91bc
T_8 = Control	194b	165	3.84b	4.06c
LSD0.05	49	51	0.63	1.04
Significant level	*	NS	*	**
CV (%)	12.6	15.6	8.6	10.8

*Significant at the 5% level, **Significant at the 1% level.

Assessment of farm reservoir

Harvesting of rain water in the reservoir and its subsequent use could play a vital role for intensification of crop production in coastal areas. So, experiment was conducted to assess the use of existing farm reservoir for crop production and to estimate economic benefit of farm reservoir for land productivity improvement. A farm reservoir (FR) of 6- × 6- × 2- m size having side slope 1:1, storage capacity 34.67 m^3 was constructed. The FR area was 16% of the service area. Twenty-five centimeter height embankment was constructed around the pond to store 9.77 m^3 extra rainwater than normal FR capacity. Two inlets were provided in FR to collect runoff. When FR was filled up to the soil surface, then inlets were closed.

In Aman season, 41-day-old seedlings of BRRI dhan32 were transplanted at 20- × 20-cm spacing on 7 August and was harvested on 6 November 2011. Fertilizers were applied at 220, 105, and 110 kg/ha of urea, TSP and MP respectively. Whole amount of TSP and MP were applied as basal. Urea was top-dressed in two equal splits at 12 and 45 DAT. Fifteen centimeter height levee was maintained around the plot to conserve rainwater for fulfillment of water demand. Water storage was maximum (44.44 m^3) at mid August 2011. There was no water stress in Aman season. Grain yield was 4.07 t/ha. From the long-term (1983-2011) average rainfall (2119 mm), it is observed that there is no need of supplemental irrigation for Aman rice cultivation at Sonagazi area. However, at the end of Aman season (November), 61% (27.15 m^3) stored water was available in the FR, which was insufficient to cultivate Rabi crop.

Rabi crops cultivation

BARI tomato (Ratan) was cultivated as rainfed (T_0) and irrigated (thrice at 14 days interval, T_1) crop after BRRI dhan32. Twenty-seven-day-old seedlings were transplanted as dibbling method on 18 December 2011 at 50- × 50-cm spacing. One meter buffer zone between two plots and 30 cm drain was provided to drain out excess water. Fertilizer was applied at 550, 450, 250 and 9000 kg/ha of urea, TSP, MP and cow dung respectively. Whole amount of TSP, MP and cowdung was applied at final land preparation. Urea was top-dressed in three equal splits after first, second and third irrigations. Mulching was done after urea application. Irrigation water was provided from the FR by hand sprinkler by coupling the sprinkler with discharge pipe of a small centrifugal pump. Amount of applied irrigation water was measured by volumetric method. First irrigation was applied at 14 days after transplant (DAT), second and third at 28 and 42 DAT. Additional 10% water was added to leach down soil salinity. Total amount of irrigation water used was 57 mm for T_1. Electrical conductivities of soil (ECe) and irrigation water (EC_w) before irrigation were 4.7 dS/m and 2.15 dS/m respectively that was 75% of potential yield according to FAO report. Figure 1 shows the fortnight water storage capacity of FR.

About 29% water of total storage was used for irrigation and about 11% water of total was remained after last irrigation, which could be used to irrigate 82 m^2 areas. Therefore, it is evident that for early plantation, about 36% more area could be cultivated.

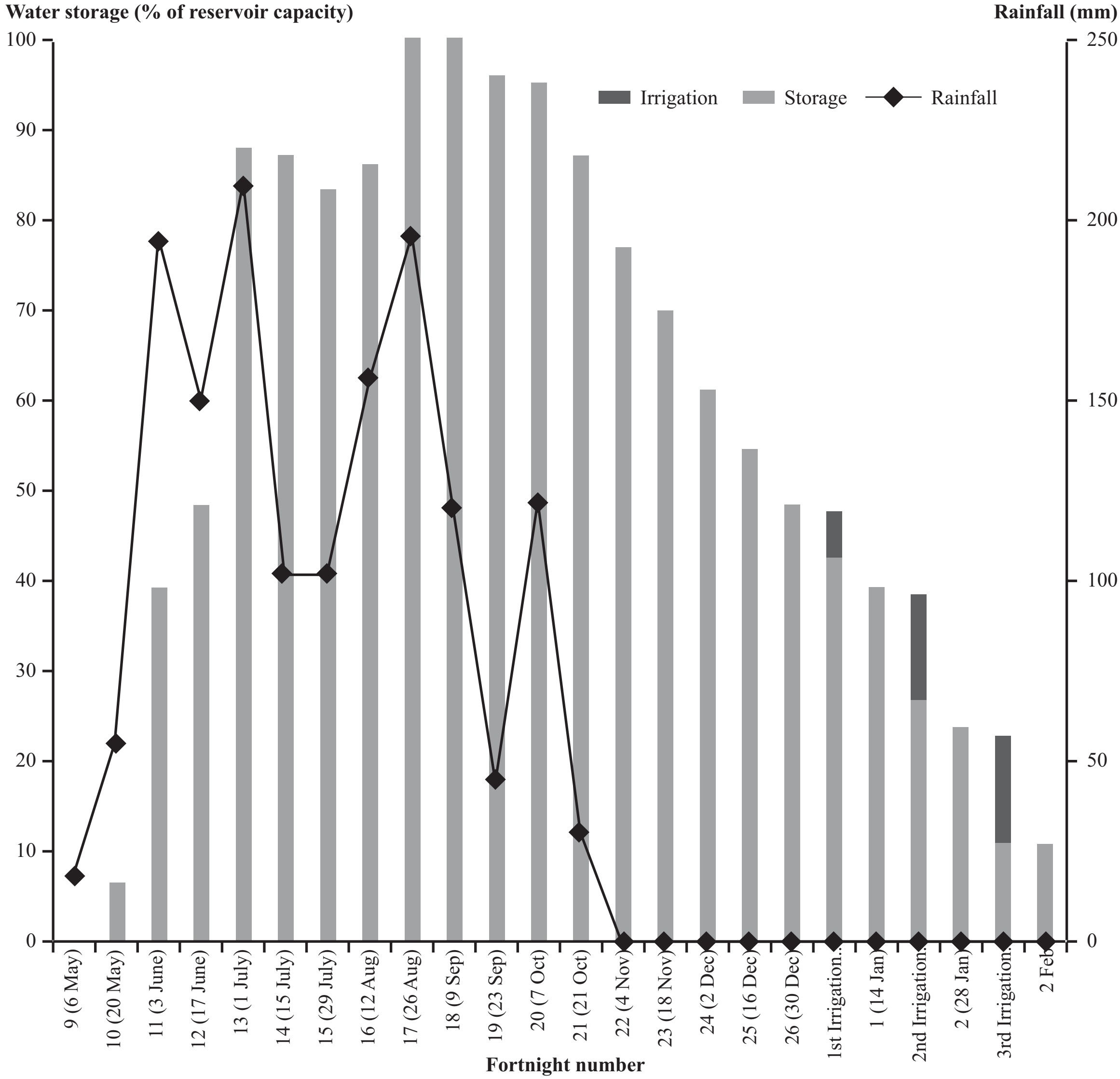


Fig. 1. Fortnightly water storage (%) of full capacity of FR, 2011-12.

Table 2 shows yields of tomato in rainfed and irrigated conditions. The higher yield of tomato (47.22 t/ha) was obtained as irrigated crop. The highest rice equivalent yield (REY) was recorded in rainfed T. Aman (BRRI dhan32)-irrigated tomato (33.13 t/ha) system than rainfed T. Aman (BRRI dhan32) rice-rainfed tomato (28.71 t/ha) one (Table 2). The variation in yield equivalence was mostly governed by Rabi crop (tomato) irrigation.

Rainwater harvesting in a reservoir with 25 cm high embankment conserved more water than without embankment, which could increase irrigated area of Rabi crops profitably in coastal area. It is also evident that Rabi crop cultivation with pond water is profitable in the coastal saline area.

VARIETAL DEVELOPMENT

Pedigree nursery for salt tolerance in Aus 2011

A total of 125 F_5 and F_7 progeny rows were grown at Sonagazi site. Twenty-five-day-old single seedling was transplanted @ single seedling with a

Table 2. Yield and rice equivalent yield (REY) of crops under rainfed and irrigated conditions at BRRI RS farm, Sonagazi 2010-11.

Cropping sequence	Yield (t/ha)			Total REY (t/ha)
	T. Aman	Rabi	Rice equivalent	
Rainfed T.Aman (BRRI dhan32)-Fallow	4.07	-	-	4.07
Rainfed T. Aman (BRRI dhan32)-Rainfed tomato	4.07	40.04	24.64	28.71
Rainfed T. Aman (BRRI dhan32)-Irrigated tomato	4.07	47.22	29.06	33.13

Local market price of rice = Tk 16.25/kg and tomato = Tk 10.00/kg.

$$REY = \frac{\text{Price of crop (Tk/t)} \times \text{Yield (t/ha)}}{\text{Price of rice (Tk/t)}}$$

spacing of 25- × 15- cm. Fertilizers @ 80:60:40:20 kg/ha of N, P_2O_5, K_2O, S were used with split application of N at 15, 30, 50 DAT. Total amount of P, K and S were applied at the time of final land preparation.

Eight genetically fixed lines were selected based on plant type, earliness and salt tolerance (Table 3). These advanced lines will be evaluated as observational trial.

Observational trial for salt tolerance

Observational trial (OT) was conducted in Aus season 2011 to select lines homogeneous for morpho-agronomic characters having early seedling emergence, short growth duration and tolerance to lodging. Twenty-six genotypes were seeded directly in a non-replicated trial with unit plot size 5 m × 4 rows having 25 cm spacing between the rows with sufficient moisture in the field. Fertilizer doses were 60: 40: 40 kg NPK/ha and P and K were applied at the time of land preparation. Nitrogen was applied at three equal splits at 10 DAT, maximum tillering and PI stages. Gypsum and $ZnSO_4$ @ 100 and 10 kg/ha, respectively were applied during land preparation. Fourteen genotypes were selected based on growth duration, yield, homogeneity of morpho-agronomic traits and superiority in one or more traits over the check (Table 4).

RYT for salinity tolerance

Regional yield trial (RYT) was conducted during Aus 2011 at BRRI RS, Sonagazi to find out their performance as salt tolerant genotypes. Six breeding lines were evaluated against BRRI dhan27 and Binnatoa. The treatments utilized RCB design with three replications. Unit plot size was 5.4 m × 10 rows. Dibbling method was followed for stand establishment in April at 25 cm apart. Fertilizer dose was @ 80:60:40 kg/ha of N, P_2O_5, K_2O, respectively. Gypsum and $ZnSO_4$ was applied @ 100 and 10 kg/ha respectively. Nitrogen was applied in three equal splits. Total amount of P, K, gypsum and $ZnSO_4$ was applied at final land preparation.

The highest grain yield (3.7 t/ha) was obtained from OMCS 2000 followed by AS996 (3.6 t/ha), which were higher by 0.3-0.9 t/ha compared to BRRI dhan27 and Binnatoa. These two lines required 2-8 days more for maturity compared to the check varieties.

PEST MANAGEMENT

Evaluation of bacterial blight resistant genotypes

Bacterial blight (BB) resistant genotypes

Table1 3. List of selected progenies from pedigree nursery, salinity tolerance, Aus 2011, BRRI Sonagazi.

	BR no.	Parentage	Progenies selected
F_5	BR7770	T_7B_2/IR71866-3R-3-1// IR71866-3R-3-1	1 Bulk
	BR7771	T_7B_3/IR71866-3R-3-1// IR71866-3R-3-1	2 Bulk
	BR7772	TB_2/IR71866-3R-3-1// IR71866-3R-3-1	1 Bulk
	BR7773	BRRI dhan27/IR71866-3R-3-1// IR71866-3R-3-1	1 Bulk
	BR7774	T_7B_2/IR71866-3R-3-1//T7B3/ IR72593-B-13-3-2-1	2 Bulk
F_7	BR7436	Binnatoa/BR24	1 Bulk

Table 4. Performance of selected genotypes from OT, salinity tolerance Aus 2011, BRRI Sonagazi.

Genotype	Duration (day)	Yield (t/ha)
BR7770-3	124	3.4
BR7772-6	125	3.6
BR7773-5-l	124	3.3
BR7558-1	124	3.4
BR7559-1	124	2.9
BR7442-1	128	3.4
BR7442-7	128	3.6
BR74445-2	128	4.1
BR7445-6	128	3.1
BR7445-8	128	4.5
Binnatoa (Local ck)	112	2.3

(pyramid lines) were evaluated at BRRI RS, Sonagazi farm during Aman 2011 and Boro 2011-12 to find out their performance. Twelve pyramid lines were tested. Thirty-five-day-old 2-3 seedlings/hill of genotypes was transplanted at 20- × 20-cm spacing. Unit plot size was 3- × 2-m with three replications. Cultivation procedure and fertilizers were used as BRRI recommended method. Yield components and percent leaf area damaged were taken at dough to maturity.

Percent leaf area damaged by bacterial blight organism ranged from 3-75 in Aman and 3-10 in Boro season in the IRBB genotypes and checks. All the genotypes performed better in disease reaction in natural condition. IRBB66 produced 3.52 t/ha grain yield with 4% leaf damage as T. Aman crop followed by IRBB21 (3.27 t/ha, 3% leaf damage, which are better than IR24, Purbachi and TN1. In Boro season, none of the entries showed better performance compared to BRRI dhn28 and BRRI dhan29. The experiment needs to be repeated because transplanting was delayed due to late in receiving of seeds from Philipines.

Chemical control of sheath blight disease

The efficacy of new chemicals against sheath blight disease of rice was evaluated during T. Aman 2011 at BRRI RS, Sonagazi. Nine fungicides (Emiscore, Fiscal 10EC, Green 300EC, Hunchat 75WP, Nato 10EC, Dizole 300EC, Suzala 10EC, Hinzol 10EC, Enstal 5EC) were tested with one diseased control treatment. Thirty days old 2-3 seedlings/hill of BR11 was transplanted at 20- × 15-cm spacing. Unit plot size was 3- × 2-m and repeated thrice. Fertilizers were used as per recommended dose. Cultural management was done as and when necessary. The plants were inoculated at panicle initiation stage with local *Rhizoctonia solani* culture grown on PDA medium. Eight hills were inoculated from central area at random. New fungicides were sprayed at their recommended dose twice; once at five days after inoculation and second time at seven days after first spray. Relative lesion height (RLH) was taken at dough to maturity stage.

Among the tested fungicides, Dizole 300EC, Emiscore and Fiscal 10 EC reduced fungal growth by 70.63-87.31%.

Incidence of diseases on BRRI released T. Aman varieties

An experiment was conducted during T. Aman 2011 at BRRI RS, Sonagazi to know the varietal reaction against naturally occurring rice diseases in coastal areas. The experiment was laid out in RCBD with three replications. Natural incidence of rice diseases were recorded from the stability analysis experiment plots of BRRI RS, Sonagazi farm. Disease incidence (DI) and disease severity (DS) data were taken during reproductive stage following double diagonal method.

Five major diseases viz brown spot (BS), bacterial leaf blight (BLB), false smut, narrow brown spot (NBS) and sheath blight (ShB) were recorded (Table 5). Brown spot disease was most prevalent in all the varieties with severity (3-7) and high incidence (5-50%). Incidence of BLB was observed in almost all the varieties except BR5, BR22, BRRI dhan37, BRRI dhan38, BRRI dhan46.

The DI and DS of BLB ranged 2-50 % and 2-5 respectively. False smut disease was observed in BRRI dhan49 with DI ranged from 40-50 % and DS scale 7. Narrow brown leaf spot was observed in BRRI dhan30, BRRI dhan31, BRRI dhan33, BRRI dhan40 and BRRI dhan46 with DI ranging from 5-50% and DS scale of 3-7. Sheath blight disease was observed in BR11, BRRI dhan32, BRRI dhan39, BRRI dhan46 with DI ranged from 10-50 % and DS scale of 1-7.

Table 5. Disease incidence and its severity of BRRI released T. Aman varieties T. Aman 2010, BRRI RS, Sonagazi.

Variety	Disease									
	BS		BLB		False smut		NBS		Sheath blight	
	DI (%)	DS	DI (%)	DS	DI (%)	DS	DI (%)	DS	DI (%)	DS
BR3	50	7	50	5	-	-	-	-	-	-
BR4	35	7	15	4	-	-	-	-	-	-
BR5	15	5	-	-	-	-	-	-	-	-
BR10	50	7	50	5	-	-	-	-	-	-
BR11	25	5	40	5	-	-	-	-	50	7
BR22	32	7	-	-	-	-	-	-	-	-
BR23	15	5	12	3	-	-	-	-	-	-
BR25	22	5	10	3	-	-	-	-	20	3
BRRI dhan30	45	7	12	3	-	-	15	5	-	-
BRRI dhan31	50	7	15	4	-	-	20	5	-	-
BRRI dhan32	50	7	25	4	-	-			40	5
BRRI dhan33	37	7	10	3	-	-	10	5	-	-
BRRI dhan34	13	5	5	2	-	-	-	-	-	-
BRRI dhan37	13	5	-	-	-	-	-	-	-	-
BRRI dhan38	6	4	-	-	-	-	-	-	-	-
BRRI dhan39	10	4	25	4	-	-	-	-	30	3
BRRI dhan40	25	5	5	2	-	-	5	3	20	3
BRRI dhan41	25	3	5	2	-	-	-	-	25	3
BRRI dhan44	50	7	5	2	-	-	-	-	-	-
BRRI dhan46	18	4	-	-	-	-	50	7	10	1
BRRI dhan49	8	4	8	3	40	7	-	-		
BRRI dhan51	15	5	10	3	-	-	-	-	20	3
BRRI dhan52	10	4	10	3	-	-	-	-	20	3
IR64s	10	4	10	3	-	-	-	-	25	3

SOCIO ECONOMIC

Stability analysis of BRRI varieties

Varietal stability was investigated at BRRI RS, Sonagazi farm to determine the stability index of BRRI proposed and released varieties, generate season, year and location-wise database on BRRI varieties. Stability analysis of BRRI released T. Aman varieties were conducted during T. Aman 2010 in collaboration with Statistics Division of BRRI HQ. Twenty one T. Aman rice varieties were tested. The experiment was laid out in RCB design with three replications. Unit plot size was 3- × 4-m. The crop was fertilized @ 130-50-60 kg/ha of urea, TSP and MOP. Full doses of TSP and MOP were applied during final land preparation. Thirty-day-old seedlings was transplanted at 20- × 20-cm spacing. Plant protection measures were followed as and when ever necessary. At maturity, the crop was harvested. The grain yield was recorded at 14% moisture. Among all the varieties, the highest yield (4.9 t/ha) was obtained from BR11 and the lowest yield was found in BRRI dhan37 (Table 6).

TECHNOLOGY TRANSFER

Farmers' training

Dissemination of knowledge through training is a good option for updating farmer's knowledge on modern rice cultivation technologies and to adopt modern rice varieties. These training programmes were conducted in four upazila of Cox's bazar districts in collaboration with DAE where about 30 farmers participated in each programme. In these training programmes, modern rice varieties and associated technologies were discussed by the BRRI RS, Sonagazi scientist.

Four farmers' training programmes were conducted in four upazila of Cox's bazar districts in which 120 farmers participated. Most of the farmers were very much impressed by taking the rice production training.

Breeder seed and truthfully labelled seeds (TLS) production

Quality seed is a prime requirement for higher rice production. So, it is necessary to make avenue for

Table 6. Grain yield of T. Aman rice varieties from stability analysis at BRRI RS farm, Sonagazi during Aman 2010.

Variety	Panicle (no./m^2)	Yield (t/ha)	Growth duration
	Short duration (Up to 129 days)		
BRRI dhan33	124	3.8	125
BRRI dhan34	147	2.98	128
BRRI dhan39	145	3.9	125
BRRI dhan46	161	3.88	128
	Medium duration (130 to 140 days)		
BR3	162	4.0	140
BR4	143	4.45	140
BR11	144	4.9	140
BR25	151	4.4	130
BRRI dhan30	148	4.2	140
BRRI dhan31	189	3.9	140
BRRI dhan32	195	4.6	135
BRRI dhan37	196	2.87	140
BRRI dhan38	236	3.10	140
BRRI dhan40	142	4.1	138
BRRI dhan49	187	4.8	136
	Long duration (above 140 days)		
BR5	186	2.60	145
BR10	181	4.8	150
BR22	194	4.4	152
BR23	136	4.2	152
BRRI dhan41	171	3.95	145
BRRI dhan44	164	4.8	148
BRRI dhan51	136	3.7	145
BRRI dhan52	140	4.1	145

quality seed supply in the region. Nucleus seed stock was collected from GRS Division of BRRI. Single seedling was transplanted per hill. For breeder seed production all official formalities with SCA and BRRI authority were performed through proper channel.

Considering three season (Aus, T. Aman and Boro) breeder seed was produced 11.44 ton and TLS 11.2 ton (Table 7).

Table 7. Seed production of BRRI varieties, BRRI RS farm, Sonagazi, 2010-11.

Variety	Season	Breeder seed (ton)	TLS (ton)	Total (ton)
BRRI dhan27	Aus 2011	-	0.8	0.8
BRRI dhan43	Aus 2011	-	1.23	1.23
BRRI dhan48	Aus 2011	-	0.3	0.3
BR11	Aman 2011	1.6	0.84	2.44
BR22	Aman 2011	-	0.75	0.75
BR23	Aman 2011	-	1.44	1.44
BRRI dhan32	Aman 2011	-	1.42	1.42
BRRI dhan40	Aman 2011	0.76	1.04	1.80
BRRI dhan44	Aman 2011	-	0.61	0.61
BRRI dhan46	Aman 2011	-	0.63	0.63
BRRI dhan49	Aman 2011	2.33	2.14	4.47
BRRI dhan14	Boro 2012	1.481		1.481
BRRI dhan16	Boro 2012	1.997		1.997
BRRI dhan28	Boro 2012	1.5		1.5
BRRI dhan55	Boro 2012	1.77		1.77
Total		11.44	11.2	22.64

BRRI ANNUAL REPORT

For July 2011-June 2012

Bangladesh Rice Research Institute (BRRI)

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Contents

Preface

BRRI Annual Report 2011-12 contains a brief presentation of research works carried out by 19 research divisions and nine regional stations of the institute during June 2011 to July 2012. The significant research outcomes covering seven programme areas are the main focus of the document.

The programme areas consist of varietal development, crop-soil-water management, rice farming systems, pest management, socio-economics and policy, technology transfer and farm mechanization. BRRI is well aware of research planning to sustain self-sufficiency in food production.

Considering this, BRRI scientists have been engaged in developing different stress tolerant rice varieties and some premium quality ones that can compete in the international market.

Side by side they worked to develop and disseminate cost-saving and profitable technologies such as urea super granule (USG) applicator, seeding by drum seeder, leaf colour chart for proper use of urea, integrated crop management (ICM) practices, use of quality seed, water saving techniques like alternate wetting and drying (AWD), rice based farming systems and popularization of BRRI machinery.

In addition, demonstration of variety and relevant crop management technologies were improved in different agro-ecological zones of the country.

Above all, in the present report readers will be introduced with the various research activities that attempted to minimize yield gap between research level and farmer's fields.

Moreover, readers interested to look into the details on specific subject of this summarized version may consult 'Proceedings of BRRI Annual Research Review for 2011-12' which is available in the website (www.brri.gov.bd).

We acknowledge the efforts that helped bring out the publication and special thanks for those who contributed with different capacities.

We hope that the report will be useful for the scientists, extension agents, policy makers and other partners to be updated on rice research at BRRI.

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* Abroad for higher studies
\+ On deputation outside BRRI
*+ On deputation for higher studies
** Transferred
*** Joined BRRI
++ Resigned from BRRI

Weather information

Temperature. In the reporting year the monthly mean maximum temperature was the highest in May in all the BRRI agromateorology stations, one at BRRI head quarters and three other regional stations. It ranges from 32.2°C in Habiganj to 36.16°C in Barisal (Fig. 1). Similar to mean maximum temperature the monthly mean minimum temperature was the lowest in January in all the agromateorology stations ranging from 12.4°C in Comilla (Fig. 1).

Rainfall and evaporation. The annual total rainfall varied from 2,426 mm in Habiganj to 1,435 mm in Gazipur. The highest monthly total rainfall 518.6 mm was recorded in June at Habiganj followed by 482.6 mm in August at Barisal. Drought prevailed in November, December, January, February and March in all the stations because of less rainfall than evaporation (Fig. 2).

Solar radiation and sunshine. The monthly mean daily solar radiation was relatively lower in November to January. The highest monthly mean solar radiation 404.42 cal cm^2/day was recorded in March in Gazipur and the lowest monthly mean solar radiation of 211.3 Cal cm^2/day was recorded in December at Barisal (Fig. 2).

The highest mean daily hours of bright sunshine prevailed in March at Gazipur and Barisal but in Habiganj it was observed in October. The lowest mean daily hours of bright sunshine prevailed in August in Gazipur and Barisal but in Habiganj it was in June (Fig. 3).

Relative humidity. The monthly mean relative humidity at the morning did not varied much. The relative humidity at 9 am or 2 pm was relatively lower in February ranging from 44.82 to 96.5% and the relative humidity at 9 am or 2 pm was relatively higher in of August ranging from 73.5 to 95.1% (Fig. 4).

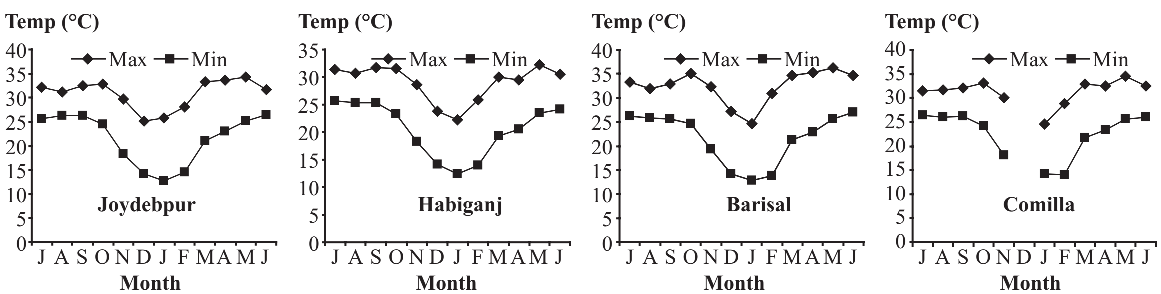

Fig. 1. Monthly mean maximum and minimum temperature (°C) of Gazipur and other three regional stations, July 2011 to June 2012.

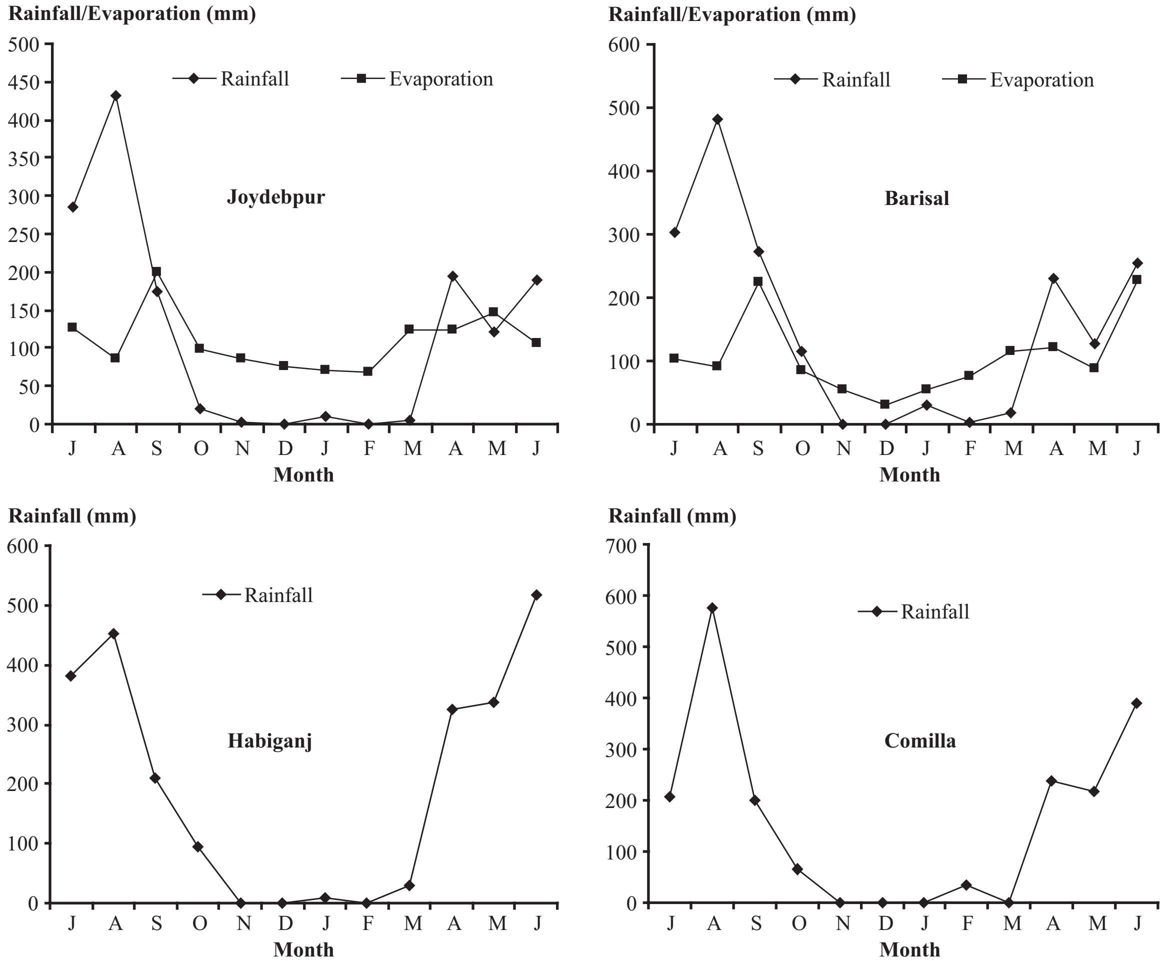

Fig. 2. Monthly total rainfall (mm) and evaporation (mm) of Gazipur and other three regional stations, July 2011 to June 2012.

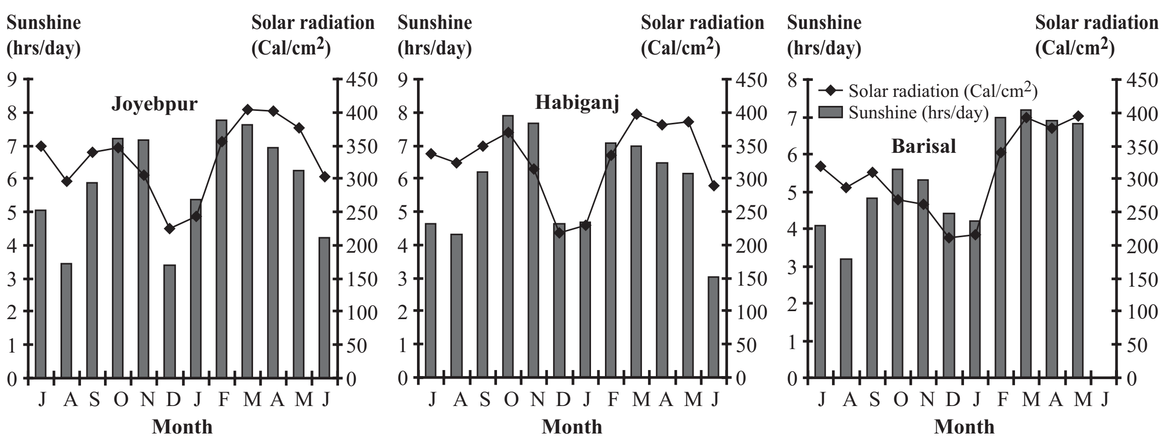

Fig. 3. Monthly solar radiation (cal/cm2 per day) and sunshine (hrs/day) of Gazipur and other two regional stations, July 2011 to June 2012.

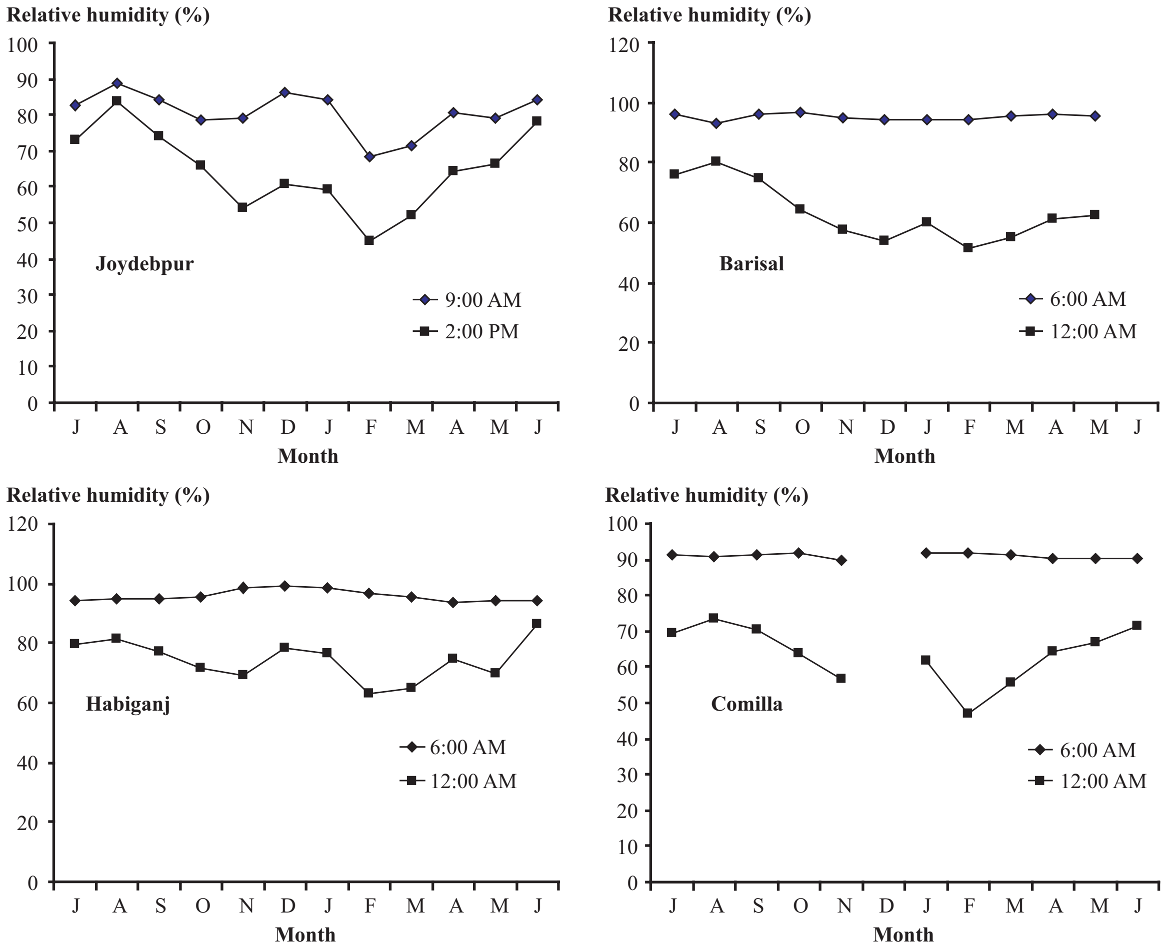

Fig. 4. Monthly mean relative humidity (%) of Gazipur and other three regional stations, July 2011 to June 2012.

Abbreviation and Acronyms

AEZ	=	agroecological zone
ALART	=	advanced line adaptive research trial
As	=	arsenic
AT	=	active tillering
AWD	=	alternate wetting and drying
AYT	=	advanced yield trial
B. Aman	=	broadcast Aman
BADC	=	Bangladesh Agricultural Development Corporation
B. Aus	=	broadcast Aus (upland rice)
Bak	=	bakanae
BARI	=	Bangladesh Agriculture Research Institute
BB	=	bacterial blight
B	=	Blast
BC	=	backcross
BCR	=	benefit-cost-ratio
BI	=	blast
BLB	=	bacterial leaf blight
BLB	=	bacterial leaf blight
BINA	=	Bangladesh Institute of Nuclear Agriculture
BMDA	=	Barind Multi Purpose Development Authority
BPH	=	brown planthopper
BR	=	Bangladesh rice
BS	=	breeder seed
BRRI	=	Bangladesh Rice Research Institute
BWDB	=	Bangladesh Water Development Board
BShB	=	bacterial sheath blight
CAB	=	Commonwealth Agriculture Bureau
ck	=	check
cm	=	centimetre
CDB	=	Carabid beetle
CMS	=	cytoplasmic male sterile
CV	=	common variance, co-efficient of variation
DAE	=	Department of Agricultural Extension (Bangladesh)
DAP	=	drought animal power
DAS	=	days after seeding
DAT	=	days after transplanting
DH	=	dead heart
DHB	=	dark-headed borer
DMRT	=	Duncan's multiple range test
DNA	=	deoxyribonucleic acid
DTF	=	days to flowering
DWSR	=	Direct wet seeded rice

DWR	=	deepwater rice
ET	=	evapotranspiration
FS	=	foundation seed
GH	=	grasshopper
GM	=	gall midge
GMB	=	green mirid bug
GLH	=	green leafhopper
GoB	=	Government of Bangladesh
GRS	=	Genetic Resources and Seed
GSR	=	green super rice
GQN	=	Grain Quality and Nutrition
HA	=	Habiganj Aman
HAT	=	hours after treatment
HB	=	Habiganj Boro
ht	=	height
IIRON	=	International Irrigated Rice Observational Nursery
INGER	=	International Network for Genetic Evaluation of Rice
INM	=	integrated nutrient management
IPM	=	integrated pest management
IPNS	=	integrated plant nutrition system
IRRI	=	International Rice Research Institute (Philippines)
IRSSTN	=	International Rice Soil Stress Tolerance Nursery
IURON	=	International Upland Rice Observational Nursery
LCC	=	leaf colour chart
LBB	=	lady bird beetle
LHC	=	long-horned cricket
Lit/ha	=	litre per hectare
LR	=	leaf roller
LSc	=	leaf scald
LSD	=	least significant difference
LV	=	local variety
MAS	=	marker assisted selection
ML	=	monogenic line
MLT	=	mulitlocation trial
MMT	=	million metric tons
MR	=	moderately resistant
MT	=	maximum tillering
MV rice	=	modern variety rice
meq	=	milliequivalent
NGO	=	non-government organization

NIL = near isogenic line
NIR = net irrigation requirement
NSB = National Seed Board (Bangladesh)

OC = oil cake
OHLH = orange headed leafhopper
OT = observational trial
OYT = observational yield trial

PI = panicle initiation
PQR = premium quality rice
PVART = proposed variety adaptive research trial
PVS = participatory varietal selection
PVT = proposed variety trial
PYT = preliminary yield trial

QTL = quantitative trait loci

RCB design = randomized complete block design
RF = rainfall
RH = rice hispa
RLF = rice leaf folder
RLR = rice leaf roller
RPT = rice production training
RS = Regional Station
RTV = rice tungro virus
RWM = rice whorl maggot
RWS = relative water supply
RYT = regional yield trial

SAAO = Sub Assistant Agricultural Officer
SB = stem borer
SCA = Seed Certification Agency (Bangladesh)
SD = standard deviation
SES = standard evaluation system
ShB = sheath blight
ShR = sheath rot
SPDP = seed production and dissemination trial
SR = solar radiation, stem rot
STB = soil test based
STPD = staphylinid
SYT = secondary yield trial

T. Aman = transplanted Aman
T. Aus = transplanted Aus
TLS = truthfully labelled seed
TSP = triple superphosphate

USG	=	urea supergranule
WBPH	=	white-backed planthopper
WS	=	wet season
WSR	=	wet-seeded rice
WTR	=	weed tolerant rice
wt	=	weight
YSB	=	yellow stem borer