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Plant Breeding Division

Research Highlights

Rice

- NERICA mutant N_{10}-350-P-5-4 has been released as Binadhan-21 by NSB for growing in Aus season. Proposed Variety Trial (PVT) of one advanced dual tolerant (salinity and submergence) rice line (RC-251) has been evaluated by the SCA. Application will be made for variety release for tidal floodprone areas. One rice line was found promising for Bacterial leaf blight tolerance. The mutant RM-Kas-80(C)-1 derived from the phosphorus use efficient local Aus rice cultivar Kasalath by irradiating its seeds with 80 Gy Carbon ion beams produced average grain yield of 5.59 tha^{-1} which 10.56% more than BRRI dhan39 but one week late in maturity. Five M_8 mutants of deepwater rice which were developed by irradiating the seeds of the local cultivar Laksmi digha with 200 Gy dose of gamma rays produced higher grain yield (3.58 to 3.75 tha^{-1}) and their plant height ranged between 116 to 210 cm have been selected for Advance Yield Trial in the next Aman season. Five M_6 mutants of BR11 have been selected which were almost free of bacterial leaf blight or with minimum symptoms in the last Aman season apart from 10 M_3R_1 recurrent irradiated populations with minimum symptoms of Blast, BLB or Sheath Blight were also selected. Moreover, four M_6 mutants of Biroi rice of which three shorter in plant height, lodging resistant with higher yield and white pericarp color, and the other tall, lodging susceptible but high yielding with red pericarp color have been selected. The mutant RM-40(C)-4-2-8 with extra long fine grains developed by irradiating the seeds of BRRI dhan29 with 40 Gy dose of carbon ion beams produced average grain yield of 6.14 tha^{-1} grains over 12 locations which was 14.3% more than the mega variety BRRI dhan28. This mutant required one week more time to mature than BRRI dhan28. Additionally, 19 plants were selected from the M_3 populations of NERICA-4 irradiated with nitrogen ion beams.

Rapeseed-Mustard

- Two yellow seeded rapeseed (*B. rapa* var. yellow sarson) mutants with higher seed yield potential and early maturity have been selected for further evaluation. One rapeseed (*B. napus*) mutants with higher seed yield and early maturity have been selected for further evaluation. Forty Five rapeseed mutants from different trials have been selected in respect of maturity period along with some others improved yield components. Some early maturing and high yielding mutants/lines in different generations have also been selected, which need further trials.

Groundnut

- Two mutants B6/282/63 and B6/282/64 having the higher pod yield ha^{-1} along with higher shelling percentage and higher or equal kernel sizes than the most popular groundnut variety Binachinabadam-4 will be put into Advance Yield Trial in the next Rabi season.

Sesame

- Three advanced mutants (SM-01, SM-02 and SM-06) were found promising in respect to seed yield and other agronomic characters. Some other early maturing and high yielding mutants/lines in different generations have also been selected, which need further trials.

Soybean

- One mutant (SBM-22) with higher seed yield potential has been registered as Binasoybean-6 by the NSB. Three advanced mutants (SBM-02, SBM-05 & SBM-07) were found promising regarding maturing period along with improved yield components. Three promising salt tolerant soybean mutants (SGB-07, SGB-06 & SGB-02) having higher seed yield have also been selected for further selection. In addition, there are several desirable mutants in different generation need further screening and evaluation.

Mungbean

- One promising mutant (MBM-427-87-3) of mungbean was selected for earliness, semi synchronous pod maturity, disease tolerant and higher yield from on-farm trial.

Lentil

- Three promising mutants performed well in respect of seed yield and disease reaction. Moreover, a good number of mutants with higher number of pods and earliness were selected for further evaluation.

Blackgram

- Two advanced promising mutant lines were selected for higher seed yield and a good number of mutants were selected for earliness, higher number of pods, synchrony in pod maturity and erect plant type.

Grasspea

- Four mutants were selected for higher yield and earliness and further evaluation will be made in the next season. Besides, a good number of mutants were selected based on earliness and higher number of pods as well as yield.

Chickpea

- One promising mutant (CPM-8-300) with bolder seed size, higher seed yield and tolerant to diseases was selected from on-farm trial.

Jute

- Four mutants JRO-524-1000-8, JRO-524-1000-9, JRO-524-1000-10 and JRO-524-700-3 with taller plant height and higher fiber yield than the parent, JRO-524 have been selected for Advance Yield Trial in the next growing season.

Evaluation trial of one dual tolerant rice line for tidal flood prone areas

This experiment was conducted with one advanced line (RC-251) along with one check variety (BRRI dhan78) at 8 locations (two on-stations and 6 farmers' field) to evaluate rice line for both salinity and submergence tolerance in tidal flood prone areas during T. aman season 2018. The team of Seed Certification Agency (SCA) was evaluated the field.

The experiment followed RCB design with three replications. The size of the unit plots were 5m × 6m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on days to maturity and grain yield were recorded. This line can tolerate 8 dS/m in saline soil and can also survive 15 days of under complete submergence. DUS Tests result of RC-251 (Proposed Variety) with check BRRI dhan78 is shown in Table 5.

From the table it is observed that its life cycle was 115-125 days, grain yield was in average 5.3 t/ha at T. Aman season which was more than the check variety, BRRI dhan78 (Table 2). The rice line RC-251 contained medium slender grain and 25.1% amylose content. In the DUS test it is observed that there was distinct variation between the rice line (RC-251) and check variety in some of the characters (Table 5).

Table 1: Morphological and agronomical characters of RC-251 rice line

Strain/variety	Plant height (cm)	Days to maturity	Filled grains panicle^{-1} (no.)	1000-grain wt. (g)	Grain yield (tha^{-1})
RC-251	116	115-125	145	21.8	5.3
BRRI dhan78 (check)	120	125-135	127	23.5	4.7

Table 2. Performance of the RC-251 rice line grown in different locations under evaluation trials during Aman season, 2018 (Evaluation was done by SCA)

Locations		Strain/Variety	Days to maturity	Grain yield (tha^{-1})
Mymensingh	BINA HQ, farm	RC-251	123	5.70
		BRRI dhan-78	130	4.94
Bagerhat, Khulna	Famer's field	RC-251	115	5.69
		BRRI dhan-78	125	4.51
Barisal	BINA Sub-station, Rahmatpur	RC-251	117	5.10
		BRRI dhan-78	131	4.68
Jhalokhathi	Famer's field	RC-251	119	5.15
		BRRI dhan-78	131	4.68
Sadar, Bhola	Famer's field	RC-251	119	5.79
		BRRI dhan-78	130	5.10
Doulatkhan, Bhola	Famer's field	RC-251	118	4.86
		BRRI dhan-78	130	4.74
Mohipur, Patuakhali	Famer's field	RC-251	119	4.98
		BRRI dhan-78	130	4.67
Patharghata, Borguna	Famer's field	RC-251	128	5.47
		BRRI dhan-78	132	4.62

Table 3: Grain characteristics of RC-251 rice line

Strain/ Variety	Milling yield (%)	Head rice yield (%)	Chalkiness[a]	Whole grain length (mm)	Dehulled grain/kernel				Amylose (%)
					length (mm)	Breadth (mm)	L/B ratio	Size and shape	
RC-251	72	70	wb1	8.5	6.7	2.2	3.05	Medium slender	25.1
BRRI dhan78 (check)	69	65	wb1	8.0	5.6	2.0	2.80	Medium medium	25.2

[a] Wb1 = Less than 10% chalkiness

Table 4. Reaction against diseases and insect pests in natural condition of RC-251 rice line

Strain/variety	BB	ShB	BPH
RC-251	2.0	3.0	00
BRRI dhan78 (check)	3.5	3.0	00

BB= Bacterial blight, ShB = Sheath blight, BPH = Brown plant hopper
Scale: 0-9, where, 0= highly resistance and 9= highly susceptible

Table 5: DUS characters of RC-251 and check variety, BRRI dhan78

SN	Characteristics	BRRI dhan78 (Check Variety)		RC-251 (Proposed Variety)		Remarks
		Code	State	Code	State	
1	Leaf sheath: anthocyanin color	1	Absent	1	Absent	
2	Leaf color	2	Green	2	Green	
3	Penultimate leaf : pubescence of blade	5	Medium	3	Weak	Distinct
4	Penultimate leaf : anthocyanin color of auricles & collar	1	Absent	1	Absent	
5	Penultimate leaf: ligule	9	Present	9	Present	
6	Penultimate leaf: shape of the ligule	3	Split or two-cleft	3	two-cleft	
7	Flag leaf: attitude of blade	1	Erect	1	Erect	
8	Time of heading (50% of plants with heads	5	Medium	5	Medium	
9	Male strility	-		-		
10	Lemma &palea: anthocyanin coloration	1	Absent	1	Absent	
11	Lemma &palea: anthocyanin coloration below apex	1	Absent	1	Absent	
12	Lemma: anthocyanin coloration of apex	1	Absent	1	Absent	
13	Spikelet: color of stigma	1	White	1	White	
14	Culm diameter	3	Medium	3	Medium	
15	Culm: Length	7	Long	7	Long	
16	Stem: anthocyanin coloration of nodes	1	Absent	1	Absent	
17	Stem: Intensity of antho coloration of nodes	-	-	-	-	
18	Stem: anthocyanin coloration of internodes	1	Absent	1	Absent	
19	Panicle: length	7	Long	7	Long	
20	Panicle: curvature of main axis	5	Medium	5	Medium	

21	Panicle: number of effective tillers in plant	5	Medium	5	Medium	
22	Spikelet: Pubescence of lemma &palea	7	Strong	7	Strong	
23	Spikelet: color of tip of lemma	2	Yellowish	5	Purple	Distinct
24	Panicle: awn in spikelet	1	Absent	1	Absent	
25	Panicle: length longest awn	-		-		
26a	Panicle: distribution of awns	-		-		
26b	Panicle: color of awns	-		-		
27	Panicle: attitude of branches	3	Semi-erect	3	Semi-erect	
28	Panicle: exertion	5-7	just to moderately exerted	7	Moderatelty exerted	
29	Time of maturity	5	Medium	5	Medium	
30	Grain: wt of 1000 fully developed grains (at 12%)	5	Medium	5	Medium	
31	Grain: length (without dehulling)	7	Long	7	Long	
32	Spikelet : Sterile lemma length	3	Medium	3	Medium	
33	Decorticated grain: length (After dehulling, before milling)	3	Medium	5	Long	Distinct
34	Leaf senescence	1	Late & Slow	1	Late & Slow	
35	Decorticated grain: shape (Length-breadth ratio	5	Medium	7	Medium slender	Distinct
36	Decorticated, unpolished grain: color	2	Light brown	2	Light brown	
37	Polished grain: size of white core or chalkiness	1	Absent or very small	1	Absent	
38	Endosperm : content of amylose	5	High (>25%)	3	Intermediate	Distinct
39	Decorticated grain: aroma	1	Absent	1	Absent	
40	If any					

Remarks: DUS tests characters of the candidate variety of RC-251with check variety BRRI dhan78

Distinctness: The above serial number23, 30, 35 and 38 indicated that the candidate variety is distinctly different from the check variety BRRI dhan78.

Uniformity: At 50% heading date time only 0.5% off-type was observed for both the lines. It indicated that the candidate variety of RC-251 is uniform according to UPOV standard.

Stability: In the test plots of two consecutive seasons trials, no remarkable variation and segregation were noted which imply the stability of the candidate variety.

Zonal yield trial of introgressed bacterial leaf blight resistant rice lines in Aman season, 2018

Two BLB introgressed lines along with one check Near isogenic pyramided BLB resistant lines (IRBB60) were put into zonal yield trial during aman season, 2018 **at** BINA HQs Mymensingh, BINA sub-station Nalitabari, Sherpur and BINA sub-station, Tajhat, Rangpur. The experiment was laid out in RCBD with three replications. Unit plot size was 4m x 5m and spacing between hills and rows were 15 cm x 20 cm. Data on days to maturity, plant height, total tillers/ plant , no. of effective tillers /plant, panicle length, filled grains/ panicle, unfilled grains/panicle, 1000 grain weight (g) and grain yield /plot(kg) were recorded from five randomly selected plants from each plot. Plot yield was converted to t/ha. Beside this two seedlings of each line/strain were inoculated at maximum tillering stage to evaluate their reaction to bacterial blight only at BINA HQs, Mymensingh. Inoculation was done by clipping the leaves 2-3 cm from the tip with sterilized scissors dipped in bacterial suspension of 3 day-old culture of *X. oryzae* pv *oryzae* growing on Modified Wakimoto's Medium. Three isolates of *X. oryzae* pv *oryzae* (*Xoo*) were used to inoculate each line to test for bacterial blight resistance genes. The plants were assessed at 14 days after inoculation. The agronomic performance of SSB-3 is shown in Table 6-9.

From the Table 1-3, it is observed that out of two test entries, SSB-4 matured earlier followed by SSB-3 at all the three locations. Line SSB-3 produced the highest filled grains/ panicle, panicle length and seed yield (around 6.3 t/ha). For disease reaction, among the tested materials, SSB-3 showed tolerance against 3 BLB isolates. Other two places SSB-3 also performed better in respect of grain yield and BLB disease. This SSB-3 line will be evaluated in farmers field in the next year in different agro ecological zones.

Table 6: Mean agronomic performance of introgressed BLB resistant rice lines over location

Mutant/Varieties	DF (days)	DM (days)	PH(cm)	TT	ET	PL(cm)	FG	UG	TSW(gm)	Y/P(kg)
BINA HQs, Mymensingh										
SSB-3	91.00	129	107.62	11.62	10.32	27.87	152	32	23.22	6.89
SSB-4	86.33	119	105.39	10.03	9.44	24.5	129	28	22.45	4.85
IRBB60	83.67	117	96.44	10.5	8.56	24.22	104	36	22.01	3.94
SD	3.71	6.43	5.92	0.82	0.88	2.03	24.01	4.00	0.61	1.51
BINA Substation, Nalitabari										
SSB-3	89.00	132	100	10.6	10.2	25.1	144	39	23.22	5.73
SSB-4	88.33	124	101.8	9.5	9.5	22.2	127.5	18	22.45	5.15
IRBB60	90.67	121	94.2	9	8.8	24.1	109.6	28	22.01	4.65
SD	1.21	5.69	3.97	0.82	0.70	1.47	17.20	10.50	0.61	0.54
BINA Substation, Rangpur										
SSB-3	89.56	121	103.8	11.6	10.2	26.6	141	36	23.28	6.23
SSB-4	85.67	116	97.2	10.9	9.65	23.7	120	31	22.45	4.75
IRBB60	87.24	115	87.5	9.8	9.4	23.1	116	28	22.01	4.52
SD	1.96	3.21	8.20	0.91	0.41	1.87	13.43	4.04	0.64	0.93
Means over location										
SSB-3	89.85	127.33	103.81	11.27	10.24	26.52	145.67	35.67	23.24	6.28
SSB-4	86.78	119.67	101.46	10.14	9.53	23.47	125.50	25.67	22.45	4.92
IRBB60	87.19	117.67	92.71	9.77	8.92	23.81	109.87	30.67	22.01	4.37
SD	1.67	5.10	5.85	0.78	0.66	1.68	17.95	5.00	0.62	0.99

On farm and on station trial of five NERICA mutants and one advanced line

Six rice lines along with two check varieties BRRI dhan28 and BRRI dhan29 were tested in Boro season 2018-19 at BINA substation, Chapainawabganj. Seeds were sown on 3 December 2018 and transplanted to the field on 15 January 2019. The experiment was laid out in RCBD with three replications. Unit plot size was 4m x 5m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on days to 50% flowering, days to maturity, plant height, total tillers plant^{-1}, effective tillers hill-^{1}, panicle length (cm), grain yield (kg/plot) and phenotypic performance were recorded from five randomly selected plants from each plot.

Among the six lines, duration was highest in N4/250/P-2(5)-11-2 and lowest in N4/250/P-1(2). Tallest plant was found in case of N4/250/P-2(6)-26. Total tiller was highest in N4/250/P-2(6)-26 and lowest was found in N10/300/P-2-3-5-1 whereas effective tiller highest in the check variety BRRI dhan 28 and lowest in N10/300/P-2-3-5-1 Filled grain was highest in N10/300/P-2-3-5-1and lowest in BRRI dhan 28 . Yield was found highest in N4/250/P-2(5)-11-2 compared to the check variety and other lines (Table 1).

Based on early maturity and higher seed yield and phenotypic acceptability two lines were selected and will be evaluated as preliminary yield trial in next growing season.

Table 7: Mean agronomic performance of rice mutants

Mutant/Varieties	DF (days)	DM (days)	PH (cm)	TT	ET	PL (cm)	FG	UG	TSW (gm)	Y/P
N4/250/P-2(5)-11-2	**115.67**	**155.67**	101.12	10.83	10.96	23.47	167.33	18.80	**25.90**	**7.46**
N4/250/P-1(2)	**99.33**	**132.67**	101.58	11.83	10.96	22.47	110.07	15.73	**19.80**	7.15
N4/250/P-2(6)-26	102.67	134.33	**109.99**	**12.95**	11.79	**22.10**	104.00	15.73	20.20	7.07
N10/300/P-2-3-5-1	110.33	151.33	101.12	**9.12**	**9.04**	25.23	**174.80**	**24.27**	20.23	6.15
N10/300/P-2-3-5-2	113.00	152.00	105.96	10.83	10.08	24.53	154.47	28.53	20.23	6.10
SH-1	103.67	140.00	**87.75**	10.46	9.71	23.07	111.13	20.33	20.73	6.18
BRRIdhan 28	100.00	132.33	102.58	12.87	**12.00**	22.57	**99.67**	**12.20**	23.63	**5.88**
BRRIdhan 29	107.33	150.00	92.13	11.00	10.80	**25.27**	130.60	21.53	22.07	6.15
SD	**6.07**	**9.73**	**7.16**	**1.28**	**1.01**	**1.27**	**30.07**	**5.23**	**2.16**	**0.61**

Regional yield trial of six promising rice lines

Six rice lines along with one check varieties BRRI dhan 56 were tested in Aman season 2018-19 at BINA headquarter, Mymensingh. Seeds were sown on 3 July 2018 and transplanted to the field on 10 September 2018. The experiment was laid out in RCBD with two replications. Unit plot size was 5m x 6m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on days to 50% flowering, days to maturity, plant height, total tillers plant^{-1}, effective tillers hill-^{1}, panicle length (cm), grain yield (kg/plot) and phenotypic performance were recorded from five randomly selected plants from each plot.

From the Table 2, it is observed that N1/300/P-P-6-5-5(2) line had the highest plant height (138.47cm) whereas N4/250/P-2(6)-26had the lowest (101.33 cm). First flowering was found earliest in N4/250/P-2(6)-26(72.33e days) lines followed by N10/300/P-2-3-5-2 (98.00a days). But early maturity happened in N4/250/P-1(2) (93.00f days) followed by N4/250/P-2(6)-26 (98.33 days) and N4/250/P-2(5)-11-2 line took more days (135.33a days) than any other lines. The highest effective tillers/hill (10.80) and the highest number of total tillers/hill (11.73) was found in N4/250/P-1(2) and lowest effective tillers/hill (6.60) and lowest number of total tillers/hill (7.00) in N10/300/P-2-3-5-2. The experiment revealed the highest panicle length (23.67 cm) in N4/250/P-2(6)-26 followed by SH-1 (26.47 cm). This N4/250/P-2(5)-11-2 line produced the highest seed yield (6.67 kg) and lowest was found in N1/300/P-P-6-5-5(2) (1.13).

Based on early maturity and higher seed yield and phenotypic acceptability two lines were selected and will be evaluated as preliminary yield trial in next growing season.

Table 8: Mean agronomic performance of rice mutants

Mutant/Varieties	DF (days)	DM (days)	PH (cm)	TT	ET	PL (cm)	FG	UG	TSW (gm)	Y/P (kg)
N1/300/P-P-6-5-5(2)	88.67	128.33	**138.47**	7.40	6.70	25.17	**167.50**	41.53	24.40	**1.13**
N4/250/P-2(6)-26	**72.33**	98.33	**101.33**	10.40	9.73	**23.67**	126.33	20.53	16.92	4.30
N4/250/P-1(2)	72.67	**93.00**	103.67	**11.73**	**10.80**	24.57	**98.33**	36.53	19.65	4.70
N4/250/P-2(5)-11-2	97.67	**135.33**	105.40	9.47	8.93	25.20	122.53	42.20	25.92	**6.67**
N10/300/P-2-3-5-2	**98.00**	134.67	112.20	**7.00**	**6.60**	25.73	128.83	**61.87**	20.13	3.43
SH-1	80.67	118.00	103.40	8.07	7.80	**26.47**	108.13	**16.07**	20.73	5.53
BRRIdhan 56	75.67	106.67	111.40	7.93	7.80	26.13	116.53	35.33	21.34	5.40
SD	**11.17**	**17.35**	**12.86**	**1.74**	**1.56**	**0.96**	**21.94**	**15.14**	**3.02**	**1.78**

Preliminary yield trial of rice lines for earliness and higher grain yield

Thirty rice lines were tested in Boro season 2018-19 at BINA headquarter, Mymensingh. The experiment was laid out in RCBD with two replications. Unit plot size was 3m x 2m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on days to 50% flowering, days to maturity, plant height, total tillers plant^{-1}, effective tillers hill-^{1}, panicle length (cm), grain yield (Kg/plot) and phenotypic performance were recorded from five randomly selected plants from each plot.

From the Table 3, we found that BRRI dhan28 had the highest plant height (113.40cm) whereas MARF=12 had the lowest (84.80cm). First flowering found earlier in MARF=19 (104.67 days) and MARF=49 and MARF=62 lines took more days (116.33 days). Early maturity occurred in MARF=45 (134.67 days) whereas MARF=81took more days (152.1 days) than any other lines. The highest effective tillers/hill (14.13) and the highest number of total tillers/hill (15.60) was found in MARF=76 and lowest effective tillers/hill (9.27) and lowest number of total tillers/hill (10.23) in MARF=52. The experiment revealed that the highest panicle length (26.33cm) in MARF=49 followed by MARF=72 (21.20cm). MARF=91 line produced the highest seed yield (1.92kg) and lowest was found in MARF=12(1.28).

Based on early maturity and higher seed yield and phenotypic acceptability ten lines were selected and will be evaluated as preliminary yield trial in next growing season.

Table 9: Mean agronomic performance of 30 rice lines

Mutant/Varieties	**DF (days)**	**DM (days)**	**PH (cm)**	**TT**	**ET**	**PL (cm)**	**FG**	**UG**	**TSW (gm)**	**Y/P (kg)**
MARF=7	106.33	144.00	94.27	10.67	9.87	22.13	100.80	29.27	20.90	1.52
MARF=10	108.33	141.33	87.60	10.80	10.13	22.93	113.60	22.53	23.10	1.57
MARF=12	109.67	139.33	**84.80**	10.27	9.73	22.47	129.13	34.67	23.77	**1.28**
MARF=19	**104.67**	143.67	96.00	10.33	9.47	22.53	107.40	22.80	24.07	1.45
MARF=20	113.00	150.33	96.33	11.60	10.87	24.27	98.93	27.60	24.03	1.31

MARF=23	109.00	147.33	93.53	11.27	10.33	23.47	**87.53**	22.20	**26.23**	1.30
MARF=27	107.33	140.33	87.93	11.07	10.07	22.87	247.33	**57.67**	20.97	1.43
MARF=35	110.00	146.33	99.80	12.20	11.00	24.00	139.33	40.60	21.50	1.43
MARF=37	110.00	148.00	95.67	11.10	9.77	21.60	123.03	21.58	20.57	1.67
MARF=45	111.33	**136.67**	94.40	11.53	10.27	24.27	104.70	27.90	24.67	1.57
MARF=49	**116.33**	147.67	97.73	11.80	10.87	**26.33**	125.10	31.80	19.83	1.66
MARF=52	115.00	151.00	102.27	**10.23**	**9.27**	23.97	118.60	20.93	22.17	1.67
MARF=53	112.67	148.67	100.80	11.40	10.60	25.80	115.53	35.73	21.03	1.70
MARF=55	114.67	145.00	101.13	11.67	10.67	22.43	125.87	27.27	20.70	1.74
MARF=58	114.67	143.33	105.53	11.47	10.73	24.33	127.67	24.80	22.93	1.63
MARF=62	**116.33**	148.00	97.13	11.67	10.67	23.40	112.60	31.33	20.63	1.60
MARF=69	110.67	144.67	107.13	11.40	10.27	23.67	112.07	17.73	24.47	1.73
MARF=72	117.67	149.00	96.27	12.87	11.53	**21.20**	139.93	29.33	20.00	1.81
MARF=75	111.67	148.00	106.70	12.43	11.60	23.77	112.80	40.67	24.70	1.77
MARF=76	113.67	149.00	100.60	**15.60**	**14.13**	23.67	150.67	35.07	21.67	1.61
MARF=78	112.00	151.33	98.53	11.67	11.03	22.97	128.87	34.33	23.23	1.64
MARF=82	110.00	149.33	99.60	14.53	13.60	23.40	132.37	33.80	22.27	1.49
MARF=81	112.50	**152.50**	93.50	13.20	12.00	24.20	124.30	48.10	22.40	1.88
MARF=86	107.33	143.00	93.20	13.00	11.93	22.47	103.27	23.73	23.43	1.40
MARF=91	108.00	149.00	103.70	14.70	12.70	24.67	123.15	28.20	23.85	**1.92**
Binadhan-17	112.00	146.00	104.00	10.10	9.70	24.14	138.00	28.00	**19.55**	1.73
BRRIdhan 28	108.33	143.67	**113.40**	11.53	10.53	21.33	115.27	20.00	23.90	1.55
BRRIdhan 29	108.00	139.00	101.80	11.30	10.70	25.40	135.50	39.50	22.65	1.40
SD	**3.29**	**4.06**	**6.30**	**1.36**	**1.17**	**1.25**	**27.97**	**8.99**	**1.73**	**0.17**

Advanced yield trial of rice lines for earliness and higher grain yield

Eight rice lines along with two check varieties were tested in Aman season 2018-19 at BINA HQs farm and BINA substation, Magura. Seeds were sown on 3 august 2018 and transplanted to the field on 10 September 2018. The experiment was laid out in RCBD with three replications. Unit plot size was 4m x 3m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on days to 50% flowering, days to maturity, plant height, total tillers plant^{-1}, effective tillers hill-^{1}, panicle length (cm), grain yield (Kg/plot) and phenotypic performance were recorded from five randomly selected plants from each plot.

Among the lines Magic-10 was found early flowering in both locations. Total tiller was found highest in Magic-62 at BINA HQs farm but in Magura highest was found in case of check variety BRRI dhan29. Number of filled grain was ranged from 144.53 to 71.53, both highest and lowest was found in Magura in case of Magic-78 and Magic-12 respectively. Highest yield was found in BINA HQs farm was 5.00(Magic-27) whereas it was much higher in Magura in case of Magic-82.

Based on early maturity and higher seed yield and phenotypic acceptability four lines were selected and will be evaluated as preliminary yield trial in next growing season.

Table 10: Mean agronomic performance of 8 rice lines over location

Mutant/Varieties	DF (days)	DM (days)	PH (cm)	TT	ET	PL (cm)	FG	UG	TSW (gm)	Y/P (kg)
BINA HQs farm, Mymensingh										
Magic-10	**102.00**	136.00	90.00	12.33	10.93	21.67	110.00	39.07	20.33	4.93
Magic-12	105.33	135.00	107.80	11.07	10.13	22.27	112.73	21.47	22.03	4.83
Magic-27	112.33	140.00	98.53	**10.67**	**9.53**	**21.47**	107.93	21.33	22.00	**5.00**
Magic-62	**118.33**	150.67	99.93	**13.27**	**12.07**	23.93	**131.40**	**41.13**	17.53	4.57
Magic-72	121.67	**159.67**	**88.60**	13.07	12.00	23.40	110.93	21.40	21.63	**3.40**
Magic-78	116.67	148.33	**111.20**	11.20	10.40	**24.93**	105.00	31.93	24.23	4.47
Magic-82	114.67	151.67	101.93	12.20	11.13	23.07	135.47	26.87	21.93	5.17
Magic-86	105.00	140.33	101.40	11.47	10.67	23.73	107.80	28.47	22.53	4.93
BRRIDhan 28	102.67	141.33	90.80	12.13	10.73	22.00	**104.67**	**27.27**	21.50	4.67
BRRIDhan 29	116.67	**156.33**	89.53	11.67	10.67	22.07	110.87	32.73	22.07	4.37
SD	**7.17**	**8.59**	**8.01**	**0.85**	**0.78**	**1.13**	**10.76**	**7.09**	**1.72**	**0.50**
BINA Sub-station, Magura										
Magic-10	**101.00**	**139.00**	**80.47**	**7.13**	**7.70**	**19.73**	82.73	5.73	**20.67**	5.93
Magic-12	105.67	**139.00**	103.00	8.63	9.67	23.40	**71.53**	9.20	21.82	6.33
Magic-27	111.33	140.00	88.90	10.37	11.67	21.60	69.27	11.93	21.76	5.57
Magic-62	117.33	152.00	100.13	11.04	12.00	25.73	111.07	25.13	18.21	6.70
Magic-72	**122.33**	**153.00**	97.93	12.17	**12.80**	25.60	83.73	26.20	22.00	5.93
Magic-78	117.00	145.00	**115.00**	10.22	11.00	**28.27**	**144.53**	17.80	**23.80**	7.03
Magic-82	116.33	151.00	102.47	11.89	13.47	25.07	136.53	**29.00**	22.26	**7.37**
Magic-86	104.67	**139.00**	84.20	12.23	11.13	21.87	68.27	8.00	23.23	6.10
BRRIDhan 28	103.00	**139.00**	95.80	13.13	11.33	21.60	81.53	**4.80**	21.87	**5.65**
BRRIDhan 29	117.33	153.00	104.27	**14.67**	12.20	26.00	110.20	23.07	22.43	6.85
SD	**7.47**	**6.51**	**10.31**	**2.19**	**1.64**	**2.66**	**27.98**	**9.23**	**1.52**	**0.61**
Means over location										
Magic-10	101.50	137.50	85.24	9.73	9.32	20.70	96.37	22.40	20.50	5.43
Magic-12	105.50	137.00	105.40	9.85	9.90	22.84	92.13	15.34	21.93	5.58
Magic-27	111.83	140.00	93.72	10.52	10.60	21.54	88.60	16.63	21.88	5.29
Magic-62	117.83	151.34	100.03	12.16	12.04	24.83	121.24	33.13	17.87	5.64
Magic-72	122.00	156.34	93.27	12.62	12.40	24.50	97.33	23.80	21.82	4.67
Magic-78	116.84	146.67	113.10	10.71	10.70	26.60	124.77	24.87	24.02	5.75
Magic-82	115.50	151.34	102.20	12.05	12.30	24.07	136.00	27.94	22.10	6.27
Magic-86	104.84	139.67	92.80	11.85	10.90	22.80	88.04	18.24	22.88	5.52
BRRIDhan 28	102.84	140.17	93.30	12.63	11.03	21.80	93.10	16.04	21.69	5.16
BRRIDhan 29	117.00	154.67	96.90	13.17	11.44	24.04	110.54	27.90	22.25	5.61
SD	**7.31**	**7.45**	**7.87**	**1.23**	**1.01**	**1.77**	**17.14**	**6.01**	**1.61**	**0.42**

Evaluation and seed multiplication of 28 BLB introgressed pre-breeding rice lines

Twenty eight BLB introgressed rice lines collected from IRRI, Philippines and were grown for seed multiplication and agronomic performance during aman season, 2018 **at** BINA HQs Mymensingh . Unit plot size was 2m x 1m and spacing between hills and rows were 15 cm x 20 cm. Data on days to maturity, plant height, total tillers/ plant, no. of effective tillers /plant, panicle length, filled grains/ panicle, unfilled grains/panicle, 1000 grain weight (g) and grain yield /plot(kg) were recorded from five randomly selected plants from each plot. The result is shown in Table 9. Nine lines were selected for further evaluation in the next year.

Table 11: Agronomic performance of 28 BLB introgressed pre-breeding rice lines

Entry name	Days to maturity	Plant height (cm)	Total tillers plant^{-1}	No. effective tillers plant^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	1000 seed wt. (g)	Grain yield plot^{-1} (kg)
CSA-1	112	108.2	10.4	9.8	23.8	117	24	25.6	1.4
CSA-2	114	121.2	6.6	6.2	25	142.8	24.4	25.2	1.2
CSA-3	117	113.2	9.8	9.4	26.4	111	22	23	1.2
CSA-4	111	95.2	9	8.4	23.2	86.5	28	22.3	0.93
CSA-5	115	93	7.8	7.6	24	84.2	11	22.6	0.65
CSA-6	117	90.2	9.6	8.8	23.2	93.8	24	21.4	0.68
CSA-7	114	90.4	10	9.8	22.4	95	20	22.14	0.78
CSA-8	113	92.4	8.4	8.00	23.5	90	29	22.4	0.65
CSA-9	114	90.6	10.4	9.8	22.8	98	17	22.7	0.95
SW-10	118	112.6	8.2	8.2	26.6	120	18	25.4	1.65
SW-11	125	94.6	11	10.8	23.4	162.6	35.8	20.5	1.83
SW-12	115	98.4	10.2	10.2	23.8	131	25	20.5	1.23
SW-13	132	91.8	8.6	8.4	22	186	42	19.0	1.57
SW-14	128	99	9.8	9.8	22.2	140	46	21.6	1.73
SW-15	131	93.8	10.6	10.2	24.6	175	51.8	20.10	1.52
SW-16	130	87.8	10.6	8	22.8	158	17	20.00	1.42
SW-17	134	88.3	10.6	10.4	22.2	124.8	32.4	21.30	1.47
SW-18	125	89	12.4	11.8	23.4	153	32	20.40	1.52
SW-19	138	93.2	12.8	12.4	24	132.4	44.8	24.8	1.69
SW-20	140	97.6	13	12.8	24.6	174	34	20.00	1.57
SW-21	140	95.6	11.2	10.6	24.2	143	41	20.84	1.52
SW-22	137	96.6	10.2	10	24	138	28	20.40	1.43
SW-23	137	95.6	12	11.4	24.2	201.6	32	19.4	1.48
SW-24	135	103	10.2	9.4	24	196	31.2	24.5	1.63
SW-26	142	97.2	11.8	11	22.8	168	30	20.56	1.53
SW-27	134	100.8	14.2	13.6	22.2	156	22	19.5	1.43
SW-28	133	96.4	12.6	12	23.8	222	36	19.4	1.51

Evaluation of 24 elite salt-tolerant rice lines for higher tolerance

The experiment was conducted with 24 elite salt tolerant rice lines along with check variety BRRI dham78 to select the superior advanced salt tolerant rice genotypes suitable for the coastal saline soils of Bangladesh. Seeds of elite salt tolerant lines and check varieties were received from IRRI in January and were sown in the seedbed on 22 January at BRRI Farm, Satkhira. Seedlings were transplanted on 5 March 2019 in no or low saline site Harodda, Satkhira Sadar and 6 March in high saline sites of Kamarkati, Ashashuni which were two months delayed than the recommended time of transplanting. Twenty-five genotypes including check variety, BRRI dhan67 were evaluated in trial sites (Table 1). The trials were conducted following row-column design with two replications in each site. The unit plot size was 5 square meters. Seedlings were transplanted at the rate of 3 seedings/hill maintaining the spacing of 20 cm x 20 cm. Fertilizers at the rate of 120, 19, 60, 20 and 3.6 kg/ha of N, P, K, S and Zn, respectively, in the form of Urea, Triple Super Phosphate, Muriate of Potash, Gypsum and Zinc Sulphate. Nitrogen was applied in three equal splits at 15, 30, 50 days after transplanting (DAT). Total amount of P, K, S and Zn were applied at the time of final land preparation**.** Data on days to maturity, plant height, total tillers/ plant, no. of effective tillers /plant, panicle length, filled grains/ panicle, unfilled grains/panicle' 1000 grain weight (g) and grain yield /plot(kg) were recorded from five randomly selected plants from each plot.

The IRRI provided advanced lines and other 10 lines and check variety, BRRI dhan67 from BRRI were tested in 2 Upazilas of Satkhira district. The soil salinity of the on-farm trial conducted at Harodda village in Satkhira Sadar was close to 4 dSm^{-1} at the maturity of the crop. All entries performed well at seedling stage and at establishment.

In no or low saline sites the performance of the tested entries are given in Table 10. As the transplanting was done delayed by two months, the early maturing entries were severely affected by stem borer and the late maturing varieties were affected by water stress.

Table 12. Days to maturity and grain yield of tested entries in low saline sites

Sl. no.	Pedigree number	On-farm	
		Days to maturity	Grain yield (tha^{-1})
1	IR 121094-B-B-AJY 3-2-B	138	1.31
2	IR16T1009	-	-
3	IR117834-10-1-RGA-1-RGA-1-RGA-1	128	2.45
4	IR117841-2-1-RGA1-RGA-1-RGA-1	-	-
5	IR117841-5-1-RGA-1-RGA-1-RGA-1	151	1.22
6	IR 117841-8-1 RGA-1 RGA-1 RGA-1	133	2.50
7	IR 112462-B-25-2-1-1	142	1.71
8	IR15T1302	132	2.08
9	IR16T1075	-	-
10	IR 117749-B-B-CMU 6-1-B	125	2.27
11	IR 58443-6B-10-3	133	3.03
12	NSIC RC 182	-	-
13	IRRI 104 (S. check)	120	3.01
14	IRRI 154 (S. check)	131	2.63
15	IR64 (Check)	121	1.50

16	SVIN359-IRSSTN-TA18	136	2.02
17	SVIN423-IRSSTN-TA18	144	0.78
18	SVIN4-1-IRSSTN-TA18	135	0.36
19	SVIN362-IRSSTN-TA18	153	2.41
20	SVIN395-IRSSTN-TA18	-	-
21	SVIN374-IRSSTN-TA18	-	-
22	SVIN361-IRSSTN-TA18	-	-
23	SVIN402-IRSSTN-TA18	-	-
24	SVIN398-IRSSTN-TA18	150	2.11
25	BRRI dhan67 (Check)	136	3.17

At Ashashuni, degree of salinity increased day by day and the most of the genotypes were damaged. The salinity ranged from 5.50 to 10.20 dSm^{-1} on March 16, 2019 to April 25, 1019 (Table 12).

Table 13. Dynamics of salinity in different growth stage of rice in Kaligonj and Ashshuni, Satkhira

Ashashuni	
Date	**Salinity (dSm^{-1})**
06.03.2019	5.50
13.03.2019	6.00
20.03.2019	6.40
31.03.2019	9.12
11.04.2019	10.20
25.04.2019	8.20

In saline *ghers (*Ashashuni), IR 58443-6B-10-3, SVIN423-IRSSTN-TA18, SVIN362-IRSSTN-TA18, SVIN361-IRSSTN-TA18 and BRRI dhan67 could tolerate salinity at early vegetative stage but damaged at later stage. The tested entries also could not tolerate or escape high salinity at reproductive phase in saline *ghers*.

Preliminary yield trial of temperate nursery rice lines (IRTON) in *Boro* season

An experiment was carried out with five cold tolerant and high yielding rice lines to assess the earliness and yield performance over different locations especially northern part of Bangladesh. BRRIdhan-28 was used as a check variety at Boro season. Seeds were sown at 09-25th December 2018 and transplanted 09 January to 14th February 2019 at different locations (Table 1). The experiment followed by RCB design with three replications. The size of the unit plots were 3.0 m × 2.0 m. Seedlings were transplanted at 15 cm distance within rows of 20 cm apart. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MOP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tiller, panicle length, filled as well as unfilled grains panicle^{-1} were recorded after harvest from five randomly selected competitive plants. Maturity was assessed by plot basis. Grain yield data were recorded from an area of 1.0 m^2 which was later converted to tha^{-1}. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 2.

Table 14. Date of seed sowing and seedling transplanting of five rice lines and the check variety

Locations	Date of sowing	Date of transplanting
Rangpur	9 December 2018	22 January 2019
Sunamganj	9 December 2018	21 January 2019
Thakurgaon	25 December 2018	14 February 2019
Mymensingh	9 December 2018	22 January 2019

It appears that the line IRTON-5 had significantly taller plant than others at all locations. The line IRTON-11 produced highest number of effective tiller per plant at all locations except Sunamganj. The highest number of effective tillers was found in Sunamganj. None of the lines had significantly higher number of tillers than the check variety except Sunamganj. Number of effective tillers did not differ significantly among the lines than the check variety at Mymensingh. One line IRTON-11 had significantly longer panicle length at all location except Mymensingh.

Table 15. Mean performance of five IRTON lines along with check variety grown at Rangpur, Sunamganj, Thakurgaon and Mymensingh during rabi season 2018-19.

Lines/variety	Plant height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Days to maturity	Days to 50% flowering	1000 seed weight	Grain yield (tha^{-1})
Rangpur									
IRTON-13	91.27 c	10.60 abc	21.73 b	128.07 a	17.00 ab	158.00 b	130.00 bc	24.33 c	5.39 d
IRTON-2	87.07 d	10.20 bc	19.87 b	107.53 c	22.47 a	169.33 a	138.00 a	25.67 b	7.51 a
IRTON-6	92.33 bc	11.20 abc	19.37 b	107.33 c	11.73 bc	158.67 b	129.00 c	30.00 a	6.18 c
IRTON-11	93.60 bc	12.20 a	25.87 a	117.17 b	18.60 ab	153.33 c	123.00 d	25.00 bc	6.71 b
IRTON-5	98.20a	10.00 c	21.43 b	114.90 bc	5.03 c	167.67 a	133.00 b	30.00 a	6.51 bc
BRRIdhan-28	94.60 b	11.80 ab	21.07 b	118.80 ab	13.80 b	159.33 b	129.33 c	22.67 d	5.46 d
CV	**1.79**	**8.08**	**8.32**	**4.55**	**25.8**	**1.22**	**1.37**	**2.57**	**3.22**
SE	**1.36**	**0.73**	**1.46**	**4.30**	**3.1**	**1.6**	**1.46**	**0.56**	**1.65**
Sunamganj									
IRTON-13	88.00 b	12.67 bc	22.33 ab	120.00 a	16.00 c	131.0 bc	110.67 e	24.33 c	6.76 c
IRTON-2	94.33 ab	16.67 a	19 .67 c	83.00 b	39.33b	143.33 a	124.33 a	25.67 b	7.14 b
IRTON-6	94.67 ab	16.67 a	20.67 bc	85.33 b	58.00 a	142.00 a	120.67 b	30.00 a	7.56 a
IRTON-11	90.67 b	14.00 b	23.67 a	80.00 b	20.00 c	128.67 c	109.33 e	25.00 bc	6.28 d
IRTON-5	101.33 a	17.33 a	21.00 bc	107.00 a	14.00 c	141.00 a	116.67 c	30.00 a	7.79 a
BRRIdhan-28	92.33 ab	11.33 c	21.67 b	104.00 a	15.67 c	132.67 b	112.67 d	22.67 d	6.39 d
CV	**5.34**	**9.05**	**4.41**	**9.43**	**17.84**	**1.13**	**0.73**	**2.57**	**1.79**
SE	**4.08**	**1.09**	**0.77**	**7.43**	**3.96**	**1.26**	**0.69**	**0.55**	**0.10**
Thakurgaon									

IRTON-13	90.27 d	10.51 b	21.73 b	128.33 a	17.00 ab	158.00 b	131.00 bc	25.00 b	5.62 c
IRTON-2	86.20 e	10.50 b	19.87b	108.33 cd	22.47 a	169.33 a	137.67 a	25.67 b	7.21 a
IRTON-6	92.10 cd	10.70 ab	19.37b	107.67 d	11.73 bc	158.67 b	129.00 c	30.00 a	6.38 b
IRTON-11	92.93 c	12.10 a	25.87a	117.67 bc	18.60 ab	153.33 c	123.00 d	25.00 b	6.61 b
IRTON-5	98.40 a	10.17 b	21.43b	115.03bcd	5.03 c	167.67 a	134.33 ab	30.00 a	6.69 b
BRRIdhan-28	95.27 b	11.70 ab	21.07b	119.13 ab	13.80 b	159.33 b	130.00 c	22.67 c	5.37 c
CV	**1.36**	**7.94**	**8.32**	**4.55**	**25.68**	**1.22**	**1.51**	**1.92**	**3.23**
SE	**1.03**	**0.71**	**1.46**	**4.31**	**3.1**	**1.60**	**1.61**	**0.41**	**0.17**
Mymensingh									
IRTON-13	86.00 bc	11.27 a	24.40 a	126.00a	66.67 ab	146.67 c	121.33 b	24.33 c	4.58 a
IRTON-2	83.00 c	10.87a	20.87 b	111.67 bc	81.67 a	154.00 b	124.33 a	25.67 b	4.64 a
IRTON-6	90.73 ab	10.60a	20.40b	117.00 ab	85.00 a	157.00 a	116.00 d	30.00 a	4.60 a
IRTON-11	74.73 d	13.07a	21.33b	104.33 c	32.67 bc	141.33 d	115.00 d	25.00 bc	4.00 b
IRTON-5	92.13 a	10.40a	20.73b	103.33 c	38.00 bc	154.67 b	125.67 a	30.00 a	4.43 a
BRRIdhan-28	74.60 d	10.80a	20.07b	111.00 bc	30.00 c	146.33 c	118.00 c	22.67 d	3.73 c
CV	**3.59**	**5.82**	**6.81**	**5.99**	**15.34**	**0.50**	**0.66**	**2.57**	**2.77**
SE	**2.45**	**0.53**	**1.20**	**5.50**	**3.98**	**0.61**	**0.64**	**0.55**	**0.10**
Combined means									
IRTON-13	88.88bc	11.26 b	22.55 b	125.60 a	29.17 b	148.42 c	123.25 c	24.50 d	5.58 de
IRTON-2	87.65 c	12.06 ab	20.07 c	102.63 d	41.48 a	159.00 a	131.08 a	25.67 b	6.63 a
IRTON-6	92.46 b	12.29 ab	19.95 c	104.33 cd	41.62 a	154.08 b	123.67 c	30.00 a	6.18 bc
IRTON-11	87.98 c	12.84 a	24.18 a	104.79 cd	22.47 bc	144.17 d	117.58 d	25.00 c	5.90 cd
IRTON-5	97.52 a	11.98 ab	21.15 bc	110.07 bc	15.52 c	157.75 a	127.42 b	30.00 a	6.35 ab
BRRIdhan-28	89.20 bc	11.41 b	20.97 c	113.23 b	18.32 bc	149.42 c	122.50 c	22.67 e	5.24 e
CV	**5.08**	**14.63**	**7.99**	**7.92**	**52.33**	**2.11**	**1.79**	**2.12**	**7.19**
SE	**1.88**	**0.72**	**0.70**	**3.56**	**6.00**	**1.11**	**1.07**	**0.23**	**0.18**
Location means									
Rangpur	92.84 a	11.00 b	21.56 a	115.63 a	14.77 c	161.06 a	130.39 a	26.28 a	6.30 b
Sunamganj	93.56 a	14.78 a	21.50 a	96.56 b	27.17 b	136.44 c	115.72 c	26.28 a	7.00 a
Thakurgaon	92.53 a	10.95 b	21.56 a	116.03 a	14.77 c	161.06 a	130.83 a	26.39 a	6.31 b
Mymensingh	83.53 b	11.17 b	21.30 a	112.22 a	55.67 a	150.00 b	120.06 b	26.28 a	4.33 c
SE	**1.54**	**0.58**	**0.57**	**2.91**	**4.90**	**0.91**	**0.87**	**0.19**	**0.14**

At Mymensingh the line IRTON-13 had produced longer panicle than other lines and this line IRTON-13 also had produced significantly same length with IRTON-11 at other three locations while IRTON-6 had produced shortest panicle at all over location. IRTON-13 had produced highest number of filled grains at all locations and did not differ significantly with check variety at all locations except Mymensingh. The highest 1000 grain weight was produced by IRTON-6 and the check variety BRRIdhan-28 had lowest 1000 grain weight. For maturity, the line IRTON-11 matured 3 to 7 days earlier than check variety BRRI dhan-28. IRTON-13 and BRRI dhan-28 matured in same time at all locations. IRTON-2 took more time to mature but produced highest yield at Rangpur, Thakurgaon and Mymensingh. At Sunamganj IRTON-5 and IRTON-6 produced significantly highest yield than others. All IRTON lines produced higher yield than check variety at all over locations. The lines IRTON-2, IRTON-5 and IRTON-6 had produced higher yield but they need more time (7-14 days) to mature. IRTON-11 took the shortest time following IRTON-13.

IRTON-13 and IRTON-11 have been selected for their higher yield and short duration respectively which showed the better performance than that the popular boro rice variety BRRI dhan-28. IRTON-2 and IRTON-5 have been selected based on higher yield. These four lines (IRTON-2, IRTON-5, IRTON-13 and IRTON-11) were selected for next year evaluation.

Screening of disease (Blast) tolerant rice lines (IRBN) in Aman and *Boro* season

Twenty seven IRBN rice lines along with one check variety Binadhan-11 tested in both season of Aman 2018 and Boro 2018-19 at BINA Headquarter farm, Mymensingh. In Aman season seeds were sown on 05 July 2018 and transplanted to the field on 1st August 2018. In Boro season seeds were sown on 03 December 2018 and transplanted to the field on 18 January 2019. The experiment was laid out in RCBD with two replications. Unit plot size was 2m x 1m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on plant height, total tillers/plant, effective tillers hill-^{1}(no.), panicle length (cm) and grain yield m^{2} (g) were recorded from five randomly selected plants from each plot. Maturity was assessed by plot basis. Grain yield data were recorded from an area of 1.0 m^{2}. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 3 and Table 4.

From the Table 3, in aman season it is observed that IIBN-16 line had the highest plant height (112.84 cm) whereas IRBN-38 and IRBN-73 had the lowest. The highest number of effective tillers/hill (16.67) was observed in IRBN-2 which was significantly similar with IRBN-3, IRBN-17 and IRBN-32 and lowest number of effective tillers hill^{-1} (5.50) was in IRBN-12. The panicle length ranged 22 cm to 27.8 cm. The longest panicle length (27.8) was observed in IRBN-27 which was significantly similar with IRBN-1, IRBN-9, IRBN-17 and IRBN-27 while shortest panicle length (22.0) observed in IRBN-31.

Table 16. Mean performance of IRBN rice lines along with check variety during Aman season 2018.

Lines/variety	Plant height (cm)	Effective tillers/hill (no.)	Panicle length (cm)	Filled grains/panicle (no.)	Days to maturity	1000 grain weight (g)	Grain yield (g m^{-2})
IRBN-1	101.5 cde	8.7 abcdef	27.3 ab	289.0 abcd	137.0 fg	25.0 abc	725.5 abcde
IRBN-2	94.0 ghij	10.3 a	24.5 defgh	255.5 bcd	139.0 cde	25.0 abc	764.8 abcd
IRBN-3	101.3 cdef	10.0 ab	25.7 abcde	201.5 d	130.0 h	22.5 abcd	601.5 defgh
IRBN-5	93.5 hijk	8.8 abcdef	20.8 k	259.0 bcd	130.0 h	21.5 bcd	656.3 cdefgh
IRBN-6	107.5 abc	7.8 cdefgh	26.5 abcd	390.5abc	138.5 def	25.0 abc	733.8 abcd
IRBN-9	104.0 bcd	8.8 abcdef	27.2 abc	296.5 abcd	139.0 cde	20.0 cd	714.5 abcdef
IRBN-11	98.16 defghi	6.8 hi	25.7 abcd	389.5 abc	139.0 cde	27.5 a	870.5 a
IRBN-12	99.34 defgh	5.8 i	22.2 ijk	357.5 abcd	139.0 cde	25.0 abc	686.8 cdef
IRBN-13	100.34 defgh	7.8 cdefgh	23.0 ghijk	240.0 cd	140.0 bcd	27.5 a	703.5 bcdef
IRBN-14	100.67 cdefg	7.2 fghi	22.8 hijk	313.0 abcd	130.0 h	22.5 abcd	501.0 h
IRBN-15	107.34 abc	7.3 efghi	25.7 abcde	449.0 a	136.5 g	27.5 a	793.8 abc
IRBN-16	112.84 a	6.7 hi	25.2 bcdef	455.0 a	155.0 a	25.0 abc	866.5 ab
IRBN-17	94.5 fghij	9.2 abcd	27.3 ab	394.0 abc	155.0 a	22.5 abcd	496.8 h
IRBN-18	109.84 b	6.0 i	25.0 cdefg	363.5 abcd	137.5 efg	25.0 abc	866.3 ab

IRBN-24	92.5 ijk	7.3 efghi	23.0 ghijk	449.5 a	140.0 bcd	25.0 abc	688.0 cdef
IRBN-25	88.5 jkl	10.3 a	23.2 ghijk	295.0 abcd	141.0 b	17.5 d	782.3 abc
IRBN-26	101.84 cde	7.0 ghi	22.5 ijk	373.5 abcd	130.0 h	20.0 cd	509.3 gh
IRBN-27	100.16 defgh	8.3 bcdefg	27.8 a	258.5 bcd	130.0 h	27.5 a	568.3 efgh
IRBN-28	96.16 efghi	5.8 j	23.2 fghij	445.0 a	129.5 h	20.0 cd	551.8 fgh
IRBN-29	100.67 cdefg	7.3 efghi	25.5bcdef	228.5cd	137.5 efg	22.5 abcd	667.3 cdefg
IRBN-30	101.83 cde	7.5 defghi	24.2 dfghij	420.5 ab	129.5h	25.0 abc	609.5 defgh
IRBN-31	93.5 hijk	7.3 efghi	22.0 jk	301.0 abcd	129.5 h	22.0 bcd	748.5 abcd
IRBN-32	108.84ab	9.5 abc	24.2 dfghij	240.0 cd	139.5 bcd	26.0 ab	715.0 abcdef
IRBN-34	87.84 jkl	7.0 ghi	23.5 efghij	396.0 abc	140.5 bc	22.5 abcd	681.3 cdef
IRBN-73	85.33l	8.3 bcdefg	23.8 efghij	224.0 cd	129.5 h	25.0 abc	320.8 l
Binadhan-11	86.67 kl	9.0 bcde	23.3 fghij	202.0d	136.5 g	20.0 cd	733.5 abcd
CV	**3.41**	**10.62**	**4.63**	**3.37**	**0.67**	**4.68**	**1.15**
SE	**3.37**	**0.84**	**1.13**	**3.68**	**0.92**	**1.11**	**7.77**

The number of filled grains per panicle ranged from 201.50 to 455.00. IRBN-16 had the highest number of filled grains per panicle (455.0) which was followed by IRBN-24 (449.5), IRBN-15 (449.0). IRBN-3 had the lowest number of filled grains per panicle (201.5). Days to maturity among the IRBN lines ranged from 129.5 days to 155.00 days. IRBN-28, IRBN-30, IRBN-31 and IRBN-73 took the lowest days to maturity (129.5 days) which was followed by IRBN-3, IRBN-5 IRBN-14, IRBN-26 and IRBN-27 (130.0 days). IRBN-16 and IRBN-117 took the highest days to maturity (155.00 days). 1000 grain weight ranged from 17.5 g to 27.50 g. The highest 1000 grain weight was recorded in IRBN-11, IRBN-13, IRBN-15, and IRBN-27 while IRBN-25 had minimum 1000 grain weight (17.5 g). Grain yield (g) ranged from 320.8 g to 870.5 g. IRBN-11 had maximum yield (870.5 g) which was followed by IRBN-16 (866.5 g), IRBN-18 (866.3g). IRBN-73 had minimum yield per plant (320.8 g).

Based on early maturity and higher seed yield 7 IRBN rice lines (IRBN-2, IRBN-5, IRBN-6, IRBN-11, IRBN-16, IRBN-18 and IRBN-25 were selected for aman season and will be evaluated in next Aman season.

In *Boro* season from the Table 4, it is observed that IIBN-18 had the highest plant height (107.5 cm) whereas IRBN-73 had the lowest. The highest number of effective tillers/hill (20.34) was observed in IRBN-9 which was significantly similar with IRBN-73 (20.28) and lowest number of effective tillers/hill (6.25) was in IRBN-24. The panicle length ranged 20.01 cm to 29.33 cm. The longest panicle length (29.84cm) was observed in IRBN-17 which was significantly similar with IRBN-27 while shortest panicle length (20.01cm) observed in IRBN-26 followed by IRBN-24. The number of filled grains per panicle ranged from 72.84 to 219.17. There are six lines had produced lower number of filled grains per panicle than check variety BRRI dhan-28. IRBN-14 had the highest number of filled grains per panicle (219.17) which was followed by IRBN-31 (173.67) and IRBN-29 had the lowest number of filled grains per panicle (29.33). Days to maturity among the IRBN lines ranged from 151.0 days to 171.50 days. The popular boro rice variety BRRI dhan-28 (Check variety) and IRBN-30 took the lowest days to maturity (151.0 days) which was significantly similar with IRBN-28 (152.0 days). IRBN-25 took the highest days to maturity (171.50 days). 1000 grain weight ranged from 20.00g to 27.84 g. The highest 1000 grain weight was recorded in IRBN-16 and IRBN-26 while IRBN-25 had minimum 1000 grain weight (17.5 g) which was significantly similar with IRBN-18. There are sixteen lines had produced higher grain yield than check variety BRRI dhan-28. Grain yield (g) ranged from 632.5g to 900.0g. IRBN-14 had maximum yield (900.0g) while IRBN-30 had minimum yield per plant (632.5 g).

Table 17. Mean performance of IRBN rice lines along with check variety during *Boro* season 2018-19.

Lines/variety	Plant height (cm)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains/panicle (no.)	Days to maturity	1000 grain weight (g)	Grain yield (gm^{-2})
IRBN-1	87.69 hi	12.09 hi	22.84 ef	117.5 hi	154.5 efgh	22.50 efgh	775.0 g
IRBN-2	88.66 ghi	12.83 efg	22.5efgh	96 .0 m	154.0 fgh	24.50 cd	825.0 e
IRBN-3	102.50bc	17.67 b	24.50 cd	89.3 m	157.0 cd	20.67 kl	825.0 e
IRBN-5	99.00 de	12.17 ghi	20.67 kl	114.5 j	160.5 b	24.50 cd	669.0 j
IRBN-6	98.84 e	13.17 def	24.50 cd	130.7 f	155.5 cdef	23.00 e	875.0 bc
IRBN-9	99.34 de	20.34 a	23.00 e	96.50 l	154.5 efgh	21.67 ij	849.75 d
IRBN-11	91.66 fg	8.50 lm	20.84 k	77.5 p	155.5 cdef	21.10 jk	675.25 j
IRBN-12	100.5bcd	8.33 lm	21.10 jk	102.0 k	156.5 cdef	22.67 fg	668.25 j
IRBN-13	103.5 b	13.49 cde	22.67 efg	84.7 0 0	153.5 ghi	24.84 c	662.50 j
IRBN-14	99.84cde	9.67 k	24.84 c	219.17 a	155.5 cdef	21.00 jk	900.0 a
IRBN-15	103 b	6.84 n	21.0 jk	109.66 k	157.5 cd	26.17 b	819.50 e
IRBN-16	103.16 b	7.84 m	26.17 b	165.83 c	160.5 b	27.84 a	597.5 l
IRBN-17	98.84 e	11.84 ij	27.84 a	146.17 e	156.0 cdef	22.00 ghi	707.50 i
IRBN-18	107.5 a	8.67 l	22.00 ghi	84.84 n	157.0 cde	20.17 l	858.75 cd
IRBN-24	94.66 f	6.25 n	20.17 l	122.67 g	157.0 cde	21.00 jk	798.50 f
IRBN-25	83.84 j	7.9 m	21.00 k	114.34 j	171.50 a	20.00 l	673.75 j
IRBN-26	79.66 k	9.67 k	20.0 l	137.5 f	154.0 fgh	27.33 a	857.25cd
IRBN-27	87.66hi	13.33 cdef	29.33 a	113.34 jk	152.0 hi	21.84 hi	677.5 j
IRBN-28	85.66 ij	12.67 fgh	21.84 hi	119.34 hi	156.0 cdef	22.33 fghi	853.0 d
IRBN-29	89.66 gh	9.0 kl	22.33fghi	72.84 q	158.0 bc	22.84 ef	754.0 h
IRBN-30	87.16hi	8.33 lm	22.84 ef	158.33 d	151.0 i	22.00 ghi	632.5 k
IRBN-31	93.34 f	11.33 j	22.0 ghi	173.67 b	156.0 cdef	24.00 d	824.25 e
IRBN-32	102 bcd	13.67 cd	24.0 d	109.34 k	155.0 def	22.00 ghi	875.0 bc
IRBN-34	85.66 ij	14.00 c	22 ghi	149.17 e	154.0 fgh	23.00 e	882.50 ab
IRBN-73	73.84 l	20.28 a	23.0 e	83.34 0 o	157.50 cd	22.50 efgh	785.0 fg
BRRIdhan-28	89.34 gh	7.84 m	21.67 ij	93.84 m	151.0 i	20.84 k	725.0 i
CV	3.41	10.62	4.63	26.14	0.87	1.03	1.22
SE	3.37	0.84	1.13	85.32	1.37	1.32	9.38

Based on early maturity and higher seed yield 7 IRBN rice lines (IRBN-2, IRBN-3, IRBN-6, IRBN-9, IRBN-14, IRBN-18, IRBN-32 and IRBN-34) were selected for *boro* season season and will be evaluated in next *Boro* season.

Screening of insect (Brown plant hopper) resistant rice lines (IRBPH)

This experiment was carried out to assess insect resistant with high yield attributes of twenty two rice lines along with one check variety Binadhan-11 tested in both Aman and *Boro* season 2018-19 at BINA Headquarter farm, Mymensingh.

In Aman season seeds were sown on 9th July 2018 and transplanted to the field on 9th August 2018. The experiment followed RCB design with three replications. The size of a unit plot was 2.0 m × 1.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tiller, panicle length, filled and unfilled grains panicle^{-1} and phenotypic performance were recorded after harvesting from 5 randomly selected competitive hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 5 and Table 6.

From the Table 5, in aman season it is observed that the average range of plant height among the lines was 87.50 cm to 111.34cm. IRBPH-46 line had the highest plant height (111.34 cm) whereas IRBPH- 47 had the lowest. The highest number of effective tillers/hill (11.67) was observed in IRBPH-25 which was significantly similar with IRBPH-41. IRBPHN -5, IRBPH-9 and IRBPH-47 had the lowest number of effective tillers/hill. The panicle length ranged 20 cm to 26.83 cm. The longest panicle length (26.83) was observed in IRBPH-44 which was significantly similar with IRBPH-46, while shortest panicle length (20.0) observed in IRBPH-29. The panicle length of check variety was 22 cm. There were 17 lines had longer panicle length than check variety. The number of filled grains per panicle ranged from 57.50 to 142.83. IRBPH -14 had the highest number of filled grains per panicle (142.83) and IRBPH -24 had the lowest number of filled grains per panicle (57.50). There are only two lines (IRBPH-18 and IRBPH-32) had produced lower number of filled grains per panicle than check variety Binadhan-11. Thousand grain weights ranged from 18.50g to 29.00 g. The highest 1000 grain weight was recorded in IRBN-20, IRBPH-25and IRBN-45 while IRBN-32 and IRBN-35 had minimum 1000 grain weight (18.0 g). The check variety took 141.50 days to maturity. There were only two varieties (IRBPH-2 and IRBPH-5) matured earlier than other lines and check variety. IRBPH-2 matured in 124 days and IRBPH-5 matured in 126 days. Grain yield (g/m2) ranged from 320.84g to 576.17g. IBPHN- 21 had maximum yield per m^2 (576.17g) which was followed by IBPHN- 35 (567.16 g). IBPHN-5 had minimum yield per m^2 (320.84 g).

Based on higher seed yield and early maturity 8 lines (IRBPH-2, IRBPH-5, IRBPH-21, IRBPH-23, IRBPH-24, IRBPH-35, IRBPH-38, IRBPH-44) were selected and will be evaluated in the preliminary yield trial in next aman season.

Table 18. Mean performance of IBPHN rice lines along with check variety at BINA Hqs, Mymensingh during aman season 2018

Lines/ variety	Plant height (cm)	Effective tillers plant $^{-1}$ (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Days to 50 % of flowering	Days to maturity	1000 grain weight (g)	Grain yield (g m^{-2})
IRBPH-2	93.00 jk	10.50 bc	22.17 fghi	81.50 h	99.50 k	124.00 j	21.50 cd	468.16 h
IRBPH-5	78.16 n	6.00 ij	20.00 j	106.00 d	103.00 h	126.00 l	22.50 bcd	320.84 n
IRBPH-9	99.16 fgh	4.83 j	22.50 fgh	98.66 ef	105.00 f	141.50 ef	25.00 abc	361.34 m
IRBPH-17	104.16 e	8.17 efgh	22.67 efgh	90.34 g	104.00 g	143.00 c	25.00 abc	439.66 k
IRBPH-18	100.33 f	8.67 efg	21.33 hij	79.34 hi	104.00 g	143.00 c	25.00 abc	517.16 ef
IRBPH-20	91.00 k	10.00 cd	23.34 defg	80.16 hi	105.00 f	141.50 ef	**29.00 a**	456.16 l
IRBPH-21	104.00 e	8.00 fgh	22.50 fgh	121.50 b	103.00 h	144.00 b	22.50 bcd	576.17 a
IRBPH-23	104.84 de	7.84 gh	21.67 hi	93.83 fg	102.50 hi	141.00 fg	25.00 abc	557.84 bc
IRBPH-24	109.33 ab	8.50 efg	25.00 bc	**57.50 k**	109.00 c	142.50 cd	22.50 bcd	549.34 c
IRBPH-25	95.83 ij	11.83 a	23.17 defg	66.00 j	111.00 a	144.50 b	27.50 a	457.83 hi
IRBPH-26	96.67 ghi	7.50 gh	23.34 defg	99.34 e	109.00 c	146.00 b	25.00 abc	527.17 de
IRBPH-27	106.50 bcde	8.50 efg	24.17 cd	80.50 hi	104.00 g	140.00 h	26.50 ab	482.16 g
IRBPH-29	99.5 fg	7.17 hi	20.17 j	114.66 c	102.00 ij	141.50 ef	25.00 abc	463.17 hi
IRBPH-32	83.16 m	7.17 hi	21.00 ij	76.00 l	110.00 b	142.00 de	18.50 d	291.50 o
IRBPH-35	108.17 abc	7.83 gh	24.00 cde	117.17 bc	109.00 c	144.50 b	18.50 d	567.16 ab
IRBPH-38	96.00 hij	9.34 cde	23.50 def	93.00 g	105.00 f	144.00 d	22.50 bcd	553.17 c
IRBPH-40	105.16 cde	8.17 efgh	25.17 bc	117.17 bc	106.00 e	142.50 cd	22.50 bcd	442.83 jk
IRBPH-41	106.16 bcde	11.67 ab	23.34 defg	107.34 d	107.00 d	144.00 b	25.00 abc	513.33 f
IRBPH-44	107.50 bcd	9.17 def	26.83 a	**142.83 a**	108.50 c	141.00 fg	22.50 bcd	527.50 de
IRBPH-45	98.83 fghi	8.33 efgh	24.50 cd	91.84 g	102.50 hi	140.50 gh	28.00 a	550.00 c
IRBPH-46	111.34 a	8.67 efg	26.17 ab	93.34 g	101.50 j	140.00 h	26.50 ab	528.83 d
IRBPH-47	87.50 l	5.67 j	21.33 hij	118.84 bc	102.00 ij	140.50 gh	20.00 d	385.00 l
Binadhan-11	93.00 jk	8.34 efgh	22.00 ghi	79.50 hi	103.00 h	141.50 ef	26.00 abc	453.79 ij
CV	1.55	6.81	3.11	2.54	0.43	0.33	9.39	1.15
SE	1.54	0.57	0.72	2.44	0.45	0.47	2.25	5.50

From the Table 6, in *boro* season it is observed that the average range of plant height among the lines was 79.0 cm to 105.00cm. The line IRBPH-24 had the highest plant height (105.00 cm) which was significantly similar with IRBPH-44 where as IRBPH- 26 had the lowest. The highest number of effective tillers/hill (10.83) was observed in IRBPH-20 whereas IRBPH-47 had the lowest number of effective tillers/hill. The panicle length ranged 20.34 cm to 25.84 cm. The longest panicle length (25.84cm) was observed in IRBPH-44.While the shortest panicle length (20.34) observed in IRBPH-5 and IRBPH-29. The panicle length of check variety was 22 cm. There were 16 lines had longer panicle length than check variety. The check variety BRRIdhan-28 and IRBPH-2 matured earlier than other lines. They took only 146.50 days to maturity. Thousand seed weight ranged from 18.50g to 27.00 g. The highest 1000 grain weight was recorded in IRBPH-9 while IRBPH -27 had minimum 1000 grain weight (18.5 g). Among the twenty two lines, only one line (IRBPH-45) had lowest grain yield (g/m^2). Grain yield (g/m^2)

ranged from 553.00g to 875.0g. IBPHN- 18 had maximum yield per m^2 (875.0g) where as IBPHN-45 had minimum yield per m^2 (553.0 g).

Table 19. Mean performance of IBPHN rice lines along with check variety at BINA Hqs, Mymensingh during boro season 2018-19

Lines/ variety	Plant height (cm)	Effective tillers plant $^{-1}$ (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Days to 50 % of flowering	Days to maturity	1000 grain weight (g)	Grain yield (g m^{-2})
IRBPH-2	85.5 ij	8.50 abcde	22.50 hij	76.50 h	120.50 g	146.50	23.00 efg	**770.75 cde**
IRBPH-5	86.5 hij	5.33 e	20.34 m	94.67 cd	125.50 e	150.00 f	21.00 hij	**781.00 c**
IRBPH-9	92.5 def	6.33 de	22.84 fghij	79.84 gh	125.50 e	150.00 f	27.00 a	**745.25 fg**
IRBPH-17	88 .0 ghij	8.42 abcde	20.34 m	70.50 ij	126.50 e	148.50 gh	20.00 ijkl	**754.25 ef**
IRBPH-18	91.0 efg	9.84 abc	23.67 efgh	60.83 l	129.50 cd	149.50 fg	21.00 hij	**875.00 a**
IRBPH-20	89.0 fghi	10.83 a	23.33 fghi	64.84 jkl	129.50 cd	147.50 hi	26.00 abc	**757.50 def**
IRBPH-21	96.5 cd	8.00 abcde	23.67 efgh	111.16 a	140.50 a	158.50 a	26.50 ab	689.00 h
IRBPH-23	98 cd	8.34 abcde	24.84 abcde	90.66 de	135.50 b	157.50 ab	21.00 hij	**775.00 cd**
IRBPH-24	105.0 a	8.33 abcde	25.50 ab	65.33 jkl	135.50 b	158.50 a	21.50 ghi	**700.00 h**
IRBPH-25	84.0 jk	10.50 ab	22.67 ghij	74.16 hi	129.50 cd	149.50 fg	23.50 def	**850.00 b**
IRBPH-26	79.0 l	8.67 abcd	20.67 lm	64.00 kl	125.50 e	149.50 fg	23.50 def	**737.50 fg**
IRBPH-27	92.5 def	7.33 bcde	24.00 cdefg	68.66 ijk	129.50 cd	153.50 d	18.50 l	**727.75 g**
IRBPH-29	98.5 bc	7.34 bcde	23.83 defgh	95.00 cd	120.50 g	147.50 hi	24.50 cde	**740.00 fg**
IRBPH-32	85.5 ij	7.84 abcde	21.50 jklm	115.67 a	123.50 f	147.50 hi	19.50 jkl	**774.25 cde**
IRBPH-35	95.0 cde	8.33 abcde	23.00 fghi	102.34 b	123.50 f	148.50 gh	21.00 hij	**697.00 h**
IRBPH-38	90.0 fgh	8.67 abcd	22.17 ijk	113.16a	128.50 d	150.50 ef	20.50 ijk	**842.50 b**
IRBPH-40	95.5 cd	8.00 abcde	25.17 abcd	86.33 ef	119.50 g	151.50 e	21.00 hij	690.00 h
IRBPH-41	87.0 ghij	10.17 abc	24.00 cdefg	114.34 a	120.50 g	148.50 gh	19.50 jkl	630.25 i
IRBPH-44	102.0 ab	9.00 abcd	25.84 a	98.50 bc	130.50 c	156.00 c	20.00 ijkl	688.75 h
IRBPH-45	95.5 cd	9.50 abcd	24.17 bcdef	83.84 fg	130.50 c	156.50 bc	25.00 bcd	**553.00 k**
IRBPH-46	99.0 bc	8.00 abcde	25.33 abc	91.17 de	128.50 d	157.00 bc	24.00 def	**774.25 cde**
IRBPH-47	80.5 kl	7.00 cde	20.83 klm	97.34 bc	128.50 d	150.50 ef	19.00 kl	610.00 ij
BRRIdhan-28	88 .0 ghij	8.17 abcde	22.00 ijkl	77.00 h	112.50 h	146.50	22.50 fgh	590.00 j
CV	2.19	18.93	3.0	3.30	0.54	0.47	4.20	1.37
SE	2.0	1.58	0.69	2.86	0.69	0.72	0.92	10.04

Based on higher seed yield and early maturity 8 lines (IRBPH-2, IRBPH-5, IRBPH-17, IRBPH-18, IRBPH-23, IRBPH-25, IRBPH-32, IRBPH-38, IRBPH-46) were selected and will be evaluated in the preliminary yield trial in next boro season.

Screening of disease tolerant rice lines (IRBBN)

This experiment was carried out to assess disease tolerant, short duration with high yield attributes of twenty eight rice lines along with one check variety Binadhan-11 and BRRIdhan-28 tested in both Aman' 2018 and *boro* season 2018-19 at BINA Headquarter farm, Mymensingh. In Aman season seeds were sown on 5th July 2018 and transplanted to the field on 4th August 2018. The experiment followed RCB design with three replications. The size of a unit plot was 2.0 m × 1.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tiller, panicle length, filled and unfilled grains panicle^{-1} and phenotypic performance were recorded after harvesting from 5 randomly selected competitive hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 7 and Table 8.

From the Table 7, in aman season it is observed that the average range of plant height among the lines was 79.0 cm to 108.33cm. IIBBN-22 had the highest plant height (112.84 cm), which was significantly similar with IRBBN-31 whereas IRBBN-62 had the lowest. The highest number of effective tillers/hill (11.00) was observed in IRBBN-34 which was significantly similar with IRBBN-9 and lowest number of effective tillers/hill (5.50) was found in IRBN-16. The panicle length ranged 19.8 cm to 28.5 cm. The longest panicle length (28.5) was observed in IRBBN-2 which was significantly similar with IRBBN-16, IRBBN-26 while shortest panicle length (19.8) observed in IRBN-32. The number of filled grains per panicle ranged from 51.0 to 161.8, IRBBN-17 had the highest number of filled grains per panicle while IRBBN-34 had the lowest number of filled grains per panicle. Days to maturity among the IRBBN lines ranged from 125.5 days to 144.50 days. The check variety Binadhan-11 and other 4 IRBBN lines (IRBBN-14, IRBBN-25, IRBBN-31 and IRBBN-32) matured in 131.0 days. Six lines ((IRBBN-21, IRBBN-24, IRBBN-26, IRBBN-27, IRBBN-28 and IRBBN-29) took the lowesr time to maturity than Check variety. IRBBN-24 took the lowest days to maturity (129.5 days) and IRBBN-16 took the highest days to maturity (144.50 days). Thousand seed weight ranged from 19.0 g to 27.50 g. The highest 1000 seed weight was recorded in IRBBN-2, IRBBN-12 and IRBBN-17, while IRBBN-32 had minimum 1000 seed weight (19.0 g). Grain yield (g) ranged from 316.8 g to 577.7 g. IRBBN-17 had maximum yield whereas IRBBN-52 had minimum yield per plant. There were five lines (IRBBN-9, IRBBN-12, IRBBN-17 IRBBN-18 and IRBBN-31) had produced higher yield than check variety.

Table 20. Mean performance of IRBBN rice lines along with check variety at BINA Hqs, Mymensingh during Aman season 2018

Lines/variety	Plant height (cm)	Effective tillers plant $^{-1}$ (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Days to 50 % of flowering	Days to maturity	1000 grain weight (g)	Grain yield (g m^{-2})
IRBBN-2	105.33 b	8.7 bcde	28.5 a	106.2 h	108 c	140.5 cd	27.5 a	478.2 d
IRBBN-6	106.83 ab	7.3 bcdefghi	24.3 cdefg	86.0 0	118.5 a	139.5 de	25.0 ab	421.7 f
IRBBN-9	105.83 ab	9.5 ab	25.7 bcd	69.2 q	104.5 e	136.5 g	24.0 abc	518.0 b
IRBBN-12	106.33 ab	8.7bcde	22.7 ghijk	96.8 kl	118.5 a	138.0 f	27.5a	520.7 b
IRBBN-13	101.67 de	5.8 ij	22.2 ijkl	112.5 g	97.5 g	131.0 h	22.0 bcd	463.0 e
IRBBN-14	101.33 de	6.8 defghij	23.8 efghi	108.5 h	108.5 c	139.0 ef	23.5 bcd	499.8 c
IRBBN-16	97.5 f	5.5 j	27.8 ab	138.3 c	105.5 de	144.5 a	22.5 bcd	342.5 k
IRBBN-17	104.0 bcd	6.5 efghi	24.7 cdefg	161.8 a	104.5 e	139.5 ef	27.5 a	577.7 a
IRBBN-18	96.83 f	7.8 bcdefg	25.3 cde	93.0 m	104.5 e	139.5 ef	22.5 bcd	501.3 c
IRBBN-21	96.5 fg	6.5 efghij	21.0 klm	135.3 d	99.5 f	129.5 l	25.0 ab	477.0 d
IRBBN-22	108.67 a	8.2 bcdefghi	25.2 cdef	101.2 ij	107.5	138.0 f	21.5 bcd	458.0 e

IRBBN-24	96.67 fg	8.0 bcdefghi	23.0 fghijk	149.2 b	94 h	125.5 j	22.0 bcd	343.0 k
IRBBN-25	97.33 f	6.2 ghij	20.8 lm	68.0 q	100.5 f	131.0 h	19.5 cd	311.8 m
IRBBN-26	93.17 hi	7.2 cddefghi	26.3 abc	122.8 f	104.5 e	130.5 hi	25.0 ab	371.8 l
IRBBN-27	97.17 f	6.3 fghij	21.7 jklm	129.8 e	96.5 g	130.5 hi	20.0 cd	376.0 l
IRBBN-28	106.17 ab	8.2 bcdefgh	23.3 efghij	68.7 q	105.5 de	130.5 hi	21.0 bcd	454.2 e
IRBBN-29	104.33 bc	6.0 hij	25.8 bcd	89.7 n	99.5 f	130.5 hi	22.5 bcd	329.8 l
IRBBN-31	108.33 a	7.0 defghi	24.3 cdefg	85.0 o	104.5 e	131.0 h	25.0 ab	516.7 b
IRBBN-32	93.83 gh	7.7 bcdefghi	19.8 m	55.7 s	97.5 g	131.0 h	19.0 d	394.3 h
IRBBN-33	90.33 i	7.8 bcdefghi	22.7 ghijkl	146.3 b	105.5 de	142.0 b	21.0 bcd	430.7 f
IRBBN-34	104.5 bc	11.0 a	23.8defghi	51.0 t	105 de	140.5 cd	25.0 ab	454.5 e
IRBBN-45	82.5 jk	8.5 bcdef	22.3 hijk	95.8 lm	105.5 de	138.0 f	25.0 ab	409.7 g
IRBBN-46	84.5 j	9.0 abcd	23.0 ghijkl	133.0 d	104.5 e	139.0 ef	25.0 ab	358.2 j
IRBBN-52	78.5 l	7.7 bcdefghi	23.7defghi	129.5 e	117.5 a	141.0 bc	22.5 bcd	316.8 m
IRBBN-55	82.33 jk	8.3 bcdefg	22.7 ghijkl	102.5 l	115.5 b	142.0 b	25.5 ab	357.3 j
IRBBN-56	80.83 kl	9.3abc	24.5 cdefg	98.7 jkl	106 d	140.5 cd	25.0 ab	389.8 h
IRBBN-60	80.5 kl	7.8 bcdefghi	23.2 bcdef	64.2 r	105.5 de	139.5 de	21.5 bcd	345.3 k
IRBBN-62	79 l	6.2 ghi	23.0 fghijk	75.2 p	105.5 de	138.0 f	25.0 ab	337.5 kl
Binadhan-11	99.0 ef	6.0 hij	23.7defghi	99.7 ijk	99.5 f	131.0 h	22.5 bcd	499.3 c
CV	1.48	14.61	4.6	1.35	0.56	0.51	9.59	1.16
SE	1.42	1.105	1.1	1.39	0.6	0.69	2.25	4.9

Based on higher seed yield and early maturity and grain quality 5 lines (IRBBN-6, IRBBN-9, IRBBN-17 IRBBN-18, IRBBN-31) were selected and will be evaluated in the preliminary yield trial in next aman season.

From the Table 8, in boro season it is observed that the average range of plant height among the lines was 71. 5cm to 105.00 cm. IRBBN-14 had the highest plant height whereas IRBBN-52 had the lowest. The number of effective tillers/hill ranged in 6.5 to 22.5. The highest number of effective tillers/hill was observed in IRBBN-46 and lowest number of effective tillers/hill (5.50) was found in IRBBN-24.

Table 21. Mean performance of IRBBN rice lines along with check variety at BINA Hqs, Mymensingh during *Boro* season 2018-19.

Lines/ variety	Plant height (cm)	Effective tillers plant $^{-1}$ (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Days to 50 % of flowering	Days to maturity	1000 grain weight (g)	Grain yield (g m^{-2})
IRBBN-2	94.5 cdef	10.3 bcdef	23.3 abcd	82.3 hij	124.5 fg	152.5 bcd	23.5 de	612.5 m
IRBBN-6	96 bcde	13.3 b	23.0 abcde	93.8 f	117.5 l	150.5 fg	21 gh	792.5 bcde
IRBBN-9	90.5 efgh	8.0 ghi	21.7 bcdefg	68.3 m	117.5 l	150.5 fg	23.5 de	807.5 b
IRBBN-12	100.5ab	9.8 cdefgh	21.2 defghi	79.2 ijkl	124.5 fg	150.5 fg	28.5 a	775.8e
IRBBN-13	95b bcde	7.2 hi	19.5 hi	97.8 f	123.5 gh	150.5 fg	21.5 gh	790.0 cde
IRBBN-14	105 a	9.8 cdefgh	22.8 abcde	169.5 a	125.5 ef	150.5 fg	25.5 b	787.5 cde
IRBBN-16	93 defg	10.0cdefgh	23.8 abc	105.5 e	125.0 efg	151.5 def	21.0 gh	537.5 p
IRBBN-17	99 bc	9.8 cdefgh	24.0 ab	85.3 gh	126.5 de	150.5 fg	23.5 de	802.5 bc
IRBBN-18	83.5 jklm	9.0 efghi	21.5 cdefgh	75.0 kl	119.5 k	150.0 gh	21.5 gh	754.3 f
IRBBN-21	97 bcd	7.8 ghi	22.8 abcde	163.8 b	120.5 jk	152.0 cde	23.0 ef	807.5 b
IRBBN-22	91.5 defg	9.0 efghi	20.3 fghi	80.2 hijk	122.0 hij	149.0 hi	21.5 gh	692.5 i
IRBBN-24	80.5 lmno	6.5 i	20.0 ghi	119.3 c	123.5 gh	151.0 efg	22.0 fg	727.5 g
IRBBN-25	88.5 ghij	12.3 bcd	20.8 efghi	94.3 f	122.0 hij	151.0 efg	19.0 i	777.5 de
IRBBN-26	81.5 klmn	7.7 hi	23.0 abcde	98.2 f	115.5 m	148.0 l	22.0 fg	697.5 hi
IRBBN-27	88.5 ghij	9.0 efghi	19.0 i	66.5 m	121.0 ijk	150.0 gh	20.5 h	725.0 g
IRBBN-28	89.5 fghi	7.3 hi	20.8 efghi	65.7m	126.5 de	151.0 efg	24.5 bcd	867.5 a
IRBBN-29	82 klmn	8.5 fghi	19.0 i	74.7 l	121.0 ijk	150.5 fg	21.0 gh	545.0 p

IRBBN-31	96.5 bcd	8.3 ghi	22.2 abcdefg	59.2 n	123.5 gh	150.0 gh	23.0 ef	793.8 bcd
IRBBN-32	85 hijk	10.3 bcdefgh	20.7 efghi	95.7 f	122.5 hi	150.5 fg	19.0 l	858.0 a
IRBBN-33	84 ijkl	9.5 cdefghi	20.8 efghi	83.3 ghi	125.5ef	151.5 def	18.5 l	610.0 m
IRBBN-34	93.5 cdefg	12.2 bcde	21.3 defghi	77.0 jkl	129.5 c	151.5 def	21.0 gh	670.0 j
IRBBN-45	75 pq	11.0 bcdefg	20.0 ghi	104.2 e	134.5 b	153.0 bc	25.0 bc	648.5 kl
IRBBN-46	78 mnop	22.5 a	21.0 defghi	83.5 ghi	135.5 ab	154.5 a	24.0 cde	582.5 n
IRBBN-52	71.5 q	9.3 defghi	19.0 i	85.3 gh	134.0 b	153.5 ab	24.0 cde	657.5 jk
IRBBN-55	80.5 lmno	12.7 bc	22.7 abcdef	115.5 cd	135.5 ab	154.5 a	22.0 fg	712.5 gh
IRBBN-56	79 mnop	12.3 bcd	24.2 a	104.8 e	136.5 a	154.5 a	24.0 cde	637.5 l
IRBBN-60	74.5 pq	10.0 cdefgh	20.7 fghi	67.5 m	127.5 d	152.5 bcd	23.5 de	658.8 jk
IRBBN-62	77.5 nop	11.8 bcde	21.5 defghi	88.0 g	135.0 ab	152.5 bcd	21 gh	712.5 gh
BRRIdhan-28	88 ghij	11.7 bcdef	20.3 fghi	113.0 d	115.5 m	149.0 hi	21.0 gh	562.5 o
CV	3.34	15.11	5.45	2.81	0.6	0.36	2.65	1.18
SE	2.92	1.55	1.17	2.62	0.77	0.55	0.60	8.39

The panicle length ranged 19.0 cm to 24.2 cm. The longest panicle length (24.2) was observed in IRBBN-56 while shortest panicle length (19.0) observed in IRBBN-27, IRBBN-29 and IRBBN-32. The number of filled grains per panicle ranged from 65.7 to 169.5, IRBBN-14 had the highest number of filled grains per panicle while IRBBN-28 had the lowest number of filled grains per panicle which was significantly similar with IRBBN-26 and IRBBN-60. Days to maturity among the IRBBN lines ranged from 148.0 days to 154.50 days. The check variety BRRIdhan-28 and another one line IRBBN-22 matured in 149.0 days. There was only one line IRBBN-26 took the lowest time to maturity than Check variety. IRBBN-46, IRBBN-55 and IRBBN-56 took the highest days to maturity (154.50 days). Thousand seed weight ranged from 18.5 g to 28.50 g. The highest 1000 seed weight was recorded in IRBBN-12, while IRBBN-33 had minimum 1000 seed weight (18.50 g).Grain yield (g) ranged from 537.5g to 867.5g. IRBBN-28 had maximum yield whereas IRBBN-16 had minimum yield per plant. Maximum lines had produced higher yield than check variety.

Based on higher seed yield and early maturity and grain quality 10 lines (IRBBN-6, IRBBN-9, IRBBN-17 IRBBN-18, IRBBN-21, IRBBN-22, IRBBN-26, IRBBN-28 IRBBN-31 and IRBBN-32) were selected and will be evaluated in the preliminary yield trial in next boro season. There were three lines (IRBBN-6, IRBBN-17 and IRBBN-31) performed better in both season.

Evaluation of the morphological and molecular characteristics of introgressed drought tolerant rice genotypes using SSR markers

Twenty nine drought tolerant genotypes including two recipient parents, one donor parent and three standard check varieties were used for this experiment. All the genotypes displayed considerable amount of differences in their mean performances with respect to all the characters studied. This result had also been explained by highly significant mean sum of square for the said characters, which indicated that, the genotypes under study were genetically divergent.

In this study, B_{11}/12 genotype showed the highest plant height and Binadhan-17 and B_{17}/20 genotype showed the lowest plant height. The maximum total number of tillers per plant was recorded in B_{11}/33 genotype while the lowest value was found in the genotype B_{11}/11. The maximum number of effective tillers per plant was recorded in B_{11}/3 and B_{11}/8 genotype. The B_{11}/25 genotype showed highest panicle length along with NERICA-4 and B_{11}/11, B_{11}/28, B_{11}/6, and B_{17}/20 showed lowest panicle length. B_{11}/21 was early flowering genotype along with NERICA-4 and B_{17}/6 was late flowering genotype. B_{17}/48 was early maturing genotype which took 145 day to mature followed by Binadhan-17 which took 142 day. The maximum number of filled grains was found in B17/48 along with Binadhan 17 and BRRIdhan 83 and the minimum number was found in B_{11}/26. The highest 1000-seed weight was recorded in B_{11}/4 genotype and the lowest value was recorded in B_{11}/25.). The highest value was recorded in B_{11}/50 genotype along with the parent Binadhan 11. High level of variation existing within the varieties as well as the characters will make opportunity for further improvement of the drought tolerant rice varieties.

Table 22: Different morphological parameters related to yield of 29 rice genotypes along with their control.

Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of total tillers plant^{-1}	No. of total effective tillers plant^{-1}	Panicle length (cm)	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	Weight of 1000–seed (g)	Grain yield (g) plant^{-1}
B_{11}/72	123.0 c	155.0 ab	101.0 fghi	12.30 jkl	10.70 fghi	23.40 defgh	455.0 d	100.0 k	26.79 b	19.70 h
B_{11}/54	122.0 cd	154.0 bc	104.3 ef	9.700 no	8.000 jk	23.60 defg	403.0 f	113.0 ij	22.60 no	22.72 e
B_{11}/11	120.0 de	153.0 cd	103.7 efg	**7.000 p**	**6.300 l**	**21.40 kl**	445.0 d	145.0 h	22.90 n	22.27 e
B_{11}/3	120.0 de	152.0 de	115.0 c	18.00 e	**21.00 a**	24.00 def	235.0 lm	215.0 c	24.70 hij	15.20 k
B_{11}/12	122.0 cd	152.0 de	**136.0 a**	16.00 g	14.00 cd	24.20 de	225.0 m	76.00 l	24.50 ijk	15.20 k
B_{11}/26	120.0 de	153.0 cd	98.30 hijk	11.30 m	10.00 ghi	22.60 ghijk	**155.0 p**	54.00 mn	22.30 op	18.18 i
B_{11}/30	118.0 ef	155.0 ab	110.7 cd	12.30 jkl	10.70 fghi	24.60 cd	380.0 g	**50.00 n**	25.05 gh	21.21 f
B_{11}/31	122.0 cd	154.0 bc	97.70 ijk	12.70 ijk	11.70 efg	22.60 ghijk	350.0 h	60.00 mn	25.62 ef	16.10 j
B_{11}/25	117.0 fg	154.0 bc	113.0 c	18.00 e	15.00 c	**26.00** ab	185.0 o	200.0 d	**19.00 r**	12.42 m
B_{11}/28	120.0 de	153.0 cd	92.30 lm	9.000 o	7.300 kl	**21.40 kl**	264.0 k	150.0 gh	22.58 no	23.48 d
B_{11}/50	122.0 cd	**156.0 a**	106.7 de	15.00 h	13.30 de	22.80 fghij	325.0 i	150.0 gh	25.93 de	25.80 b
B_{11}/58	118.0 ef	155.0 ab	101.7 fghi	16.00 g	13.00 de	22.00 ijkl	300.0 j	95.00 k	24.30 jkl	23.94 d
B_{11}/33	118.0 ef	154.0 bc	112.0 c	**27.00 a**	20.00 a	25.60 bc	245.0 l	170.0 ef	24.80 hi	18.18 i
B_{11}/21	**111.0 kl**	149.0 g	94.70 klm	11.30 m	9.700 hi	22.40 ghijk	355.0 h	96.00 k	23.50 m	18.18 i
B_{11}/4	122.0 cd	149.0 g	92.30 lm	12.00 klm	10.00 ghi	24.20 de	420.0 e	200.0 d	**32.95 a**	20.45 g
B_{11}/8	113.0 ijk	149.0 g	122.0 b	24.00 b	**21.00 a**	25.60 bc	403.0 f	117.0 i	23.40 m	18.18 i

B_{11}/6	**127.0 a**	153.0 cd	90.30 mn	12.00 klm	10.70 fghi	**21.20 lm**	351.0 h	95.00 k	22.99 n	18.18 i
B11/49	116.0 fgh	152.0 de	91.00 mn	13.00 ij	11.70 efg	24.00 def	454.0 d	65.00 lm	24.87 hi	19.69 h
B_{17}/53	118.0 ef	147.0 h	96.00 jkl	10.00 n	9.310 ij	23.20 efghi	500.0 c	197.0 d	22.44 op	23.72 d
B_{17}/20	114.0 hij	153.0 cd	**82.30 p**	17.30 ef	15.30 c	**21.60 jkl**	375.0 g	145.0 h	25.55 ef	19.69 h
B17/48	114.0 hij	**145.0 i**	87.00 no	12.00 klm	10.30 ghi	22.20 hijkl	**563.0 b**	112.0 ij	20.11 q	19.70 h
B_{17}/34	116.0 fgh	147.0 h	93.30 lm	13.30 i	12.30 ef	22.00 ijkl	444.0 d	300.0 b	23.97 l	21.21 f
Binadhan-11	125.0 b	150.0 fg	99.33 ghij	12.70 ijk	11.30 fgh	24.40 de	335.0 i	**50.00 n**	25.90 de	**33.33 a**
Binadhan-17	116.0 fgh	**142.0 j**	82.30 p	11.70 lm	11.00 fghi	20.20 mn	**1025. a**	**360.0 a**	26.30 cd	20.18 gh
NERICA-4	**108.0 m**	147.0 h	102.7 efgh	7.700 p	6.700 kl	**27.00 a**	558.0 b	140.0 h	26.68 bc	**9.100 n**
Binadhan-19	113.0 ijk	154.0 bc	83.00 op	17.00 f	15.00 c	**19.60 n**	385.0 g	113.0 ij	24.60 ij	19.70 h
BRRIdhan 26	110.0 l	152.0 de	102.0 fghi	20.00 c	18.00 b	23.40 defgh	200.0 n	160.0 fg	22.10 p	13.64 l
BRRIdhan 83	112.0 jk	147.0 h	107.0 de	19.00 d	17.00 b	26.00 ab	**569.0 b**	174.0 e	25.30 fg	24.79 c
B_{11}/7	115.0 ghi	151.0 ef	98.00 ijk	15.00 h	13.00 de	21.60 jkl	354.0 h	103.0 jk	24.10 kl	19.62 h
Level of sig.	**	**	**	**	**	**	**	**	**	**
LSD(0.05)	**1.874**	**1.266**	**4.015**	**0.746**	**1.466**	**1.047**	**13.58**	**11.25**	**0.384**	**0.571**
CV (%)	**0.97**	**0.51**	**2.44**	**3.21**	**7.15**	**2.76**	**2.14**	**4.98**	**0.96**	**1.77**

Table 23: Mean performance of 29 rice lines of different morphological parameters related to yield.

	Days of Flowering	Days of Maturity	Plant Height (cm)	Total number of tiller per plant	Effective number of tiller per plant	Panicle Length (cm)	Filled grain per panicle	Unfilled grain per panicle	1000-seed weight (g)	Yield per plant (g)
Minimum	108	142	82.30	7	6.300	19	155	50	19	9.10
Maximum	127	156	136	27	21	27	1025	360	32.95	33.33
Mean	117.655	151.276	100.539	14.217	12.528	23.200	388.207	138.103	24.339	19.785
Coefficient of Variation	0.97%	0.51%	2.44%	3.21%	7.15%	2.76%	2.14%	4.98%	0.96%	1.77%

4.5. UPGMA (Unweighted Pair Group Method of Arithmetic Mean)

4.5.1. Dendrogram

A phylogenetic tree was constructed based on Nei's genetic distance using UPGMA indicated segregation of 29 drought tolerant rice genotypes into main clusters C1 and C2; B_{11}/54, B_{11}/11, B_{11}/3, B_{11}/12, B_{11}/26, B_{11}/30, B_{17}/20, B_{17}/48, B_{17}/34, B_{17}/53, Binadhan–11, Binadhan–17, B_{11}/31, B_{11}/7, B_{11}/25, B_{11}/28, B_{11}/50, B_{11}/58, B_{11}/33, B_{11}/21, B_{11}/4, NERICA-4, B_{11}/8, B_{11}/49, Binadhan-19, BRRIdhan 26 and BRRIdhan 83 are grouped in cluster 1 and B_{11}/72 and B_{11}/6 are in cluster 2. Cluster 1 again formed in two sub-cluster, sub-cluster 1 and sub-cluster 2, where BRRIdhan 26, B_{11}/3, B_{11}/25, B_{11}/8, Binadhan–11, B_{11}/3, B_{11}/50, B_{11}/54, B_{11}/21, B_{11}/4, B_{11}/49 and B_{11}/11 are in the same sub cluster 1 and B_{17}/48, B_{17}/34, B_{17}/53, Binadhan–17, B_{11}/7, B_{11}/58, Binadhan-19, BRRIdhan 83, B_{11}/28, B_{11}/30, B_{11}/12, B_{11}/26, NERICA-4 and B_{17}/20 in the other sub cluster 2; these sub cluster are sub divided into several sub cluster (Figure 4.9).

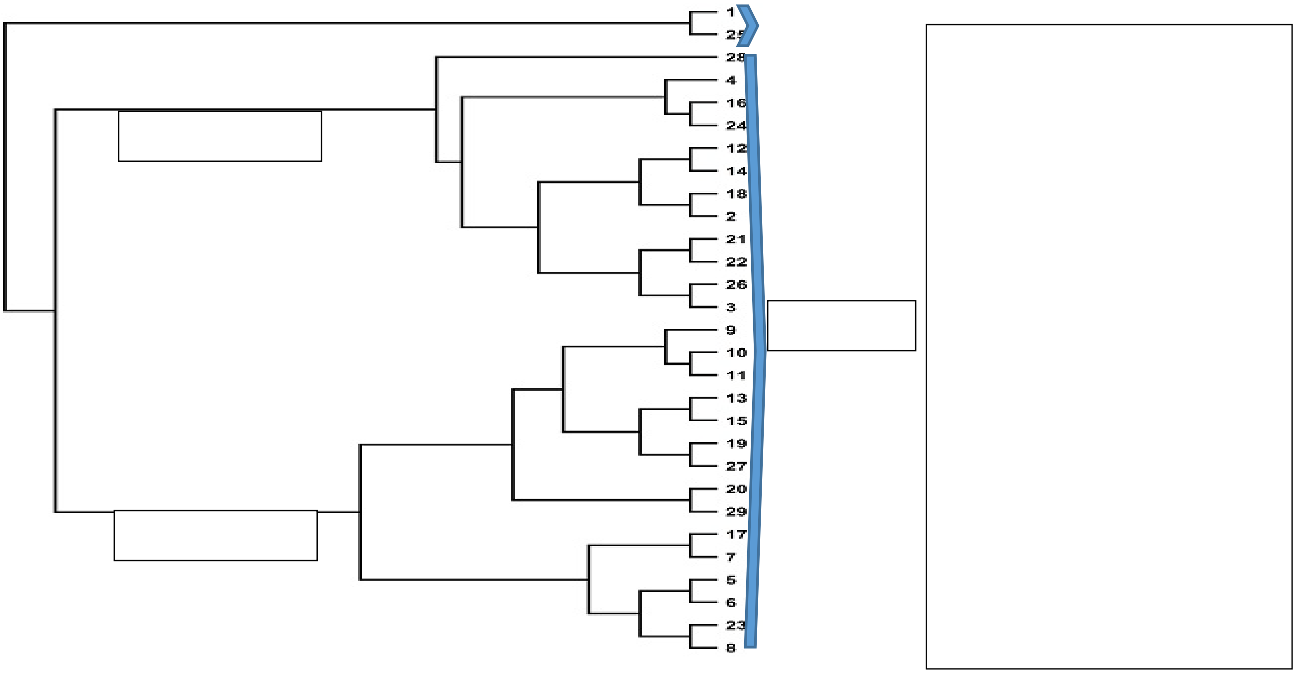


Figure 4.9. UPGMA dendrogram based on Nei's genetic distance, summarizing data on differentiation between 29 rice genotypes, according to drought tolerant locus specific SSR marker analysis.

Screening of rice genotypes for salinity and submergence tolerance through microsatellite markers

Molecular characterization of rice genotypes for salinity tolerance

Five markers (RM212, RM10694, RM243, RM490 and RM10793) were used to evaluate 16 rice genotypes for salinity tolerance.

Allelic information

Using five primers across 16 genotypes, 14 alleles were identified. The loci RM10793 had the highest number of alleles (4), whereas the loci RM212 and RM10694 had the lowest number of alleles (2). The average value of the allele was 2.8. The highest genetic diversity was found for RM10793 (0.6719) and lowest for RM490 (0.3203. In molecular analysis microsatellite loci are also multi allelic and the alleles are co-dominant suggesting their relative superiority in detecting DNA polymorphism. On an average 66.25% of the 16 genotypes shared a common major allele ranging from 43.75% (RM10793) to 81.25% (RM490) at each locus. Polymorphism information content (PIC) value is a reflection of allele diversity and frequency among the varieties. PIC value of each marker can be evaluated on the basis of its alleles. PIC varied significantly for all the studied SSR loci. In the present study, the level of polymorphism among the 16 genotypes was evaluated by calculating PIC values for each of the 5 loci. The PIC value ranged from 0.2944 (RM490) to 0.6116 (RM10793) with an average of 0.3872 per locus .

Banding pattern of 16 rice genotypes using five SSR markers

Figures of banding patterns of 16 rice genotypes for molecular analysis using five SSR markers are presented (**Fig. 1-3**). The banding patterns were compared with reference to those of Binadhan-7 and Binadhan-10. The genotypes which gave bands with same position or near with salinity tolerant Binadhan-10 were supposed to be tolerant to salinity.

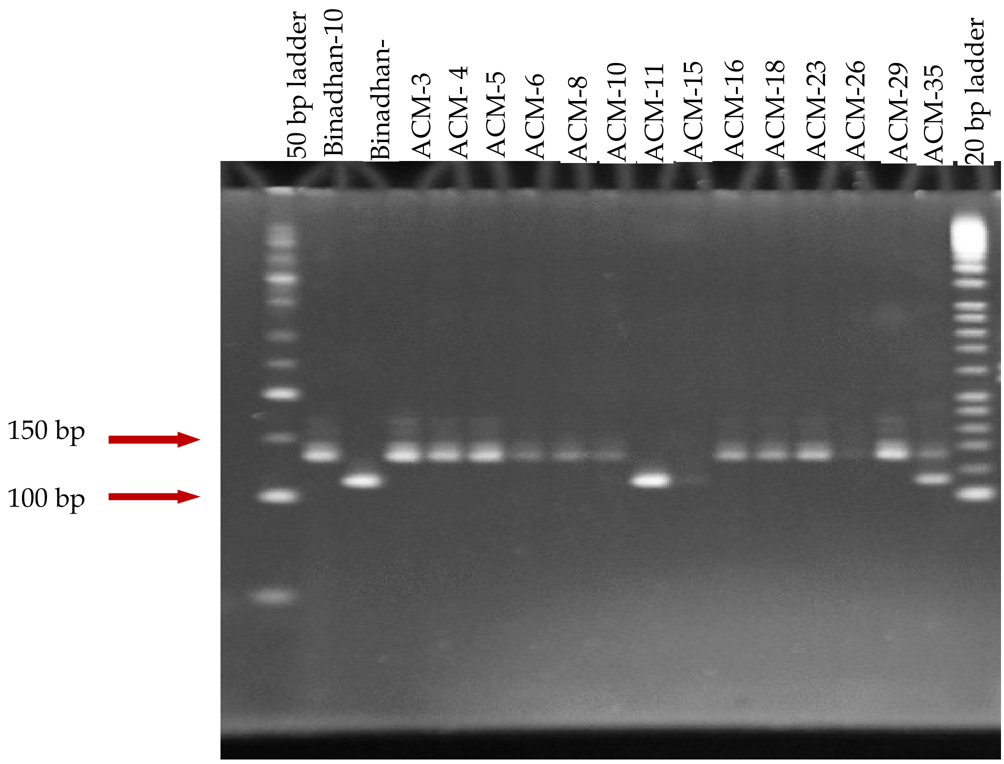


Fig Banding pattern of 16 rice genotypes for SSR marker RM212

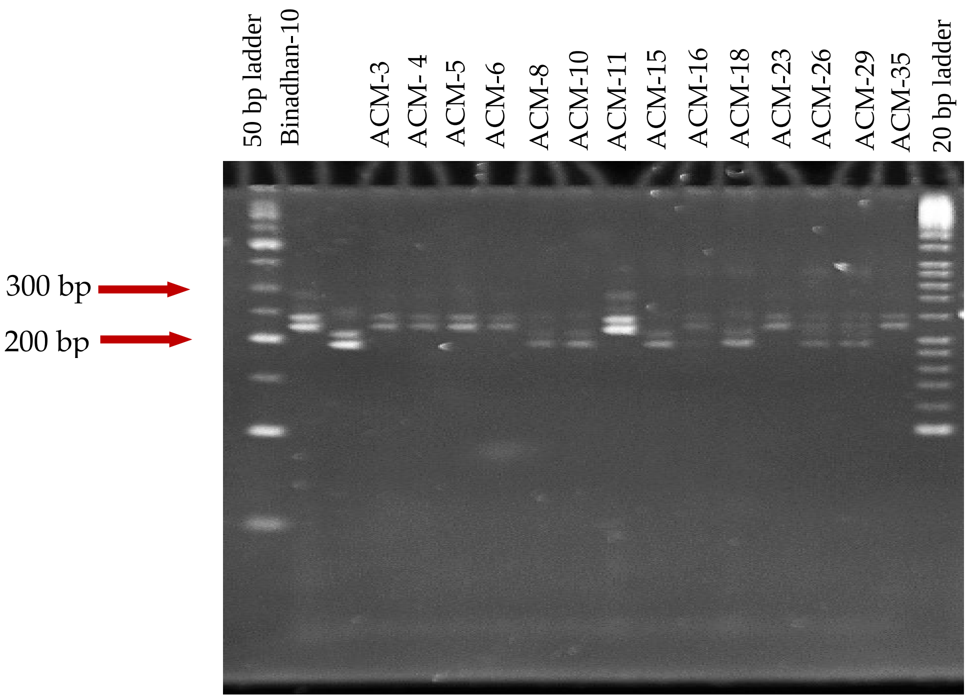


Fig Banding pattern of 16 rice genotypes for SSR marker RM10694

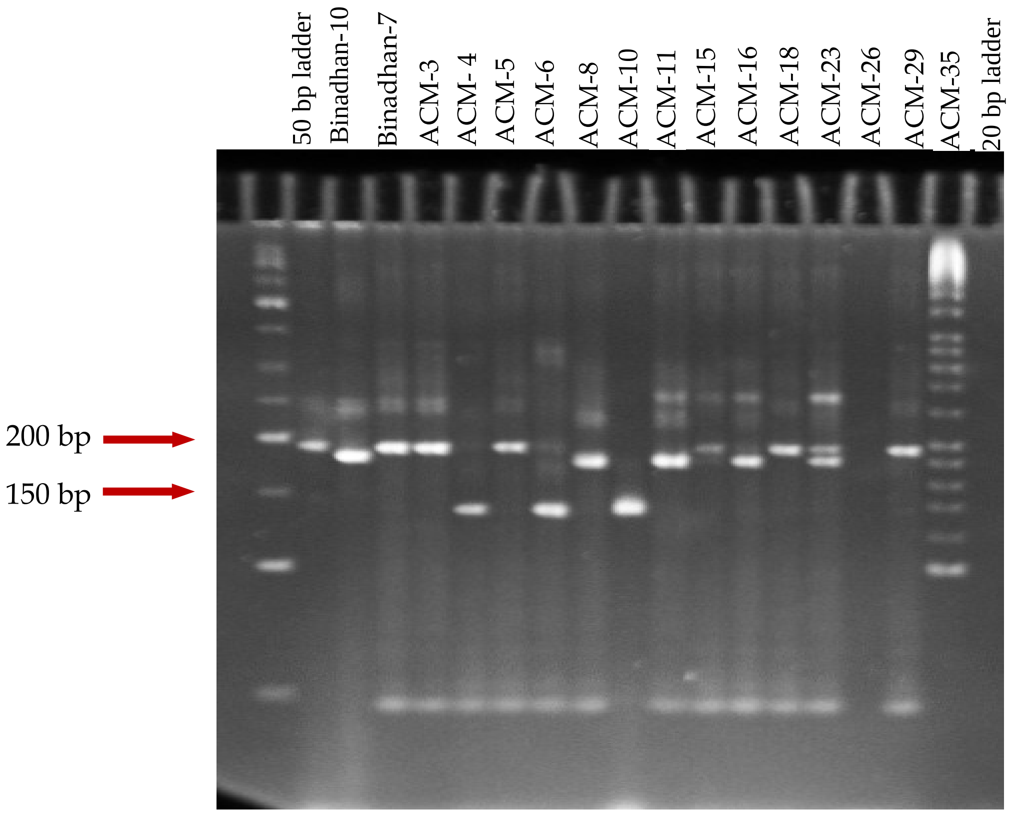


Fig Banding pattern of 16 rice genotypes for SSR marker RM10793

Molecular characterization of rice genotypes for submergence tolerance

Two markers (Sub1BC2 and RM7481) were used to evaluate 16 rice genotypes for submergence tolerance.

Allelic information

Using two primers across 16 genotypes, seven alleles were identified. The loci Sub1BC2 had the highest number of alleles (4), whereas the loci RM7481 had the lowest number of alleles (3). The average value of the allele was 3.5 . The highest genetic diversity was found for Sub1BC2 (0.7266) and lowest for RM7481 (0.5859). On an average 43.75% of the 16 genotypes shared a common major allele ranging from 31.25% (Sub1BC2) to 56.25% (RM7481) at each locus. PIC varied significantly for all the studied SSR loci. Here, the level of polymorphism among the 16 genotypes was evaluated by calculating PIC values for each of the two loci. The PIC value ranged from 0.5197 (RM7481) to 0.6750 (Sub1BC2) with an average of 0.5974 per locus.

Banding pattern of 16 rice genotypes using two SSR markers

Figures of banding patterns of 16 rice genotypes for molecular analysis using two SSR markers are presented (**Fig**.4-5). The banding patterns were compared with reference to those of Binadhan-7 and Binadhan-11. The genotypes which gave bands with same position or near with submergence tolerant Binadhan-11 were supposed to be tolerant to submergence.

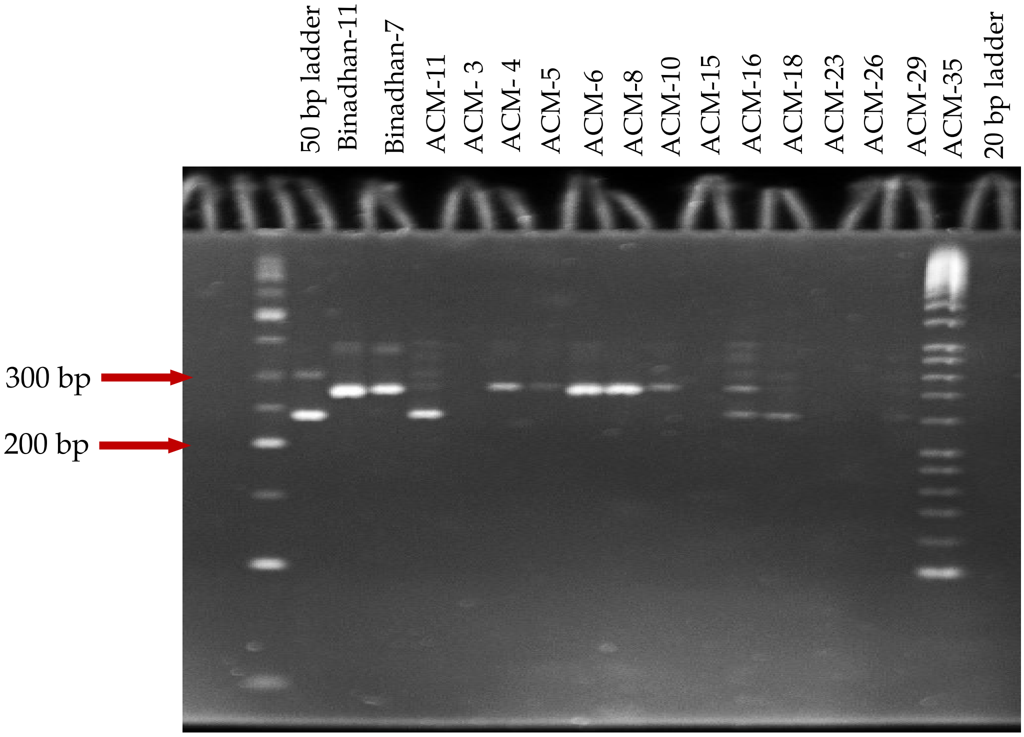


Fig 3: Banding pattern of 16 rice genotypes for SSR marker Sub1BC2

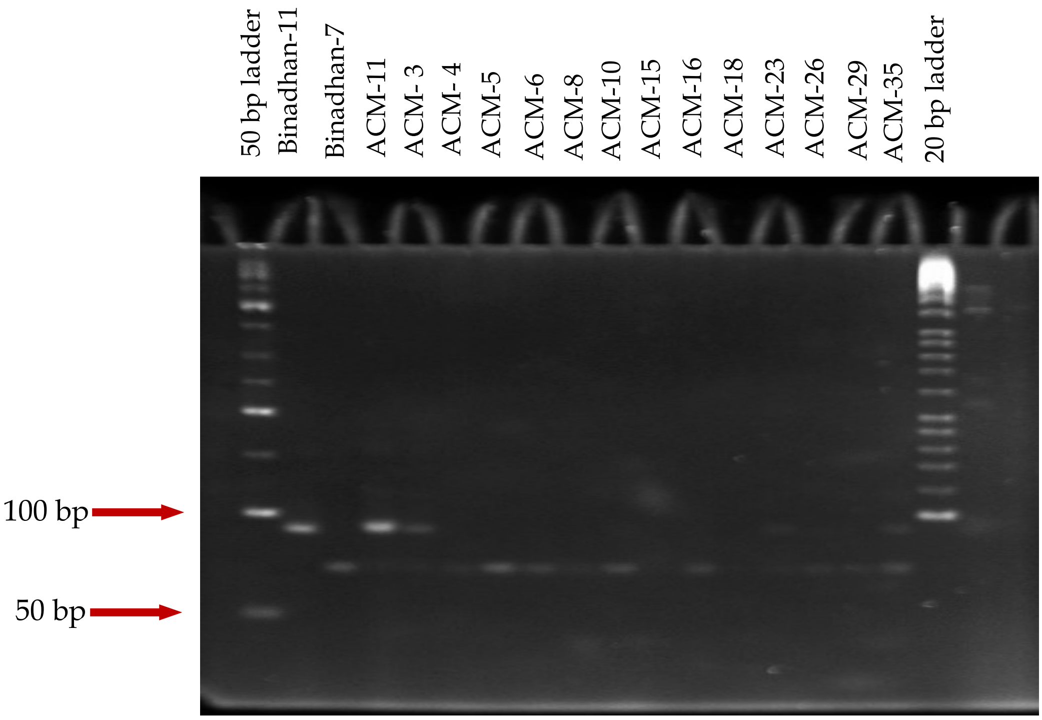


Fig 4.: Banding pattern of 16 rice genotypes for SSR marker RM7481

Molecular characterization of 16 rice genotypes was done using five SSR markers (RM212, RM10694, RM243, RM490 and RM10793) for salinity tolerance and two SSR markers (Sub1BC2 and RM7481) for submergence tolerance.

The genotypes ACM-3, ACM-4, ACM-6, ACM-16 and ACM-35 showed same banding pattern as BINA dhan-10 for all the five salinity specific markers. Besides, ACM-5 and ACM-35 showed same banding pattern as Binadhan-10 for four markers, ACM-10, ACM-18 and ACM-29 showed for three markers and ACM-11 and ACM-26 showed for two markers while ACM-8 showed banding for one marker. It suggests that they may have salinity tolerant gene. These five markers detected a total of 14 alleles per locus among the 16 genotypes with an average of 2.8allele. The PIC values ranged from 0.2944 (RM490) to a high of 0.6116 (RM10793) with the average value 0.3872. Highest genetic diversity (0.6719) was observed in loci RM10793 where the lowest gene diversity (0.3203)was observed in RM490 with a mean genetic diversity of 0.4516.

ACM-3 and ACM-23 showed same banding pattern as Binadhan-11 for both of the submergence specific markers while ACM-11, ACM-18 and ACM-35 showed same banding pattern as Binadhan-11 for one marker indicating these rice lines may have submergence tolerant gene. The two markers detected seven alleles for 16 genotypes with an average of 3.5 allele.The PIC values ranged from 0.5197 (RM7481) to 0.6750 (Sub1BC2) with the average value of0.5974 per locus.The highest genetic diversity was found for Sub1BC2 (0.7266) and lowest for RM7481 (0.5859). The frequency of the major allele ranged from 31.25% (Sub1BC2) to 56.25% (RM7481)at each locus with a mean frequency of 43.75%.

Screening of bacterial leaf blight introgressed rice lines for bacterial leaf blight resistance

The exotic and indigenous advanced and approved twenty five rice genotypes were screened for the presence and absence of three bacterial leaf blight resistance genes viz. *Xa4*, *xa5* and *Xa21* using PCR based gene linked markers MP, RM122 and RM21, respectively. The susceptible line Tn-1 and its near-isogenic lines (NILs), IRBB60 were included as check for respective genes. Amplification of marker MP which is a sequence-tagged site (STS) marker linked to *Xa4*, revealed a 140 bp fragment specific for *Xa4* mediated BLB resistance in NIL IRBB60, and a 160 bp DNA fragment that corresponds to a susceptible variety Tn-1(Figure-4.1). Microsatellite marker RM122 was used for the screening of *xa5* resistance gene, which showed resistant and susceptible amplicons of 230bp and 250 bp, respectively (Figure-4.2). Another microsatellite marker RM21 was also used for the screening of *xa21* resistance gene showed resistant and susceptible amplicons of 230bp and 290bp, respectively (Figure-4.3).

Xa4 Linked Marker (STS) for BLB Resistance

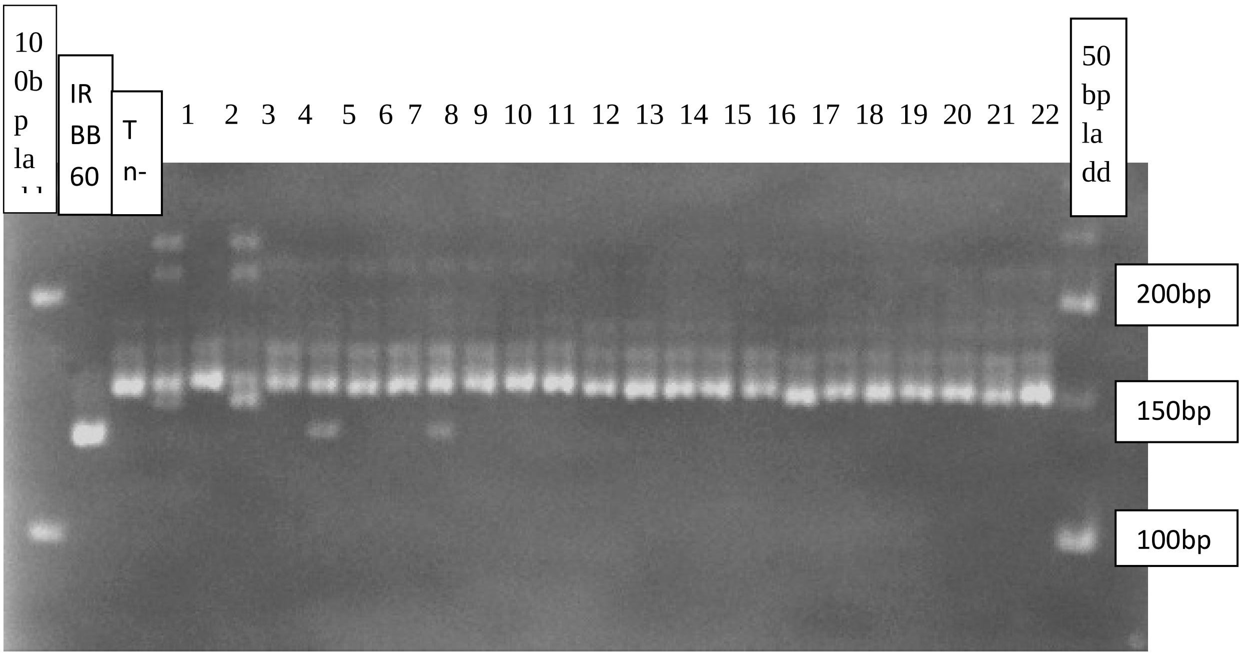


Figure 4.2: Banding pattern of rice genotypes using MP marker

Morphological screening of twenty rice varieties against the bacterial leaf blight pathogen as regards to the genetic potentiality of resistance performed significant result. In respect of primer MP, two genotypes were found as BLB resistant (CSA-5 and CSA-8) compared with check NIL (IRBB60). CSA-1, CSA-3 and BD-37 were moderately resistant and CSA-2, CSA-4, CSA-6, CSA-7, CSA-9, BD-29, BD-30, BD-31, BD-32, BD-33, BD-34, BD-35, BD-38, BD-39, BD-41, BD-42, BD-43 and BD-44 genotypes were found as highly susceptible to BLB compared with check (Tn-1).(fig 4.2)

*Xa5*Linked Marker (SSR) for BLB Resistance

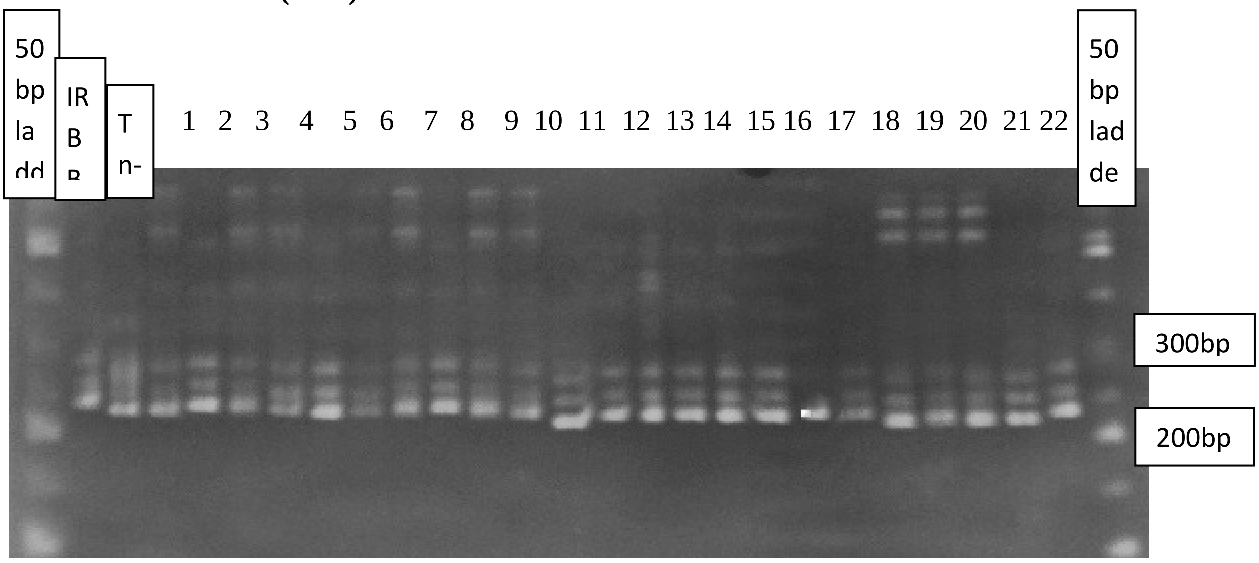


Figure 4.3: Banding pattern of rice genotypes using RM122 marker.

For *Xa5* linked marker analysis for BLB resistant line detection, amplification was made using marker RM122. IRBB60 gave band approximately at 250 bp which indicated the presence of resistant *Xa5* gene. CSA-2, CSA-3, CSA-7, CSA-8, CSA-9, BD-29, BD-37, BD-38 and BD-44 lines gave band approximately 250bp and were regarded as resistant lines. CSA-1, CSA-4, CSA-5, CSA-6, BD-30, BD-31, BD-32, BD-33, BD-34, BD-35, BD-39, BD-41, BD-42 and BD-43 gave band approximately 230bp which are same as susceptible check Tn-1, so these varieties were also predicted as susceptible to BLB. (Figure-4.3)

***Xa21* Linked Marker (SSR) for BLB Resistance**

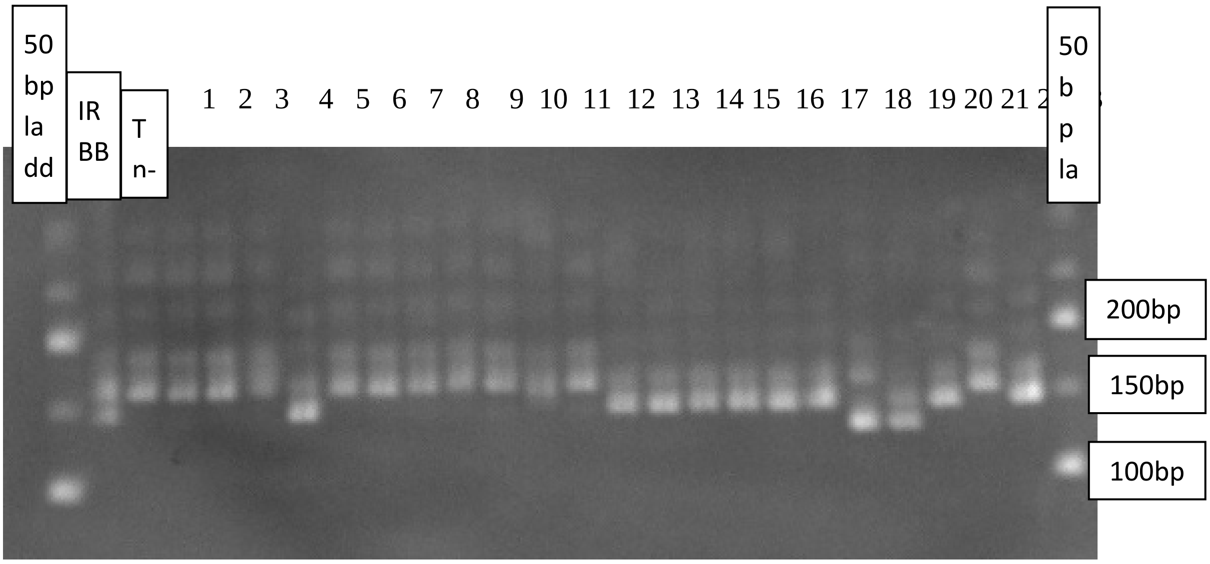


Figure 4.4: Banding pattern of rice genotypes using RM21 marker

DNA amplification of 25 rice lines and varieties was done using RM21 primer linked to BLB resistant gene *Xa21*. The amplified product gave band approximately 130 bp position for BLB resistant lines and varieties and 190bp position for the susceptible lines and varieties. IRBB60 gave band approximately at 130 bp which indicated the presence of resistant *Xa21* gene. In respect of primer RM21, nine genotypes CSA-4, BD-31, BD-32, BD-33, BD-34, BD-35, BD-37, BD-38 and BD-39 lines were regarded as resistant lines and CSA-1, CSA-2, CSA-3, CSA-5, CSA-6, CSA-7, CSA-8, CSA-9, BD-29, BD-30, BD-41, BD-42, BD-43 and BD-44 gave band approximately 190bp which were regarded as susceptible lines because of same banding pattern of susceptible check Tn-1, so these varieties were also predicted as susceptible to BLB. (Figure-4.4)

Markers used in this study MP1, RM122, and RM21 were for genes *Xa4, Xa5* and *Xa21*, respectively showing their presence in rice genotypes. Two check variety (IRBB60 and Tn-1) are used in this study for identifying resistant and susceptible check variety respectively. Two genotypes (CSA-5, CSA-8) of rice were detected with presence of *Xa4* gene by MP marker, nine genotypes (CSA-2, CSA-3, CSA-7, CSA-8, CSA-9, BD-29, BD-37, BD-38 and BD-44) were detected with presence of *Xa5* gene by RM122 marker and nine genotypes (CSA-4, BD-31, BD-32, BD-33, BD-34, BD-35, BD-37, BD-38 and BD-39) were detected with presence of *Xa21* gene by RM21 marker.

According to this study CSA-8 is more significant and highly resistant line of Bacterial Leaf Blight because both *Xa4* and *Xa5* genes are present in this rice line. On the other side BD-37 and BD-38 are also more significant and highly resistant lines for BLB because both *Xa5* and *Xa21* genes are present in these rice lines. Therefore, these genotypes could be used in breeding program for the development of BLB resistant high yielding rice variety.

T. AMAN

Zonal yield trial with M_7 Kasalath mutants

Seeds of a M_7 mutant of Kasalath, derived from 80Gy carbon ion beams irradiation, were sown at four locations during 14 July to 25 July 2018 and seedlings were transplanted during 9 August to 3 September 2018 (Table 1) along with a check variety BRRI dhan39 at 15cm distance within rows of 20cm apart. The experiment followed RCB design with three replications. The size of the unit plots were 6.0m × 5.0m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tillers, panicle length, and filled and unfilled grains panicle^{-1} were recorded after harvest from 5 randomly selected competitive hill. Maturity was assessed plot basis. Grain yield was recorded from an area of 10.0 m^2 which was later converted to t ha^{-1}. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in Table 2.

Table 25. Date of sowing and transplanting of a M_7 Kasalath mutant and check variety at different locations of Bangladesh

Location	Date of sowing	Date of transplanting	Seedling age (days)
BINA HQ farm, Mymensingh	**1 7 July 2018**	**20 August 2018**	**34**
Farmer's field at Sutiakhali, Mymensingh	1 7 July 2018	13 August 2018	27
BINA sub-station farm, Cumilla	14 July 2018	25 August 2018	42
Farmer's field at Kamalpur, Cumilla	14 July 2018	25 August 2018	42
BINA sub-station farm, Rangpur	18 July 2018	12 August 2018	25
BINA sub-station, Magura	17 July 2018	9 August 2018	24
Farmer's field at Shibrampur, Magura	17 July 2018	9 August 2018	24

BINA sub-station, Chapai Nawabganj	15 July 2018	11 August 2018	27
BINA sub-station farm, Barishal	25 July 2018	20 August 2018	27
Farmer's field at Gazalia, Barishal	25 July 2018	3 September 2018	41

Table 26. Yield and yield attributes of the M_7 Kasalath mutant along with BRRI dhan39 in T. aman season, 2018-19

Variety/Line	Days to maturity	Plant height (cm)	Effective tillerplant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1}(no.)	Yield (tha^{-1})
BINA HQs farm, Mymensingh							
RM-Kas-80(C)-1	132	113.93	8.7	25.67	142	52	6.7
BRRI dhan39	125	98.80	7.0	23.27	125	21	4.4
$LSD_{(0.05)}$		5.36	NS	NS	NS	30.82	0.91
Farmer's field at Sutiakhali, Mymensingh							
RM-Kas-80(C)-1	122	111.73	7.2	24.00	123	40	4.6
BRRI dhan39	115	99.33	7.2	24.00	95	41	3.5
$LSD_{(0.05)}$		6.96	NS	NS	25	NS	0.34
BINA Sub-station farm, Cumilla							
RM-Kas-80(C)-1	124	133	13.5	25.33	111.73	21	6.9
BRRI dhan39	114	119	12.2	25.80	102.07	14	5.2
$LSD_{(0.05)}$		6.83	NS	NS	NS	NS	0.38
Farmer's field at Kamalpur, Cumilla							
RM-Kas-80(C)-1	124	123	15.3	24.20	92.50	19	4.7
BRRI dhan39	114	117	11.9	24.97	97.13	12	4.7
$LSD_{(0.05)}$		NS	NS	NS	4.44	NS	NS
BINA sub-station farm, Rangpur							
RM-Kas-80(C)-1	121	113.00	11.5	22.07	92.00	16.33	5.39
BRRI dhan39	116	109.07	9.6	25.27	69.67	11.33	4.08
$LSD_{(0.05)}$		NS	0.76	NS	17.44	NS	0.41
BINA sub-station, Magura							
RM-Kas-80(C)-1		118.40	8.73	25.80	90.60	17.40	6.30
BRRI dhan39		109.07	9.6	25.27	81.40	11.80	7.47
$LSD_{(0.05)}$		NS	NS	NS	NS	NS	0.57
Farmer's field at Shibrampur, Magura							
RM-Kas-80(C)-1		117.07	8.73	24.07	88.33	18.00	5.83
BRRI dhan39		111.33	10.73	24.20	80.87	14.00	6.37
$LSD_{(0.05)}$		NS	NS	NS	6.21	NS	0.87
BINA sub-station farm, Chapai Nawabganj							
RM-Kas-80(C)-1		111.97	11.80	22.53	83.33	10.67	5.20
BRRI dhan39		88.80	9.78	24.20	69.67	10.00	3.97
$LSD_{(0.05)}$		0.87	NS	1.52	7.98	NS	0.22
BINA sub-station farm, Barishal							
RM-Kas-80(C)-1	126	100	10.9	23.53	92.46	33.60	5.52
BRRI dhan39	116	101	9.5	24.13	90.53	25.47	5.62
$LSD_{(0.05)}$		NS	0.54	NS	NS	NS	NS
Farmer's field at Gazalia, Barishal							
RM-Kas-80(C)-1	133	110	8.4	23.32	102.66	25.46	5.19
BRRI dhan39	121	101	9.1	25.90	84.13	23.53	5.09
$LSD_{(0.05)}$		NS	NS	NS	NS	NS	NS
Combined means over all locations							

RM-Kas-80(C)-1	115	10.55	24.23	101.84	25.38	5.59
BRRI dhan39	105	9.58	24.13	88.93	18.49	5.03
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS
LSD(0.05) for mutant × location interaction	NS	NS	NS	NS	NS	NS

It appeared that the mutant had mostly taller plant height at all locations than the check variety (Table 2).The plant height of the mutant did not differ significantly with the check variety at Cumilla, Rangpur, Magura and Barishal at both sub-station farms and farmer's fields. Like plant height, the mutant had higher number of effective tillers at all locations than the check variety except at Magura in both sub-station farm and farmer's field and at Barishal in the farmer's field only. The effective tiller number of the mutant differed significantly only at Rangpur and Barishal sub-station farms. Panicle length of the mutant did not differ significantly at any location from the check variety except at Chapai Nawabganj sub-station (Table 2)

Number of filled grains panicle^{-1} was higher in the mutants than the check variety at all locations except at Cumilla farmer's field (Table 2). At Cumilla farmer's field the check variety had significantly higher number of filled grains. But at Mymensingh farmer's field and at Rangpur sub-station farm the mutant had significantly higher number of filled grains panicle^{-1}. Number of unfilled grains of the mutants and the check variety did not differ significantly at any location except BINA HQs farm at Mymensingh. At BINA HQs farm, Mymensingh the mutant had significantly higher number of unfilled grains than the check variety.

The mutant produced significantly higher grain yield than the check variety at five out of 10 locations and showed non-significant difference at three locations (Table 2). However, the combined means (averaged over 10 locations) of grain yield and yield attributes of the mutant did not show any significant difference with the check variety (Table 2). Finally, this mutant would be put into on-farm and on-station trial in the next T. Aman season.

Preliminary yield trial with some deepwater mutants

Seeds of nine mutants and the parent cv. Laksmi digha were sown on 26 April 2018 at BINA HQs Farm, Mymensingh. Seedlings were transplanted on 30 May and 31 May 2018 at BINA sub-station farms, Barishal and Gopalganj, respectively, following RCB designs at 15cm distances within rows of 20cm apart. A unit plot size was 3.0m × 2.0m. Fertilizers were applied at the rate of N-54 kg, P- 60 kg and K-40 kg ha^{-1} in the form of Urea, TSP and MoP. TSP and MoP were applied during final land preparation but urea was applied as top dressing after 10 and 30 days of transplanting. Data on plant height, number of effective tiller hill^{-1}, panicle length, and filled and unfilled grains panicle^{-1} were recorded from five randomly selected competitive hills at maturity. Grain yield was recorded from 1.0 m^2 land which was converted later to tha^{-1}. Maturity was assessed plot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 3.

Table 27. Grain yield and yield components of some deepwater rice mutants at Gopalganj and Barishal

Variety/ mutant	Days to maturity	Plant height (cm)	Effective tiller $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$(no.)	Grain yield (tha^{-1})
BINA sub-station farm, Gopalganj							
LD-200-1-3-2-2	146	198.80	10.33	26.27	86.83	99.00	3.75
LD-200-1-3-2-13	143	191.90	7.53	30.47	97.70	102.33	3.78
LD-200-1-3-2-1	145	187.53	9.08	32.07	116.20	87.33	3.62
LD-200-1-3-2-4	142	204.23	9.33	26.10	80.47	102.33	3.69
LD-200-1-3-3-9	143	194.67	9.42	26.47	94.87	99.33	3.68
LD-200-1-3-2-10	142	206.43	10.00	26.10	92.33	101.33	3.50
LD-200-1-3-3-8	145	188.93	10.08	31.37	105.40	92.00	3.55
LD-200-1-3-3-5	144	190.07	8.18	30.70	104.00	92.00	3.36
LD-200-1-3-2-9	145	210.73	9.03	31.97	113.93	100.00	3.24
Laksmi digha (P)	196	226.92	11.33	31.17	65.83	38.33	2.35
$LSD_{(0.05)}$	3.75	12.05	2.28	2.82	3.75	15.27	0.52
BINA sub-station farm, Barishal							
LD-200-1-3-2-2	147	123.40	10.08	19.73	102.25	66.33	3.17
LD-200-1-3-2-13	138	116.27	9.75	18.23	104.67	77.00	3.45
LD-200-1-3-2-1	146	121.93	9.67	17.67	118.73	62.67	3.27
LD-200-1-3-2-4	140	122.33	10.50	16.90	127.73	57.00	3.41
LD-200-1-3-3-9	139	123.53	9.92	18.07	114.33	70.00	3.68
LD-200-1-3-2-10	140	125.53	11.00	17.97	128.81	81.00	3.72
LD-200-1-3-3-8	143	133.93	9.75	18.70	103.25	64.67	3.69
LD-200-1-3-3-5	147	136.40	9.92	17.13	109.22	79.33	3.15
LD-200-1-3-2-9	135	124.20	9.63	19.13	87.86	69.00	3.22
Laksmi digha (P)	207	119.53	11.17	15.60	67.99	31.33	2.01
$LSD_{(0.05)}$	3.34	NS	NS	2.02	4.95	18.44	0.40

Maturity period of the parent Laksmi digha was the longest at both the locations (Table 3). At Gopalganj, the mutants took 142-146 days to mature and at Barishal 135-147 days while the parent took 196 and 207 days, respectively. Plant height of the parent at Gopalganj was significantly the tallest of all. Among the mutants, LD-200-1-3-2-9 had the tallest plant height followed by LD-200-1-3-2-10 and LD-200-1-3-2-4 but no showed significant difference with each other. It is interesting to note that the parent although had the tallest height at Gopalganj yet it showed the shortest height at Barisahl, might be due to the absence of required water depth. It is known to all that the deepwater rice does not show potential plant height in absence of required water depth. At Barishal, the mutant LD-200-1-3-3-5 had the tallest plant height followed by LD-200-1-3-3-8. But none of the mutants differed significantly with each other and even with the parent (Table 3).

Number of effective tillers of the parent was the highest at both Gopalganj and Barishal although did not show significant difference with the mutants at Barishal (Table 3). Panicle length of the parent and the mutants was much longer at Gopalganj than Barishal. The unusual panicle length of the parent and the mutants at Barishal might be due to unfavorable growing environment. However, the mutants had significantly higher number of filled grains panicle^{-1} and also higher grain yield ha^{-1}(Table 3). The parent Laksmi digha had the lowest grain yield at both the locations might be due to its lowest filled grains plant^{-1}. Grain yield of the mutant LD-200-1-3-2-13 did not differ significantly with eight others except LD-200-1-3-2-9. At Barishal, the mutant LD-200-1-3-2-10 had the highest grain yield which did not differ significantly with five others. Finally, five mutants with higher grain yield ha^{-1} and filled grains panicle^{-1} will be put into Advanced Yield Trial in the next growing season.

Evaluation of some bacterial leaf blight tolerant M_6 mutants of BR11

Seeds of five M_5 mutants derived from irradiating the seeds of highly BLB susceptible BR11 variety of T. Aman rice with 300 Gy dose of gamma rays were sown on 24 July and seedlings were transplanted on 5 September 2018 along with the parent BR11 at BINA HQs farm, Mymensingh. The experiment followed non replicated design. The distances between plants were 15cm and between rows were 20cm. A unit plot size was 3.0m × 2.0m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tillers, panicle length, filled and unfilled grains panicle^{-1} were recorded from five randomly selected competitive hills at maturity. Maturity was assessed plot basis. Grain yield was recorded from an area of 1.0 m^2 which later converted to t ha^{-1}.The recorded data were finally subjected to proper statistical analysis and are presented in Table 4.

Table 28. Grain yield and yield components of some bacterial leaf blight tolerant M_6 mutants of BR11

Variety/ mutant	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield (tha^{-1})
BR-11-300-2-1	147	101.0±1.41	7.2±0.86	21.00±0.95	130.8±14.60	40.6±10.83	5.2±0.02
BR-11-300-2-2	150	115.8±2.52	8.6±0.60	14.62±0.75	188.8±23.87	37.0±16.32	5.5±0.10
BR-11-300-2-3	150	97.4±1.80	11.4±1.29	22.80±1.01	128.0±12.40	24.0±7.48	4.4±0.07
BR-11-300-2-4	140	96.6±1.66	9.4±1.03	19.80±0.58	164.8±7.68	29.2±5.73	5.6±0.03
BR-11-300-2-5	147	113.6±1.57	10.0±1.04	25.40±0.60	291.8±11.66	43.0±7.46	7.0±0.06
BR11(Parent)	147	101.8±1.07	6.6±0.25	20.20±0.35	92.00±7.24	28.0±3.27	5.4±0.04

The maturity of the mutants and parent ranged between 140-150 days with BR-11-300-2-4 being the shortest and BR-11-300-2-2 and BR-11-3002-3 the longest (Table 4). Plant height ranged between 96.6 to 115.8cm with BR-11-300-2-4 the shortest and BR-11-300-2-2 the tallest. Number of effective tillers hill^{-1} ranged between 6.6 to 11.4 with the parent being the lowest and the mutant BR-11-300-2-3 the highest. Panicle length ranged between 14.6 cm to 25.4 with BR-11-300-2-2 being the shortest and BR-11-300-2-5 the tallest. Number of filled grains panicle^{-1} ranged between 92.0 to 291.8 with the parent being the lowest and the mutant BR-11-300-2-5 the highest. Number of unfilled grains Panicle^{-1} ranged between 24.0 to43 with the mutant BR-11-300-2-3 being the lowest and the mutant BR-11-300-2-5 the highest. Grain yield ranged between 4.4 to 7.0 tha^{-1}with BR-11-300-2-3 being the lowest and BR-11-300-2-5 the highest (Table 4). There were more variations in all the yield components of the mutants than the parent except grain yield. The mutants BR-11-300-2-1 and BR-11-300-2-4 had lower variations for grain yield even than the parent which indicated these two mutants already attained homzygosity for this trait. However, the mutants that produced higher grain yield than the parent apart from having higher number of effective tiller, longer panicle length, higher filled and lower unfilled grains panicle^{-1} will be put into Preliminary Yield Trial in next T.Aman season for evaluation of yield and further selection for yield and components.

Evaluation of some M_5 mutants of Biroi rice in T. Aman season

Seeds of six M_5 mutants derived from irradiating the seeds of local Biroi rice with 250 Gy dose of gamma rays were sown on 26 July and seedlings were transplanted on 06 September 2018 along with the parent Biroi at BINA HQs farm, Mymensingh. The experiment followed non replicated design. The distances between plants were 15cm and between rows were 20cm. A unit plot size was 3.0m × 2.0m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tiller, panicle length, filled and unfilled grains panicle^{-1} were recorded from five randomly selected competitive hills at maturity. Maturity was assessed plot basis. Grain yield was recorded from an area of 1.0 m^2 which later converted to tha^{-1}.The recorded data were finally subjected to proper statistical analysis and are presented in Table 5.

Table 29. Grain yield and yield components of some M_6 mutants of Biroi

Variety/ mutant	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	Grain yield (tha^{-1})
Biroi-250-2-1	148	136.8±2.63	8.0±0.55	25.0±0.95	205.8±6.26	44.0±9.33	4.0±0.02

Biroi-250-2-2	148	92.8±1.94	7.0±0.45	24.8±0.49	166.6±9.93	57.6±7.11	6.18±0.08
Biroi-250-2-3	146	85.60±1.70	7.4±0.81	24.8±0.49	194.4±14.96	55.6±9.37	6.86±0.05
Biroi-250-2-4	146	96.2±1.98	8.0±0.71	23.8±1.02	166.2±18.79	23.00±6.24	6.43±0.04
Biroi-250-2-5	148	134.2±2.03	7.6±0.60	14.87±0.37	180.0±6.61	24.6±1.63	3.9±0.03
Biroi-250-2-6	148	130.4±1.21	7.0±0.63	26.8±1.30	233.6±16.63	35.2±6.98	5.34±0.09
Biroi (Parent)	143	125.8±1.85	10.6±0.68	24.2±0.58	122.0±5.15	24.2±1.91	4.05±0.02

The maturity of the mutants and parent ranged between 143-148 days with the parent being the shortest (Table 5). Plant height ranged between 85.60 to 136.8cm with Biroi-250-2-3 being the shortest and Biroi-250-2-1the tallest. Number of effective tiller ranged between 7.0 to 10.6 with the parent being the highest and the mutants Biroi-250-2-6 and Biroi-250-2-2 the lowest. Panicle length ranged between 14.87 cm to 26.8 with the mutant Biroi-250-2-6 being the longest and Biroi-250-2-5 the shortest (Table 5). Filled grains panicle^{-1} ranged between 122.0 to 233.6 with the parent being the lowest and the mutant Biroi-250-2-6 the highest. Unfilled grains panicle^{-1} ranged 24.2 to 57.6 with once again the parent being the lowest and the mutant Biroi-250-2-3being the highest. Grain yield ranged between 3.9 to 6.86 tha^{-1} with the mutant Biroi-250-2-5 being the lowest and Biroi-250-2-3 the highest (Table 5). There were less variations in plant height of Biroi-250-2-6 and Biroi-250-2-3; in number of effective tiller of Biroi-250-2-6, Biroi-250-2-5, Biroi-250-2-2 and Biroi-250-2-1; in panicle length of Biroi-250-2-5, Biroi-250-2-3 and Biroi-250-2-2 and unfilled grains panicle^{-1} of Biroi-250-2-5 than the parent which indicated these mutants already attained homozygosity for these traits. Moreover, in the number of filled grains panicle^{-1}, the mutants Biroi-250-2-5 and Biroi-250-2-1 had closer variations to the parent and in grain yield hill-1 all the mutants had closer variations to the parent (Table 5). Decorticated grain color of the mutants was mostly white except one. The mutant Biroi-250-2-6 had red decorticated grain color but it had lodging problem. But the mutants having white decorticated grain color were mostly dwarf in plant height. Therefore, the mutant with red decorticated grains will be put into Preliminary Yield Trial along with the dwarf but white decorticated grains in the next T. aman season. Moreover, a hybridization program for introgressing the lodging resistant trait from the dwarf white decorticated grained mutant in the lodging susceptible red decorticated grain colored mutants will be carried out in the next T. Aman season.

Evaluation of recurrent gamma ray irradiated M_3R_1 mutants of BR 11

Seeds of nine M_3R_1 mutants derived from re-irradiating the seeds of 150 Gy gamma ray irradiated seeds of BR11with 250 Gy dose of gamma were sown on 26 July and seedlings were transplanted on 06 September 2018 along with the parent BR11 at BINA HQs farm, Mymensingh. The experiment followed non replicated design. The distances between plants were 15cm and between rows were 20cm. A unit plot size was 3.0m × 2.0m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tillers, panicle length, number of filled and unfilled grains panicle^{-1} were recorded from five randomly selected competitive hills at maturity. Maturity was assessed plot basis. Grain yield was recorded from an area of 1.0m^2 which later converted to tha^{-1}. The recorded data were finally subjected to proper statistical analysis and are presented in Table 6.

The maturity period of the mutants and parent ranged between 143-150 days with the parent being the longest (Table 6). Plant height ranged between 101.8 to 122.0cm with the parent being the shortest and the mutant BR-11-P-18 the tallest. Number of effective tiller ranged between 6.4 to 8.8 with the mutant BR-11-P-37 being the lowest and the mutant BR-11-P-18 the highest. Panicle length ranged between 14.87 to 24.6cm with the mutant BR-11-P-32 being the longest and BR-11-P-26 the shortest (Table 6). Number of filled grains panicle^{-1} ranged between 92.0 to 198.8 with the parent being the lowest and the mutant BR-11-P-21 the highest.

Table 30. Grain yield and yield components of some M_3 R_1 mutants of BR11

Variety/Line	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1}(no.)	Grain yield (tha^{-1})
BR-11-P-18	149	122.0±2.77	8.8±1.32	23.4±0.51	129.8±3.68	31.6±5.20	5.0±0.03
BR-11-P- 19	148	117.2± 2.4	7.2±0.67	21.8±0.67	146.2±9.06	26.0 ± 3.4	5.3±0.51
BR-11-P-20	147	115.2±0.73	8.2±0.58	22.00±1.05	125.8±17.70	37.0±3.21	5.2±0.03
BR-11-P-21	146	117.0±1.87	7.6±0.06	24.0±0.32	198.8±21.80	27.8±2.27	4.7±0.05
BR-11-P-26	147	114.4±2.46	7.0±0.77	14.87±0.73	146.2±4.15	35.8±2.24	5.5±0.21
BR-11-P-32	145	117.4±1.50	6.6±0.75	24.6±0.24	154.0±9.27	30.8±4.76	4.8±0.03
BR-11-P-33	143	113.6±1.96	7.4±0.51	24.20±0.58	161.8±5.97	46.40±6.24	4.6±0.03
BR-11-P-37	147	115.4±0.75	6.4±0.24	24.40±0.68	173.2±11.60	41.6±6.96	4.8±0.03
BR-11-P-38	148	112.4±2.98	7.0±0.60	24.0±0.84	150.4±10.37	40.6±1.91	4.7±0.05
BR11(Parent)	150	101.8±1.07	6.6±0.24	20.20±0.37	92.0±7.24	28.0±3.27	5.4±0.06

Number of unfilled grains panicle^{-1} ranged from 26.0 to 46.4 with the mutant BR-11-P- 19 being the lowest and the mutant BR-11-P-33 the highest. Grain yield ranged from 4.6 to 5.5 tha^{-1} with the mutant BR-11-P-33 being the lowest and BR-11-P-26 the highest (Table 6). There were less variations in plant height of BR-11-P-37 and BR-11-P-20; in number of effective tiller of BR-11-P-21; in panicle length of BR-11-P-32 and BR-11-P-21and in unfilled grains panicle^{-1} of BR-

11-P-38, BR-11-P-26, BR-11-P-21 and BR-11-P-20 and in and grain yield hill^{-1} of all the mutants except BR-11-P- 19 and BR-11-P-26 than the parent which indicated these mutants already attained homozygosity for these traits. Moreover, in the number of effective tiller hill^{-1} the mutant BR-11-P-37 had equal standard error with the parent also indicated this mutant already attained homozygosity for number of effective tiller hill^{-1} (Table 6). Therefore, the mutants produced higher or closer yield to the parent along with attained homozygosity in most of the traits will be put into preliminary yield trial, in the next T. Aman season.

Evaluation of BC_1F_1 generation of Luxmidigha × Binadhan-18 cross

The seeds of 11 BC_1F_1 populations derived from crossing between Laksmi digha and Binadhan-18 were sown on 10 August 2018 at BINA Hqs farm, Mymensingh. The parents were also included in this experiment. Seedlings were transplanted on 11 September 2018 at 15cm distances within rows of 20cm apart. The experiment followed non replicated design. A unit plot size was 2m ×1m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tiller hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded from randomly selected five competitive hills at maturity. Maturity was assessed pot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 7.

Table 31. Grain yield and yield components of some BC_1F_1generation of Laksmi digha × Binadhan-18 cross

Cross/parent	Days of maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield hill^{-1} (g)
BC_1F_1 (1)	122	163	6	22.8	40	25	21
BC_1F_1 (2)	127	149	5	21.9	122	60	24
BC_1F_1 (3)	131	153	8	22.7	141	35	26
BC_1F_1 (4)	126	144	6	22.3	160	30	28
BC_1F_1 (5)	122	146	7	22.7	155	5	30
BC_1F_1 (6)	128	144	6	22.80	141	6	26
BC1F1 (7)	127	149	6	22.6	135	9	21
BC_1F_1 (8)	126	147	7	23	140	22	23
BC_1F_1 (9)	129	141	9	23.2	125	11	22
BC_1F_1 (10)	123	143	10	23.1	127	10	19
BC_1F_1 (11)	125	146	6	23	129	6	26
Luxmi digha	125	173	5	22.5	185	30	18.7
Binadhan-18	130	105	7	23	52	10	27
Mean ± SE	126.23±0.79	146.38±4.24	6.77±0.41	22.74±0.10	127.08±11.06	19.92±4.44	23.98±0.98

Days to maturity of the backcross population ranged from 122 to 131 days with BC_1F_1 (1) the lowest and BC_1F_1 (3) the longest (Table 7). Three populations had earlier maturity than both the parents either with significant or not significant differences. All the back cross population had significantly shorter plant height than parent Laksmi digha (Table 7). Number of effective tiller ranged from 5-10 with BC_1F_1 (2) being the lowest while BC_1F_1 (10) the highest (Table 7). Three populations had significantly higher number of effective tiller and two had longer panicle length than both parents. Ten populations had significantly higher number of filled grains panicle^{-1} than recipient parent. Two populations had significantly higher grain yield hill^{-1} than both parents (Table 7). All these populations will be further evaluated and screened in the next growing season.

Growing of BC_1F_1 generation of Kasalath mutant × Binadhan-18 cross

The seeds of eight BC_1F_1 derived from crossing between Kasalath mutant and Binadhan-18 were sown on 10 August 2018 at BINA Hqs farm, Mymensingh. The parents were also included in this experiment. Seedlings were transplanted on 11 September 2018 at 15cm distances within rows of 20cm apart. The experiment followed non replicated design. A unit plot size was 2m ×1m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tiller, panicle length, filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded from randomly selected five competitive hills at maturity. Maturity was assessed pot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 8.

Table 32. Grain yield and yield components of some BC1F1 of Kasalath × Binadhan-18 cross

Back cross/ parent	Days of maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield hill^{-1} (g)
BC_1F_1 (1)	134	101	5	23.1	122	60	28.1
BC_1F_11 (2)	132	99	6	23.3	145	23	26
BC_1F_1 (3)	128	96	5	23.3	89	12	25.3
BC_1F_1 (4)	133	102	6	23.7	66	19	26
BC_1F_11 (5)	129	105	4	23.5	45	20	23
BC_1F_1 (6)	127	101	5	23.00	33	11	20
BC_1F_1(7)	125	100	5	23.4	30	22	21
$BC_1F_1$8)	130	98	4	23.3	35	5	20
Kasalath mutant (P)	136	95	4	22.6	67	35	27
Binadhan-18(P)	134	99	7	23.2	62	17	30
Mean ± SE	130.80±1.12	99.60±0.9	5.10±0.31	23.24±0.09	69.40±12.29	22.40±4.	24.64±1.10

Days to maturity of the backcross populations ranged from 125 to 134 days with BC_1F_1 (7) the shortest and BC_1F_1 (1) the longest (Table 8). Seven populations had earlier maturity than both parents either with significant or not significant difference. Five back cross populations had significantly longer plant height than both of parent (Table 8). Number of effective tillers ranged from 4 to 6 with BC_1F_1 (5) and BC_1F_1 (8) the lowest while BC_1F_1 (2) and BC_1F_1 (4) the highest (Table 8). Six populations had significantly higher effective tiller number and eight had longer panicle length than donor parent. From the table shown ten populations had significantly higher number of filled grains panicle^{-1} than recipient parent and two populations had significantly higher grain yield hill^{-1} than both parents (Table 8). All these populations will be further evaluated and screened in the next growing season.

BORO

Field evaluation trial with a short duration high yielding M_{11} mutant line

This trial was carried out with a short duration and high yielding mutant RM-40(C)-4-2-8 to assess the yield potential over locations. The short duration Boro rice variety, BRRI dhan28 was used as a check variety. Seeds were sown during 23 November to 13 December 2017 and transplanted during 09 January to 21 January 2018 (Table 4). The experiments in the trial followed RCB designs with three replications. The size of the unit plots were 6.0m × 5.0m. Seedlings were transplanted at 15cm distance within rows of 20cm apart. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tiller hill^{-1}, panicle length, and number of filled and unfilled grains panicle^{-1} were recorded after harvest from five randomly selected competitive hills. Days to maturity was assessed on plot basis. Grain yield was recorded from an area of 10.0m^2 which was later converted to t ha^{-1}. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 9.

Table 33. Date of sowing and transplanting of the short duration premium quality rice mutant and check variety at different locations of Bangladesh

Location	Date of sowing	Date of transplanting	Seedling age (days)
BINA Hqs farm, Mymensingh	02 December 2018	23 January 2019	53
Farmer’s field, Mymensingh	02 December 2018	28 January 2019	58
BINA sub-station farm, Jamalpur	17 December 2018	06 February 2019	52
Farmer’s field, Jamalpur	17 December 2018	05 February 2019	51

BINA sub-station farm, Gopalganj	23 December 2018	11 February 2019	50
Farmer's field, Gopalganj	02 December 2018	27 January 2019	57
BINA sub-station farm, Barishal	13 December 2018	23 January 2019	42
Farmer's field, Barishal	13 December 2018	20 January 2019	38
BINA sub-station farm, Magura	23 December 2018	02 February 2019	42
Farmer's field, Magura	23 December 2018	02 February 2019	42
BINA sub-station farm, Rangpur	17 December 2018	25 January 2019	40
Farmer's field, Rangpur	17 December 2018	26 January 2019	41

It appears that the mutant RM-40(C)-4-2-8 with premium quality grain had significantly higher number of filled grains panicle^{-1} which was attributed to its significantly longer panicle length than the check variety, BRRI dhan28 (Table 9). The average grain yield ha^{-1} of this mutant over 12 locations of Bangladesh was also significantly higher than the check variety (Table 11) although it took some more time to mature not over 12 days and had taller plant height (Table 10).

Table 34. Yield attributes of a short duration high yielding mutant line along with BRRI dhan28 in 2018-19

Variety/Line	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)
RM-40(C)-4-2-8	149	122.07	8.20	27.40	155.2	25.33
BRRI dhan 28	137	109.27	11.67	24.67	114.0	17.13
LSD$_{(0.05)}$	-	6.89	2.50	0.58	1.89	3.47

Table 35. Grain yield of a short duration high yielding mutant line along with BRRI dhan28 in 2018-19

Mutant/check variety	Grain yield at different locations (tha^{-1})												Average (t ha^{-1})
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	
RM(2)-40 ©-4-2-8	6.83	5.86	6.83	6.61	7.2	7.37	3.81	3.19	7.25	7.10	5.80	5.80	6.14
BRRIdhan28 (check)	6.56	5.5	6.01	5.86	6.12	5.44	3.25	3.05	5.85	5.72	5.60	5.50	5.37
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

L1= BINA Hqs farm, Mymensingh, L2= Farmer's field, Mymensingh, L3= BINA sub-station farm, Magura, L4= Farmer's field, Magura, L5= BINA sub-station farm, Barishal, L6= Farmer's field , Barishal, L7= BINA Sub-station farm, Gopalganj, L8= Farmer's field, Gopalganj, L9= BINA sub-station farm, Rangpur, L10= Farmer's field , Rangpur, L11= BINA Sub-station farm, Jamalpur, L12= Farmer's field, Jamalpur

Evaluation and screening of BC_1F_2 populations of Laksmi digha mutant × Binadhan-18 cross

The seeds of 26 BC_1F_2 derived from crossing between Laksmi digha and Binadhan-18 were sown on 9 January 2019 at BINA Hqs farm, Mymensingh to select the plants with early maturity and higher yield. The parents Laksmi digha and Binadhan-18 were also included in this experiment. Seedlings were transplanted on 20 February 2019 at 15cm distances within rows of

20cm apart. The experiment followed non replicated design. A unit plot size was 2m ×1m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number effective tiller hill^{-1}, panicle length, noumber of filled and unfilled grains panicle^{-1} and grain yield hill^{-1} were recorded from randomly selected five competitive hills at maturity. Days to maturity was assessed plot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 12.

Table 36. Grain yield and yield components of some BC_1F_2 mutants of Laksmi digha × Binadhan-18 cross

Backcross/parent	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1}(no.)	Grain yield hill^{-1} (g)
BC_1F_2 (1)	105	103	4	23.1	120	25	29.3
BC_1F_2 (2)	110	105	6	23.5	145	85	32.6
BC_1F_2 (3)	109	145	9	23.6	128	6	28.3
BC_1F_2 (4)	122	127	11	23.3	121	17	25.2
BC_1F_2 (5)	125	129	15	23.6	195	6	33.8
BC_1F_2 (6)	131	133	13	23.10	190	12	31.3
BC_1F_2 (7)	107	140	16	24.0	225	68	35.3
BC_1F_2 (8)	110	106	18	23.9	163	18	37.9
BC_1F_2 (9)	105	109	21	23.6	169	5	36.3
BC_1F_2 (10)	106	121	20	23.5	145	56	29.6
BC_1F_2 (11)	108	115	17	23.3	138	48	27.2
BC_1F_2 (12)	106	135	12	23.4	127	43	26.2
BC_1F_2 (13)	122	133	9	23.1	133	5	28.4
BC_1F_2 (14)	120	140	14	23.6	68	13	23.6
BC_1F_2 15)	135	133	13	23.5	66	20	23.1
BC_1F_2 (16)	121	127	16	23.7	101	26	21.1
BC_1F_2 (17)	115	121	18	23.8	123	7	33.3
BC_1F_2 (18)	117	120	11	23.9	131	16	30.6
BC_1F_2 (19)	121	126	11	23.3	120	22	24.7
BC_1F_2 (20)	131	121	14	23.6	125	9	21.6
BC_1F_2 (21)	128	128	15	22.9	120	7	23.2
BC_1F_2 22)	127	126	9	23.1	111	10	23.0
BC_1F_2 (23)	126	121	11	24.0	121	13	24.2
BC_1F_2 (24)	111	120	10	23.6	11	15	23.0
BC_1F_2 (25)	125	119	9	23.3	69	50	20.0
BC_1F_2 26)	130	117	7	22.9	65	20	21.2
Luxmidigha (P)	129	168	6	23.0	170	22	17.3
Binadhan-18(P)	132	108	7	23.2	69	32	25.3
Mean ± SE	115.50±4.28	124.86±2.60	12.21±0.84	23.44±0.06	123.54±8.70	24.14±3.88	27.02±1.01

Days to maturity of the backcross population ranged from 105 to 135 days with BC_1F_2 (1) and BC_1F_2 (9) the lowest and BC_1F_2 (15) the longest (Table 12). Twenty populations had shorter maturity than both parents either with significant or no significant difference. All the back cross population had significantly shorter plant height than parent Laksmi digha but only four than parent Binadhan-18 (Table 12). Number of effective tiller hill^{-1} ranged from 4 to 18 with BC_1F_2 (1) being the lowest while BC_1F_2 (17) the highest (Table 12). Twenty three populations had significantly higher effective tiller hill^{-1} number and 20 had longer panicle length than both parents. Three populations had significantly higher number of filled grains panicle^{-1} than recipient parent. Thirteen populations had significantly higher grain yield hill^{-1} than both parents (Table 12). All these populations will be further evaluated and screened in the next growing season.

Confirmation of F_1 between Laksmi digha × Binadhan-18 cross

The seeds of 13 F_1 derived from crossing between Laksmi digha and Binadhan-18 were sown on 17 December 2017 at BINA Hqs farm, Mymensingh to confirm that these are really F_1or not. The parents were also included in this experiment. A single seedling was transplanted on 31 January 2018 in a pot filled with clay loam soil. The experiment followed non replicated design. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tiller hill^{-1}, panicle length, number of filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded at maturity. Days to maturity was assessed visually on the pot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 13.

Table 37. Grain yield and yield components of some F_1 mutants of Binadhan-18 × Laksmi digha cross

Cross/ parent	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1}(no.)	Unfilled grains panicle^{-1} (no.)	grain yield hill^{-1} (g)
F_1 (1)	127.00	163.00	6.00	23.10	152.00	32.00	24.50
F_1 (2)	132.00	160.00	8.00	23.00	170.00	45.00	27.00
F_1 (3)	122.00	155.00	6.00	22.90	130.00	105.00	20.10
F_1 (4)	125.00	161.00	4.00	23.50	137.00	86.00	23.40
F_1 (5)	131.00	145.00	5.00	24.00	135.00	71.00	18.20
F_1 (6)	126.00	158.00	6.00	23.00	130.00	62.00	19.00
F_1 (7)	127.00	145.00	5.00	23.10	126.00	60.00	22.00
F_1 (8)	126.00	149.00	5.00	23.20	120.00	50.00	23.00
F_1 (9)	131.00	157.00	4.00	23.00	65.00	125.00	20.00
F_1 (10)	133.00	154.00	3.00	23.20	102.00	45.00	28.00
F_1 (11)	126.00	144.00	4.00	23.00	105.00	35.00	16.00
F_1 (12)	129.00	151.00	3.00	23.50	97.00	52.00	19.00
F_1 (13)	127.00	147.00	4.00	24.80	131.00	20.00	24.00
Binadhan-18 (P_1^*)	134.00	102.00	9.00	23.70	67.00	19.00	32.48
Laksmi digha (P_2)	130.00	180.00	4.00	22.00	258.00	37.00	20.46
Mid parent (MP)	132.00	141.00	6.50	22.85	162.50	28.00	26.47

Mean ± SE	128.40±0.87	151.40±4.26	5.07±0.44	23.27±0.16	128.33±11.81	56.27±7.77	22.48±1.11

P_1- Parent-1, P_2-Parent-2, MP- Mid parent

It is revealed that all the 13 F_1 plants showed significantly shorter maturity period than mid and recipient parent, eight of them even showed shorter maturity period than the early maturing donor parent (Table 13). Ten F_1 plants had significantly taller plant height than the mid parent except three F_1 from the cross. Three F_1 plants had significantly shorter plant height than the mid parent but taller than recipient parent, Binadhan-18. In contrast, all the F_1s had significantly shorter plant height than the donor parent, Laksmi digha. Number of effective tiller hill^{-1} of one F_1 plant was significantly higher than mid parent, seven than donor parent but none was found higher than recipient parent, Binadhan-18. Panicle length was significantly higher in all the F_1 plants than the donor parent, nine than the mid parent, and only one than the recipient parent (Table 13). None of the F_1 plants had significantly higher number of filled grains panicle^{-1} than mid parent although all of them had higher filled grains than recipient parent. Number of unfilled grains panicle^{-1} was significantly higher in 11 of the F_1s than mid parent. Only one F_1 plant had significantly higher grain yield hill^{-1} than mid parent. Finally, it could be concluded that these results confirm most of the F_1s contain characters either intermediate of the two parents or like the donor parent. This will be further confirmed used by SSR marker.

Confirmation of F_1 of Binadhan-18 × Kasalath mutant cross

The seeds of 11 F_1 derived from crossing between Binadhan-18 and Kasalath mutant, Kas- 80 (C)-1 were sown on 17 December 2017 at BINA Hqs farm, Mymensingh to confirm that these are really F_1 or not. The parents were also included in this experiment. A single seedling was transplanted on 31 January 2018 in a pot filled with clay loam soil. The experiment followed non replicated design. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tiller hill^{-1}, panicle length, number of filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded at maturity. Days to maturity was assessed visually on the pot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 14.

Table 38. Grain yield and yield components of some F_1 mutants of X Binadhan-18 × Kasalath mutant cross

Cross/parent	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield hill^{-1} (g)
F_1 (1)	134	101	6	23.0	46	12	22.1
F_1 (2)	131	99	5	23.2	48	5	18.6
F_1 (3)	135	98	4	23.0	53	16	24.1

F_1 (4)	133	101	5	23.2	54	19	30.1
F_1 (5)	140	103	9	23.5	125	43	33.0
F_1 (6)	136	106	6	23.0	110	50	20.3
F_1 (7)	131	102	3	22.7	95	33	27.0
F_1 (8)	134	101	4	23.1	92	25	26.5
F_1 (9)	134	104	7	22.9	77	33	22.0
F_1 (10)	132	101	5	22.8	55	20	23.0
F_1 (11)	130	102	5	23.4	84	20	29.0
Binadhan-18 (P_1*)	132	104	8	23.5	65	17	30.1
Kasalath mutant (P_2)	138	97	4	22.8	70	35	26.3
Mid Parent (MP)	135	100.5	6	23.15	67.5	26	28.2
Mean ± SE	133.85±0.80	101.46±0.69	5.46±0.48	23.08±0.07	74.92±6.94	25.23±3.56	25.55±1.19

P_1- Parent-1, P_2-Parent-2, MP- Mid parent

Ten F_1 plants required significantly shorter period to mature than the mid, eight of them also had significantly shorter maturity period than the donor parent (Table 14). The remaining F_1 required longer period to mature even than the donor parent with longest duration. Five F_1 plants had significantly taller plant height than the mid parent but compare to the donor parent all of them had significantly taller height. Only one F_1 plant showed taller plant height even than the tallest recipient parent. Two F_1 plants had significantly higher number of effective tiller than the mid and recipient parents but eight than the mid and donor parents. Panicle length of three F_1 plants was significantly longer than the mid parent but 10 than the donor parent. Six F_1 plants had significantly higher number of filled grains panicle^{-1} than the mid, donor and recipient parents. But five of them also had significantly higher number of unfilled grains panicle^{-1} than the mid and donor parents. Two F_1 plants had significantly higher grain yield hill^{-1} than the mid parent but three than the donor parent.

Finally, it could be concluded that these results confirm most of the F_1s contain characters either intermediate of the two parents or like the donor parent. This will be further confirmed used by SSR marker.

AUS

Evaluation of M_3 populations of NERICA-4 irradiated with nitrogen ion beams

The seeds three M_3 populations of NERICA-4 derived from irradiating its seeds with 2×10^{16} ions/cm^2 of nitrogen ion beam were sown in Aus season on 02 May at BINA Hqs Farm, Mymensingh and single seedlings hill^{-1} transplanted on 11 June 2019. The experiment was conducted following plant-progeny-row. A unit plot comprised four rows of 2.0m length. Distance between plants and rows were 15cm and 20cm, respectively. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. At maturity, based on earliness and taller plant height, six plants from N4-16(N)-

20, five plants from N4-16(N)-19 and eight plants from N4-16(N)-18 were selected. Data on plant height, number of effective tiller hill^{-1}, panicle length, and number of filled and unfilled grains panicle^{-1} were recorded from all the selected plants of all three populations. Days to maturity was assessed visually population basis. Finally the data were subjected to proper statistical analyses and are presented in Table 15.

Table 39. Average yield and attributes of three selected M_3 populations derived from N-ion beams irradiated NERICA-4 rice

M_3 population/ check	Days to maturity	Plant height (cm)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1}(no.)	Grain yield (g hill^{-1})
N4-16(N)-19	99	102.0± 0.73	9.50 ± 1.23	28.33± 0.42	95.50 ± 6.93	25.33± 2.26	13.55 ± 1.70
N4-16(N)-18	100	102.4± 0.68	9.60 ± 0.68	29.8± 0.91	103.6± 13.25	26.40± 2.6	17.32 ± 1.97
N4-16(N)-20	100	100.75± 0.56	8.38 ± 0.42	29.25± 0.86	106.5± 5.59	22.13± 2.91	10.54 ± 0.93
BRRI dhan-48(C)*	107	87.6± 0.40	7.2 ± 0.37	19.2± 0.37	72.2± 4.30	12.4± 0.93	15.32± 0.78
Binadhan-19(C) *	99	83.4± 0.50	8.8 ± 0.58	21.2± 0.37	73.0 ± 1.40	14.0± 1.0	12.93± 0.23

*C- check variety

It appears that all the three populations had taller plant height, higher number of number of effective tiller hill^{-1}, longer panicle length and higher number of filled grains panicle^{-1} than both the check varieties (Table 15). The variations among individual hill for all the mentioned traits were also higher in all the three populations except N4-16(N)-20. This population had lower variation among individual hill for number of effective tiller compare to the check variety, Binadhan-19. Two populations N4-16(N)-19 and N4-16(N)-18 had produced higher grain yield hill^{-1} than Binadhan-19 but the later even than BRRI dhan48. Variations among individual hill for grain yield were higher in all the three populations than both the check varieties. Higher variations among individual hill for all the traits indicate the scope of further selection. Therefore, all the 19 selected hills will be screened in the next Aus season.

Oilseed Crops

RAPESEED-MUSTARD

On-station and on-farm yield trials with three F_7 rapeseed lines

Three F_7 rapeseed lines from cross Tori-7×Binasharisha-4 were set into this trial to assess their performance. For on-station trial the experiment was conducted at the experimental farms of BINA Hqs, Mymensingh, BINA sub-stations Magura, Rangpur, Ishurdi and Nalitabari and for on-farm trial the same experiment was conducted at farmers' field of Mymensingh, Magura, Rangpur, Nalitabari, Manikganj and Tangil. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 23 October 2018 at BINA Hqs and within first week of November 2018 at other places. Unit plot size was 20m^2 (5m × 4m) with 25cm line to line spacing. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on days to maturity, plant height, branches plant^{-1}, siliquae plant^{-1}, siliqua length and seeds siliqua^{-1} were taken from 10 randomly selected plants from each plot. Maturity period was counted when 90% siliquae were matured. Seed yield of each plot was recorded after harvest and converted to kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

Results of on-station & on-farm trials presented separately showed significant variations among the lines and check for most of the characters for individual location and combined over locations (Table 1). Results combined over all 11 locations (five of on-station & six on-farm),

on an average, maturity period ranged from 81 days in Tori-7 to 85 days in BARI Sharisa-15.

All the lines and BARI Sharisa-15 required longer maturity period than Tori-7. BARI Sharisa-15 produced the highest plant height (114cm) having non-significant difference with RL-01 (111cm) and Tori-7 produced the shorter plant height (95cm). RL-01 produced higher number of branches plant^{-1} (4.8) where as BARI sharisa-15 produced the lowest number (4.1). BARI Sharisa-15 produced the lowest number of siliquae plant^{-1} (68) followed by Tori-7 (93). All the lines and Tori-7 produced significantly higher number of siliquae plant^{-1} than BARI Sharisa-15. Number of seeds siliqua^{-1} was the highest in BARI Sharisa -15 (19) followed by RL-01 and RL-04 (17) and the lowest number was found in RL-03 and Tori-7. Line RL-03 produced the highest seed yield of 1405 kg ha^{-1} having non-significant difference three other lines and BARI Sharisa-15, and Tori-7 produced the lowest seed yield of 1235 kg ha^{-1}.

Table 40: Performance of F_7 rapeseed lines and check varieties for different characters

Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliqua length (cm)	Seeds siliqua^{-1} (no.)	Seed yield (kg ha^{-1})
On-station trial							
BINA Hqs., Mymensingh							
RL-01	75b	114a	4.1ab	95a	4.2a	17c	1091b
RL-03	80a	114a	4.2ab	89ab	4.1ab	16c	2333a
RL-04	76b	115a	4.4ab	70ab	4.3a	19b	1903ab
Tori-7	72c	94b	4.7a	95a	3.7b	19b	1717ab
BARI Sharisa-15	80a	122a	3.3b	54b	4.1ab	25a	1728ab
BINA sub-station, Ishurdi							
RL-01	83a	98a	4.3ab	59ab	5.6ab	17bc	1867a
RL-03	81ab	95a	4.3ab	48b	6.0ab	15c	1887a
RL-04	79b	89a	3.6b	64ab	6.3a	20bc	1860a
Tori-7	82a	111a	3.0b	71a	5.3b	27b	1057b
BARI Sharisa-15	82ab	98a	5.3a	48b	5.3b	38a	1450ab
BINA sub-station, Rangpur							
RL-01	83c	112abc	4.6a	125ab	5.0a	26a	2040a
RL-03	81d	111bc	3.6ab	127ab	4.9a	21ab	1693a
RL-04	84b	120a	4.3ab	138a	4.7ab	22ab	1737a

Tori-7	80e	104c	3.0b	100b	4.2b	17b	1840a
BARI-15	85a	119ab	3.6ab	97b	5.0a	20ab	1630a
BINA sub-station, Magura							
RL-01	77a	80bc	3.6ab	82ab	3.8bc	18b	1156a
RL-03	87a	79c	3.7ab	83a	4.2a	17b	1300a
RL-04	76a	79c	4.0a	84a	3.8ab	15c	1307a
Tori-7	84a	94a	3.0b	82ab	3.4c	17b	1280a
BARI Sharisa-15	77a	91ab	4.0a	78b	3.0d	22a	1353a
BINA sub-station, Nalitabari							
RL-01	89a	98a	4.8a	91a	3.6a	16a	1483a
RL-03	89a	99a	4.2ab	112a	3.7a	15a	1333a
RL-04	92a	107a	3.0c	98a	3.8a	19a	1492a
Tori-7	92a	99a	3.8abc	79a	3.8a	17a	1492a
BARI Sharisa-15	90a	95a	3.4bc	76a	3.7a	19a	1407a
Combined means of five locations							
RL-01	81c	100c	4.3a	90a	4.4a	19b	1527b
RL-03	84a	100c	4.0a	92a	4.6a	17b	1709a
RL-04	81c	102bc	3.9bc	91a	4.6a	17b	1660a
Tori-7	82bc	100c	3.5c	85b	4.1c	19b	1477c
BARI Sharisa-15	83a	105a	3.9ab	71c	4.2bc	25a	1514bc
Location means							
Hqs.Mymensingh	85bc	112abc	5.1a	71de	4.6ab	18bc	1413b
Sub-station, Ishurdi	85bc	104de	4.3abc	82cde	4.6ab	5e	1249c
Sub-station, Rangpur	77d	113ab	4.6abc	89cd	3.7c	15d	1207c
Sub-station, Magura	84c	106cd	5.1a	71de	5.1a	18bc	1413b
Sub-station, Nalitabari	87b	99e	3.8c	117a	4.7a	21a	1441a
On-farm trial							
Mymensingh							
RL-01	88a	115a	4.3ab	97a	4.8a	17b	1280ab
RL-03	84a	115a	4.4ab	91ab	4.7ab	17b	1260ab
RL-04	88a	116a	4.6ab	72ab	4.9a	15c	1413a
Tori-7	78b	95b	4.9a	96a	4.3b	17b	977b
BARI Sharisa-15	85a	123a	3.5b	55b	4.7ab	22a	1317a
Tangail							
RL-01	75b	123a	4.5a	92a	4.1a	14bc	1183a
RL-03	80a	117ab	4.5a	85a	3.6b	14c	1283a
RL-04	76b	117ab	4.2a	102a	3.9a	15b	1367a
Tori-7	72c	108b	5.1a	106a	3.0c	13d	783b
BARI Sharisa-15	80a	121a	4.6a	60b	4.1a	20a	1417a
Manikganj							
RL-01	80b	109a	4.4a	85a	4.6a	21b	1074c
RL-03	79b	111a	4.3ab	80a	4.1b	18b	1741ab
RL-04	83a	110a	4.2ab	70a	3.9b	19b	1722b
Tori-7	85a	120a	4.4a	66a	3.9b	20b	1852a
BARI Sharisa-15	85a	111.1a	3.2b	32b	2.8c	24a	1852a
Rangpur							
RL-01	87a	112abc	4.6a	125ab	5.0a	26a	2040a
RL-03	84a	111bc	3.6ab	127ab	4.9a	21ab	1693a
RL-04	89a	120a	4.3ab	138a	4.7ab	22ab	1737a
Tori-7	90a	104c	3.0b	100b	4.2b	17b	1840a
BARI-15	84a	119ab	3.6ab	97b	5.0a	20ab	1630a
Magura							
RL-01	88a	115a	4.3ab	97a	5.3ab	26a	1280ab
RL-03	84a	115a	4.4ab	91ab	5.4ab	21ab	1260ab
RL-04	88a	116a	4.6ab	72ab	5.6ab	22ab	1413a
Tori-7	78b	95b	4.9a	96a	5.9a	17b	977b
BARI Sharisa-15	85a	123a	3.5b	55b	4.5b	20ab	1317a
Nalitibari							
RL-01	87a	89ab	5.7a	104a	2.7a	13b	1207a
RL-03	86a	97a	5.5ab	103a	3.2a	13b	1267a
RL-04	89a	89ab	5.0ab	108a	2.9a	16b	1267a

Tori-7	86a	77b	4.6b	120a	3.1a	16b	1200a
BARI-15	85a	96a	4.9ab	57b	3.1a	21a	1327a
Combined means of six locations							
RL-01	84b	111b	4.6a	100a	4.4a	20a	1344bc
RL-03	83b	111b	4.5a	96b	4.3a	17b	1417b
RL-04	86a	111b	4.5a	94bc	4.3a	18b	1487a
Tori-7	82bc	100bc	4.5a	97b	4.1b	17b	1272c
BARI Sharisa-15	84b	116a	3.9c	59c	4.0b	21a	1477ab
Location means							
Mymensingh	77d	113ab	4.1bc	81cde	4.1bc	19ab	1754a
Tangail	83c	117a	3.8c	117a	4.7a	21a	1788a
Manikganj	90a	111bc	3.8c	91c	3.7c	17bcd	1442b
Rangpur	83c	113ab	4.9ab	112ab	3.9c	16cd	1552b
Magura	85bc	106cd	4.0c	65e	4.7a	16cd	1249c
Nalitabari	87b	90f	5.1a	98bc	3.0d	16d	1253c
Combined means over all 11 locations							
RL-01	84a	111ab	4.8a	97a	4.4ab	17b	1337a
RL-03	84a	108b	4.6b	97a	4.3ab	15c	1405a
RL-04	84a	110b	4.bc	97a	4.2b	17b	1390a
Tori-7	81b	95c	4.3bc	93a	3.8c	15c	1235b
BARI-15	85a	114a	4.1c	68b	4.5a	19a	1389a

N. B.: In a column, values with same letter(s) for individual location/combined means do not differ significantly at 5% level by DMRT

On-station and on-farm yield trial with M_7 rapeseed mutants (*B. rapa* var. yellow sarson)

Four M_7 rapeseed mutants along with two check varieties were evaluated through on-station and on-farm trials in different locations. The on-station trial was conducted at BINA Hqs. farm, Mymensingh and BINA sub-station farms at Magura, Rangpur, Ishurdi & Nalitabari. On-farm trial was conducted at farmers' field of Mymensingh, Magura, Rangpur, Nalitabari, Manikganj and Tangil. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 10 November 2018 at BINA Hqs. and from 26 October to 7 November 2018 at rest of the locations. Unit plot size was $20m^2$ ($5m \times 4m$) keeping 25cm line to line spacing and 6-8cm from plant to plant within line. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data were taken on maturity, plant height, branches plant^{-1}, siliquae plant^{-1}, siliqua length and seeds siliqua^{-1} from 10 randomly selected plants of each plot. Maturity period was considered when 90% siliquae were matured. Seed yield of each plot was recorded after harvest and converted to kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means.

Results of on-station & on-farm trials presented separately showed significant variations among the lines and check for most of the characters for individual location and combined over locations (Table 2). Results combined over all 11 locations (five of on-station & six of on-farm), on an average, except for days to maturity, all other characters showed significant differences among the mutants and check for both individual location and combined over locations. The check variety BARI Sharisa-15 produced the highest plant height (106cm) followed by mutant RM-07 and BARI Sharisa-17 (100cm). RM-10 produced the shortest plant height of 98cm which was statistically similar with RM-03 (99cm). Mutant RM-07 produced higher number of siliquae plant^{-1} (85) followed by RM-03 (82).

Table 41: Mean of M_7 rapeseed mutants and check varieties for different characters

Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliquae length	Seeds siliqua^{-1} (no.)	Seed yield (kg ha^{-1})
On-station trial							
BINA Hqs., Mymensingh							
RM-03	81a	106a	3.8b	66a	4.1a	21d	1517a
RM-07	83a	104a	4.0b	74a	4.3a	24c	1643a
RM-10	81a	100a	4.2b	75a	4.2a	26bc	1567a
BARI Sharisa-15	77b	119a	4.6ab	71a	4.3a	28b	1633a
BARI Sharisa-17	82a	82a	5.8a	89a	3.7b	40a	1500a
BINA sub-station, Ishurdi							
RM03	83a	98a	4.3ab	59ab	5.6ab	17bc	1867a
RM07	81ab	95a	4.3ab	48b	6.0ab	15c	1887a
RM10	79b	89a	3.6b	64ab	6.3a	20bc	1860a
BARI Sharisa-15	82a	111a	3.0b	71a	5.3b	27b	1057b
BARI Sharisa-17	82ab	98a	5.3a	48b	5.3b	38a	1450ab
BINA sub-station, Rangpur							
RM03	81a	98a	4.0a	113a	5.0ab	19a	1343ab
RM07	82a	106a	4.6a	112a	4.9ab	18a	1107bc
RM10	82a	98a	4.0a	85a	4.3b	21a	1403a
BARI Sharisa-15	84a	104a	4.0a	94a	6.5a	20a	1153ab
BARI Sharisa-17	82a	97a	4.6a	75a	4.2b	21a	917c
BINA sub-station, Magura							
RM03	82ab	80bc	3.6ab	77a	3.8bc	18b	1156ab
RM07	83a	79c	3.7ab	87a	4.2a	17b	1300a
RM10	84a	79c	4.0a	76a	3.8ab	15c	1307a
BARI Sharisa-15	82ab	94a	3.0b	84a	3.4c	17b	1280a
BARI Sharisa-17	78b	91ab	4.0a	77a	3.0d	22a	1353a
BINA sub-station, Nalitabari							
RM03	80a	92a	4.8a	79ab	3.4a	19a	1492a
RM07	82a	99a	5.0a	94ab	3.3a	18a	1497a
RM10	84a	100a	5.2a	99a	3.2a	19a	1323a
BARI Sharisa-15	84a	100a	5.0a	72b	3.0a	18a	1427a
BARI Sharisa-17	80a	100a	5.0a	85ab	3.2a	20a	1473a
Combined means over five locations							
RM03	81	95	4.1	79	4.4	19	1475
RM07	82	97	4.3	83	4.5	18	1487
RM10	82	93	4.2	80	4.4	20	1492
BARI Sharisa-15	82	106	3.9	78	4.5	22	1310
BARI Sharisa-17	81	94	4.9	75	3.9	28	1339
Location means							
Hqs., Mymensingh	82c	85c	3.6f	80bcd	3.6de	18d	1279cd
Sub-station, Ishurdi	85ab	101b	5.0b	90ab	3.4ef	19cd	1392bc
Sub-station,Rangpur	82bc	116a	4.7bcd	68def	3.9cd	23b	1573a
Sub-station,Magura	87a	100b	5.6a	66ef	5.1b	28a	1573a
Sub-station, Nalitabari	84bc	99b	4.2def	94a	4.8b	20cd	1194d
On-farm trial							
Mymensingh							
RM-03	86a	107a	5.1ab	83a	3.5a	20ab	1363a
RM-07	81a	106a	4.5b	100a	3.8a	22a	1440a

RM-10	86a	90b	4.7ab	76a	3.4a	17b	1350a
BARI Sharisa-15	86a	101ab	5.6a	93a	3.1a	18ab	1395a
BARI Sharisa-17	86a	101ab	5.4ab	97a	3.1a	18ab	1413a
Tangail							
RM-03	82a	112b	4.8b	67ab	4.1a	20b	1550a
RM-07	85a	121a	5.4a	70ab	4.1a	21b	1567a
RM-10	82a	117ab	5.0ab	86a	4.2a	22b	1550a
BARI Sharisa-15	81a	117ab	4.6b	67ab	4.0a	20b	1650a
BARI Sharisa-17	82a	113b	3.7c	51b	3.0b	29a	1550a
Manikganj							
RM-03	80b	109a	4.4a	85a	4.6a	21b	1074c
RM-07	79b	111a	4.3ab	80a	4.1b	18b	1741ab
RM-10	83a	110a	4.2ab	70a	3.9b	19b	1722b
BARI Sharisa-15	85a	120a	4.4a	66a	3.9b	20b	1852a
BARI Sharisa-17	85a	111a	3.2b	32b	2.8c	24a	1852a
Rangpur							
RM-03	84a	91a	3.6a	106ab	4.3b	18a	1388ab
RM-07	84a	106a	4.6a	112a	4.9ab	18a	1107bc
RM-10	83a	98a	4.0a	85ab	4.3b	21a	1403a
BARI Sharisa-15	85a	104a	4.0a	94ab	6.5a	20a	1153abc
BARI Sharisa-17	82a	97a	4.6a	75b	4.2b	21a	917c
Magura							
RM-03	87a	97b	5.4a	77a	5.2a	26b	1500a
RM-07	86a	91b	5.6a	58a	5.1a	29ab	1517a
RM-10	88a	99b	5.8a	61a	5.0a	30a	1617a
BARI Sharisa-15	88a	98b	4.9a	54a	5.1a	28ab	1667a
BARI Sharisa-17	88a	117a	6.2a	78a	5.0a	26b	1567a
Nalitabari							
RM-03	84a	101ab	5.6a	93a	3.1a	18a	1395a
RM-07	88a	101a	5.4a	97a	3.1a	18a	1413a
RM-10	88a	100ab	4.8a	76a	3.2a	19a	1452a
BARI Sharisa-15	88a	98ab	4.4a	86a	3.4a	19a	1575a
BARI Sharisa-17	85a	92b	4.8a	78a	3.4a	18a	1377a
Combined means over six locations							
RM-03	84	103	4.8	85	4.1	21	1378
RM-07	84	106	5.0	86	4.2	21	1464
RM-10	85	102	4.8	76	4.0	21	1516
BARI Sharisa-15	86	106	4.7	77	4.3	21	1549
BARI Sharisa-17	85	105	4.7	69	4.6	23	1446
Location means							
Mymensingh	81c	102b	4.0cde	75cde	4.1c	28a	1572a
Tangail	82bc	101b	4.2de	96a	5.0b	20cd	1185d
Manikganj	82c	98b	5.0bc	86abc	3.2f	19cd	1442b
Rangpur	82bc	112a	4.1ef	67ef	3.9cd	20c	1648a
Magura	81c	98b	4.1ef	58f	5.7a	23b	1624a
Nalitabari	86a	98b	5.0bc	86abc	3.3f	19cd	1442b
Combined means over all 11 locations							
RM-03	83ns	99b	4.5ab	82a	4.2a	20c	1422b
RM-07	83	100ab	4.7a	85a	4.3a	20c	1474ab
RM-10	84	98b	4.5ab	78ab	4.2a	21b	1505a
BARI Sharisa-15	84	106a	4.3b	77ab	4.4a	21b	1440ab
BARI Sharisa-17	83	100ab	4.8a	71b	3.7b	25a	1397b

N. B.: In a column, values with same letter(s) for individual location/combined means do not differ significantly at 5% level.

Siliqua length ranged from 3.7cm in BARI Sharisa-17 to 4.4cm BARI Sharisa-15. Check variety BARI Sharisa-17 produced the lowest number of siliquae, but produced the highest number of seeds siliqua^{-1}. Finally RM-10 produced the highest seed yield (1505 kg ha^{-1}) which is statistically similar with BARI Sharisa-15 (1440 kg ha^{-1}). Another check variety BARI Sharisa-17 produced the lowest seed yield (1397 kg ha^{-1}).

On-station yield trial with three advanced mustard mutants (*B. juncea*)

Three mustard mutants along with check variety Binasarisha-8 were evaluated to assess overall performance of the mutants for earliness, yield attributes and seed yield as compared to the check. The experiment was conducted at BINA sub-station farms at Magura and Rangpur. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 12m^2 (4m × 3m) keeping 25-30cm spacing between two lines and 6-8cm among the plants in a row. Seeds were sown on 5 November 2018. Recommended production packages like application of recommended fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data were taken for plant height, branches plant^{-1}, siliquae plant^{-1}, seeds siliqua^{-1}, maturity period and seed yield. Maturity period was counted when 90% siliquae were matured and most of the plants turned into brownish in colour in each plot. Seed yield of each plot was recorded after harvest and appropriate statistical analyses were performed for comparison of means of each character which are presented in Table 3. Results showed significant variations among the mutants and check for most of the characters in two individual locations and combined over locations. On an average, plant height ranged from 131cm in MM-37 to 137cm in MM-35 and MM-36. MM-35 produced the highest number of siliquae plant^{-1} (113) and Binasarisha-8 produced the lowest number (88). Mutant MM-37 produced the highest seed yield 1697 kg ha^{-1} having non-significant difference with mutant MM-36 (1671 kg ha^{-1}). Mutant MM-35 and Binasarisha-8 produced statistically similar seed yield (1450 and 1504 kg ha^{-1}, respectively). Between two locations, higher seed yield (1771 kg ha^{-1}) was obtained from Magura.

Table 42. Mean performance of rapeseed mutants and check for different characters

Mutants/ variety	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliqua length (cm)	Seeds siliqua^{-1} (no.)	Seed yield (kg ha^{-1})
BINA sub-station, Rangpur							
MM-35	97b	123a	2.6a	108a	3.6b	12b	1233c
MM-36	96b	119a	2.6a	96a	3.6b	13b	1620a
MM-37	104a	122a	2.8a	108a	3.6b	13b	1310bc
Binasarisha-8	103a	110b	2.4a	79a	6.6a	22a	1397b
BINA sub-station, Magura							
MM-35	97b	151a	4.5a	118a	4.3a	11a	1667b
MM-36	96b	156a	3.5bc	105a	4.4a	12a	1722ab
MM-37	104a	141b	4.1ab	98a	4.2a	12a	2083a
Binasarisha-8	103a	157a	3.2c	96a	4.3a	12a	1611b
Combined means over two locations							

MM-35	97b	137a	3.5a	113a	3.9c	12b	1450b
MM-36	96b	137a	3.1a	101b	4.4b	12b	1671a
MM-37	104a	131b	3.5a	103b	3.9c	12b	1697a
Binasarisha-8	103a	133b	2.8b	88c	5.4a	17a	1504b
Location means							
Rangpur	100a	118b	2.6b	98b	4.3a	15a	1390b
Magura	100a	151a	3.8a	104a	4.3a	12b	1771a

In a column, values with same letter(s) for individual location/combined means do not differ significantly at 5% level

Preliminary yield trial with M_6 rapeseed mutant (*B. rapa* var. yellow sarson)

Six rapeseed mutants along with check variety BARI Sharisa-17 were evaluated to assess overall performance of the mutants for earliness, yield attributes and seed yield as compared to the check. The trial was conducted at BINA Hqs. farm, Mymensingh. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 12 November 2018. Unit plot size was $20m^2$ (5m × 4m) with 25cm line to line spacing and 6-8cm from plant to plant within line. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on days to maturity, plant height, branches plant^{-1}, siliquae plant^{-1}, siliqua length and seeds siliqua^{-1} were taken from 10 randomly selected plants from each plot. Maturity period was counted when 90% siliquae were matured. Seed yield of each plot was recorded after harvest and converted to kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

Table 43. Mean performance of mutants and check for different character

Mutants/check	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliqua length	Seeds siliqua^{-1} (no.)	Seed yield (kg ha^{-1})
RM-03	88b	94d	3.5b	63b	4.1c	22d	1200bc
RM-11	96a	120ab	5.3ab	81a	4.0bc	24cd	1400abc
RM-13	86b	123a	4.0ab	59b	4.3b	27bcd	1560a
RM-15	86b	91d	4.0ab	49c	5.5a	22d	1100c
RM-18	87b	114abc	4.6ab	63b	3.9bc	28bc	1570a
RM-20	84b	108bc	4.3ab	41d	3.4d	35a	1430ab
BARI Sharisa-17	97a	102cd	5.5a	66b	3.0e	32ab	1400ab

N. B.: In a column, values with same letter(s) do not differ significantly at 5% level.

Results showed significant variations among the mutants and check for all the characters (Table 4). On an average, maturity period ranged from 84 days in mutant RM-20 to 97 days in check variety BARI Sharisa-17. Mutant RM-13 produced the tallest plant (123cm) followed by RM-11 (120cm). BARI Sharisa-17 produced the highest number of branches (5.5) and showed non-significant differences with all the mutants except RM-03. Mutant RM-11 produced the highest number of siliquae plant^{-1} (81) and RM-20 produced the lowest number (41). The longest siliqua was found in RM-15 (5.5cm) and the shortest one was found in BARI Sarisha-17 (3.0cm). Mutant RM-18 produced the highest seed yield (1570 kg ha^{-1}) having non-significant difference with three other mutants and BARI Sharisa-17, and RM-15 produced the lowest (1100 kg ha^{-1}).

Growing of M_5 population

A large number of M_5 variants developed from Binasarisha-9 and Binasarisha-10 were grown in plant progeny rows for selecting desirable mutant at BINA Head quarter farm, Mymensingh. From them a total of 7 lines have been selected primarily for future selection in M_6 generations.

Growing of M_4 population

A large number of M_5 variants developed from BARI Sharisha-15 were grown for selecting desirable mutant at BINA Head Quarter farm, Mymensingh. From them a total of 5 lines have been selected primarily for future selection in M_5 generations.

Growing of F_5 population

F_5 population developed from the cross between BARI Sarisha- 14 X Tori-7 and BARI Sarisha-15 X Tori-7 were grown at BINA Headquarters farm, Mymensingh. From them, 18 lines were selected primarily for further selection in F_6 generation.

Growing of F_4 population

F_4 population developed from the cross between BARI Sarisha- 14 X Binasarisha-4 and MRH X Tori-7 were grown at BINA Head quarters farm, Mymensingh. From them 15 lines were selected primarily for further selection in F_3 generation.

Crossing of Binasarisha-4, Binasarisha-9 and Binasarisha-10 with Tori-7, BARI Sarisha-14, BARI Sarisha-15 and BARI Sarisha-17

Binasarisha-4, Binasarisha-9 and Binasarisha-10 were crossed with Tori-7, BARI sarisha-14 BARI sarisha-15 and BARI sarisha-17 and F_1 seeds were harvested to grow F_1 generations.

GROUNDNUT

Preliminary yield trial with M_5 population of groundnut

An experiment was conducted at BINA Headquarters farm, Mymensingh with 15 M_5 mutant lines of groundnut to evaluate and select for high yielding mutants with bold pods and kernels, and higher shelling percentage. Binachinabadam-4 was included in this experiment as a check variety. The experiment followed RCB design with three replicates. A unit plot size was 2.0m × 0.6m. Seeds were sown on 09 January 2019 at 15cm distances within rows of 30cm apart. Recommended fertilizer dose, cultural and intercultural operations were also followed. Data were recorded on plant height, pod number, pod yield plant^{-1}, 100-pod and kernel weight from randomly selected 10 competitive plants at maturity. Pod yield was also recorded from an area of 1.0m^2 which later converted to tha^{-1}. Shelling percentage was calculated using the following formula-

$$\text{Shelling percentage} = \frac{\text{Kernel weight of 100 g pod}}{\text{Unshelled weight of 100 g pod}} \times 100$$

Finally, the data were analyzed following proper statistical design and are presented in Table 1.

Table 44.Yield and yield contributing characters of mutants and the parent variety

Mutants/ Check	Plant height (cm)	Pod plant^{-1} (no.)	Pod weight plant^{-1} (g)	100 pod weight (g)	100 kernel weight (g)	Pod yield (tha^{-1})	Shelling (%)
B6/282/11	43.42	14.10	11.63	79.83	35.79	2.92	62.46
B6/282/50	58.40	18.80	13.20	63.64	29.13	2.51	75.97
B6/282/53	36.08	15.00	14.20	92.29	35.95	2.81	69.87
B6/282/56	62.23	15.70	13.92	67.69	29.70	2.50	73.53
B6/282/62	60.92	16.13	12.13	72.83	32.35	1.83	74.35
B6/282/63	60.41	18.47	14.33	76.73	35.05	3.00	81.63
B6/282/64	74.39	16.66	12.02	70.21	29.83	3.20	75.65
B6/282/65	57.34	13.71	12.24	74.06	33.32	2.67	73.33
B6/282/66	60.61	16.91	11.92	69.36	29.37	2.57	71.28
B6/282/67	54.35	23.10	12.98	56.36	27.79	2.22	68.15
B6/282/68	55.30	19.72	12.14	63.45	28.46	2.82	75.30
B6/282/70	64.56	20.18	12.76	63.73	29.37	2.93	73.64
B6/282/77	60.38	16.32	13.78	75.32	29.05	3.00	64.02
B6/282/80	51.38	15.91	13.95	86.83	36.82	3.17	69.74
BCB-4 (C)	50.57	21.65	15.04	71.03	30.00	3.02	72.77
LSD(0.05)	0.72	0.20	0.30	0.21	0.28	0.12	1.08

It appears that two mutants B6/282/53 and B6/282/11 had significantly shorter plant height than the check variety Binachinabadam-4 (Table 1). One mutant B6/282/67 had significantly higher pod number than the check variety, although none of the mutants had higher pod yield plant^{-1}. Seven mutants: B6/282/53, B6/282/80, B6/282/11, B6/282/63, B6/282/77, B6/282/65 and B6/282/62 had significantly bigger pod sizes, expressed here as 100-pod and also kernel sizes (100-kernel weight) than the check variety except mutant B6/282/77. Mutant B6/282/77 had smaller kernel than the check variety (Table 1). Finally the two mutants B6/282/63 and B6/282/64 having the higher pod yield ha^{-1} along with higher shelling percentage and higher or equal kernel sizes than the most popular groundnut variety will be put into Advance Yield Trial in the next Rabi season.

Crossing groundnut varieties having large seeds with thin shell varieties

With a view to develop 3-4 large seeded groundnut variety(s) with higher shelling percentage, a crossing program was undertaken in 2018. Four groundnut varieties, of which one parent had two large seeds, another large pod with 3-4 seeds and the other two with thin shell and two seeds were crossed in all possible combinations following full diallel design. The experiment was carried out at pot yard of BINA Hqs at Mymensingh in earthen pots of 22 cm size, filled with mixture of sandy loam soil and farm yard manure in 1: 1 ratio. Five seeds were sown on 02 August 2018 and thinned to three plants after 10 to15 days after sowing (DAS). Recommended fertilizer dose, cultural and intercultural operations were also followed. All the fertilizers were applied before seed sowing. Required cultural and intercultural operations were followed. Crossing was done following the technique of Azad (2008). Early formed buds close to the soil surface were used for hybridization so that the pegs could easily penetrate into the soil. The well developed buds close to the soil of the recipient parents were emasculated during 4.30- 6.30 PM. A small incision was made on the depressed side of the bud, at two-thirds of its length. Then pressing the top cone-like structure consisting of calyx and standard petal was detached, and afterwards wings, keel and anthers were removed. The emasculated buds were covered with green colored straw tube sealed on one side to avoid fertilization with undesirable foreign pollen. Before pollination, flowers from the entire male parents were collected early in the morning by 6.00 -7.00 AM to avoid setting and to ensure steady supply of male flowers. During 6.00-8.30 AM, pollination was performed by collecting pollen from male parents. The standards and wings (petals) were removed and then the tubular keel petal was pressed with forceps. The extruded pollen was collected on the forceps and applied to the stigmatic end of the female flower. Finally, the stigma was further covered with red colored straw tube. After completion of crossing, the newly formed flowers were removed daily from the recipient parents. At maturity, the crossed pods were harvested carefully. Data on percent success of the crosses were recorded and presented in Table 2.

Table 45. Success of crosses in a 4×4 full diallel design of four groundnut varieties.

Female parent	Male parent	Emasculated and pollinated flowers (no.)	Success of cross (%)
Binachinabadam-4	Dacca-1	79	11
Dacca-1	Binachinabadam-4	73	10
Binachinabadam-4	GC-1-24-1-1-1	68	8
GC-1-24-1-1-1	Binachinabadam-4	66	9
Binachinabadam-4	Chinabadam	71	8
Chinabadam	Binachinabadam-4	67	11
Dacca-1	GC-1-24-1-1-1	73	9
GC-1-24-1-1-1	Dacca-1	82	10
Dacca-1	Chinabadam	79	11

Chinabadam	Dacca-1	72	12
GC-1-24-1-1-1	Chinabadam	58	7
Chinabadam	GC-1-24-1-1-1	69	11

The success of cross ranged from 7 to 12 % (Table 2) with Dacca-1×Chinabadam being the lowest and Chinabadam × GC-1-24-1-1-1the highest. The obtained cross seeds will be sown in the next Rabi season to confirm F_1.

Confirmation of F_1 derived from crossing between large seeded groundnuts varieties with thin shell varieties

An experiment was conducted at BINA Headquarters farm, Mymensingh with 12 F_1 and reciprocal crosses derived from crossing among four parents in all possible combinations. Of the parents, one parent had two large seeds, another large pod with 3-4 seeds and the other two with thin shell and two seeds. The parents were also included in the experiment. The experiment followed RCB design with three replicates. A unit plot comprised a row of six plants. Seeds were sown on 2 August 2018 at 15cm distances within rows of 30cm apart. Recommended fertilizer dose, cultural and intercultural operations were also followed. Data were recorded on plant height, pod number, pod yield plant^{-1}, 100-pod and kernel weight from all the plants at maturity. Shelling percentage was calculated using the following formula-

Shelling percentage = $\frac{\text{Kernel weight of 100 g pod}}{\text{Unshelled weight of 100 g pod}} \times 100$

Table 46. Pod yield and attributes of 12 F_1 and reciprocal crosses, derived from crossing four parents of bold groundnut in all possible combinations, and mid parents

Genotype/ Cross	Plant height (cm)	Total pod plant^{-1} (no)	Mature pod plant^{-1} (no.)	Pod yield plant^{-1} (g)	100 pod weight (g)	100 kernel weight (g)	Shelling %
G1×G2	46.57	17.00	12.13	8.73	53.47	29.00	70.65
G2×G1	42.60	25.33	14.33	8.40	47.70	23.47	75.46
G1	40.17	18.33	11.63	8.10	54.77	25.13	75.27
G2	49.30	15.67	13.20	7.47	60.77	26.10	72.07
Mid parent(MP)	44.74	17.00	12.42	7.78	57.77	25.62	73.67
G1×G3	41.80	18.00	12.02	11.03	70.07	25.07	74.33
G3×G1	48.47	24.00	12.24	13.47	97.03	34.30	66.33
G1	40.17	18.33	11.63	8.10	54.77	25.13	75.27
G3	49.57	19.00	14.20	11.40	83.23	32.77	64.76
Mid parent(MP)	44.87	18.67	12.92	9.75	69.00	28.95	70.02
G1×G4	47.53	21.00	11.92	16.90	101.17	34.03	60.53
G4×G1	34.40	12.00	12.98	7.17	84.90	41.97	66.00
G1	40.17	18.33	11.63	8.10	54.77	25.13	75.27
G4	36.37	15.00	13.92	8.85	77.53	70.33	72.02
Mid parent(MP)	38.27	16.67	12.78	8.48	66.15	47.73	73.65
G2×G3	42.53	22.00	12.14	11.93	73.33	27.30	70.40

G3×G2	45.83	19.33	12.76	8.30	74.87	31.83	65.47
G2	49.30	15.67	13.20	7.47	60.77	26.10	72.07
G3	49.57	19.00	14.20	11.40	83.23	32.77	64.76
Mid parent(MP)	49.44	17.34	13.70	9.43	72.00	29.44	68.42
G2×G4	40.60	7.67	13.78	4.03	83.13	36.87	61.80
G4×G2	43.17	14.67	13.95	11.30	72.03	31.90	67.30
G2	49.30	15.67	13.20	7.47	60.77	26.10	72.07
G4	36.37	15.00	13.92	8.85	77.53	70.33	72.02
Mid parent(MP)	42.84	15.34	15.92	8.16	69.15	48.22	72.07
G3×G4	40.67	12.67	15.04	9.83	106.03	47.23	77.43
G4×G3	33.43	11.00	12.38	9.58	86.17	47.20	69.31
G3	49.57	19.00	14.20	11.40	83.23	32.77	64.76
G4	36.37	15.00	13.92	8.85	77.53	70.33	72.02
Mid parent(MP)	42.97	17.00	14.06	10.13	80.38	51.55	68.42

The cross G_1×$G_{2,}$ and the reciprocal cross G_4× G_2 and G_3×G_1 showed heterosis for plant height (Table 3). But the cross G_1×G_4 showed heterobeltiosis. For pod plant^{-1}, the crosses G_1 ×G_4, G_2 × G_3 and the reciprocal crossesG_2× G_1 and G_3× G_1 showed heterobeltiosis. Mature pod plant^{-1}, showed heterobeltiosis for the cross G_3× G_1 and the reciprocal cross G_4 × G_1 showed heterosis. For 100-pod weight, four crosses showed hetrobeltiosis and one cross heterosis (Table 2). All the reciprocal crosses showed heterobeltiosis except G_2×G_1, G_2×G_1 did not show any heterosis. For pod yield plant^{-1} the crosses G_1×G_4 and G_2×G and the reciprocal cross G_4×G_2 showed heterosis on the other hand the crosses G_1×G_2 and G_1×G_3 and reciprocal crosses G_2×G_1 and G_3×G_1 showed heterobeltiosis. For 100-kernel weight, the cross G_1×G_2 and G_3×G_1 showed heterobeltiosis and one reciprocal cross G_3×G_2 showed heterosis. Finally, shelling percentage showed hetrobeltiosis for G_3×G_4 and heterosis for G_1×G_3 and G_2×G_3 crosses. The results from most of the crosses/reciproprocal crosses had heterosis/heterobeltiosis for at least one trait which confirms them as F_1s. Therefore, these F_1s will be evaluated and selected in F_2 generation based on large seed and higher shelling percentage in the coming Rabi season.

SESAME

Regional yield trial with promising M_6 sesame mutants

Three promising mutants along with two check varieties (Binatil-2 and BARI Til-4) were evaluated through this trial. The experiment was conducted at the experimental field of BINA sub-station farms at Magura and Faridpur during March to June 2019. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20m^2 (4m × 5m) keeping 25cm spacing between two rows and 6-8cm among the plants in rows. Seeds were sown within second week of March 2019. Recommended production packages like application of recommended doses of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data were taken on plant height, number of branches plant^{-1}, number of capsules plant^{-1} and number seeds capsule^{-1} from 10 randomly selected plants from each plot. Maturity period was counted when 80% capsules were matured and most of the plants turned into straw or yellowish color in each plot. Seed yield of each plot was recorded and converted in kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

Table 47. Mean performance of sesame lines along with check varieties for different quantitative characters

Mutants/check	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Capsules plant^{-1} (no.)	Capsule length	Seeds capsule^{-1} (no.)	Seed yield (kg ha^{-1})
On-station, Magura							
SM-01	88	94b	0	82d	2.6a	53ab	920c
SM-02	84	106a	0	92a	2.4a	56a	920c
SM-06	86	97ab	0	90b	2.4a	51ab	1020b
Binatil-2	82	97ab	3a	87c	2.5a	50b	1085a
BARI Til-4	85	103a	2b	88c	1.6b	54ab	920c
Farmers' field, Faridpur							
SM-01	85	143	0	112a	2.5	75ab	1215b
SM-02	87	135	0	98b	2.4	68cd	1265a
SM-06	89	135	0	106c	2.4	71bc	1215b
Binatil-2	83	143	2.0b	89d	2.2	65d	1215b
BARI Til-4	85	134	2.6a	109b	2.5	79a	1065c
Combined means over two locations							
SM-01	86	119a	0	97a	2.5	64b	1068b
SM-02	85	121a	0	95a	2.4	62c	1085ab
SM-06	87	116b	0	98a	2.4	61c	1118ab
Binatil-2	82	120a	2.5a	88b	2.4	57d	1150a
BARI Til-4	85	118ab	2.3a	98a	2.1	67a	993c
Location Means							
Magura	85	99b	1a	99b	2.1 ns	53b	973b
Faridpur	85	138a	0.9a	103a	2.4	72a	1192a

N.B.: In a column, values with same letter(s) for individual location/combined means do not differ significantly at 5% level

The results showed significant variations for most of the characters among three mutants and two check varieties (Table 1). On an average, days to maturity showed non-significant difference and ranged from 82 in Binatil-2 to 87 days in SM-06. Mutant SM-02 produced the tallest plant (121cm) having non-significant difference with others except SM-06. All three mutants were branchless or uniculm type.The lowest number of capsules were produced in Binatil-2 (88) and three mutants & BARI Til-4 produced statistically number (95 to 98). Binatil-2 produced the highest yield of 1150 kg ha^{-1} but having non-significant difference with three mutants and BARI Til-4 where produced the lowest seed yield of 993 kg ha^{-1}.

Growing of M_3 population

A large number of M_3 populations from China Black, China White and Pahari Till were grown in plant progeny rows for selecting desirable mutants at BINA Hqs. farm, Mymensingh. From them primarily a total of 5 mutant variants have been selected for further selection in subsequent generations.

Maintenance of germplasm

Twenty five germplasm lines (local and exotic collections) along with five stable mutants were grown at BINA Hqs. farm, Mymensingh. After harvest, seeds of all these germplasm were collected and preserved as breeding materials for future research programme.

SOYBEAN

On-station and on-farm yield trials with advance soybean mutants during Rabi 2018

Three promising mutants (SB-02, SB-05 and SB-07) along with check varietiy BARI Soybean-5 were evaluated through this trial. The experiment was conducted at the experimental field of BINA Hqs. farm, Mymensingh and BINA sub-station farms at Magura and Rangpur and farmers' field at Noakhali and Chandpur during January to April 2018. The experiment was laid out in randomized complete block design with three replications. Sowing was done within first week of January 2019. Spacing between rows was 30cm and 7-10cm between plants in a row. Unit plot size was $12m^2$ ($4m \times 3m$). Recommended managements were followed to ensure proper growth and development of plants. Data on various characters such as plant height, number of branches plant^{-1}, pods plant^{-1} and seeds pod^{-1} were taken from 10 randomly selected plants of each plot. Maturity period was counted when the plant and pods of each plot turned into yellowish brown color and almost all the leaves shed. Seed yield of each plot was recorded and converted to kg ha^{-1}. Data recorded from the experiment were analyzed following appropriate statistical design.

Results of on-station & on-farm trials presented separately showed significant variations among the mutants and check for most of the characters for individual location and combined over locations (Table 1). Results combined over all four locations (two on-station & two on-farm), on an average, maturity period showed non-significant differences. Plant height and branches plant^{-1} ranged from 82 to 76cm and 2.2 to 1.8, respectively. Mutant SB-07 produced the highest plant height (82cm) followed by mutant SB-02 (81cm). Check variety BARI Soybean-5 produced the shortest plant height (76cm). Mutant SB-02 produced 61 pods plant^{-1} (61.0) and check variety BARI Soybean-5 produced 56 pods plant^{-1}. Mutant SB-02 produced the highest seed yield (1927 kg ha^{-1}) followed by SB-05 (1817 kg ha^{-1}) and BARI Soybean-05 produced the lowest seed yield (1587 kg ha^{-1}).

Table 48. Mean performance of soybean mutants along with check varieties for different quantitative characters

Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield (kg ha^{-1})
On-station trial							
BINA Hqs., Mymensingh							
SB-02	113a	82a	2.3ab	57a	2.2b	13b	1950a
SB-05	112b	77b	2.4a	55b	2.3a	14a	1858a
SB-07	109c	82a	2.0b	51bc	2.1c	12c	1898b
BARI Soybean-5	112b	76bc	2.3ab	51c	2.2ab	14a	1689b
BINA sub-station, Magura							
SB-02	112b	80a	2.5a	77a	2.5a	14a	1920a
SB-05	116ab	76b	2.3b	74ab	2.0b	14a	1796b
SB-07	117a	80a	2.1c	70b	2.0c	13ab	1323c
BARI Soybean-5	116ab	77ab	2.1c	72ab	2.5bc	14a	1382bc
Combined means of two locations							
SB-02	113	81	2.4	67	2.4	14	1935
SB-05	114	77	2.4	65	2.2	14	1827
SB-07	113	81	2.1	61	2.1	13	16101
BARI Soybean-5	114	77	2.2	62	2.4	14	1536
On-farm trial							
Chandpur							
SB-02	119b	80b	2.1a	57a	2.0a	14a	1950a
SB-05	122a	81ab	1.8b	52b	1.9b	12b	1820b
SB-07	118bc	83a	1.6c	49c	1.3c	13ab	1725c
BARI Soybean-5	116c	77c	1.7bc	52b	1.7bc	14a	1623bc
Noakhali							
SB-02	118a	81ab	1.9a	53a	2.0a	14a	1886a
SB-05	117ab	79b	1.7ab	48ab	1.5b	14a	1793b
SB-07	116b	83a	1.6b	45b	1.3c	12b	1657bc
BARI Soybean-5	117ab	72c	1.6ab	47ab	1.9bc	12b	1655c
Combined means of two locations							
SB-02	119	81	2.0	55	2.0	14	1918
SB-05	120	80	1.8	50	1.7	13	1807
SB-07	117	83	1.6	47	1.3	13	1691
BARI Soybean-5	117	75	1.7	50	1.8	13	1639
Combined means over four locations (On-station and on-farm together)							
SB-02	116 NS	81b	2.2a	61a	2.1a	14a	1927a
SB-05	117 NS	78c	2.0a	57ab	1.9a	13a	1817b
SB-07	115 NS	82a	1.8b	54c	1.6b	12b	1651c
BARI Soybean-5	115 NS	76d	1.9b	56b	2.0a	14a	1587d
Location means (On-station and On-farm together)							
Mymensingh	112d	79ab	2.2a	54b	2.2a	13b	1845a
Magura	115c	78b	2.2a	74a	2.2a	14a	1605c
Chandpur	119a	80a	1.8b	53b	1.7b	13b	1780b
Noakhali	117b	79ab	1.7b	48c	1.6b	13b	1746b

N. B.: In a column, values with same letter do not differ significantly at 5% level.

Field evaluation of selected salt tolerant soybean mutants during Rabi 2019

Five promising soybean mutant (SGB-01, SGB-02, SGB-03, SGB-04 and SGB-05) with two check(Lokon and GC-840) were evaluated through this trial. The experiment was conducted at farmers' field of Noakhali. The experiment was laid out in randomized complete block design with three replications. Sowing was done on 5 January 2019. Spacing between rows was 30cm and 7-10cm between plants in a row. Unit plot size was 12m^2 (4m × 3m). Recommended managements were followed to ensure proper growth and development of plants. Data on various characters such as plant height, number of branches plant^{-1}, pods plant^{-1} and seeds pod^{-1} were taken from 10 randomly selected plants of each plot. Maturity period was counted when the plant and pods of each plot turned into yellowish brown color and almost all the leaves shed. Seed yield of each plot was recorded and converted to kg ha^{-1}. Data recorded from the experiment were analyzed following appropriate statistical design.

Table 49. Mean performance of soybean mutants along with check varieties for different quantitative characters during Rabi 2018

Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Pod length (cm)	Seed yield (kg ha^{-1})
SGB-01	96b	50a	3.0ab	50ab	3.0a	4ab	1920c
SGB-02	95b	28c	2.6b	65a	2.8a	3b	1990b
SGB-03	95b	32bc	2.7b	41b	2.7a	4ab	1810d
SGB-04	95b	28c	3.3a	47ab	2.3a	3b	1830d
SGB-05	96b	38abc	4.0a	56ab	3.0a	4ab	1840d
GC-480	99a	46ab	3.0ab	45ab	2.7a	5a	1970b
Lokon	99a	38abc	3.0ab	66a	3.0a	4ab	2450a

On an average, maturity period ranged from 95 to 99 days. All the mutants matured earlier than the check. Lokon and GC-480 required the longest maturity period of 99 days and the mutants required 95 to 96 days. Plant height and branches plant^{-1} ranged from 28cm to 50cm and 2.6 to 4.0, respectively. Mutant SGB-01 produced the highest plant height of 50cm followed by GC-480 (46cm) and mutant SGB-02 produced the shortest plant (28cm). Lokon produced the highest number of pods plant^{-1} (66.0) which was statistically similar with the mutant SGB-02 (65). Longer pod was found in GC-480 (4.5cm) followed by SGB-014 and Lokon (4cm). Pod length of SGB-03, SGB-04 and SGB-05 is similar statistically and among them SGB-02 produced the smaller pod (3cm). Lokon produced the highest seed yield of 2450 kg ha^{-1} followed by SGB-02 (1990 kg ha^{-1}) and GC-480 (1970 kg ha^{-1}).

Growing of M_4 and M_5 populations

A large number of M_4 and M_5 population from BARI Soybean-5, Binasoybean-2, Lokon and Sohage were grown in plant progeny rows for selecting desirable mutants at BINA Hqs. farm, Mymensingh. From them primarily a total of 19 mutant variants have been selected for further selection in subsequent generations.

Growing of M_2 population

To create genetic variability, seeds of two popular soybean varieties, Lokon and Taiwan-02 were irradiated with 250, 300, 350 and 400Gy of gamma rays. M_2 seeds from five pods of each plant were collected to grow M_2 population.

Maintenance of germplasm

Fifty germplasm lines (mutants, local and exotic collections) along with three stable mutants were grown at BINA Hqs. farm, Mymensingh. After harvest, seeds of all these germplasm were collected and preserved as breeding materials for future research programme.

PULSES

MUNGBEAN

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

On-farm trials were carried out with two mutants along with two check varieties (Binamoog-8 and BARI Mung-6) at BINA sub-station Ishurdi, Magura, farmer's field Ishurdi, Magura and Natore during Kharif-1 season of 2019. Seeds were sown in RCB design with three replications. Unit plot size was 5 m × 4 m. Row to row and plant to plant distances were 40 and 10-15 cm, respectively. Due to heavy rain fall Ishurdi and Natore farmer's field were damaged. Data on days to maturity, plant height, pods plant^{-1}, pod length, seeds pod^{-1} and seed yield plot^{-1} were recorded from five randomly selected plants of each plot. Plot seed yield was converted to kg ha^{-1}. Mean values are presented in Table 34.

It is observed from Table 34 that the check variety MBM-427-87-3 had shorter plant height than other mutant and check variety (BARI Mung-6) at all the locations. From mean over locations, both the mutants matured earlier than check varieties. The highest number of pods plant^{-1} (38) and pod length (9. 3cm) was found in MBM-427-87-3. In respect of seed yield, MBM-427-87-3 produced the highest seed yield of 1822 kg ha^{-1}followed by MBM-656-51-2 (1755 kg ha^{-1}). Application will be made to release this mutant (MBM-427-87-3) as a variety.

Table 50: Mean performance of mutants along with the check varieties grown at Ishurdi Magura and farmer's field Magura during 2019

Mutants/varieties	Days to maturity	Plant height (cm)	Pods plant^{-1} (no)	Pods length (cm)	Seeds pod^{-1} (no)	Seed yield (kg ha^{-1})
Ishurdi (Sub-station)						
MBM-656-51-2	66	47b	37	8.2	11	1763b
MBM-427-87-3	63	45b	39	9.2	12	1836a
BARI Mung-6	71	51a	31	8.1	11	1671c
Magura (Sub-station)						
MBM-656-51-2	65	43ab	33	8.3	12	1813a
MBM-427-87-3	63	39b	37	9.5	12	1835a
BARI Mung-6	69	49a	33	8.5	10	1679b
Magura(Farmer's field)						

MBM-656-51-2	64	49a	36	8.2	11	1689b
MBM-427-87-3	65	42ab	38	9.3	12	1795a
BARI Mung-6	70	48a	30	8.2	11	1643b
Mean over locations						
MBM-656-51-2	65	46a	35	8.2	11	1755b
MBM-427-87-3	64	42ab	38	9.3	12	1822a
BARI Mung-6	70	49a	31	8.3	11	1664c

Regional yield trial of some promising mutants of mungbean

Two advanced mungbean mutant lines along with two check varieties were put into regional yield trial at BINA sub-station Magura, Ishurdi and farmer's field Ishurdi, Magura and Natore during Kharif-1 season of 2019. The design of experiment was RCB with three replications. Unit plot size was 4 m × 5 m. Row to row and plant to plant distance were 40 cm and 10-15 cm, respectively. Recommended cultural practices including fertilizer doses were applied as and when necessary. Due to heavy rain fall Ishurdi and Natore farmer's field were damaged. Data on various characters, such as plant height, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, days to maturity and seed yield plot^{-1} were taken from five randomly selected plants of each plot. Plot seed yield was converted to kg ha^{-1}. Mean values are presented in Table 35.

From the result mean over locations, it is observed that all the lines matured almost same days. The highest plant height was found in MBM07-y-2 (53.5 cm) followed by check variety BARI Mung-6. In case of pods/plant , the mutant MBM-07(g)-2 had the highest number of pods/plant and pod length. The number of seeds pod^{-1} was almost similar for all the mutants and check varieties. Mutant MBM-07(g)-2 produced (1751 t/ha) followed by MBM07-y-2. One promising mutant MBM-07(g)-2 will be further evaluated in the next growing season.

Table 51: Mean performance of two mutants along with two check varieties grown at BINA sub-station Ishurdi, Magura and farmer's field Magura during 2018

Name of variety	Days to maturity	Plant height (cm)	pods plant^{-1} (no.)	Pod length (cm)	seeds pod^{-1} (no.)	Seed yield (kg ha^{-1})
Magura						
MBM-07(g)-2	67	45.7b	41a	8.41	12	1748a
MBM 07-y-2	70	55.3a	37a	7.52	10	1690ab
BARI Mung-6 (check)	70	51.3ab	34ab	8.12	11	1649b
Ishurdi						
MBM-07(g)-2	68	51.3	37a	8.15	11	1763a
MBM07-y-2	69	53.3	32ab	7.57	10	1696ab
BARI Mung-6 (check)	69	55.7	30ab	8.04	10	1633b
Magura (Farmer's field)						
MBM-07(g)-2	68	48.1	39a	8.55	12	1743a
MBM 07-y-2	69	52.3	30b	7.68	10	1705a
BARI Mung-6	70	51.6	29b	8.24	11	1648b

(check)						
Mean over locations						
MBM-07(g)-2	68	48.3	39a	8.37	12	1751a
MBM07-y-2	69	53.5	33ab	7.59	10	1697ab
BARI Mung-6 (check)	70	52.8	31ab	8.13	10	1643b

Growing of M_3 generation of mungbean lines

Seeds of 4 AVRDC mungbean germplasm were irradiated with Cobalt^{60} gamma rays. Irradiation doses were 300, 400 and 500 Gy. Dose wise M_2 Bulk seeds were grown at BINA HQ farm Mymensingh. Thirty eight plants were selected based on earliness, higher yield and disease tolerance.

Growing of M_1 generation of mungbean lines for Kharif-1

Seeds of 2 AVRDC mungbean germplasm were irradiated with Cobalt^{60} gamma rays. Irradiation doses were 300, 400 and 500 Gy. Two hundred and fifty seeds per dose were grown at BINA HQs during Kharif-1 season 2018.

Germination and survival decreased with the increase of the irradiation doses. The plant height also decreased gradually with increased doses of gamma rays. Some of the early maturing plants were selected and finally, the M_1 seeds from the survived plants were bulked dose wise and kept for growing in the M_2 generation in the next growing season.

LENTIL

On-station yield trial with three promising lentil mutants along with two check varieties

On-stations trials were conducted with three mutant lines along with two check varieties at BINA sub-stations at Ishurdi, Magura and Chapainowabganj during 2018-19. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (5 m × 4 m) with 30 cm line to line distance. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on days to maturity, plant height, number of primary branches plant^{-1} and pods plant^{-1} were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kg ha^{-1}. Statistical analysis of different characters of the mutants and the check are presented in the Table 16.

Results revealed that significant variations were observed among the mutants and the check variety for pods per plant and seed yield at the three locations. On an average, maturity period varied from 98 in LM-138-3 days to 112 days in BARI Masur-6. The line LM-206-5 produced the highest number of pods plant^{-1} as well as the highest seed yield 1925 kg ha^{-1} followed by LM-118-9 with 1830 kg ha^{-1} at Magura. Mutant LM-206-5 produced the highest seed yield followed by LM-118-9 at Chapainowabgonj and Ishurdi. Evaluation will be continued in the next season.

Table 52. On-station trial with three lentil mutants/line along with two check varieties, Binamasur-6 and BARI Masur-5 at three locations, Magura, Ishurdi and Chapainowabgonj during 2018-19

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches/ plant (no.)	Pods/plant (no.)	Yield/plot (kg/ha)
Magura					
LM-138-3	106b	37.2	2.9	42.3c	1660a
LM-118-9	108a	36.5	4.0	90.2a	1830a
LM-206-5	109a	38.3	4.3	102.3a	1925a
Binamasur-8	104c	40.1	4.1	68.0ab	1812b
BARI Masur-6	109a	39.5	3.2	51.0bc	1685c
CV%	1.30	4.82	20.84	13.54	2.31
Chapainowabgonj					
LM-138-3	98d	25.2	1.4	29.6c	1490c
LM-118-9	105b	29.1	2.4	55.6a	1730a
LM-206-5	107a	29.8	2.5	69.6ab	1790a
Binamasur-8	100c	31.5	1.5	25.6c	1460d
BARI Masur-6	107a	24.8	1.6	62.6bc	1570b
CV%	1.23	3.70	12.26	14.21	0.81
Ishurdi					
LM-138-3	103d	35.2	3.4	76.1ab	1750cd
LM-118-9	110b	46.4	3.6	110.1ab	2113ab
LM-206-5	112a	43.1	4.3	120.5a	2260a
Binamasur-8	105c	34.8	3.2	65.8c	1745cd
BARI Masur-6	112a	35.7	3.2	93.3a	1890bc
CV%	2.39	4.47	3.47	14.77	2.51

On-farm yield trial with some selected lentil mutants

On-farm trials were conducted with three mutant lines along with two check varieties in farmers' field at Magura, Natore and Faridpur during 2018-19. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (5 m × 4 m) with 30 cm line to line distance. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on days to maturity, plant height, number of primary branches $plant^{-1}$ and pods $plant^{-1}$ were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into $kgha^{-1}$. Statistical analysis of different characters of the mutants and the check are presented in the Table 16...

Results revealed that significant variations were observed among the mutants and the check variety for pods per plant and seed yield at the three locations. On an average, maturity period varied from 100 days in Binamasur-8 to 112 days in BARI Masur-6. The line LM-118-9 produced the highest number of pods plant^{-1} as well as the highest seed yield 2310 kg ha^{-1} followed by Binamasur-8 with 2256 kg ha^{-1} at Magura. The mutant LM-206-5 produced the highest seed yield (1820 kg ha^{-1}) followed by LM-118-9 (1780 kg ha^{-1}) at Natore. The highest seed yield 1821 kg ha^{-1} was produced by the mutant LM-118-9 followed by LM-206-5 with 1795 kg ha$^{-.1}$ Evaluation will be continued in the next season.

Table 53. On-farm trial with three lentil mutants/line along with two check varieties, Binamasur-6 and BARI Masur-5 at three locations, Magura, Natore and Faridpur during 2018-19

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches/ plant (no.)	Pods/plant (no.)	Yield/plot (kg/ha)
			Magura		
LM-138-3	106bc	40.2	3.7a	112.3c	2160
LM-118-9	108b	46.5	4.0a	136.2a	2310a
LM-206-5	110a	48.3	2.3c	91.3.3a	1950a
Binamasur-8	106bc	45.1	4.1a	119.0ab	2256b
BARI Masur-6	110a	39.5	3.2ab	105.0bc	2000c
CV%	1.30	3.82	21.94	14.14	2.18
			Natore		
LM-138-3	101c	27.2	2.4	30.6c	1460c
LM-118-9	104b	29.5	2.4	59.6a	1780a
LM-206-5	108a	31.2	3.5	76.9a	1820a
Binamasur-8	100d	30.5	1.8	32.6c	1670d
BARI Masur-6	107a	26.8	1.7	52.1ab	1580b
CV%	1.25	3.80	12.45	14.23	0.91
			Faridpur		
LM-138-3	107c	32.2	2.5	38.1ab	1650b
LM-118-9	112b	36.1	3.8	80.4ab	1821a
LM-206-5	114a	37.5	3.3	86.5a	1795a
Binamasur-8	107c	34.8	3.2	65.8c	1790a
BARI Masur-6	112a	32.7	3.4	40.3a	1690b
CV%	2.26	4.37	3.40	14.27	2.11

Advanced yield trial with some selected mutants of lentil

The advanced yield trials were conducted with four mutants along with a check variety, Binamasur-8 at Magura and Ishurdi during 2018-19. Seeds were sown in randomized complete block design with three replications. Unit plot size was 5m x 4m and rows were 30cm apart. Normal cultural practices were done. Data on days to maturity, plant height, number of primary branches, pods per plant were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kgha^{-1}. Statistical analysis of different characters of the accessions and the check are presented in the Table.3.

Results revealed that significant variations were observed among the mutants and check varieties for most of the characters in the two locations and. On an average, maturity period varied from 102 in LM-24-3 to 1112 days in LM-185-2. The highest number of pods plant^{-1}(113) and seed yield (1840 kgha^{-1}) were found in LM-185-2 at Magura. This mutant also produced highest seed yield at Ishurdi (1992 kgha^{-1}) followed by Binamasur-8 (1980 kgha^{-1}) and LM-99-8(1888 kgha^{-1}). These mutants will be evaluated in the next season at different lentil growing areas.

Table 54. Yield and yield contributing characters of four promising mutants along with a check variety, Binamasur-8 at Magura and Ishurdi during 2018-19

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches/ plant (no.)	Pods/plant (no.)	Yield (kg/ha)
			Magura		
LM-185-2	109a	38.0	4.2	101a	1840a
LM-99-8	104c	37.0	2.5	71.0b	1781ab
LM-24-3	102d	36.1	2.6	45.3c	1610c
LM-21-6	106b	49.0	2.5	58.5c	1725b
Binamasur-8	102d	38.0	3.5	82.5a	1810a
			Ishurdi		
LM-185-2	112a	42.0	3.8	113.4ab	1992a
LM-99-8	110b	41.2	2.4	101.5b	1888ab
LM-24-3	106d	35.2	3.2	52.7b	1740c
LM-21-6	109bc	34.1	2.3	63.4ab	1724c
Binamasur-8	104e	44.1	3.4	105.1a	1980a

Screening of phosphorus use efficient genotypes in lentil in hydroponic condition and pot culture

Seven lentil genotypes *viz*., BARI Masur-6, Binamasur-8, Binamasur-9, Binamasur-10, LM-138-3, LM-118-9, ICF 20-4 and two concentration of phosphorus, 500 µM/L and low P (phosphorus) of 100 µM/L which was 5 times less than optimum condition were used in the experiment. In pot culture, dry cowdung was mixed to soils before the fertilizer application. Seeds were placed for germination on 7/12/2018 for hydroponic experiment. After 5 days seedlings were placed at hydrophonic tray with hogland solution. One group of seedlings of each genotype were grown in Hogland solution containing optimum concentration of P (500 µM/L) and another group of seedlings were grown under low phosphorus (100 µM/L). The nutrient solution was changed after every 7 days and continued up-to maturity stage. Seeds were placed in pots on 12/12/18 for pot experiment. Irrigation was applied whenever necessary. After harvesting, data were recorded on root length, plant height, primary branch, secondary branch, number of pods/plant, number of effective pods/plant, date of maturity, 100-seed weight and seed yield/plant.

Table 55. Mean seed yield per plant in seven genotypes of lentil under hydroponic condition during 2018-19

Variety	Control(g) Yield	Low P(g) Yield	% reduction in yield under low P stress
BARI Masur-6	0.417	0.333	20
Binamasur-8	0.42	0.367	12.698
Binamasur-9	0.627	0.363	42.021
Binamasur-10	0.557	0.343	38.323
ICF-20-4	0.50	0.393	20.805
LM-118-9	0.353	0.25	29.245
LM-138-3	0.5	0.363	27.333

From the table 8 it was observed that in hydroponic condition, Binamasur-9 followed by Binamasur-10 showed highest yield that is 0.627g and 0.557 g. In low P stress condition yield was drastically reduced in BARI Masur- 6 and mutant line LM-118-9. S0, it can be said that these varieties are low P susceptible. After analyzing data, we found that in % reduction rate of yield **Binamasur-8 and ICF-20-4** showed lowest value. It can be assumed that **Binamasur-8 (12.698) and ICF-20-4(20.805**) can be a source of low P tolerant.

Table 56. Mean seed yield per plant in seven genotypes of lentil under pot culture during 2018-19

Variety	Control(g) Yield	Low P(g) Yield	% reduction in yield under low P stress
BARIMasur-6	0.55	0.403	26.667
Binamasur-8	0.643	0.563	12.435
Binamasur-9	0.65	0.463	28.71
Binamasur-10	0.667	0.457	31.5
ICF-20-4	0.587	0.503	14.205
LM-118-9	0.550	0.453	17.675
LM-138-3	0.627	0.49	21.808

The result (Table 9) revealed that Binamasur-10 and Binamasur-9 showed highest yield under optimum P condition (0 .667 g and 0.65 g per plant respectively). In low P stress condition, yield was drastically reduced in Binamasur-10, Binamasur-9 and BARI Masur-6 variety. So, it can be said that these varieties are susceptible to low P. Percent reduction in yield/plant were lowest in the genotype **Binamasur-8 and ICF-20-4**(12.43 and 14.20 % respectively). It can be assumed that **Binamasur-8 and ICF-20-4** is little bit tolerant to low P stress.

Growing of M_5 generation of lentil

To create variability Binamasur-5, a popular variety was irradiated with 150 Gy, 200 Gy and 250 Gy of gamma rays. A total of 65 M_4 plants were harvested from three doses, 150 Gy, 200 Gy and 250 Gy. Selection was done on the basis of earliness and higher number of pods per plant and seed yield/plant. A total of 13 M_5 lines were selected on the basis of higher yield, earliness and disease reactions and erect plant type. All these lines will be grown for further selection in the next generation.

Table 57. Yield contributing characters of 12 promising mutants of M_5 population during 2018-2019

Sl. no.	Plant height (cm.)	Primary branches (no.)	Pods/ plant (no.)
1	54.0	2	273
2	44.3	2	188
3	51.2	1	360
4	47.7	3	144
5	53.9	2	66
6	50.6	2	66
7	52.6	1	102
8	49.4	3	112
9	48.7	2	187
10	52.4	1	120
11	52.2	1	185
12	53.4	2	215
13 (check)	55.3	2	166
G. Mean	51.2	1.8	168
Range	44.3-55.3	1-3	66-360

Growing of M_4 generation of lentil

To create variability Binamasur-5, a popular variety was irradiated with 150 Gy, 200 Gy and 250 Gy of gamma rays. A total of 120 M_4 plants were harvested from three doses, 150 Gy, 200 Gy and 250 Gy. Selection was done on the basis of earliness, number of pods and seed yield. A total of 24 lines were selected on the basis of higher yield, earliness and disease reactions and erect plant type. All these lines will be grown for further selection in the next generation.

Table 58. Yield contributing characters of selected mutants of M_4 population during 2018-2019

Sl. no.	Plant height (cm.)	Primary branch (no.)	Pods/ plant (no.)
Binamasur-5	57.1	3	192
2	50.1	2	140
3	53.3	3	188
4	49.3	2	137
5	49.9	2	146
6	63.3	3	402
7	55.5	3	445
8	58.5	4	426
9	53.6	3	445
10	62.5	3	478
11	52.3	2	103
12	47.3	2	120
13	52.6	2	147
14	49.3	2	89

15	52.7	1	50
16	49.2	2	89
17	52.7	1	50
18	49.2	2	83
19	53.3	6	300
20	58.6	2	145
21	54.6	2	105
22	46	2	50
23	60	3	95
24	58.5	2	55
Grand mean	53.72	2.45	186
Range	46-60	1-4	50-445

Growing of M_3 generation of lentil

To create variability Binamasur-5 and Binamasur-10 were irradiated with 150 Gy, 200 Gy, 250 Gy and 300 gry of gamma rays. A total of 52 M_3 plants were harvested from four doses, 150 Gy, 200 Gy and 250 Gy. Seeds of these M_2 plants were grown in plant-progeny-rows at Chapainawabgonj sub-station and BINA Hqs. Mymensingh along with the mother variety. Each row was 2 m long with 30 cm row to row distance. Normal cultural practices were done. Selection was done on the basis of earliness, no of pods per plant, seed yield, erect plant type and disease reactions. A total of 52 lines were selected on the basis of higher yield, earliness and disease reactions. All this lines will be grown for further selection in the next generation.

Table 59. Yield contributing characters of the 52 selected M_3 mutant lines along with two checks during 2018-2019

Sl. No.	Plant height(cm.)	Primary branch(no.)	Pods/ plant(no.)
Binamasur-10	39	4	165
2	41	3	225
3	40	3	140
4	40	3	248
5	43	3	272
6	49	4	330
7	43	3	140
8	44	3	239
9	40	3	289
10	47	2	217
11	45	3	320
12	46	3	290
13	48	2	272
14	42	4	275
15	39	3	223
16	42	3	250
17	45	3	275
18	47	3	181
19	37	3	226
20	39	4	231
21	40	3	403

22	39	3	274
23	41	4	242
24	53	3	200
25	46	3	158
26	38	2	248
27	46	3	212
28	39	3	312
29	40	3	220
30	39	3	155
31	37	3	205
32	34	2	180
34	34	3	180
35	39	3	180
36	50	2	139
37	41	2	148
38	49	3	178
39	52	4	324
40	47	3	260
41	42	3	224
42	55	4	344
43	43	3	142
44	40	3	236
45	42	2	155
46	36	3	172
47	40	4	108
48	32	3	109
49	41	2	166
50	45	3	156
51	40	3	254
Binamasur-5	47	3	212
Grand mean	42.41	3.0	222
Range	32-55	2-4	108-403

Blackgram

Advanced Yield Trial with two promising blackgram mutants

The trials were conducted with two promising blackgram mutants along with a check variety. BARI Mash-3 at three locations sub-stations Magura, Chapainowabganj and BINA Headquarters. The experiment was laid out in a randomized complete block design with three replications. Plant to plant distance was 3 - 4 cm in a row while line to line distance was 40 cm. Unit plot size was 20 m^2 (5 m × 4 m). Intercultural operations; like weeding, thinning, application of pesticides, etc. were done for proper growth and development of plants in each plot. Harvesting was done depending on maturity of the lines. Data on various characters as plant height, number of primary branches $plant^{-1}$, number of seeds pod^{-1}, 100-seed weight were taken from 10 randomly selected plants of each plot. Seed yield per plot was recorded and converted into kg ha^{-1}. Appropriate statistical analyses were performed by Duncan`s Multiple Range Test (Gomez and Gomez, 1984).

Table 60. Mean of yield and yield contributing characters of three promising mutants of blackgram grown at three locations, Magura, Chapainowabganj and Mymensingh during 2018

Variety	Plant height (cm)	Primary branches/ plant (no.)	Pods/plant (no.)	Seeds/pod (no.)	100-seed weight (g)	Yield (kg/ha)
BM-404	52.0 ab	4.3 a	45.2 a	6.5	4.41 a	1383a
BM-108	42.0 c	2.5b	36.0 a	6.3	3.80b	1000b
BARI Mash-3	49.9 ab	2.1 b	23.1b	6.6	4.52a	916b
BM-404	35.0	1.8	37.0 a	6.2	4.50a	1250a
BM-108	32.7	1.2	30.5 a	6.3	3.40b	1200a
BARI Mash-3	32.1	1.2	20.1 b	6.2	4.57a	1000b
BM-404	56.0a	2.8	56.6a	6.35	4.33a	1858a
BM-108	45.4b	1.9	42.2a	6.50	3.20b	1667b
BARI Mash-3	42.0b	1.2	30.0b	6.45	4.54a	1111c

Results revealed that there was significant difference for most of the characters except seeds per pod at the three locations. BM-404 was the tallest among the mutants and check at Magura, Chapain and Mymensingh. In case of primary branches per plant BM-404 had the highest number of branches and 100-seed weight was higher in the check variety, BARI Mash-3 followed by BM-404. Seed yield was the highest for BM-404 because of its bigger seed size and higher number of pods per plant. BM-404 possessed higher plant height, primary branches per plant, pods per plant and also seed yield at all the three locations. These two mutants will be evaluated in the next season.

Preliminary yield trial with five promising blackgram mutants

The trials were conducted with five promising blackgram mutants along with a check variety. BARI Mash-3 at Magura and Chapainowabganj The experiment was laid out in a randomized complete block design with three replications. Plant to plant distance was 3 - 4 cm in a row while line to line distance was 40 cm. Unit plot size was 20 m^2 (2 m × 1.6 m). Intercultural operations; like weeding, thinning, application of pesticides, etc. were done for proper growth and development of plants in each plot. Harvesting was done depending on maturity of the lines. Data on various characters as plant height, number of primary branches plant^{-1}, number of seeds pod^{-1}, 100-seed weight were taken from 10 randomly selected plants of each plot. Seed yield per plot was recorded and converted into Kg ha^{-1}. Appropriate statistical analyses were performed by Duncan`s Multiple Range Test (Gomez and Gomez, 1984).

Table 61 . Mean of yield and yield contributing characters of five promising mutants of blackgram grown at two locations, Magura and Chapainowabganj during 2018

Variety	Plant height (cm)	Primary branches/ plant (no.)	Pods/plant (no.)	Seeds/pod (no.)	100-seed weight (g)	Yield (kg/ha)
			Magura			
BM-1	56.0	3.8 a	48.2 a	6.6	4.37a	956a
BM-2	48.2	2.7a	35.0 a	6.7	3.80b	750b
BM-3	52.0	1.2b	22.3b	6.1	5.11a	620c
BM-4	53.1	2.5b	30.1a	5.8	3.52b	780b
BM-5	48.3	3.1a	40.3a	6.2	3.61b	884a
BARI Mash-3	51.9	1.2 b	22.1b	6.6	4.52a	700bc
			Chapainoabganj			
BM-1	50.0	3.0 a	40.2 a	6.6	4.37 a	860a
BM-2	46.2	2.7b	35.0 a	6.7	3.80b	670c
BM-3	50.1	2.1b	28.2ab	5.9	4.35a	750bc
BM-4	48.5	3.0a	26.1b	6.1	3.8b	620c
BM-5	40.0	3.5a	30.1a	6.4	3.71b	930a
BARI Mash-3	32.1	2.2b	19.2 b	6.3	4.56a	650c

Results revealed that there was significant difference for most of the characters except seeds per pod. It was also significant for pods per plant, 100-seed weight and seed yield at Magura and Chapainawabganj. BM-1 was the tallest among the mutants and the check at Magura. In case of primary branches per plant BM-1 had the highest number of branches and highest number of pods per plant.than the other mutants and the check variety, BARI Mash-3. Higher seed yield was observed in mutant BM-1 and BM-5 at Chapainowabganj and Magura, respectively. Seed yield was the highest for BM-1 because of its bigger seed size and higher number of pods per plant. The two mutants BM-1 and BM-5 possesed higher plant height, primary branches per plant, 100-seed weight and also seed yield at both the locations. These two mutants will be evaluated in the next season.

Growing of M_3 generation of blackgram

To create variability BARI Mash-3 was irradiated with 600 Gy, 700 Gy, 800 Gy and 900 Gy of gamma rays and was grown at BINA Headquarters farm, Mymensingh. A total of 225 M_2 plants were harvested from four doses 600 Gy, 700 Gy, 800 Gy and 900 Gy. Seeds of these 225 M_1 plants were grown in plant-progeny-rows at BINA Headquarters farm during 2018 and a total of 23 plants were selected based on higher number of pods, earliness, plant type, synchronous in pod maturity and disease and insect pest reactions. These lines will be grown in plant progeny rows in the next season.

Table 62 . Mean of yield and yield contributing characters of selected 22 M_3 mutants of blackgram at Mymensing during 2018

Sl. No.	Plant height (cm)	Primary branch (no.)	Pods/ plant (no.)	Seed/plant (no.)	Characters
1.Barimash-3, 600 Gy	46.2	2.0	42.0	7.0	More pod , Healthy plant
2.Barimash-3, 600 Gy	31.9	1.8	32.2	6.6	healthy and short plant
3.BARImash-3, 600 Gy	43.8	1.6	37.2	7.6	synchronous plant
4.BARImash-3, 600 Gy	42.5	2.3	39.0	7.2	Many pods, short synchronous
5.BARIMash-3, 600 Gy	27.0	1.6	23.8	7.0	Short, more pod, early
6.BARIMash-3, 600 Gy	29.0	2.0	25.4	6.8	early, short and synchronous
7.BARIMash-3, 600 Gy	38.0	2.0	19.0	6.8	Early, short, seeds are bold
8.BARIMash-3, 600 Gy	28.2	2.0	25.5	6.6	short, early maturity
9.BARI Mash-3, 600 Gy	44.8	1.8	36.2	6.8	More pod, plant healthy
10.BARI Mash-3, 600 Gy	37.0	1.6	36.6	6.8	Tall plant, bold seed
11.BARIMash-3, 600 Gy	28.4	1.2	33.0	6.4	Short and early
12.BARIMash-3, 600 Gy	30.4	1.2	32.6	6.4	
13.Barimash-3, 700 Gy	30.0	2.0	36.0	7.4	Large pod, tall and healthy plant
14.BARI Mash-3, 700 Gy	35.0	2.0	52.0	7.0	Tall plant, more pods
15. BARI Mash-3, 700 Gy	38.0	2.4	43.0	6.4	More pods
16.BARI Mash-3, 700 Gy	20.5	2.0	27.5	7.0	More pods
17.BARI Mash-3, 700 Gy	50.7	2.2	39.8	7.2	More pods
18.BARI Mash-3, 900 Gy	47.5	1.6	37.0	6.6	More pods
19.BARI Mash-3, 700 Gy	41.2	2.0	40.4	6.2	More pods
20.BARI Mash-3, 800 Gy	27.8	1.4	16.0	6.2	Early mature
21.BARI Mash-3, 900 Gy	50.7	2.2	40.4	7.0	Short plant, early
22. BARIMash-3, 800 Gy	47.5	3.0	52.0	7.0	Short plant, early mature
23. BARI Mash-3	41.2	2.0	40.4	6.2	Moderate
Range	20.5-50.7	1.2-3.0	16.0-52.0	6.2-7.6	
Mean	37.3	1.90	35.08	6.80	

Growing of M_4 generation of blackgram

To create variability BARI Mash-3 was irradiated with 600 Gy, 700 Gy and 800 Gy of gamma rays and were grown at BINA Hqs. farm. A total of 350 M_1 plants were harvested from three doses, 600 Gy, 700 Gy and 800 Gy. Seeds of these 410 M_2 plants were grown in plant progeny rows. A total of 125 plants were selected from M_2 generation and In M_3 generation a total of 20 lines were selected on the basis of higher pod number, earliness and synchronous in pod maturity and disease reactions. These lines will be grown in plant-progeny-rows in the next season.

Table 63. Mean yield contributing characters of selected 20 M_4 mutants of blackgram at Mymensing during 2018

Sl. No.	Plant height (cm)	Primary branch (no.)	Pods/ plant (no.))	Seeds/pod (no.)
1.BARI Mash-2	34.3	1.6	18.3	6.1
2	41.2	2.0	37.6	5.8
3	30.8	1.4	19.0	6.4
4	36.2	2.1	40.2	6.4
5	28.4	1.2	33.1	6.6
6	30.4	1.2	32.6	6.4
7	45.2	2.3	73.2	7.2
8	48.2	2.2	31.1	7.4
9	42.0	1.3	36.2	7.4
10	42.8	2.3	41.5	7.2
11	43.1	2.5	33.1	7.6
12	30.2	2.3	41.1	7.6
13	21.3	1.3	23.2	7.2
14	28.2	2.1	49.5	7.2
15	26.3	2.0	18.1	7.0
16	23.2	2.2	27.4	8.5
17	37.3	2.1	22.6	8.6
18	42.2	2.3	15.0	8.3
19	39.0	2.0	25.2	8.4
20	30.1	2.2	21.3	7.1
21	40.2	2.1	24.6	8.1
Grand mean	35.2	1.93	31.6	7.2
Range	48.2	1.2-2.5	15.0-73.2	5.8-8.6

Growing of M_1 generation of blackgram (Summer)

To create variability, three blackgram varieties, Torimash, Choitamash and local blackgram varieties were irradiated with 500 Gy, 600 Gy, 700 Gy, 800 Gy and 900 Gy of gamma rays and sown at BINA Headquarters farm, Mymensingh.Now it is in vegetative stage.

Grasspea

Advanced yield trial with six selected mutants of grasspea

The Advanced yield trials were carried out with four selected mutants along with two check variety (Binakheshari-1 and BARI khasari-2) at Magura, Chapainawabgonj and Ishurdi during 2018-2019. The experiment was conducted in randomized complete block design with three replications. Unit plot size was 3 m × 2 m with 40 cm row to row distance. Normal cultural practices were done. Data on days to maturity, plant height, primary branches plant^{-1}, pods plant^{-1} and 100-seed weight were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kgha^{-1}. Statistical analysis of different characters of the mutants and the check are presented in the Table 1.

From the result, significant variations were observed for all the characters except number of primary branches plant^{-1} at both the locations. It was observed that mutant GM-102 was the earliest for maturity and it is the tallest plant among the mutant and checks. The mutant GM-108 produced the highest number of pods and highest seed yield at Magura followed by the mutant GM-102 and BARI Kheshari-2. The mutant GM-108 produced the highest number of pods and the highest seed yield at Chapainowabganj and Ishurdi. These two mutant lines will be put into further trial in the next growing season.

Table 64. Mean of yield and yield contributing characters of six promising mutants of rasspea grown at two locations, Magura, Chapainawabgonj and Ishurdi during 2018-2019

Variety/ mutants	Days to maturity	Plant height (cm)	No of primary branch	No of pods /plant	100-seed weight (gm)	Seed yield/plot (kg)
			Magura			
GM (BN)-102	102c	86 a	3.3 a	71.1 a	6.5 a	1511 a
GM (BR)-250	103 b	71 b	3.3 a	45.1 ab	5.7 bc	1096 c
GM (BN)-105	103 b	72 b	3.5 a	26.5 b	5.1 e	1122 c
GM (BN)-108	104 b	73 b	3.7 a	46.1 ab	5.3 e	1513 a
Binakhasari-1	107 a	67 ab	3.7 a	46.2 ab	5.6 b	1073 c
BARI Khasari-2	108 a	67 ab	3.5 a	40.4 ab	5.4 cd	1206 ab
CV	0.04	9.5	9.7	22.8	3.17	13.1
LSD	0.06	10.4	0.59	21.52	0.26	112
			Chapainawabgonj			
GM (BN)-102	101 d	106 a	3.6 a	74.0 ab	4.4ab	1403 a
GM (BR)-250	102 c	86 bc	3.7 a	51.6 ab	5.01ab	1206 b
GM (BN)-105	102 c	91 abc	3.3 a	50.4 ab	5.2a	1205 b
GM (BN)-108	102 c	91 abc	3.2 a	77.8 a	4.2b	1423 a
Binakhasari-1	105 a	101 ab	3.3 a	68.6 a	4.6ab	1312ab
BARI Khasari-2	106 a	77 c	3.4 a	32.8 b	5.21a	1108c
CV	0.04	9.6	10.8	21.8	11.48	20.1
LSD (0.05)	0.05	14.8	0.59	21.5	0.8	90
			Ishurdi			
GM (BN)-102	111 d	106 a	3.7 a	80.0 ab	4.6ab	1808 a
GM (BR)-250	112 c	86 bc	3.5 a	57.6 ab	5.0 ab	1609 b

GM (BN)-105	113 c	91 abc	3.4 a	56.5 ab	5.3 a	1605 b
GM (BN)-108	113 c	91 abc	3.8 a	83.8 a	4.2b	1824 a
Binakhasari-1	115 b	101 ab	3.5 a	67.6 a	4.6ab	1711ab
BARI Khasari-2	117 a	77 c	3.5 a	32.2 b	5.01ab	1507c
CV	0.03	9.4	10.7	21.9	10.48	19.9
LSD (0.05)	0.05	14.2	0.72	20.4	0.9	95

Growing of M_4 generation of grasspea

To create variability Binakheshari-1 and BARI Kheshari-2 were irradiated with 250 Gy, 300 Gy and 350 Gy of gamma rays. A total of 50 M_4 mutants were harvested and these mutants were grown in plant- progeny-rows at Chapainawabgonj and BINA Hqs. farm. Each row was 2 m long with 30 cm row to row distance. Normal cultural practices were done. A total of 10 M_4 mutants were selected on the basis of earliness, more number of pods and disease reactions. Selection will be done in thenext generation.

Table 65. Mean values of different yield contributing characters of the selected M_4 mutants of grasspea during 2018-19

SL No	Plot	Plant height (cm)	Branch /plant (no.)	Pods/ plant (no.)	Seeds/pod	Characteristics
1	BARIkhesari-2, 300Gy, p-8	41.0	2.5	64.0	4.0	More pods
2	BARIkhesari-2, 250 Gy, p-23	63.2	3.0	79.4	3.8	More pods
3	BARIkhesari-2, 250Gy, p-35	59.8	3.0	66.6	4.6	Short plant
4	BARIkhesari-2, 250 Gy, p-34	55.8	2.6	77.8	4.2	More pods
5	BARIkhesari-2, 300Gy, p-3	39.4	2.0	68.8	3.2	More pods
6	BARIkhesari-2, 250Gy, p-11	47.6	2.1	50.4	3.4	Short stature
7	BARIkhesari-2,250Gy,p-19	52.6	2.4	72.2	3.4	More pods
8	BARIkhesari-2, 250Gy,p-27	50.8	3.0	57.8	3.4	More pods
9	BARIkhesari-2, 250Gy, p-1	51.8	2.8	62.4	3.6	Early
10	BARIkhesari-2, 300Gy, p-31	43.4	4.0	115.8	4.2	Many pods
11	Binakhesari-1 (check)	36.4	2.4	55.4	3.4	
	Range	36.4-63.2	2.0-4.0	50.4-115.8	3.7	
	Grand Mean	49.3	2.7	70.05	3.74	

Growing of M_3 generation of grasspea

To create variability Binaheshari-1 was irradiated with 250 Gy, 300 Gy and 350 Gy of gamma rays and was grown at BINA Headquarters farm, Mymensingh. A total of 120 M_2 plants were harvested separately from three doses, 250 Gy, 300 Gy and 350 Gy. Seeds of these 120 M_2 plants were grown in plant-progeny-rows in 2018-2019. A total of 24 M_3 mutants were selected on the basis of earliness, more number of pods and disease reactions. Selection will be done in the next generation.

Table 66. Mean values of different characters of the 24 selected M_3 mutants of grasspea during 2018-19

SL No	Plot	Plant height (cm)	Branch/plant (no.)	Pods/ plant(no.)	Seeds/pod
1	Binakhesari-1, 2500Gy, p-23	56.3	2	25	3
2	Binakhesari-1,250 Gy, p-25	65.2	4	51	5
3	Binakhesari-1, 250Gy, p-37	54.3	2	12	4
4	Binakhesari-1, 250 Gy, p-33	48.0	2	26	4
5	Binakhesari-1, 250Gy, p-2	57.6	3	47	4
6	Binakhesari-1,300Gy, p-15	52.3	3	14	4
7	Binakhesari-1,300Gy,p-18	50.1	3	18	4
8	Binakhesari-2,300Gy,p-28	52.2	2	20	5
9	Binakhesari-1,300Gy, p-5	66.2	4	35	5
10	Binakhesari-1,350Gy, p-30	66.1	3	24	4
11	Binakhesari-1,350Gy, p-22	47.3	1	35	11
12	Binakhesari-1,350Gy, p-27	69.2	3	28	4
13	Binakhesari-1,350Gy, p-39	48.6	2	11	4
14	BARIkhesari-2,250Gy	46.3	3	46	4
15	BARIkhesari-2,300Gy, p41	47.4	3	21	4
16	BARIkhesari-2,300Gy, p-43	44.4	2	9.0	3
17	BARIkhesari-2,300Gy, p-44	34.3	4	28	4
18	BARIkhesari-2,300Gy, p-26	49.0	1	17	4
19	Binakhesari-1,300Gy, p11	54.1	2	22	4
20	Binakhesari-1,300Gy, p-13	56.5	3	37	4
21	Binakhesari-1,300Gy, p-15	57.1	2	24	4

22	Binakhesari-1,300Gy, p-17	66.2	1	22	5
23	Binakhesari-1,300Gy,p-9	48.0	1	15	4
24	BARIkhesari-2,300Gy, p-30	66.1	3	24	4
25	Binakhesari-1 (check)	50.2	2	25	5
	Range	34-3	1-4	11.51	3-11
	Grand mean	54.1	2.44	25.44	4.4

Growing of M_2 **generation of grasspea**

To create variability Binakheshari-1 was irradiated with 250 Gy, 300 Gy and 350 Gy of gamma rays and was grown at BINA Headquarters with their parent. A total of 145 plants were selected on the basis of earliness, more number of pod and disease reactions. Seeds of these plants will be grown in plant-progeny-rows in the next season.

CHICKPEA

On-farm trial of two chickpea mutants

Two mutants along with two check varieties were put into on-farm trial at Ishurdi, Magura and farmer's field Magura during 2018-19. The experiment was carried out in a randomized complete block design with three replications. Unit plot size was 4 m × 5 m. Distances between rows and plants were 40 and 10-15 cm, respectively. Data on days to maturity, plant height, number of branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, 100-seed weight and seed yield plot^{-1} were recorded from randomly selected five plants of each plot. Plot yield was converted to t ha^{-1}. Mean values are presented in Table 36.

It is observed from the result mean over locations that CPM-8-200 matured the earliest then other mutants and check varieties. The mutant CPM-8-200 had the highest plant height (70.2 cm) whereas BARI Sola-7 produced the lowest among the test entries. The mutant CPM-8-300 produced the highest number of pods plant^{-1} followed by CPM-8-200. The 100-seed weight of CPM-8-200 was the highest, 23.9 (g) followed by CPM-8-300, 23.4 (g). Mutant CPM-8-300 produced the highest seed yield (1.83 t/ ha) among the mutants and check variety. Application will be made to release this mutant (CPM-8-300) as a variety.

Table 67: Regional yield trial of two promising mutants of chickpea during 2017-2018

Variety/mutants	Days to maturity	Plant height (cm)	Branches plant^{-1} (no)	Pods plant^{-1} (no)	Seeds pods^{-1} (no)	100-seed weight (g)	Seed yield (t ha^{-1})
Ishurdi							
CPM-8-200	123	69.3	6.3	56a	1.6	23.9a	1725ab

CPM-8-300	126	63.4	7.3	63a	1.8	23.4a	1849a
BARI Sola-7 (Check)	128	61.1	4.0	37b	1.6	15.8b	1648b
Magura							
CPM-8-200	124	71.3	5.3	54ab	1.5	23.8a	1771ab
CPM-8-300	127	69.8	6.9	67a	1.7	23.6a	1835a
BARI Sola-7 (Check)	127	65.5	4.3	38b	1.4	15.7b	1635c
Magura (Farmers field)							
CPM-8-200	126	70.1	5.1	43ab	1.8	23.9a	1769ab
CPM-8-300	129	64.2	5.5	59a	1.8	23.3a	1815a
BARI Sola-7 (Check)	130	56.4	4.9	39b	1.7	15.8b	1659b
Mean over location							
CPM-8-200	124	70.2	5.6	51ab	1.6	23.9	1755ab
CPM-8-300	127	65.8	6.6	63a	1.8	23.4	1833a
BARI Sola-7 (Check)	128	61.0	4.4	38b	1.6	15.8	1647b

Growing of M_2 generation of chickpea

Seeds of three chickpea varieties (Binasola-4, Binasola-6 and Binasola-7) were irradiated with Cobalt^{60} gamma rays. Irradiation doses were 300, 350 and 400 Gy. Dose wise Bulk seed of each varieties were grown at BINA sub-station farm Magura. Fifteen plants were selected based on bolder seed size, higher yield and disease tolerance.

Garden pea

Growing of M_2 generation of garden pea

One gardenpea variety (BARI garden pea3) was collected from Horticulture Division, Bangladesh Agricultural Research Institute (BARI) during rabi season, 2017 and seeds were irradiated with Cobalt^{60} gamma rays. Irradiation doses were 20, 40, 60, 100, 200, 400 Gy. Dose wise seeds were grown at BINA Head quarters farm Mymensingh and M_2 seeds from each plant were collected and bulked dosewise .

The dose wise bulk seeds were grown at BINA Head quarters farm Mymensingh during rabi season 2018. Due to unfavourable weather very few seeds were collected. The experiment will be done with the rest of the M_2 seeds.

Pigeon pea

Germplasm collection and evaluation of Pigeon pea

Two pigeon pea germplasm were collected from Crop Botany Department, Bangladesh Agricultural University during March, 2018 and grown at BINA Head quarters farm Mymensingh to evaluate the germplasm. The harvested seeds were collected to for crop improvement like short plant height, short duration and disease tolerant through irradiation.

Jute

Evaluation of some M_4 mutants derived from JRO-524

Seeds of eight mutants were sown on 24 March at BINA Hqs farm, Mymensingh, 20 March at BINA sub-station farm at Magura and 23 March 2018 at BINA sub-station farm, Rangpur at 5 to 7 cm distances within rows of 30cm apart. A unit plot size was 4m × 3m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. At harvest, data on plant height and base diameter were recorded from 10 randomly selected plants but dry fiber and stick weights were recorded also from selected 10 plants after proper sun drying which later converted into g plant^{-1}.

Table 68. Yield and yield contributing characters of eight mutants of JRO-524, averaged over three locations

Mutants/Check variety	Plant height(cm)	Base diameter (cm)	Dry fiber weightplant^{-1} (g)	Stick weight plant^{-1} (g)
JRO-524-1000-1	313±28	1.53±0.13	76±6	173±15
JRO-524-1000-5	324±23	1.51±0.16	73±2	189±9
JRO-524-1000-8	345±25	1.72±0.07	103±4	242±15
JRO-524-1000-9	345±29	1.68±0.23	115±6	250±14
JRO-524-1000-10	338±25	1.64±0.19	86±5	186±13
JRO-524-700-3	343±19	1.29±0.14	91±5	187±23
JRO-524-800-3	320±21	1.46±0.03	80±6	171±15
JRO-524-800-7	326±22	1.55±0.11	87±3	204±8
JRO-524(P)	322±24	1.56±0.09	83±4	208±16
LSD(0.05)	6.0	0.17	4.22	9.12

The mutants JRO-524-1000-8, JRO-524-1000-9, JRO-524-1000-10 and JRO-524-700-3 had significantly longer plant height than the parent JRO-524 although none of the mutants had broader base diameter (Table 1). For dry fiber, the mutants JRO-524-1000-8, JRO-524-1000-9 and JRO-524-700-3 had significantly higher weights but for stick, the mutants JRO-524-1000-8 and JRO-524-1000-9 had significantly higher fiber weights.

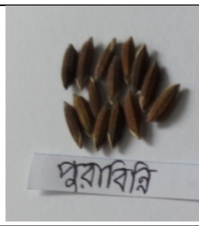
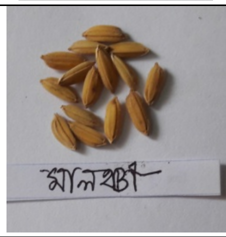
Plant height showed much variation for changing of locations but base diameter a little although the dry fiber and stick yields had some more variations than base diameter (Table 1). Finally, the mutants JRO-524-1000-8 and JRO-524-1000-9, JRO-524-1000-10 and JRO-524-700-3 that showed either significantly longer plant height or dry fiber or stick yield will be put into Advance Yield Trial in the next growing season.

Programme Area : **Plant Genetic Resources**
Project : **Plant genetic resources and their utilization in breeding**

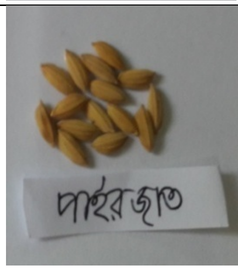
A. Collection :

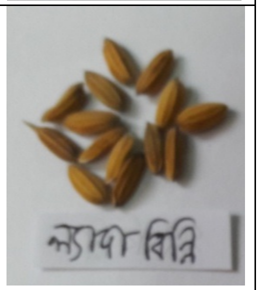
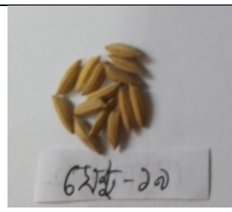
To collect plant genetic resources and their utilization in breeding ,in last year a total of 48 germplasm of different crops were collected from Mymensingh Region. Out of 48, 32 rice germplasm were collected from Nalitabari, Sherpur and one rice germplasm for aus season was collected from Bhairab, Kishoreganj. Three germplasm of brinjal and two of bittergourd, five of chilli were collected from Sherpur and Mymensingh. Three of groundnut, one of blackgram and one of turmeric germplasm were collected from Kishoreganj. Collectors visited those areas and recorded all passport information of the crop from donor during collection time. Passport data of collected germplasm has been presented in annexure-1. Collected germplasm has been registered in register book. Seeds of different germplasm were cleaned, processed, dried and stored in short term storage of BINA germplasm collection room for seed multiplication and charaterization.

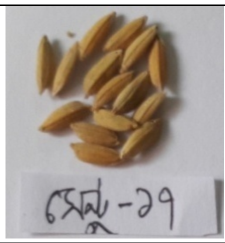
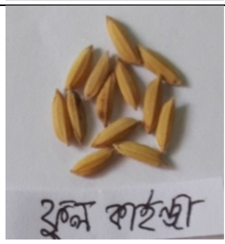
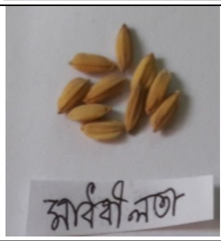
Table 69. Passport information of collected rice (*oryzae sativa*) germplasm

Sl.#	Collector's No.	Cultivar /local name	Donor's name and address	Collection date & geographical position	Photographs
1.	MM-01	Purabinni	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
2.	MM-02	Malonchi	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
3.	MM-03	Dhepa	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
4.	MM-04	Goati binni	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	

Sl.#	Collector's No.	Cultivar /local name	Donor's name and address	Collection date & geographical position	Photographs
5.	MM-05	Markabinni	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
6.	MM-06	Bishali binni	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
7.	MM-07	Lal chinishail	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
8.	MM-08	Motamarang	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
9.	MM-09	Sentu-16	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
10.	MM-10	Mery gold	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	

Sl.#	Collector's No.	Cultivar /local name	Donor's name and address	Collection date & geographical position	Photographs
11.	MM-11	Ranishail	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
12.	MM-12	Pairjaat	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
13.	MM-13	Sentushail	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
14.	MM-14	Chapal-2	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
15.	MM-15	Sentu gold-12	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
16.	MM-16	Chapal-1	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
17.	MM-17	Biroi	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	

Sl.#	Collector's No.	Cultivar /local name	Donor's name and address	Collection date & geographical position	Photographs
18.	MM-18	Shongbinni	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
19.	MM-19	Ledabinni	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
20.	MM-20	Ful lota	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
21.	MM-21	Sentu-18	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
22.	MM-22	Sentu-19	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
23.	MM-23	Rupashail	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
24.	MM-24	Champamasuri	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	

Sl.#	Collector's No.	Cultivar /local name	Donor's name and address	Collection date & geographical position	Photographs
25.	MM-25	Sentu-17	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
26.	MM-26	Ful kainja	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
27.	MM-27	Dudhbinni	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
28.	MM-28	Soto shornolota	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
29.	MM-29	Sentu-15	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
30.	MM-30	Gaind ha	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
31.	MM-31	Madhobilota	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	

Sl.#	Collector's No.	Cultivar /local name	Donor's name and address	Collection date & geographical position	Photographs
32.	MM-32	Lalmatia	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	
33.	H-01	Kalahapa	Md. Abdul Gani Village: kalitoli Union :Vairaob Upazila: Vairaob District: Kishoreganj	1 June 2018 25.14ºN90.19 ºN	

Table 70. Passport information of collected Chilli (*Capsicum frutescens L*) germplasm

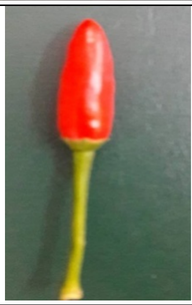
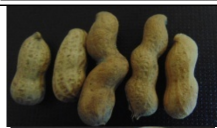
Sl.#	Collector's No.	Cultivar /local name	Donor's name and address	Collection date & geographical position	Photographs
34.	S-01	Superhot master	Abdur Rahman Village: Sutiakhali Union: Boiara Upazila: Sadar District: Mymensingh	3 June 2018 25.14ºN E-90.19 ºN	
35.	S-02	Balijhuri morich (Shampur)	Md. Atab Uddin Village: Shaympur Union: Shaympur Upazila: Melandoho District: Jamalpur	18 October 2018 24.92º N E-89.95 ºN	
36.	S-03	**Balijhuri (Kagmari)**	Alom mia Village: Jhaugora Union: Goalpara Upazila: Melandoho District: Jamalpur	2 March 2018 25.14ºN90.19 ºN	
37.	S-04	**Chatamorich**	Shah Alom Village: Sutiakhali Union: Boiara Upazila: Sadar District: Mymensingh	2 October 2018 25.45ºN E-90.24 ºN	
38.	S-05	Ulto morich	Shah Alom Village: Sutiakhali Union: Boiara Upazila: Sadar District: Mymensingh	2 March 2018 25.45ºN E-90.24 ºN	

Table 71. Passport information of collected Bittergourd (*Momordica charantia*) **and** Eggplant (*Solanum melongena)* **germplasms**

Sl.#	Collector's No.	Cultivar /local name	Donor's name and address	Collection date & geographical position	Photographs
39.	M-01	**Matikorla**	Rasel mia Village: Komorchor Union: Komorchor Upazila: Melandoho District: Jamalpur	19 October 2018 25.14ºN E-90.19 ºN	
40.	M-02	**Bolderusta**	Rasel mia Village: Komorchor Union: Komorchor Upazila: Melandoho District: Jamalpur	19 October 2018 24.92º N E-89.95 ºN	
41.	M-**03**	**Taal Begun**	Habibur Rahman Village: Belgacha Union :Belgacha Upazila : Islampur Dist. Jamalpur	28 October 2018 24.92º N E-89.95 ºN	
42.	M-**4**	**Local Begun** **(**Norshing)	Asim uddin Village: Paikar char Union : Paikar char Upazila : Norshingdi Sadar Dist. Norshingd	28 October 2018 25.14ºN90.19 ºN	
43.	M-5	**Local Begun**	Sentu hajang Village: Chatkeya Union: Noyabil Upazila: Nalitabari District: Sherpur	1 June 2018 25.14ºN E-90.19 ºN	

Table 72. Passport information of collected Groundnut **(***Momordica charantia* **) and** Blackgram **(***Solanum melongena)* **germplasm**

Sl.#	**Collector's No.**	**Cultivar /local name**	**Donor's name and address**	**Collection date & geographical position**	**Photographs**
44.	H-02	**Elachibadam (soto)**	Abdul Gani Village: Vairob Union : Vairob Upazila : Vairob Dist. Kishoreganj	19 October 2018 25.14ºN E-90.19 ºN	
45.	H-03	**Elachibadam (boro)**	Abdul Gani Village: Vairob Union : Vairob Upazila : Vairob Dist. Kishoreganj	19 October 2018 25.14ºN E-90.19 ºN	
46.	H-04	**Tridanabadam**	Abdul Gani Village: Vairob Union : Vairob Upazila : Vairob Dist. Kishoreganj	19 October 2018 25.14ºN E-90.19 ºN	 
47.	H-05	Mashkalai (Local)	Abdul Gani Village: Vairob Union : Vairob Upazila : Vairob Dist. Kishoreganj	19 October 2018 25.14ºN E-90.19 ºN	
48.	H-06	Turmeric (Local)	Abdul Gani Village: Vairob Union : Vairob Upazila : Vairob Dist. Kishoreganj	19 October 2018 25.14ºN E-90.19 ºN	

B. Morphological characterization

Twenty three of rice and two of bitter gourd germplasm were characterized at morphological level.

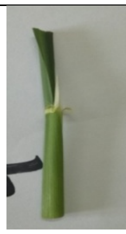
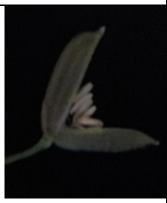
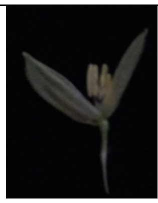
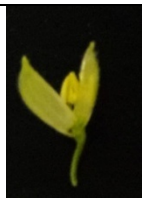
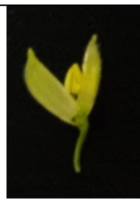
Crop: Rice (*Oryza sativa*)

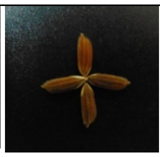
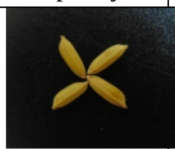
Morphological characterization of rice germplasm

Twenty three germplasm were evaluated during T. Aman, 2018 season for morpho-physiological characterization. The experiment was set at BINA Head Quarters Farm. Seeds were sown on 5th July 2018. Twenty five day old seedlings were transplanted on 1st August 2018. Unit plot size was 2m x 3m. Spacing between hills and rows were 15 and 20 cm, respectively. Normal cultural was done as when necessary. Data were recorded according to rice germplasm descriptor and evaluation form, supplied by BARC and presented in Table 2 to 6. The photographs of plant parts of rice germplasm are shown in Figure1 to 3.

Fill up of Germplasm Descriptors and Evaluation Form is as follows

Table 73. Distinctness of the morphological characters of rice germplasm (Gaindha, Purabinni, Fulkainja, Sentu-9 and Ledabinni)

Descriptors						
1	Accession Number					
2	Name	Gaindha	Purabinni	Ful kainja	Sentu-9	Leda binni
3	Former designation					
4	Seed source	Farm land	Farm land	Farm land	Farm land	Farm land
5	Country of origin	Bangladesh	Bangladesh	Bangladesh	Bangladesh	Bangladesh
6	Variety group	Aman	Aman	Aman	Aman	Aman
7	Seedling height (cm)	medium	medium	medium	long	long
LEAF (Below the flag leaf)						
8	Leaf blade: length	short	intermediate	intermediate	intermediate	short
9	Leaf blade: width	intermediate	broad	narrow	intermediate	intermediate
10	Blade pubescence	glabrous	glabrous	glabrous	glabrous	glabrous
11	Blade colour	green	green	pale green	green	Dark green
12	Leaf sheath : Anthocyanin colour	absent	absent	absent	absent	absent
13	Basal leaf sheath colour	green	green	Dark green	Dark green	green
14	Angle	intermediate	intermediate	intermediate	intermediate	intermediate
15	Flag leaf angle	intermediate	intermediate	erect	erect	intermediate
Leaf blade of rice germplasm						
LEGULE						
16	Length (mm)	3.0	4.5	3.4	6	5
17	Colour	white	Purple line	white	Purple line	white
18	Shape	Two claft	Two claft	Two claft	Two claft	Two claft
19	Collar colour	purple	purple	purple	purple	purple
20	Auricle colour	purple	purple	purple	purple	purple
Legule of rice germplasm						
DAYS TO HEADING						
21	Number of days from effective seedling date to 50% heading	Early	Early	Medium	Early	Medium
Open floret of rice germplasm						

CULM						
22	Length (Measure from the base of the plants to the neck of the panicle)	Very long	long	Very long	long	Very long
23	Culm: Anthocyanin colour)	absent	absent	absent	absent	absent
24	Number (Total tiller)	14	11	11	18	11
25	Angle	intermediate	open	intermediate	erect	erect
26	Culm diameter (from 5 mother tiller in the lowest internodes)	medium	medium	medium	medium	medium
27	Internodes colour	Light green	green	green	green	green
28	Culm : strength	weak	weak	intermediate	intermediate	Moderately strong
29	Lodging incidence (% of plants that lodged)	milk	milk	milk	0%	0%
PANICLE						
30	Length (measured from the neck to the tip of the panicle of main tillers without awns)	medium	medium	medium	long	long
31	Number of panicle per plant	high	high	intermediate	high	high
32	Type	intermediate	open	intermediate	intermediate	intermediate
33	Secondery branching	light	absent	light	light	absent
34	Exsertion	Moderately well exserted	Moderately well exserted	Moderately well exserted	Moderately well exserted	Partly exserted
35	Axis	Droopy	Droopy	Droopy	Straight	Straight
36	Shattering	low	Very low	low	Very low	Very low
37	Threshability	intermediate	intermediate	intermediate	intermediate	Moderately difficult
Panicle of rice germplasm						
GRAIN (SPIKELET)						
38	Awn: distribution	none	none	Tip only	none	Tip only
Seeds of rice germplasm						
39	Length of the longest awn	-	-	0.9 cm	-	1.0 cm
40	Awn colour	-	-	straw	-	-
41	Apiculus colour (colour of the tip of lemma)	Brown (tawny)	black	Brown (tawny)	Brown (tawny)	Purple
42	Stigma colour	yellow	Light green	yellow	yellow	Light purple
43	Lemma and palea colour	Brown spots	black	Brown	Brown	purple

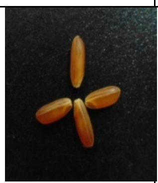
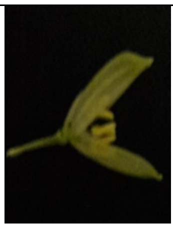
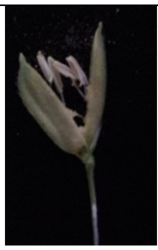
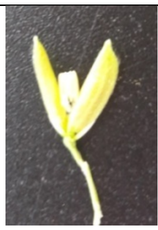
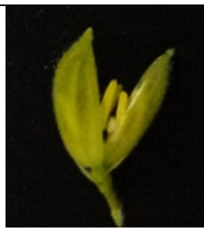
		on straw		furrows on straw	furrows on straw	
44	Lemma and palea pubescence	glabrous	glabrous	glabrous	glabrous	Short hairs
45	Sterile lemma colour	Straw	straw	straw	straw	purple
46	Sterile lemma length (measure at post harvest stage)	Long	long	long	long	long
47	Spikelet fertility	Partly sterile	fertile	Partly sterile	Partly sterile	Highly fertile
48	100 grain weight (g) (Random sample and fully developed grains adjusted at 12% of moisture)	2	2.8	1.5	2	2.7
49	Grain : length(mm)	8	8	8.5	6.5	8
50	Grain : width (mm)	3	3.5	3	3.5	4
Grains of rice germplasm						
51	Brown rice : Length (mm) (after dehulling , before milling)	6	6.5	6.5	4.5	6.5
52	Brown rice : width (mm) (after dehulling , before milling)	2.5	3	2.5	3	3.5
53	Brown rice : shape Length-width ratio of dehuled grain, before milling)	2.4	2.17	2.6	1.5	1.86
54	Seed coat (bran)colour	purple	white	white	white	white
55	Endosperm type	intermediate	waxy	waxy	waxy	waxy
56	Decorticated grain: Scent (aroma)	Non scent	Non scent	Non scent	Non scent	Non scent
57	Leaf senescence (penultimate leaves observed at the time of harvest)	intermediate	Very late	Late and slow	Very early	Very late
MATURITY						
58	Days from seeding (when 80% of grains on panicle are mature)	151	149	151	151	150
59	Yield (g)/plant	5	7	10	12	50
60	Other distinct special character (if any)					

Table 74. Distinctness of the morphological characters of rice germplasm (Biroi, Chapal, Sentu-15, Sentu-19 and Lalchinishail)

Descriptors						
1	Accession Number					
2	Name	Biroi	Chapal	Sentu-15	Sentu-19	Lalchinishail
3	Former designation					
4	Seed source	Farm land	Farm land	Farm land	Farm land	Farm land

5	Country of origin	Bangladesh	Bangladesh	Bangladesh	Bangladesh	Bangladesh
6	Variety group	Aman	Aman	Aman	Aman	Aman
7	Seedling height (cm)	medium	long	medium	medium	Long
LEAF (Below the flag leaf)						
8	Leaf blade: length	short	intermediate	intermediate	intermediate	short
9	Leaf blade: width	intermediate	broad	narrow	intermediate	intermediate
10	Blade pubescence	glabrous	glabrous	glabrous	glabrous	glabrous
11	Blade colour	green	green	Dark green	Dark green	green
12	Leaf sheath : Anthocyanin colour	absent	absent	absent	absent	absent
13	Basal leaf sheath colour	green	green	Dark green	Dark green	green
14	Angle	intermediate	intermediate	intermediate	intermediate	intermediate
15	Flag leaf angle	intermediate	intermediate	erect	erect	intermediate
Leaf blade of rice germplasm						
LEGULE						
16	Length (mm)	3.5	5	5.4	4	7
17	Colour	white	white	white	Purple line	white
18	Shape	Two claft	Two claft	Two claft	Two claft	Two claft
19	Collar colour	purple	purple	purple	purple	purple
20	Auricle colour	purple	purple	purple	purple	purple
Legule of rice germplasm						
DAYS TO HEADING						
21	Number of days from effective seedling date	Medium	Early	Early	Early	Early

	to 50% heading					
Open floret of rice germplasm						
CULM						
22	Length (Measure from the base of the plants to the neck of the panicle)	Very long	long	medium	Very long	long
23	Culm: Anthocyanin colour)	absent	absent	absent	absent	absent
24	Number (Total tiller)	11	9	16	11	15
25	Angle	intermediate	intermediate	erect	erect	intermediate
26	Culm diameter (mm) (from 5 mother tiller in the lowest internodes)	medium	medium	medium	medium	medium
27	Internodes colour	Light gold	Light gold	green	green	Light gold
28	Culm : strength	Moderately strong	weak	Moderately strong	Moderately strong	Weak
29	Lodging incidence (% of plants that lodged)	milk	heading	0%	0%	heading
PANICLE						
30	Length (measured from the neck to the tip of the panicle of main tillers without awns)	medium	medium	medium	medium	medium
31	Number of panicle per plant	high	intermediate	high	high	high
32	Type	open	intermediate	intermediate	intermediate	intermediate
33	Secondery	absent	absent	absent	light	light

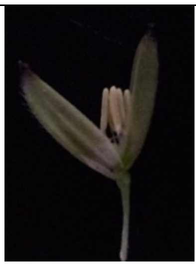
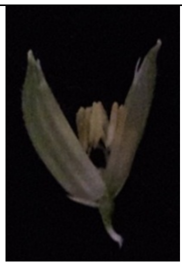
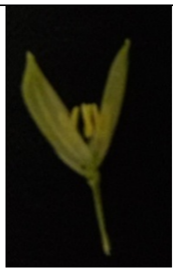
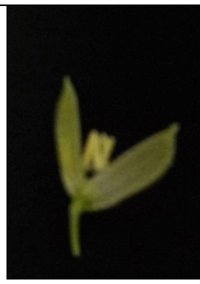
	branching					
34	Exsertion	Moderately well exserted	Moderately well exserted	just exserted	just exserted	just exserted
35	Axis	Droopy	Droopy	Straight	Droopy	Droopy
36	Shattering	low	moderate	moderate	low	moderate
37	Threshability	intermediate	loose	loose	intermediate	loose
Panicle of rice germplasm						
GRAIN (SPIKELET)						
38	Awn: distribution	none	none	none	none	none
Seeds of rice germplasm						
39	Length of the longest awn	-	-	-	-	-
40	Awn colour	-	-	-	-	-
41	Apiculus colour (colour of the tip of lemma)	Straw	Brown (tawny)	Straw	Brown (tawny)	Brown (tawny)
42	Stigma colour	white	Light green	yellow	yellow	Light purple
43	Lemma and palea colour	Brown (tawny)	Brown furrows on straw	Brown (tawny)	Reddish to light purple	purple
44	Lemma and palea pubescence	glabrous	glabrous	glabrous	Short hairs	glabrous
45	Sterile lemma colour	straw	red	gold	red	gold
46	Sterile lemma length (measure at post harvest stage)	long	long	long	long	long

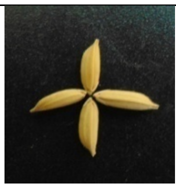
47	Spikelet fertility	Partly sterile	fertile	fertile	fertile	Highly sterile
48	100 grain weight (g) (Random sample and fully developed grains adjusted at 12% of moisture)	2	2.5	2	1.5	1.5
Grains of rice germplasm						
49	Grain : length(mm)	8	7	7.5	7.5	6.0
50	Grain : width (mm)	3	3	3	3.5	3
51	Brown rice : Length (mm) (after dehulling , before milling)	6	6	5	6	5
52	Brown rice : width (mm) (after dehulling , before milling)	1.8	2.8	2.2	3	2.5
53	Brown rice : shape Length-width ratio of dehuled grain, before milling)	3.3	2.14	2.27	2	2
54	Seed coat (bran)colour	Variable purple	white	white	white	Variable purple
55	Endosperm type	glutinous	intermediate	waxy	waxy	Non glutinous
56	Decorticated grain: Scent (aroma)	Non scented	Non scented	Non scented	Non scented	Non scented
57	Leaf senescence (penultimate leaves observed at the time of	Very early	Early	Late and slow	Late and slow	Very early

	harvest)					
MATURITY						
58	Days from seeding (when 80% of grains on panicle are mature)	145	150	151	140	149
59	Yield (g)/plant	11	13	18	16	8
60	Other distinct special character (if any)					

Table 75. Distinctness of the morphological characters of rice germplasm (Dudhbinni, Champamasuri, Soto sornolota, Motamarang and Pairjaat)

	Descriptors					
1	Accession Number					
2	Name	Dudhbinni	**Champamasuri**	Soto sornolota	**Motamarang**	**Pairjaat**
3	Former designation					
4	Seed source	Farm land	Farm land	Farm land	Farm land	Farm land
5	Country of origin	Bangladesh	Bangladesh	Bangladesh	Bangladesh	Bangladesh
6	Variety group	Aman	Aman	Aman	Aman	Aman
7	Seedling height (cm)	medium	medium	short	long	Long
LEAF (Below the flag leaf)						
8	Leaf blade: length	short	intermediate	intermediate	intermediate	short
9	Leaf blade: width	intermediate	broad	narrow	intermediate	intermediate
10	Blade pubescence	glabrous	glabrous	glabrous	glabrous	glabrous
11	Blade colour	green	green	Dark green	Dark green	green
12	Leaf sheath : Anthocyanin colour	present	absent	absent	absent	absent
13	Basal leaf sheath colour	green	green	Dark green	Dark green	green
14	Angle	Erect	Horizontal	Erect	Erect	Erect
15	Flag leaf angle	intermediate	intermediate	erect	erect	intermediate

Leaf blade of rice germplasm						
LEGULE						
16	Length (mm)	3.0	5.2	5.0	4	3.2
17	Colour	purple	white	white	Purple line	white
18	Shape	Two claft	Two claft	Two claft	Two claft	Two claft
19	Collar colour	purple	purple	purple	purple	purple
20	Auricle colour	purple	purple	purple	purple	purple
Legule of rice germplasm						
DAYS TO HEADING						
21	Number of days from effective seedling date to 50% heading	Medium	Early	Early	Early	Early
Open floret of rice germplasm						
CULM						
22	Length (Measure from the base of the plants to the neck of the panicle)	Very long	long	medium	Very long	long
23	Culm: Anthocyanin colour)	present	absent	absent	absent	absent
24	Number (Total tiller)	10	12	7	9	8
25	Angle	intermediate	erect	erect	intermediate	spreading
26	Culm diameter	medium	medium	medium	medium	medium

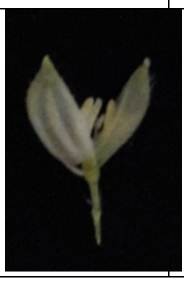
	(from 5 mother tiller in the lowest internodes)					
27	Internodes colour	green	green	Light gold	green	green
28	Culm : strength	weak	weak	weak	Intermediate	Weak
29	Lodging incidence (% of plants that lodged)	Milk	Milk	Milk	Milk	dough
PANICLE						
30	Length (measured from the neck to the tip of the panicle of main tillers without awns)	long	medium	medium	long	medium
31	Number of panicle per plant	intermediate	high	intermediate	intermediate	intermediate
32	Type	intermediate	intermediate	intermediate	intermediate	intermediate
33	Secondary branching	Absent	light	light	light	light
34	Exsertion	just exserted	partly exserted	partly exserted	just exserted	Moderately well exserted
35	Axis	Droopy	Droopy	Droopy	Droopy	Droopy
36	Shattering	low	low	low	Very low	Very low
37	Threshability	intermediate	intermediate	intermediate	intermediate	intermediate
Panicle of rice germplasm						
GRAIN (SPIKELET)						
38	Awn: distribution	none	none	none	none	none
Seeds of rice germplasm						

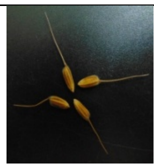
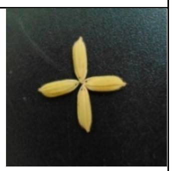
39	Length of the longest awn	-	-	-	-	-
40	Awn colour	-	-	-	-	-
41	Apiculus colour (colour of the tip of lemma)	black	Brown (tawny)	Brown (tawny)	Straw	Straw
42	Stigma colour	white	yellow	yellow	yellow	purple
43	Lemma and palea colour	black	straw	Brown (tawny)	Brown spots on straw	Gold and gold furrows on straw background
44	Lemma and palea pubescence	Short hairs	glabrous	Short hairs	Short hairs	glabrous
45	Sterile lemma colour	Red	gold	straw	gold	gold
46	Sterile lemma length (measure at post harvest stage)	Long	long	long	long	long
47	Spikelet fertility	Partly sterile	Partly sterile	fertile	fertile	Partly sterile
48	100 grain weight (g) (Random sample and fully developed grains adjusted at 12% of moisture)	2	1.5	2	1.5	2
Grains of rice germplasm						
49	Grain : length(mm)	8	8.5	7	7.5	7.5
50	Grain : width (mm)	3.5	3	3	3	3.5
51	Brown rice : Length (mm)	6.5	6.5	6	5	6

	(after dehulling , before milling)					
52	Brown rice : width (mm) (after dehulling , before milling)	3	2.5	2.5	2.2	3
53	Brown rice : shape Length-width ratio of dehuled grain, before milling)	2.17	2.6	2.4	2.27	2
54	Seed coat (bran)colour	Light brown	white	White	white	white
55	Endosperm type	Intermediate	waxy	Waxy	waxy	waxy
56	Decorticated grain: Scent (aroma)	Non scented	Non scent	Non scented	Non scent	Non scent
57	Leaf senescence (penultimate leaves observed at the time of harvest)	Intermediate	Early	Very early	Very early	Intermediate
MATURITY						
58	Days from seeding (when 80% of grains on panicle are mature)	146	140	138	149	145
59	Yield (g)/plant	13	20	16	22	7
60	Other distinct special character (if any)					

Table 76. Distinctness of the morphological characters of rice germplasm (Sentugold, Markabinni, Bishali binni, Goati binni and Shong binni)

Descriptors						
1	Accession Number					
2	Name	Sentugold	Markabinni	Bishali binni	Goati binni	Shong binni
3	Former designation					
4	Seed source	Farm land	Farm land	Farm land	Farm land	Farm land

5	Country of origin	Bangladesh	Bangladesh	Bangladesh	Bangladesh	Bangladesh
6	Variety group	Aman	Aman	Aman	Aman	Aman
7	Seedling height (cm)	medium	long	long	long	Long
LEAF (Below the flag leaf)						
8	Leaf blade: length	short	intermediate	intermediate	intermediate	short
9	Leaf blade: width	intermediate	broad	narrow	intermediate	intermediate
10	Blade pubescence	glabrous	glabrous	glabrous	glabrous	glabrous
11	Blade colour	green	green	Dark green	Dark green	green
12	Leaf sheath : Anthocyanin colour	absent	absent	absent	absent	absent
13	Basal leaf sheath colour	green	green	Dark green	Dark green	green
14	Angle	intermediate	intermediate	intermediate	intermediate	intermediate
15	Flag leaf angle	intermediate	intermediate	erect	erect	intermediate
Leaf blade of rice germplasm						
LEGULE						
16	Length (mm)	4.5	5	3.9	4	6
17	Colour	white	white	white	white	Purple line
18	Shape	Two claft	Two claft	Two claft	Two claft	Two claft
19	Collar colour	purple	purple	purple	purple	purple
20	Auricle colour	purple	purple	purple	purple	purple
Legule of rice germplasm						
DAYS TO HEADING						
21	Number of days from effective seedling date to 50% heading	Early	medium	medium	medium	medium
Open floret of rice germplasm						
CULM						
22	Length (Measure from the base of the plants to the neck of the panicle)	medium	long	long	long	Long
23	Culm: Anthocyanin colour)	absent	absent	absent	absent	absent
24	Number (Total tiller)	16	8	10	8	10

25	Angle	erect	intermediate	intermediate	erect	open
26	Culm diameter (from 5 mother tiller in the lowest internodes)	medium	medium	medium	medium	medium
27	Internodes colour	green	straw	green	straw	green
28	Culm : strength	Moderately strong	weak	Strong	Very weak	Moderately strong
29	Lodging incidence (% of plants that lodged)	No lodging	Dough	Dough	Milk	Dough
PANICLE						
30	Length (cm) (measured from the neck to the tip of the panicle of main tillers without awns)	medium	long	medium	long	medium
31	Number of panicle per plant	high	intermediate	intermediate	intermediate	Low
32	Type	intermediate	intermediate	intermediate	open	Intermediate
33	Secondary branching	light	light	light	light	Absent
34	Exsertion	partly exserted	just exserted	Just exserted	well exserted	Just exserted
35	Axis	Straight	Straight	Straight	Straight	Straight
36	Shattering	Very low	Very low	Very low	Very low	Low
37	Threshability	Moderately difficult	Moderately difficult	Easy	Difficult	Easy
Panicle of rice germplasm						
GRAIN (SPIKELET)						
38	Awn: distribution	none	none	Upper quarter only	Upper three quarters only	none
Seeds of rice germplasm						
39	Length of the longest awn	-	-	intermediate	long	-
40	Awn colour	-	-	Straw	Brown (tawny)	-
41	Apiculus colour (colour of the tip of lemma)	straw	Black	Red apex	Red apex	Straw
42	Stigma colour	yellow	yellow	purple	yellow	purple
43	Lemma and palea colour	Gold & gold furrows on straw background	Brown furrows on straw	Purple	Brown furrows on straw	Gold & gold furrows on straw background

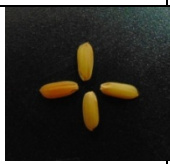
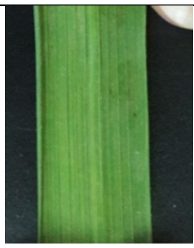
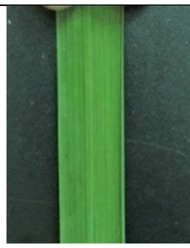
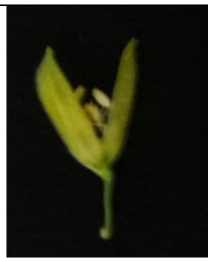
44	Lemma and palea pubescence	glabrous	Hair on upper portion	Short hair	Hair on upper portion	glabrous
45	Sterile lemma colour	straw	red	gold	red	gold
46	Sterile lemma length (measure at post harvest stage)	long	long	long	long	long
47	Spikelet fertility	fertile	Highly sterile	fertile	fertile	fertile
48	100 grain weight (g) (Random sample and fully developed grains adjusted at 12% of moisture)	2	2	2.5	2.5	2
Grains of rice germplasm						
49	Grain : length(mm)	6	9	9	8	7.5
50	Grain : width (mm)	3	3	3.5	3.5	3
51	Brown rice : Length (mm) (after dehulling , before milling)	4.5	6.5	7	6.5	6
52	Brown rice : width (mm) (after dehulling , before milling)	2.5	3	3	2.5	2.8
53	Brown rice : shape Length-width ratio of dehuled grain, before milling)	1.8	2.17	2.33	2.6	2.14
54	Seed coat (bran)colour	white	white	white	Light brown	Variable purple
55	Endosperm type	glutinous	waxy	waxy	Non waxy	intermediate
56	Decorticated grain: Scent (aroma)	Non scented	Non scented	Non scented	Non scented	Non scented
57	Leaf senescence (penultimate leaves observed at the time of harvest)	intermediate	Very early	Late and slow	Very early	Late and slow
MATURITY						
58	Days from seeding (when 80% of grains on panicle are mature)	141	151	150	150	150
59	Yield (g)/plant	42	15	33	13	11
60	Other distinct special character (if any)					

Table 77. Distinctness of the morphological characters of rice germplasm (Sentu-18, Ful lota and Marigold)

	Descriptors			
1	Accession Number			
2	Name	Sentu-18	Ful lota	Marigold
3	Former designation			
4	Seed source	Farm land	Farm land	Farm land

5	Country of origin	Bangladesh	Bangladesh	Bangladesh
6	Variety group	Aman	Aman	Aman
7	Seedling height (cm)	medium	medium	short
LEAF (Below the flag leaf)				
8	Leaf blade: length	short	intermediate	intermediate
9	Leaf blade: width	intermediate	broad	narrow
10	Blade pubescence	glabrous	glabrous	glabrous
11	Blade colour	green	green	Dark green
12	Leaf sheath : Anthocyanin colour	absent	absent	absent
13	Basal leaf sheath colour	green	green	Dark green
14	Angle	intermediate	intermediate	intermediate
15	Flag leaf angle	intermediate	intermediate	erect
Leaf blade of rice germplasm				
LEGULE				
16	Length (mm)	3.5	5	5.4
17	Colour	white	white	white
18	Shape	Two claft	Two claft	Two claft
19	Collar colour	purple	purple	purple
20	Auricle colour	purple	purple	purple
Legule of rice germplasm				
DAYS TO HEADING				
21	Number of days from effective seedling date to 50% heading	Early	Early	Early
Open floret of rice germplasm				
CULM				
22	Length (Measure from the base of the plants to the neck of the panicle)	Very long	long	long
23	Culm: Anthocyanin colour)	absent	absent	absent
24	Number (Total tiller)	7	19	13
25	Angle	open	erect	intermediate

26	Culm diameter (from 5 mother tiller in the lowest internodes)	medium	medium	medium
27	Internodes colour	Light gold	green	green
28	Culm : strength	Weak	Intermediate	Intermediate
29	Lodging incidence (% of plants that lodged)	Milk	Dough	Dough
PANICLE				
30	Length (measured from the neck to the tip of the panicle of main tillers without awns)	long	medium	Long
31	Number of panicle per plant	Low	high	high
32	Type	Intermediate	Intermediate	Intermediate
33	Secondary branching	Light	Light	Light
34	Exsertion	just exserted	partly exserted	Moderately well exserted
35	Axis	Droopy	Droopy	Droopy
36	Shattering	Very low	Very low	Verylow
37	Threshability	intermediate	intermediate	intermediate
Panicle of rice germplasm				
GRAIN (SPIKELET)				
38	Awn: distribution	none	none	none
Seeds of rice germplasm				
39	Length of the longest awn	-	-	-
40	Awn colour	-	-	-
41	Apiculus colour (colour of the tip of lemma)	brown	Brown (tawny)	Brown
42	Stigma colour	yellow	yellow	yellow
43	Lemma and palea colour	Brown (tawny)	Brown furrows on straw	Gold and gold furrows on straw background
44	Lemma and palea pubescence	Hairs on upper portion	glabrous	glabrous
45	Sterile lemma colour	red	brown	Straw
46	Sterile lemma length (measure at post harvest stage)	short	short	short

47	Spikelet fertility	fertile	fertile	Partly sterile
48	100 grain weight (g) (Random sample and fully developed grains adjusted at 12% of moisture)	2	2.5	2
Grains of rice germplasm				
49	Grain : length(mm)	7.5	7.5	6.5
50	Grain : width (mm)	3.5	3.5	3
51	Brown rice : Length (mm) (after dehulling , before milling)	6	6	5
52	Brown rice : width (mm) (after dehulling , before milling)	2.5	3.0	2.5
53	Brown rice : shape Length-width ratio of dehuled grain, before milling)	2.4	2	2.0
54	Seed coat (bran)colour	white	white	white
55	Endosperm type	glutinous	waxy	waxy
56	Decorticated grain: Scent (aroma)	Non scented	Non scented	Non scented
57	Leaf senescence (penultimate leaves observed at the time of harvest)	Very early	Late and slow	Very late
MATURITY				
58	Days from seeding (when 80% of grains on panicle are mature)	137	150	151
59	Yield (g)/plant	11	13	18
60	Other distinct special character (if any)			

Crop: Bitter gourd (*Momordica charantia*)

Morphological characterization of bitter gourd germplasm

Characterization of two germplasm of bitter gourd is being evaluated in this rabi season 2018. The purity and germination percentage were determined as 100 and 80, respectively. The genetically pure and physically healthy seeds of these germplasm were collected from the Horticulture Division, BINA. They have collected these germplasm from local area of Mymensingh. Seeds were sown in the plastic pot and healthy and vigorous seedlings of one month old were selected for transplanting in the main land. The seedlings were removed carefully from the small plastic pots by avoiding any injuries and were sown one seedling per pit in the evening time. Slight watering was provided after transplantation. Mechanical support was provided to the growing plants by dhaincha sticks to keep them erect and support the plant before flowering. The vines were tied with thin rope with the dhaincha sticks. A bamboo pandal (macha) was then prepared and allowed the vine to creep on the pandal. Fruits were picked on the basis of maturity, size, colour and age being determined for the purpose of consumption as the fruit grew rapidly and soon get beyond the marketable stage, frequent picking was done throughout the harvesting period. Fruits were picked with sharp knife and care was taken to avoid injury of the vine. Now the plants of bitter gourd are in harvesting stage. Data were recorded following IBPGR descriptors and presented in Table 10. The photographs of the important identifying traits of the bitter gourd germplasm are provided in Figure 1.

Table 78. Qualitative descriptors of Bitter gourd

SL. No.	Name of the parameters	Measurable indicators	
		Bolder Usta	**Mati korolla**
1	Early plant vigor	Very good	Good
2	Plant growth habit	Very good	Very good
3	Stem pubescence density	Intermediate	Dense
4	Stem shape	Ridge	Ridge
5	Tendril	Present	Present
6	Tendril type	Coiled	Coiled
7	Tendril branching	Single	Single
8	Leaf margin	Multifid	Multifid
9	Leaf shape	Cordate	Cordate
10	Leaf size	Small	Medium
11	Leaf pubescence density	Medium	Strong
12	Leaf blade color	Green	Dark green
14	Color of leaf spot	Brownish	Brownish
15	Flower size	Medium	Medium
16	Flower color	Yellow	Yellow
16	Sex type	Monoeceious	Monoceious
17	Peduncle shape	Angular grooved	Angular grooved
18	Fruit Curvature	Straight	Straight
19	Fruit apex shape	Pointed	Pointed
20	Fruit general shape	Spindle	Spindle
21	Fruit color of skin at commercial harvesting	Green	Whitish green
22	Intensity of greenish color of skin	Medium	Light
23	Fruit surface	Deep tubercles	Deep tubercles
24	Nature of tubercles	Medium	Dense
25	Blossom end shape	Acute	Acute
26	Fruit glossiness at harvesting	Strong	Strong
27	Flesh color of fruit	Greenish	Creamy
28	Seed color	Brown	Brownish yellow
29	Seed size	Intermediate	Intermediate

			
Leaflet of Bolder usta	Leaflet of Matikorolla	Twig of Bolder usta	Twig of Matikorolla
			
Male and female flower of Bolder usta		Male and female flower of Matikorolla	
			
Marketable maturity of bolder usta fruit	Marketable maturity of matikorla fruit	Bolder usta fruit shape in longitudinal section	Matikorla fruit shape in longitudinal section

Figure 1. Difeerent plant parts of two bitter gourd germplasm

Biotechnology Division

Research Highlights

Genetic Engineering:

We initiated the gene isolation cloning programme of salinity, drought, submergence tolerant novel genes from different local and wild rice genotypes.

- *In vitro* response were observed five indica rice varieties on MS media including vitamins and growth hormone and results was revel that BRRI dhan48 found the highest callus induction (84.14%) followed by IR64 (82.61%), BRRI dhan28 (81.76%), BRRI dhan29 (74.39%) and BRRI dhan58 (72.30%).

- Three salinity and drought tolerant genes *OsASR*, *OsCAL* and *OsNHX2* have been transferred to the high yielding rice variety

Molecular breeding:

- In T. Aman 2018 during the reporting period a total of 550 F_1 seeds were obtained from eighteen different cross combinations for tidal tolerant variety development.

- In Boro 2018-19 a total of 96 F_1 plant were selected through polymorphic primer and selected plant were backcrossed with recurrent parents for salt tolerant variety development
- In T. Aman, 2018 a total of 285 F_1 seeds were harvested from five different cross combinations for BLB and blast resistant variety development.

- Breaking yield ceiling and high yielding variety development 33 BC_2F_3 plant, 10 early maturity lines, five tall and long duration and one dwarf lines were selected during the research period.

DNA fingerprinting of Soybean and beneficial microbes

- Five soybean varieties of BINA have been characterized using SSR markers
- Characterization of rhizobial strains used for biofertilizer production at BINA
- Seventeen effective probiotic strains were isolated, characterized and identified by sequencing 16S rRNA gene.

PROGRAMM AREA: GENETIC ENGINEERING AND TISSUE CULTURE

Project 1: Development of salinity/drought tolerant crop varieties

Expt 1: *In vitro* responses of some selected high yielding rice varieties

Plant regeneration is a system that is essential for establishing an efficient application of biotechnology that can be utilized for crop improvement in future. By using mature embryo somatic embryogenesis has been proved to be more reliable method of obtaining true type plant. Therefore, in vitro regeneration from induced callus from mature embryos of five *indica* rice (*Oryza sativa* L.) varieties were investigated in this study.

The experiment was accompanied using five varieties of *indica* rice named BRRI dhan28, BRRI dhan29, BRRI dhan48, BRRI dhan58 and IR-64. To meet this purpose, callus induction potentiality of mature embryo on MS media supplemented with 2.0 mg/l of 2,4-D.

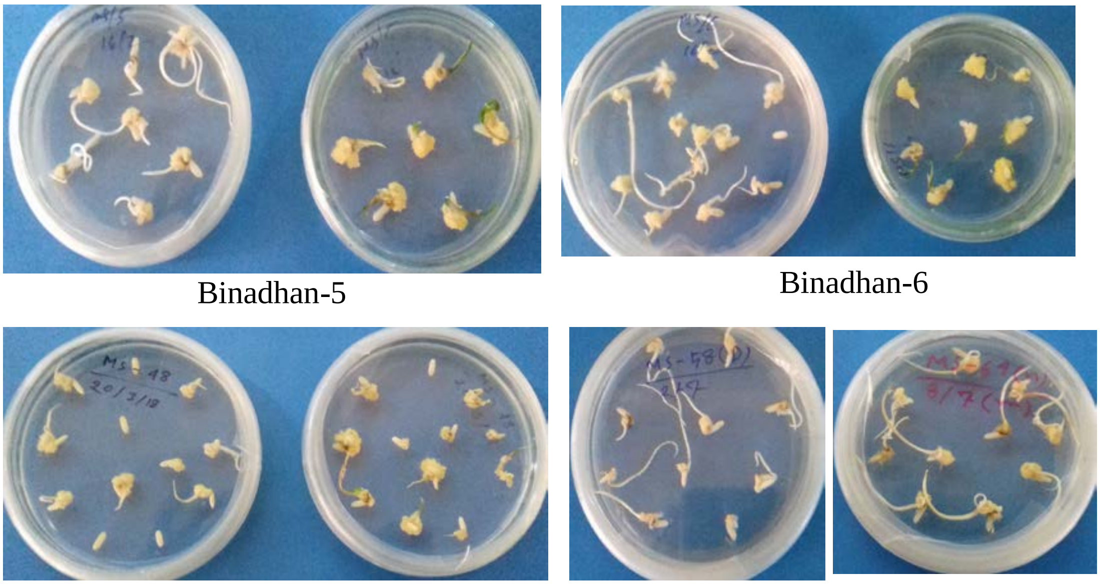
The genotypic mean square values of rice were found statistically significant for all the characters of callus induction. Highest (84.14%) percentage of callus induction was observed in BRRI dhan48 followed by IR64 (82,61%), BRRI dhan28 (81.76%), BRRI dhan29 (74.39%) and BRRI dhan58 (72.30%).

Finally the embryogenic calli were transferred to the sub cultured media for shooting and then survived calli were transferred to the rooting media for root formation.

Table 1: Varietal differences in callus induction

Variety	Percent of callus induction
IR64	82.61
BRRI dhan28	81.76
BRRI dhan29	74.39
BRRI dhan48	84.14
BRRI dhan58	72.30
CV (%)	17
LSD (0.05)	15

Since genetic engineering of crop plants greatly depends on the development of efficient methods for the regeneration of viable shoots from cultured tissues, this protocol can be followed for genetic transformation of *indica* rice. An efficient protocol for the transformation of indica rice varieties has been developed in this experiment.



Binadhan-5 Binadhan-6

BRRI dhan48 BRRI dhan58 IR64

Fig 1: Calli induction of five tested rice varieties

Expt 2: Transfer of salinity and drought tolerant genes into rice through Agrobacterium mediated gene transformation

Experiments were conducted to establish efficient gene transformation protocol for rice and to find effective method for *Agrobacterium* mediated transformation for developing transgenic rice variety with enhanced salt tolerance. Here, we used two genes like **Abscisic stress ripening (*OsASR)*** and **Calmodulin like protein1(*OsCAL)*** and embrygenic calli of two varieties (BRRI dhan48 and IR64) for transforming the high yielding rice cultivar. We used mature embryo to induce rice callus and gene transformation.

Induction of embryogenic calli from mature embryo

Mature, healthy and diseased free dehusked rice seeds were firstly wash three to five times with sterile distilled water and then sterilized with 70% ethanol for 1 to 2 minute. After that again sterilized 50% hypochloride solution including 2 to 3 drooped of tween20 and then disinfectant from sterilized seeds were removed by 7-9 washes with sterile distilled water. Surface sterilized seeds were then cultured on callus induction medium (MS salts: Murashige and Skoog medium Duchefa, Biochemie) containing B5 vitamins, 30g/l sucrose, 2.0mg/l 2,4-dichlorophenoxyacetic acid (2,4-D), at 25^0C in the dark. After three weeks the proliferating calli were subcultured onto the same medium and cultured for another three weeks. White hard embryogenic calli were appeared at this stage. The embryogenic calli of 5-6 mm diameter were subcultured in to the same medium 5 days before infection with agrobacterium. The infected calli were transferred in to an MS cocultivation medium (MS salts, B5 vitamins, 30 g/l maltose, 10.0g/l glucose 100µM acetosyringone, 3.0g/l phytagel) before transfer of calli, the Whatman no.1 filter paper was wetted with 1.0ml of AA-AS medium. Infected calli were incubated at 25^{0}C for 3 days in the dark. After three days infected calli were washed 4-5 times with sterile distilled water and finally once with aqueous solution containing cefotaxime (250mg/l) and streptomycin (250mg/l), blotted on sterile tissue paper, and transferred to MS selection medium containing cefotaxime (250 mg/l) and streptomycin (250 mg/l)). After 12 days in the selection medium, healthy portions of calli were sub cultured onto the fresh selection medium, twice at three week intervals. After three rounds of selection actively growing pieces of calli were transferred to MS regeneration medium containing 300 mg/l casamino acid, 3.0 mg/l 6-benzylaminopurine (BAP), 1.5 mg/l α-naphthaleneacetic acid (NAA), 250 mg/l cefotaxime and 250 mg/l streptomycin.

Although plants were found, used to be tested continued by molecular methods and tested the desired characters for selecting those plantlets as transgenic plant.

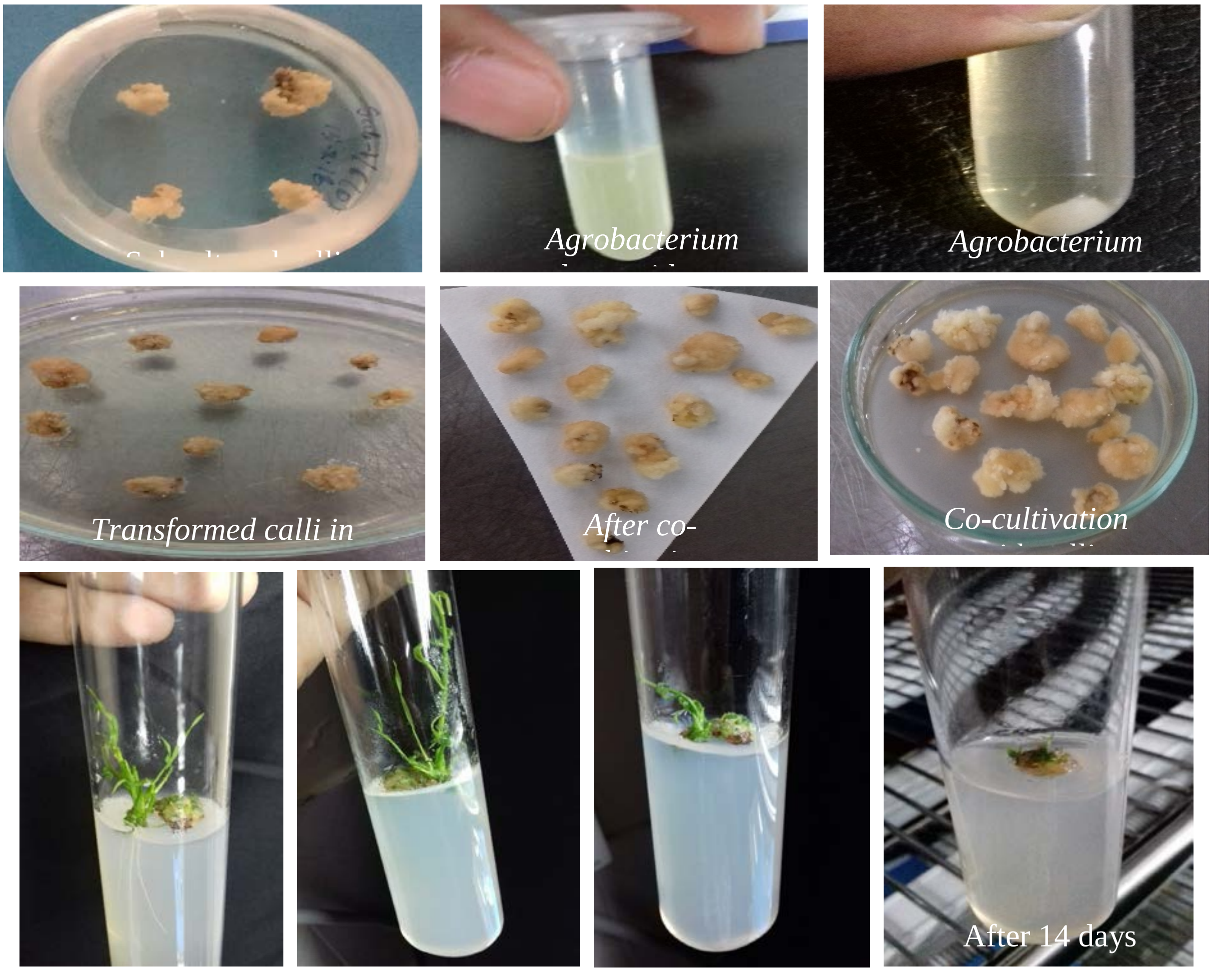


Fig 2: Co-cultivation and regeneration of transformed calli

Expt 3: Genetic transformation of *OsNHX2* genes into rice through *Agrobacterium* mediated gene transformation

Mature, healthy and disease free dehusked high yielding rice seeds (CV. FT) were surface sterilized with 70% ethanol and then with 3% sodium hypochloride solution and then disinfectant from sterilized seeds were removed by 7 washes with sterile distilled water. Surface sterilized seeds were then cultured on callus induction medium (MS salts: Murashige and Skoog, 1962) modified by IRRI at 30°C under continuous light for 10 days. After 10 days, the embryogenic calli were developed and were ready for co-cultivation (Fig. 3).

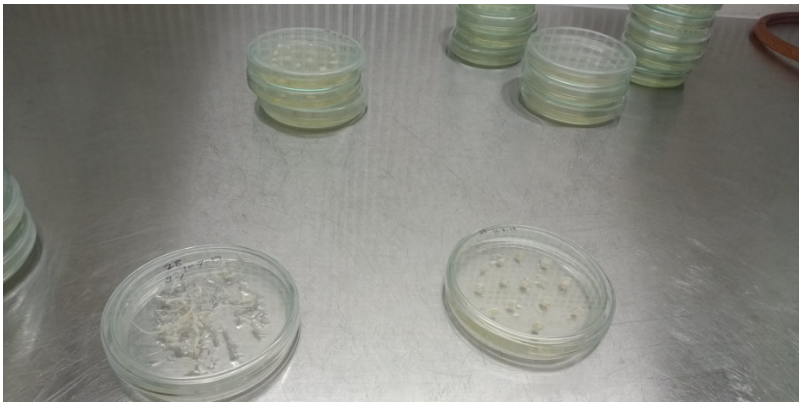


Fig 3. Callus induction from rice

Preparation of gene constructs trains for callus infection / co-cultivation

Gene constructs of *OsNHX2* gene from glycerol stocks were taken from-80^{0}C freezer and then streaked on LB medium containing spectinomycin, rifampicin and gentamycin three antibiotics selection markers. The streaked cultures were then incubated in an incubator at 28^{0}C for three days at dark conditions. The colonies, which contain our target gene, were grown after three days in LB medium

Co-cultivation of Agrobacterium and induced calli

Then, a loop full of *Agrobacterium* culture from isolated colonies were taken and suspended in 40 mL infection media (pH 5.2) in a Falcon tube. *Agrobacterium* cultures were then mixed with infection medium using 10 mL micropipette. The optical density of Agrobacterium cells in infection medium was adjusted by adding sterile infection medium for calli transformation. The calli from induction media were then transferred into the Falcon tube containing *Agrobacterium* broth and mixed gently for 1-1.5 minutes. After mixing, excess *Agrobacterium* containing media were discarded in a disinfection media and callus were put on sterile Whatman filter paper to remove excess *Agrobacterium* suspension from calli surface. After removing excess *Agrobacterium* solution, calli were then transferred to another filter paper moist with infection medium and then transferred on co-cultivation media for three days at 30^{0}C at dark conditions.

Growing transformed calli on selection medium

After three days of co-cultivation, callus were transferred into a Falcon tube and washed with sterile distilled water for 5-6 times to remove excess *Agrobacterium* from calli surface. Final washed were done with sterile distilled water containing 250 mg/L cefotaxime to kill *Agrobacterium* strains present on calli surface. The washed calli were then transferred into selection media to grow the calli for 21 days under continuous light. Based on construct nature, selection materials (Basta 5mg/L) were used in selection media to select positive transformed calli (Fig. 4)

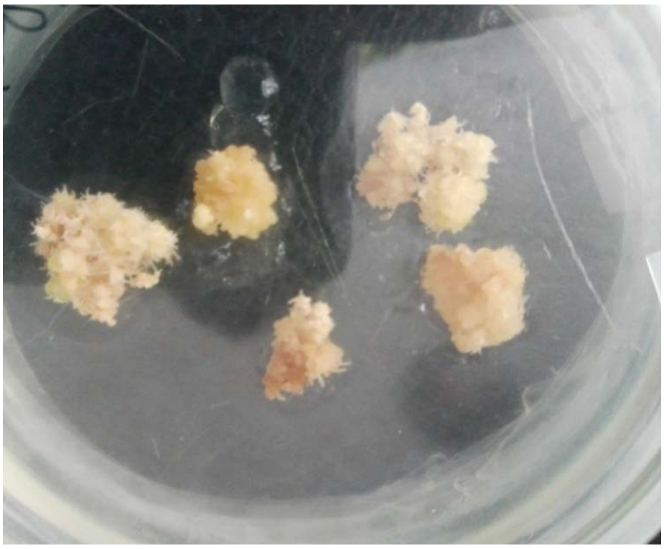


Fig 4. Calli on selection media

Regeneration and hardening of transformed calli

Selected calli were transferred into modified MS medium for regeneration for 24 days. Regenerated calli, showing green color (Fig 5) were transferred to the rooting media for shoot and root generation.

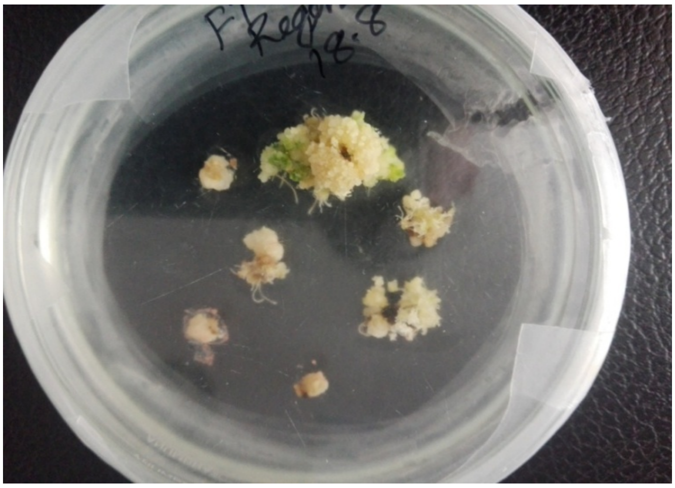


Fig 5. Regenerated calli

Root and shoot elongation

Modified MS media were used for root formation. Regenerated calli were left on modified MS media for two weeks and roots were started to emerge at this stage after 10 days.

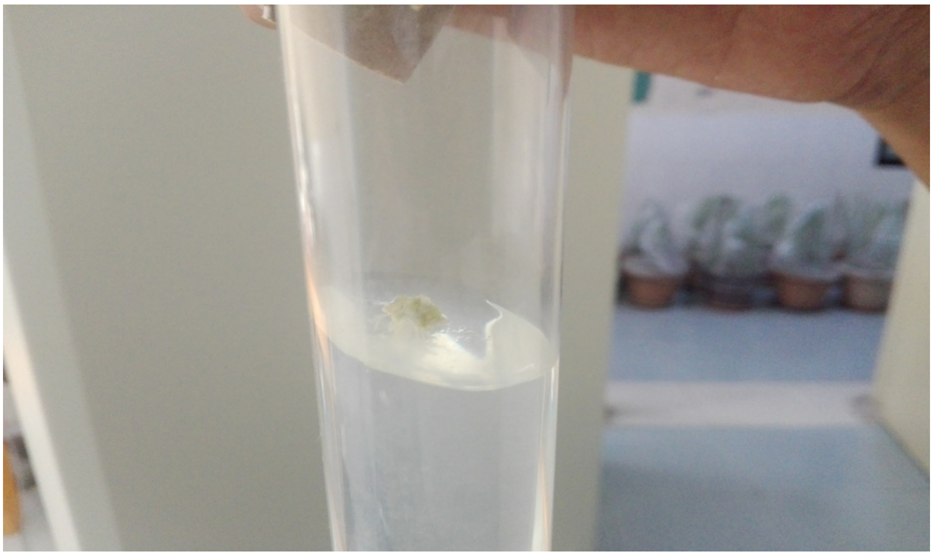


Fig 6. Root initiation

Programm Area: Marker Assisted Selection/Marker Assisted Backcrossing

Project 1: Development of high yield stress tolerant (biotic and abiotic) rice varieties through MAS techniques

Expt4: Improvement of tidal submergence tolerant rice varieties through marker assisted backcrossing breeding

In T. aman'2018 eight parents were grown for crossing purpose. Out of these, five were donor parents viz. Binadhan-11, BRRI dhan46, BRRI dhan52, BRRI dhan76, BRRI dhan77 and four were recipient parent's viz. Sadamota, Dudkalm Lalmota and moulata. Both of the parent's i.e. recipients and donor plants were grown in three sets with an interval of ten days for synchronizing the flowering. Thirty five days old single seedling were transplanted in a 5.5m × 2m row plot with 20cm × 20cm spacing. Fertilizers application, weeding and other intercultural operation were done as per BINA recommended rice production practices. Usual methods of emasculation and pollination were done. At maturity F_1 seeds were collected, dried and stored in paper bags with proper labeling. During the reporting period a total of 550 F_1 seeds were obtained from eighteen different cross combinations. These seeds will be used for future backcrossing program for development of high yielding, tidal tolerant and early maturing advance rice lines.

Table 2: List of cross combination for F_1 seeds production, T.aman 2018

Sl. No.	Crosses	No. of seeds harvested
1	Sadamota X BRRI dhan46	10
2	Sadamota X BRRIdhan52	25
3	Sadamota X BRRI dhan76	28
4	Sadamota X BRRI dhan77	65
5	Moulata X BRRI dhan46	19
6	Moulata X BRRIdhan52	84
7	Moulata X BRRI dhan76	19
8	Moulata X BRRI dhan77	16
9	Dudkalam X Binadhan-11	50
10	DudkalamX BRRI dhan46	8
11	Dudkalam X BRRIdhan52	36
12	Dudkalam X BRRI dhan76	96
13	Dudkalam X BRRI dhan77	21
14	Lalmota X Binadhan-11	27
15	Lalmota X BRRI dhan46	4
16	Lalmota X BRRIdhan52	24
17	LalmotaX BRRI dhan76	2
18	Lalmota X BRRI dhan77	16
Total number of F_1 seeds		**550**

DNA extraction and PCR activity were done for primers survey. During the reporting period a total of 48 SSR primers were surveyed and 18 primers (RM302, RM490, RM3825, RM312, RM3475, RM562, RM8094, RM10694, RM10793, RM3412, RM493, RM158, RM237, RM452, RM475, RM71, RM324 and RM573) were showed polymorphism (Fig 7). This polymorphic primer will be used for F_1 confirmation.

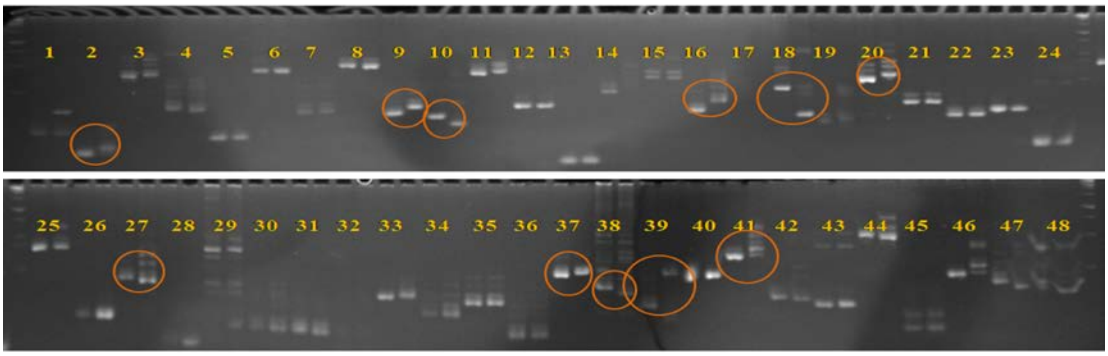


Fig 7:Primer survey for F_1 conformation

Legend:1.RM302,2.RM495,3.RM490,4.RM431,5.RM3825,6.RM312,7.RM351,8.RM3475,9.RM594,10.RM24,11.RM7075,12.RM562,13.RM10748,14.RM8094,15.RM10694,16.RM1287,17.RM10791,18.RM10793,19.RM3412,20.RM493,21.RM292,22.RM315,23.RM522,24.RM246,25.RM140,26.RM238,27.RM165,28.RM312,29.RM158,30.RM243,31.RM5,32.RM499,33.RM259,34.RM237,35.RM283,36.RM1,37.RM452,38.RM154,39.RM211, 40.RM475, 41.RM526,42.RM6,43.RM71,44.RM166,45 .RM266, 46.RM573, 47.RM208,48.RM324

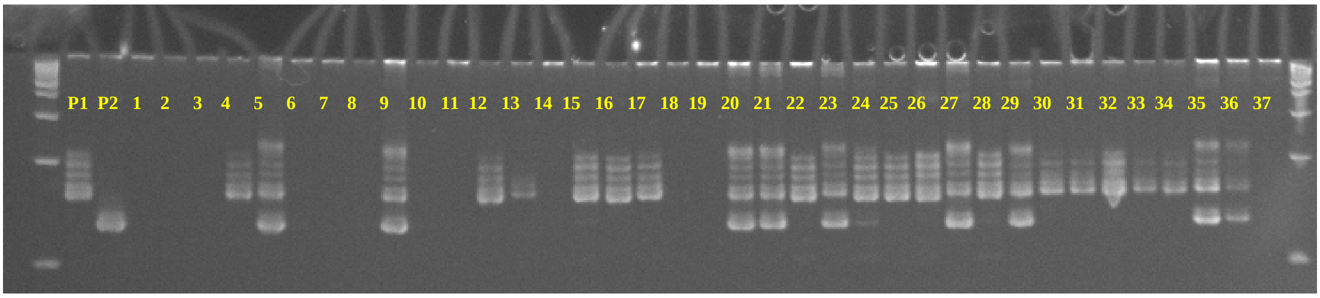
Expt 5: Development of salt tolerant rice varieties through marker assisted backcrossing

In Boro’2018-19 for salt tolerance variety development a total of 450 F_1 (production of previous Boro season) seeds were grown in some pot. But out of these only 180 F_1seedlings were survive and rest of the seedlings damaged due to cold and other various disturbances. Thirty days old F_1

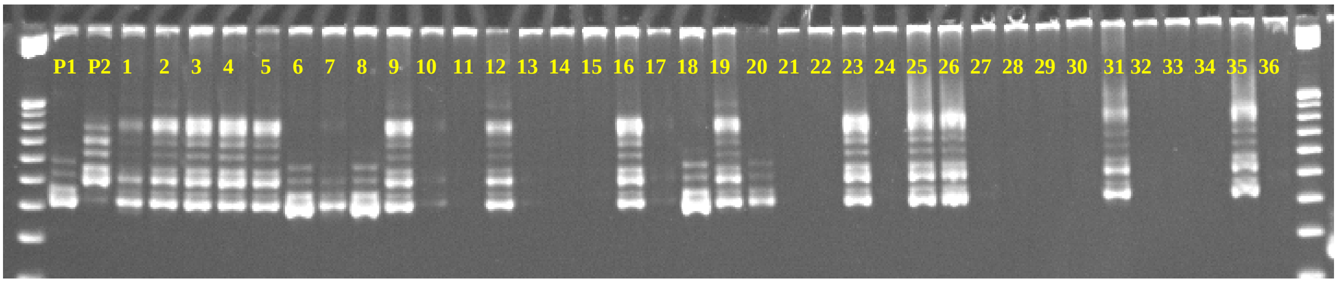
single seedlings were transplanted in a 1.5m × 1.0m size tray with 15cm × 15cm spacing both plant to plant and line to line. Fertilizers application, weeding and other intercultural operations were done as per BINA recommended rice production practices. After transplanting the F_1 seedlings and establishment the plant than leaf sample were collection for DNA isolation. After DNA isolation PCR has been done by using polymorphic primer (previous selected from primer survey) and F_1 were selected on heterozygotes DNA band sowing. During the reporting period among the 180 F_1 a total of 96 F1 plant were selected for BC_1F_1 crossing.

Table 3. List of crosses for F_1 population development

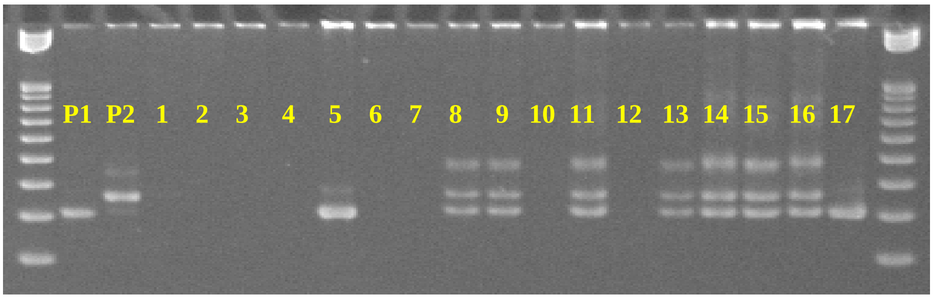
Sl. No.	Crosses	No. of seeds harvested
1	BRRI dhan48 × Binadhan-10	110
2	BRRI dhan48 × Binadhan-8	80
3	BRRI dhan58 × Binadhan-10	120
4	BRRI dhan58 × Binadhan-8	90
5	BRRI dhan58 × FL478	50
	Total number of F_1 seeds	450



F_1 conformation with RM3825 marker for BRRI dhan48 and Binadhan-8 cross



F_1 conformation with RM24 marker for BRRI dhan48 and Binadhan-10 cross



F_1 conformation with RM7075 marker for BRRI dhan48 and IR4630 cross

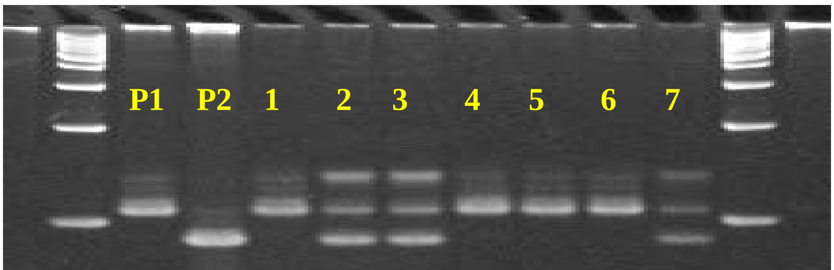
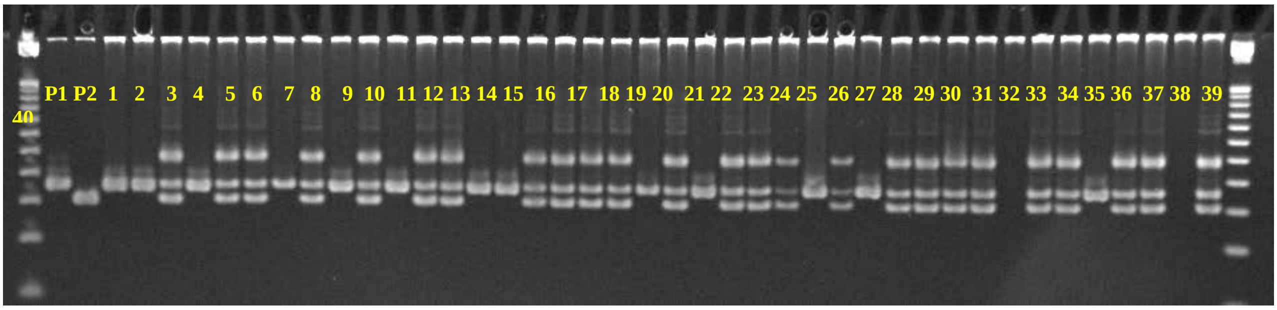
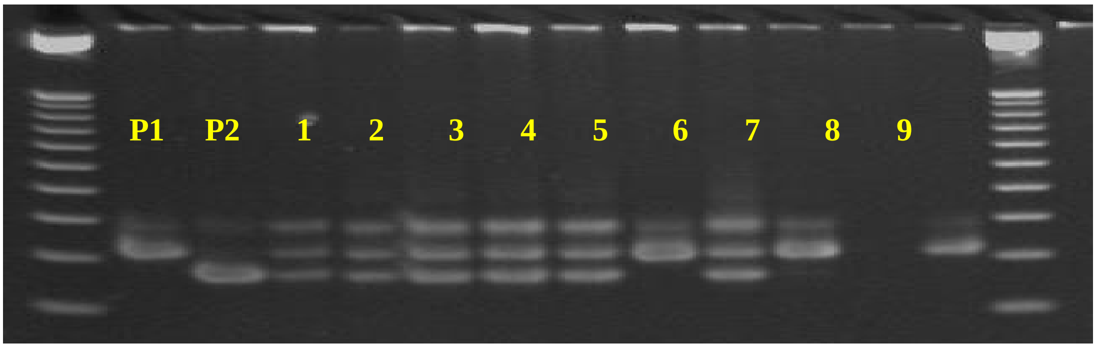


Fig 8: F_1 conformation with different selected polymorphic marker



F_1 conformation with RM5764 marker for BRRI dhan58 and Binadhan-8 cross

F_1 conformation with RM1287 marker for BRRI dhan58 and Binadhan-10 cross



F_1 conformation with RM490 marker for BRRI dhan58 and IR4630 cross

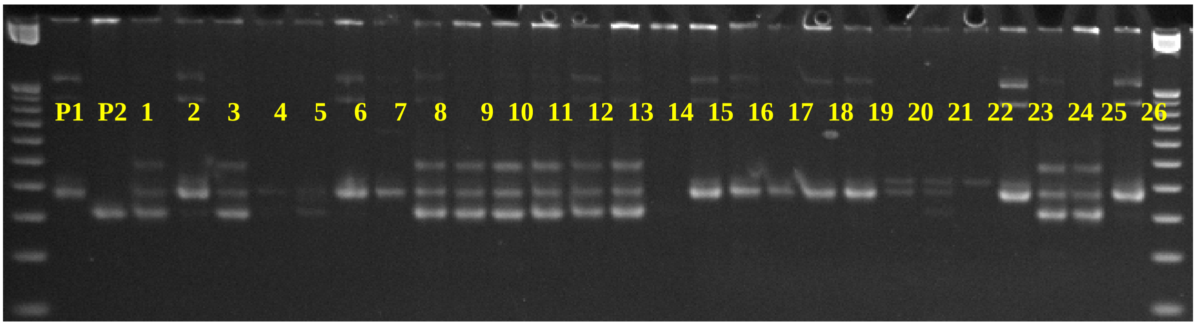


Fig 9: F_1 conformation with different selected polymorphic marker

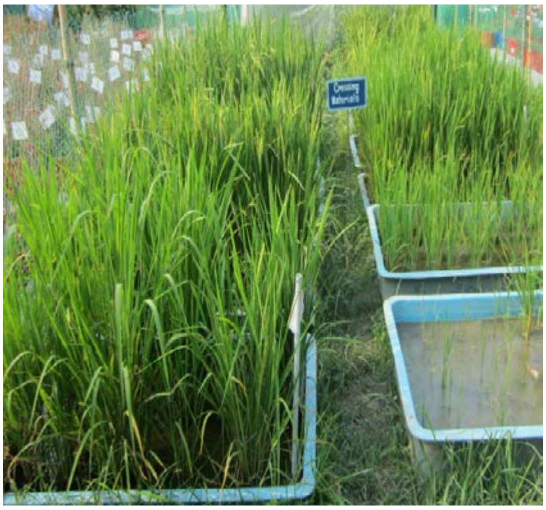
 

Fig 10: BC_1F_1 plant development through hybridization

Expt 6: Development of biotic stress (BLB and Blast) resistant rice variety through marker assisted selection

In T. Aman 2018, a total of five parents were grown for developing biotic stress (BLB and Blast) resistant rice variety. Out of these, three were recipient parents namely BRRI dhan28, BRRI dhan48, BRRI dhan58 and two were donor parents namely IRBB60 (BLB resistant line) and AIK (Blast resistant line). During the research period a total of 285 F_1 (Table 4) seeds were harvested from the five different cross combinations.

Table 4. List of crosses for F_1 population development

Sl. No.	Crosses	No. of seeds F_1
1	BRRI dhan48 × AIK	60
2	BRRI dhan58 × AIK	80
3	BRRI dhan28 × AIK	35
4	BRRI dhan48 × IRBB60	100
5	BRRI dhan58 × IRBB60	10
	Total number of F_1 seeds	285

For F1 conformation and background survey primer survey is going-on. Next T. Aman season the harvested F_1 seed will be used for BC_1F_1 generation development.

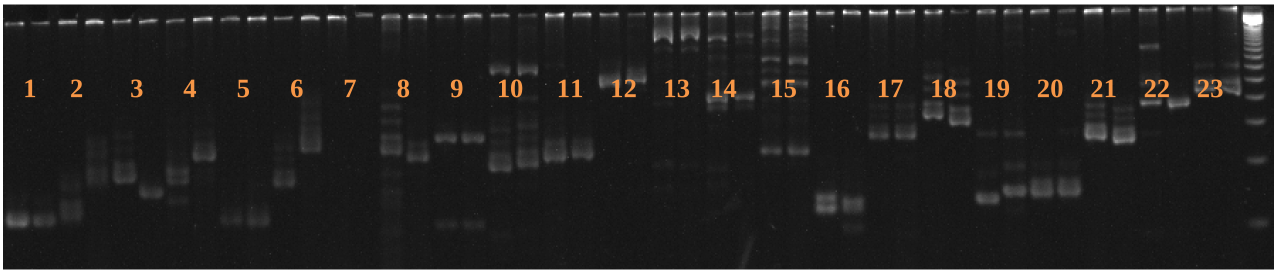


Fig 11: Polymorphic primer survey for foreground and background conformation with 23 SSR primer
Legend: 1=RM2422, 2=RM6054, 3=RM541, 4=RM30, 5=RM435, 6=RM253, 7=RM111, 8=RM510, 9=RM587, 10=RM527, 11= RM3, 12=RM3805, 13= RM11, 14=RM18, 15=RM134, 16=RM346, 17=RM429, 18=RM248, 19=RM118, 20=RM125, 21=RM234, 22=RM51, 23=RM7601.

DNA: 1=BRRI dhan48 and 2= IRBB60

Expt 7: Development of high yielding rice variety through marker assisted selection (MAS) using *Oryza rufipogon* and *Oryza sativa* hybridization

In T. Aman 2018, a total of 82 BC_2F_2 plants were transplanted in a try. Out of these only 33 BC_1F_3 plants were selected on the basis of better plant type with other agronomic characteristics. On the other hand, eighteen selected F_3 line were transplanted for sowing the yield and other better agronomic performances. Out of these, ten lines were found early maturity and medium dwarf type, five were tall and also long duration but plant type was better and one line were found very dwarf and early maturity.

Expt 8: Introgression of cold tolerant genes/QTL into HYV rice varieties

In Boro'2018-19 about 200 F_1 seeds and some lines ($F_{2\ \text{generations}}$) of different combinations (table-1) were grown in a tray. When the seedling aged, 20 days leaves were collected from every plants and F_1 plant were confirmed through primer. Out of these, F_1 plants were selected for backcrosses and F_2 generations go to F_3 generations. Fertilizers application, weeding and other intercultural operations were done as per BINA recommended rice production practices. Usual methods of emasculation and pollination were done. At maturity stage about seeds of F_2 and F_3 seeds were collected then dried and stored in paper bags with proper labeling.

Table 5 : Grouping of 10 cross combinations

Sl. No.	Cross Combinations	Plants of F_2 and F_3 generations
1	BRRI dhan28×BRRI dhan36	41 plants-**F_2 generations and F_3 generations**
2	BRRI dhan29×BRRI dhan36	16 plants- **F_2 generations and F_3 generations**
3	Iratom-24×BRRI dhan36	**F_3 generations**
4	Binadhan-17×BRRI dhan36	**F_3 generations**
5	Binadhan-18×BRRI dhan36	**F_3 generations**
6	Binadhan-5×BRRI dhan36	**F_3 generations**
7	Binadhan-6×BRRI dhan36	**F_3 generations**
8	BPR_3×BRRI dhan36	**F_3 generations**
9	BPR_4×BRRI dhan36	**F_3 generations**
10	Binadhan-8×BRRI dhan36	**F_3 generations**

Expt 9: Growing of M_1 /M_2 generation of submergence/cold tolerance rice

Growing of dry Seeds for M_1/M_2 Population of different doses with gamma rays (200, 250, 300 and 350 Gy). of BRRI dhan51, BRRI dhan52, BRRI dhan79, Binadhan-11, Binadhan-36,BPR1, BPR3, BPR4 and BPR7 mutant lines during Boro season, 2019 at BINA HQ in Mymensingh. Total 50 lines were grown in plant progeny rows for selecting true breeding lines of desirable characters like submergence tolerance, short duration, higher grain yield, fine and medium fine grain and resistance/ tolerance to major diseases/ insects etc. During boro season, spacing between hills and rows were 15 cm × 20 cm. Recommended fertilizer doses were applied. Cultural and intercultural practices were followed as and when necessary. All these mutant lines will be evaluated in the next growing season.

Expt 10: Introgression of submergences tolerant genes into HYV rice varieties.

In Boro'2018-19, about 350 F_1 seeds of different combinations (Table 6) were grown in a tray. When the seedling aged, 20 days leaves were collected from every plants and F_1 plants were confirmed through *sub1* primers. Out of these, F_1 plants were selected for backcrosses and F_2 generations. Fertilizers application, weeding and other intercultural operation were done as per BINA recommended rice production practices. Usual methods of emasculation and pollination were done. At maturity stage about seeds of F_2 seeds were collected then dried and stored in paper bags with proper labeling.

Table 6 : Grouping of 10 cross combinations

Sl.No	Cross Combinations	Plants of F_2 generations
1	Guti Swarna×BRRI dhan52	16 plants
2	Mamun Swarna×BRRI dhan52	16 plants
3	Panpata Swarna×BRRI dhan52	15 plants
4	Bilati Swarna×BRRI dhan52	17 plants
5	Binadhan-17×BRRI dhan52	16 plants
6	Binadhan-7×BRRI dhan52	15 plants
7	BRRI dhan 49×FR13A	10 plants

Project-3 DNA fingerprinting of BINA developed crop varities

Exp-11: DNA fingerprinting and confirmation of varieties/ F_1 using submergence/cold tolerant primers.

Genomic DNA Extraction: DNA was extracted from the leaves of each genotype using the Cetyl Trimethyl Ammonium Bromide (CTAB) mini-prep method at Biotechnology Lab., Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The simplified mini scale procedure for DNA isolation in PCR analysis developed at IRRI was followed. The quality of the isolated DNA in the protocol was sufficient for PCR analysis.

Confirmation of DNA samples and PCR

Isolated genomic DNA contains a large amount of RNA and pigments which cause over estimation of DNA concentration during spectrophotometer reading. Therefore, the DNA samples were evaluated both quantitatively and qualitatively using spectrophotometer and agarose gel electrophoresis respectively. Primer survey for primer selection with submergence/cold tolerant germplasms was carried out using fifty five microsatellite markers. Screening of Cold Tolerance lines using SSR Markers

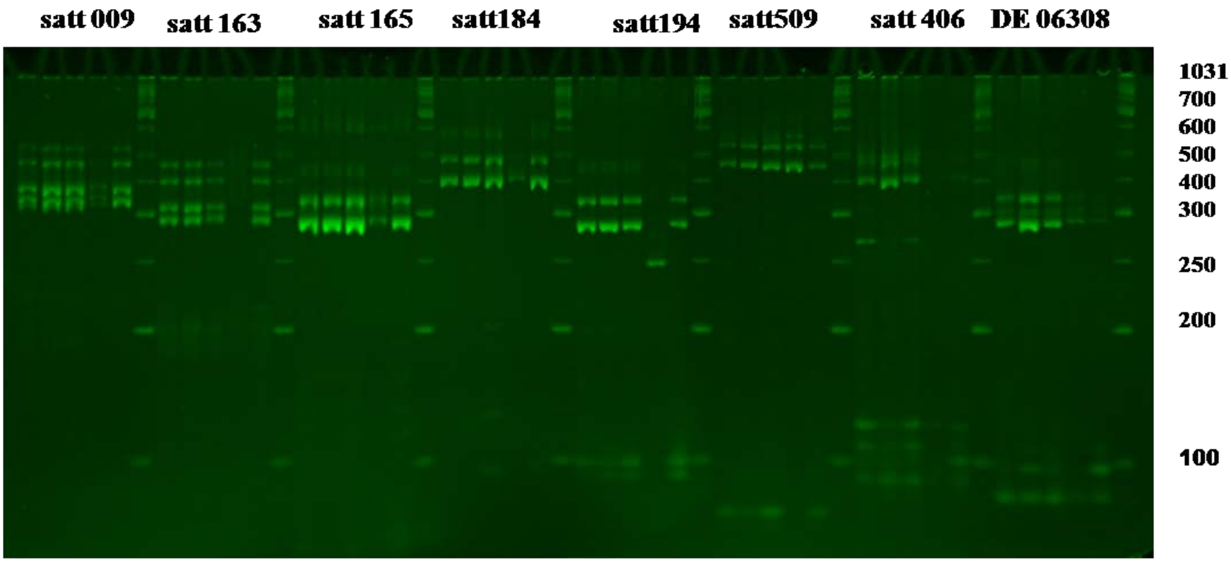
Expt 12: DNA fingerprinting of BINA developed soybean varieties

The DNA fingerprinting is a way of identifying a specific individual, rather than simply identifying a species or some particular trait which is known as genetic fingerprinting or DNA profiling. It is widely being used to identify paternity or maternity, criminals or victims. Descriptive names given to landraces or cultivated varieties illustrate the practical necessity for researchers, policy makers and farmers to identify sources of seed of proved performance. In many cases, processors and end-use consumers also want to know varietal identity. Therefore, it is important to characterize our BINA developed crop verities by DNA fingerprinting. Our objectives were to characterize and to detect the extent of diversity of BINA developed soybean varieties. We used eight different SSR primers for DNA fingerprinting of BINA developed five soybean varieties. Of the 15 primers tested, the best 8 were selected for final fingerprinting. They included Satt009, Satt163, Satt165, Satt184, Satt194, Satt509, Satt406, and BE06308. Specific characterizations of these primers are described in Table 7..

Table 7: List of SSR primer used for soybean DNA fingerprint

SSR Marker	Forward primer	Reverse Primer
Satt009	CCAACTTGAAATTACTAGAGAAA	CTTACTAGCGTATTAACCCTT
Satt163	AATAGCACGAGAAAAGGAGAGA	GTGTATGTGAAGGGGAAAAACTA
Satt165	CACGAATAACTTGACACATT	TAAAAACAAAGCAAACATAAA
Satt184	GCGCTATGTAGATTATCCAAATTACGC	GCCACTTACTGTTACTCAT
Satt194	GCGTTGTGGTCACTCTTGATAATG	GCGAGTCACGAAATAATTTTGAATAAT
Satt509	GCGCTACCGTGTGGTGGTGTGCTACCT	GCGCAAGTGGCCAGCTCATCTATT
Sat_406	GCGCGTGTGGTGGTTACATTA	GCGTTTGCAGCCATTTCCATTTAC
BE806308	GCGATTTGACCCCGTTCATACAT	GCGGCAGAAATCCGCTCTCTTTA

The primer satt 009 produced four to five bands with 300-600 bp size for different varities. The primer satt 163 produced two to four bands with 300-500 bp size for different varities. The primer satt 165 produced five to six bands with 250-700 bp size for different varieties. The primer satt 184 produced three to seven bands with 300-700 bp size for different varieties. The primer satt 194 produced one to six bands with 100-500 bp size for different varieties. The primer satt 509 produced three to four band with 100-500 bp size for different varieties. The primer satt 406 produced one to eight bands with 100-500 bp size for different varieties. Mean band presence for individual was 34.2. The total numbers of polymorphic band were 39 among



five varieties.

Fig. 12: ISSR amplified DNA fingerprint profile of five soybean varieties

The genetic relatedness among accessions was determined using Jaccard's similarity coefficients. The scale used for the genetic distance runs from 0 (meaning no genetic difference) to 1 (different for all conditions-criteria). The UPGMA dendogram found two groups among five varieties. No distinctive main clusters were identified but in general, variety Binasoybean-4 was separated from the rest of the varieties. The varieties Binasoybean-2 and Binasoybean-3 were clustered together as documented by UPGMA tree (Figure 2).

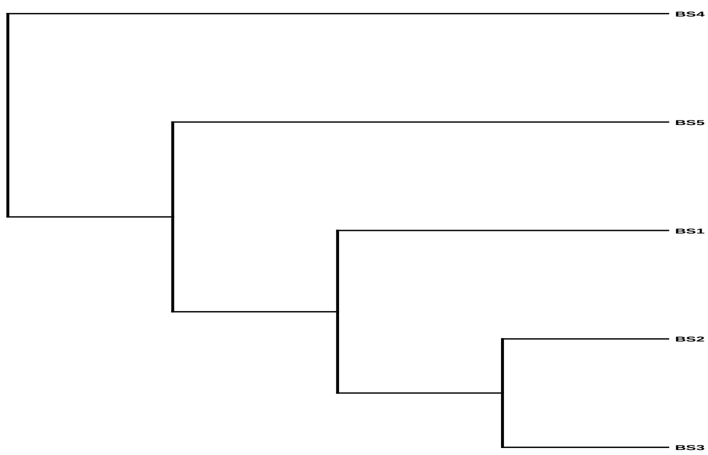


Fig. 13: Dendrogram of the genetic relationship among 5 soybean varieties based on the Jaccard similarity matrix using eight ISSR primers.

Among five varieties, Binasoybean-4 was distinctly related with other four varieties. The rest four form a single group. They are genetically distinct genotypes except Binasoybean-2 and Binasoybean-3. These two varieties showed very narrow genetic distance between them.

Expt 13: Isolation, characterization and identification of probiotic bacteria for controlling pathogenic fungi

To feed the ever increasing population and sustainable agriculture, more-efficient control of plant diseases is essential. Probiotics is naturally occurring bacterial antagonists and competitors that suppress pathogens. Probiotics are recently reemerged as a promising alternative to agrochemical use and they are important source of biotic stress antagonistics genes for genetic engineering approaches. Therefore, it is possible to control plant diseases using appropriate probiotics either by direct use or use in genetic modification. Our objectives were to find effective probiotic strains against major fungal diseases, to characterize prominent probiotic strain/s for field application and to biotic stress antagonistic genes for genetic modifications.

A total of 40 bacterial strains were isolated from stem and leaf of maize and rice and soil to find effective bacterial strains with antifungal activity against major fungal diseases of rice and wheat. We evaluated bio-control potentiality of isolated bacterial strains against major fungal pathogen of rice, wheat and sugarcane viz. *Bipolaris oryzae, Pyricularia oryzae, Magnaporthe oryzae, Bipolaris sorokiniana* and *Colletotrichum falcatum* at *in-vitro* condition. Out of forty, seventeen bacterial strains suppressed the tested fungal pathogens from 25% to 100% under in vitro plate assay (Table 8). These strains were characterized by DNA fingerprinting which formed two major groups among sixteen strains. Out of sixteen, seven strains were very close to *Bacillus sp*.

Table 8: Bio-control potential of selected bacterial strains

Bacteri al strains	*B. sorokiniana*		*P. oryzae*		*M. oryzae*		*B. oryzae*		*F. oxysporum*	
	Mean radial growth	**(%) Inhibiti on**	***Mean radial growth***	**(%) Inhibit ion**	***Mean radial growth***	**(%) Inhibit ion**	***Mean radial growth***	**(%) Inhibiti on**	***Mean radial growth***	**(%) Inhibiti on**
Contro	6.0	-	9.0	-	8.0	-	9.0	-	6.0	-
MA11	1.0	100.00	1.0	100.00	1.0	100.00	2.5	72.22	3.7	38.33
MA12	4.3	28.33	2.5	72.22	1.7	78.75	3.0	66.67	6.0	0.00
COX1	5.6	6.67	2.5	72.22	5.0	37.50	3.5	61.11	6.5	-8.33
MY3S	3.8	36.67	1.7	81.11	2.5	68.75	5.0	44.44	6.5	-8.33
GO1S	4.5	25.00	3.2	64.44	4.0	50.00	3.0	66.67	5.0	16.67
GO4S	5.0	16.67	1.0	100.00	5.0	37.50	4.5	50.00	7.0	-16.67
B22	1.0	100.00	1.0	100.00	1.0	100.00	1.0	100.00	3.5	41.67
J16	1.0	100.00	1.0	100.00	1.0	100.00	3.2	64.44	2.0	66.67
R17	5.0	16.67	1.0	100.00	1.0	75.00	6.0	33.33	9.0	50.00
R18	2.7	55.00	1.0	100.00	1.7	78.75	4.5	50.00	7.0	-16.67
GO2S	2.5	58.33	1.0	100.00	4.0	50.00	6.0	33.33	0.0	0.00
MY8	1.0	100.00	1.0	100.00	1.0	100.00	3.0	66.67	1.5	75.00
GO2W	4.2	30.00	1.5	83.33	1.7	78.75	7.0	22.22	7.0	-16.67
CR1	1.0	100.00	1.0	100.00	1.0	100.00	-	-	-	-
CR2	1.0	100.00	1.0	100.00	1.0	100.00	-	-	-	-
Maize1	1.0	100.00	1.0	100.00	1.0	100.00	-	-	-	-
Maize2	1.0	100.0	1.0	100.0	1.0	100.0	-	-	-	-

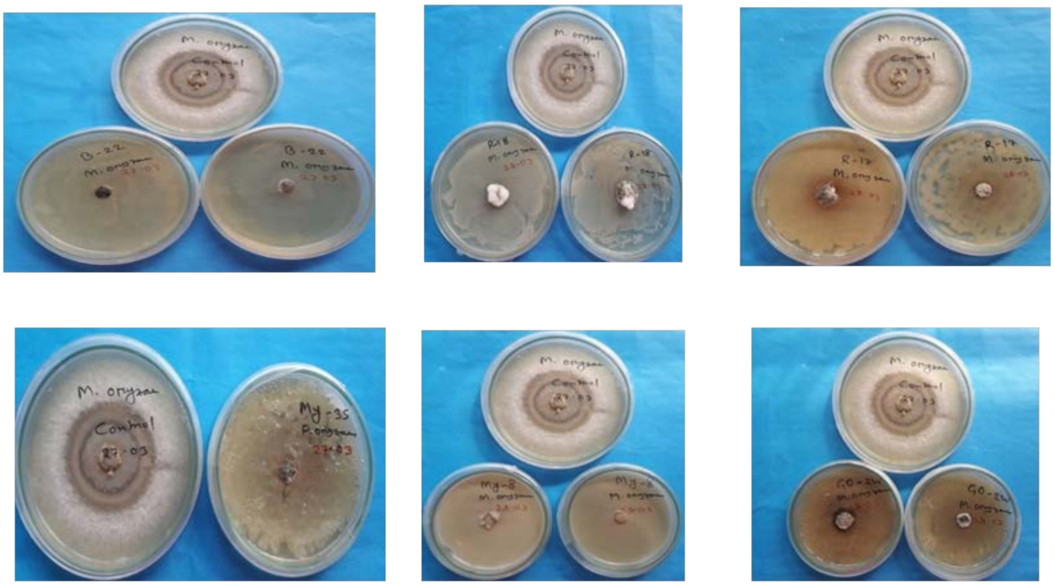


Fig.14: Antifungal activity against *Pyricularia oryzae*

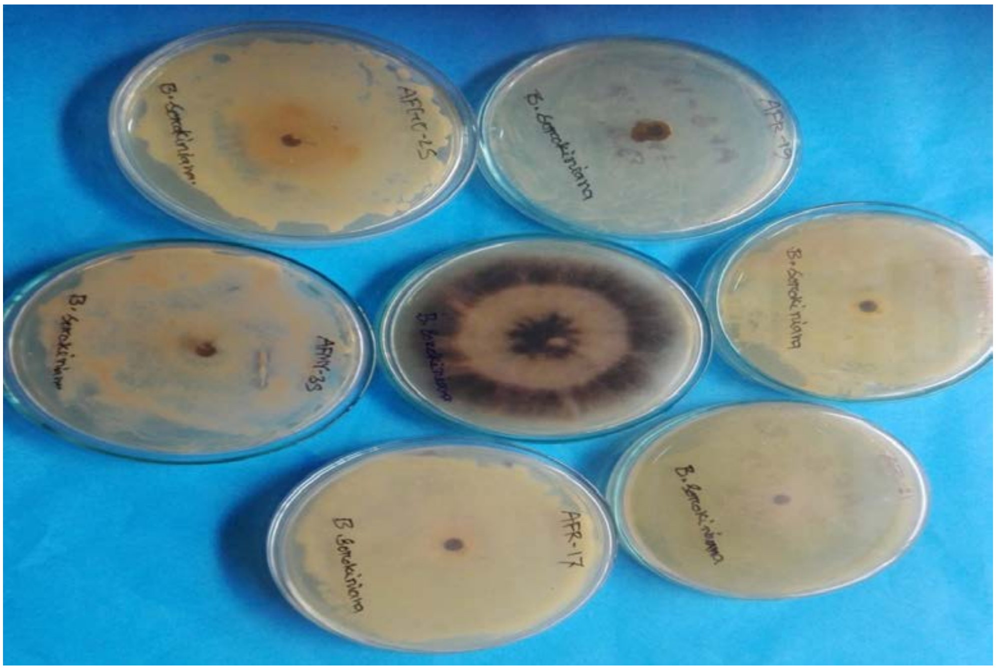


Fig.15: Antifungal activity against *Bipolaris sorokiniana*

A pot experiment was conducted at field conditions by artificial inoculation of wheat using fungal pathogen *Bipolaris sorokiniana* and selected bacterial strains were used as bio-control agents along with chemical fungicide (bactroban). Inoculation experiment revealed that the strain GO-1 showed the highest bio-control potential against leaf blight of wheat caused by *Bipolaris sorokiniana*

Table 9. Disease severity at vegetative stage

Treatments	% Disease severity
T_1 (Absolute control)	53.33 c
T_2 (Only Pathogen)	86.67 a
T_3 (Bactroban, fungicide)	73.33 ab
T_4 (B22)	66.67 bc
T_5 (GO1)	33.33 d
T_6 (Bacillus)	66.67 bc
T_7 (Bacillus+ B22+GO1)	60.00 bc
T_8 (GO4S)	60.00 bc
T_9 (MY3S)	53.33 c
T_{10} (J16+GO4S+MY3S)	53.33 c
T_{11} (B22+GO1+formulation)	60.00 bc

It showed lower disease incidence (33%) and greater seed yield (4 g/plant) while control treatment had the maximum disease incidence (87%) and the lowest seed yield (2 g/plant). Amplification, sequencing and analysis of 16S rRNA gene from promising sixteen probiotics were completed to know their taxonomic positions. The phylogenetic relationships among the selected strains were studied by generating ML phylogenetic trees. At least four different species (*Bacillus subtilis*, *B.aquimaris*, *B.megaterium* and *B. thuringiensis*) were found in our potential collection. Among four species, the *Bacillus thuringiensis strain* GO1 was the most efficient bio-control potential candidate for controlling wheat blight.

Table 10. Effect of potential bacterial strains on yield

Treatments	Grain yield/pot (gm)
T_1 (Absolute control)	13.77 ef
T_2 (Only Pathogen)	9.98 g
T_3 (Bactroban,(fungicide)	15.59 cde
T_4 (B22)	17.99 b
T_5 (GO1)	20.44 a
T_6 (Bacillus)	16.17 bc
T_7 (Bacillus+B22+GO1)	12.98 f
T_8 (GO4S)	15.71 cd
T_9 (My3S)	13.94 def
T_{10} (J16+GO4S+My3S)	15.73 cd
T_{11} (B22+GO1+formulation)	21.84 a

Expt 14. Genetic diversity of potential bacterial strains

Ribosomal RNA gene (16SrRNA) was amplified and sequenced from 16 potential strains to know their phylogenetic relationship by generating phylogenetic tree. Amplified PCR products were sequenced from 1stBASE, Singapore.

Sequences were aligned using BioEdit software and mutations were checked manuallyfor further improvement.

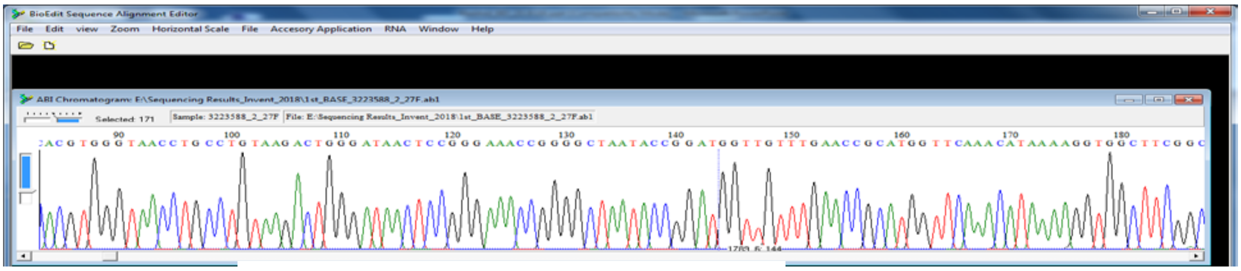


Fig 16. Quality of sequence data

Fig. 17: A Snapshot of aligned sequences of 16SrRNA gene

Phylogenetic analysis of potential strains

Kimura-2 parameter model with 1000 bootstrap replications were used during maximum likelyhood tree generation.

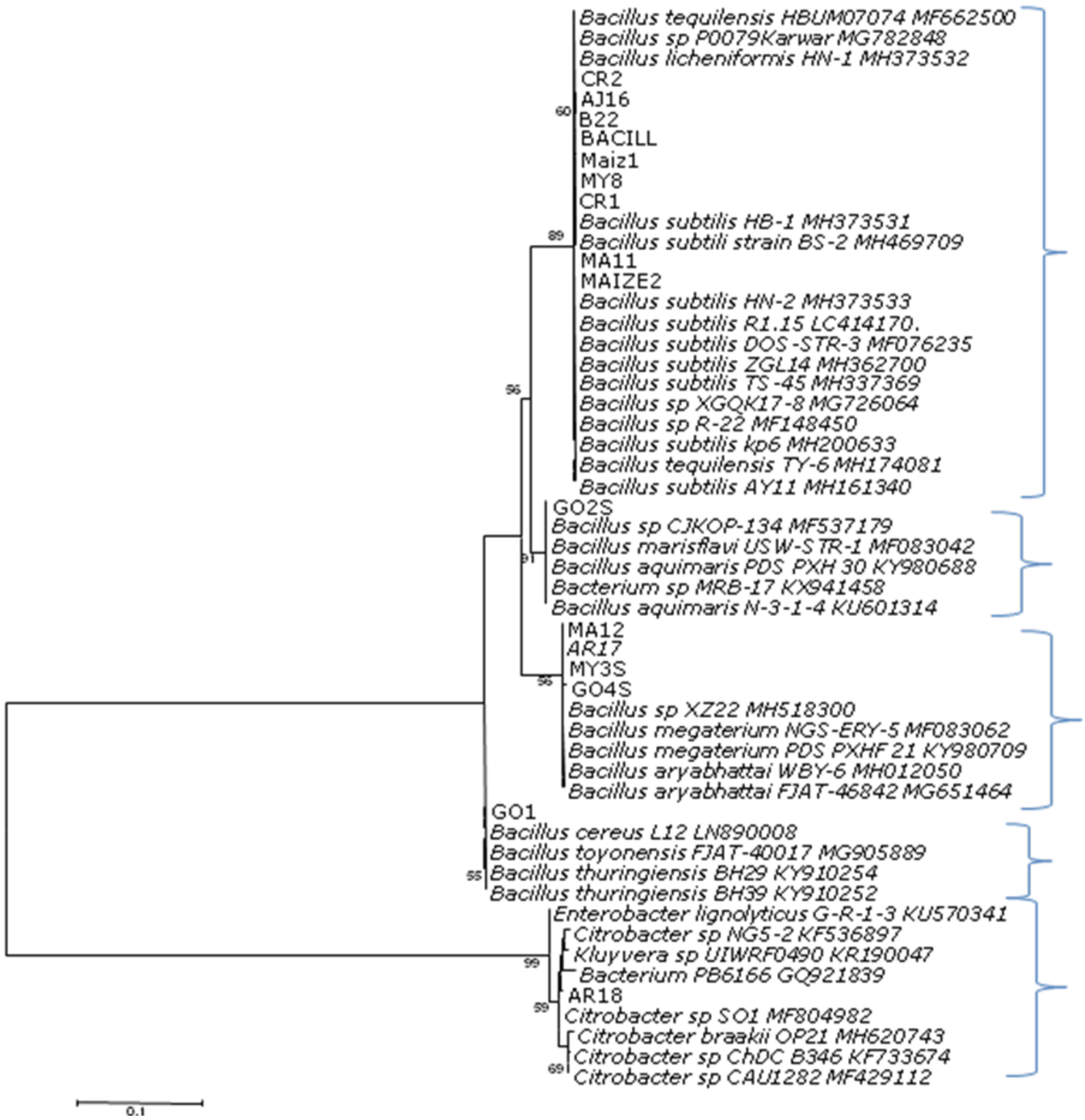
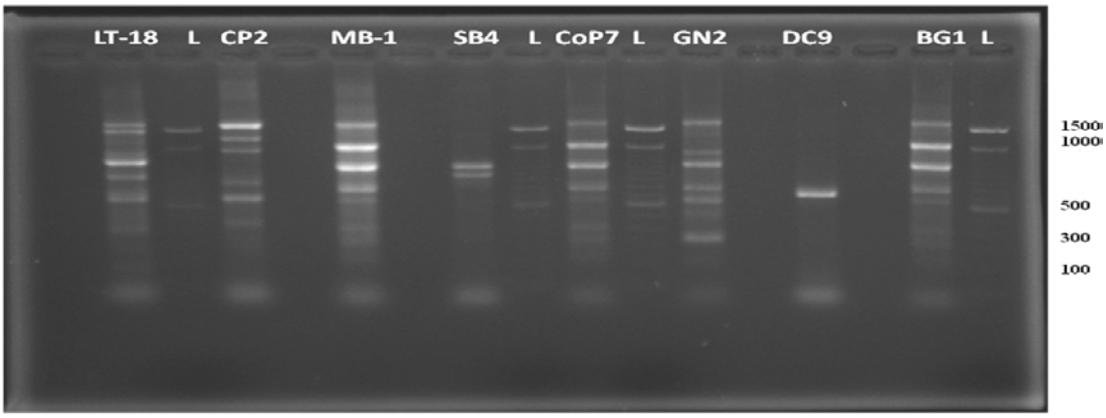


Fig. 18. ML tree of 16SrRNA gene

The phylogenetic relationships among the selected strains were studied and phylogenetic trees were generated. At least four different species (*Bacillus subtilis*, *B.aquimaris*, *B.megaterium* and *B. thuringiensis*) were found in our collection. Among four species, the *Bacillus thuringiensis strain* GO1 showed the most efficient bio-control potential candidate for wheat blight controlling as well as wheat plant growth promotion.

Expt 15. Molecular Characterization of rhizobial strains used for bio-fertilizer production at BINA

The fixation of N_2 by legumes plays key role in agricultural sustainability. Moreover, the further assessment of rhizobial genetic diversity is contributing both to the knowledge of biodiversity of rhizobia and to the usefulness of rhizobial collections, and it is developing long-term strategies to increase contributions of legume-fixed to agricultural productivity. Now a day’s molecular techniques such as DNA fingerprinting has been contributed greatly to enhance the knowledge of rhizobial diversity. Molecular characterization is important for researchers, policy makers and farmers to identify sources of bio-fertilizers of proved performance. In many cases, processors and end-use consumers also want to know varietal identity. Therefore, it is important to characterize our BINA developed rhizobial strains used in bio-fertilizers by DNA fingerprinting. Present study was conducted to determine the genotypic differences in rhizobial strains used in bio-fertilizer productions at BINA for different legumes. Enterobacterial repetitive intergenic consensus (ERIC) primer is very reliable for differentiating bacterial strains from various sources. In this study, ERIC fingerprinting method was used for the genotypic characterization and phylogenetic analysis of used strains. The results showed a high intraspecies diversity among the strains in terms of ERIC profiles. The ERIC primer set generated a reproducible and differentiating fingerprints including 1–9 fragments of 100–1500 bp (Fig 19). In general, the fingerprints generated with the ERlC derived DNA fingerprints showed the highest genetic polymorphism**.** Among the strains, strain BINACP2, used for chickpea inoculation, was more diverse strains than other strains. The strains BINAMB1 and BINAGN2, used for mungbean and groundnut inoculation were very closely related with each other. Similar trend also observed in case of the strains BINACP7 and BINABG1 those are used for cowpea and black gram inoculation.



LT-18 for lentil; CP2 for chickpea; MB1 for mungbean; SB4 for soybean; Cop 7 for cowpea; GN-2 for groundnut; DC-9 for sesbania and BG-1 for blackgram

Fig. 19: DNA fingerprint profile of rhzobial strains used for bio-fertilizer productions

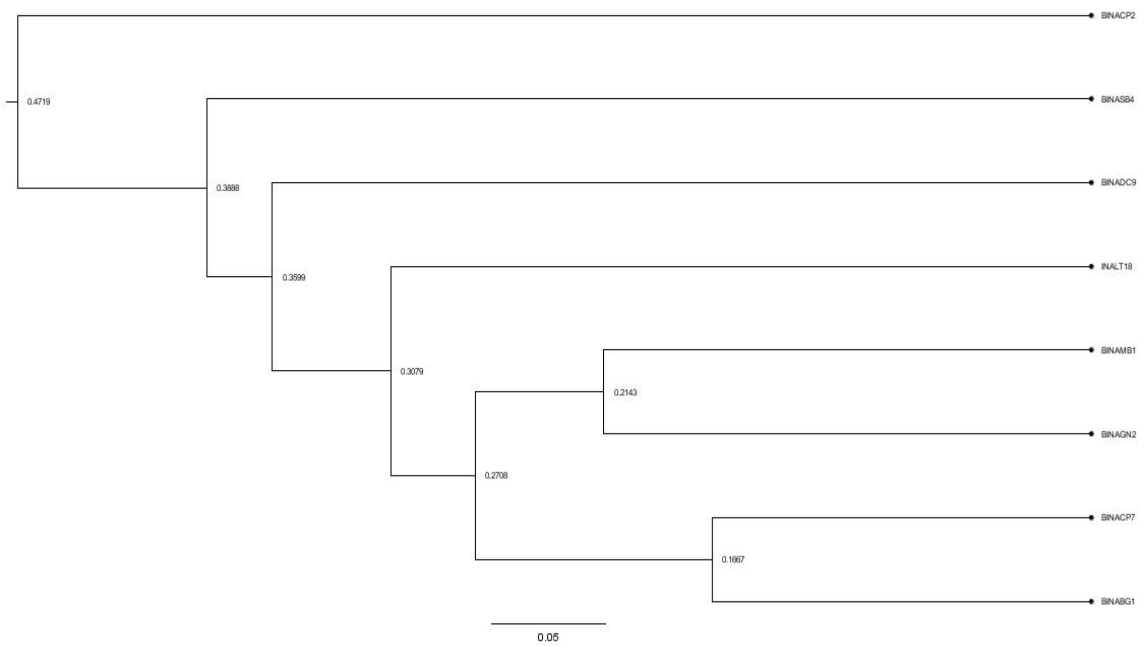


Fig. 20: A UPGMA dendogram based on ERIC-PCR DNA profile of eight rhizobal strains

Expt 16. Development of common bio-fertilizers for pea, grass pea and lentil

The increasing demand for food supply requires more-efficient use of natural resources and plant nutrient. Rhizobium is basic component of bio-fertilizers, which has emerged as a promising alternative to nitrogenous fertilizers. Rhizobial strains were isolated and characterized from Bangladesh, Germany, Turkey and Syria. Few strains showed promising results at glasshouse and pot experiment. Subsequently, we prepared bio-fertilizers from promising strains and evaluated their performance by field experiment. Our objectives were to develop common effective bio-fertilizers for lentil, pea and grass pea for increasing their yield. Experiment was conducted at BINA substation Ishordi, Pabna. There were ten treatments, eights from rhizobial strains, one nitrogenous control and one absolute control. Most of the bio-fertilizer treatments showed significant performance on yield and yield contributing characters of lentil, pea and grass pea over control treatment. Among the treatments, treatments five (strain BL153) and seven (BL129+BL153+BL640) had significant effect on growth and yield contributing characters of three legumes (lentil, pea and grass pea, Tables 11-13).

In case of pea (*Pisium sativum*), the maximum nodule and dry weight were produced by the rhizobial strain BL153 but statistically similar result also produced by the mixed culture of BL129, BL153, BL640 at vegetative stage (Table11). Similar result also observed at harvest stage. The highest number of pod/plant, 100 seed weight and seed yield were observed in the treatment five (Table11) and similar result also observed for the treatment seven.

Table 11: **Effect of rhizobial bio-fertilizers on growth and yield of motorshoti**

Treatments	At flowering stage		At harvest stage			
	Nodule weight (mg)	Plant weight (gm)	Pod/Plant (nos)	Seed/pot (nos)	100 seed weight (gm)	Seed yield / 10 plant (gm)
T_1(BL99)	47.33e	23.47de	24.88e	4.167	5.120bc	58.16de
T_2 (BL129)	54.67b	25.46c	26.00d	4.067	5.200bc	60.63bcd
T_3 (BL640)	51.83c	21.34f	23.75f	4.233	5.467ab	60.97bcd
T_4 (BL27)	54.67b	26.84b	27.00bc	4.067	5.340abc	60.18cde
T_5 (BL153)	57.37a	28.63a	28.10a	4.233	5.567a	64.87a
T_6 (BL99+100+174)	46.50e	23.83d	26.42cd	4.133	5.147bc	63.42abc
T_7 (BL129+153+640)	52.77c	26.03bc	27.33ab	4.200	5.580a	63.76ab
T_8 (GL28+70+13)	49.07d	21.25f	26.32cd	4.100	5.057c	62.47abc
T_9 (Urea)	39.08f	22.58e	22.92g	4.133	5.167bc	57.74de
T_{10} (Control)	40.33f	20.97f	21.75h	4.033	5.093c	56.83e

In case of pea (*Lathyrus sativs)*, the maximum dry weight was produced by the rhizobial strain BL153 but statistically similar result also produced by the mixed culture of BL129, BL153, BL640 at vegetative stage (Table 12). Similar result also observed at harvest stage. The highest number of pod/plant, 100 seed weight and seed yield were observed in the treatment five (table-6) and similar result also observed for the treatment seven.

Table-12: Effect of rhizobial bio-fertilizers on growth and yield of grass pea (khesari).

Treatments	At flowering stage		At harvest stage			
	Nodule weight (mg)	Plant weight (gm)	Pod/plant (nos)	Seed/pot (nos)	100 seed weight (gm)	Seed yield / 10 plant (gm)
T_1(BL99)	83.60f	17.00e	35.57cde	3.533	4.797ab	58.86c
T_2 (BL129)	101.4c	20.51b	37.50 c	3.567	4.617bcd	59.30bc
T_3 (BL640)	87.25e	17.44de	35.33de	3.587	4.380de	59.80abc
T_4 (BL27)	90.83d	18.97c	37.27cd	3.520	4.687abc	57.19c
T_5 (BL153)	105.8b	22.63a	45.43a	3.633	4.977a	62.98ab
T_6 (	86.55e	18.31cd	41.33b	3.533	4.373de	57.22 c
T_7	110.0a	22.13a	44.83a	3.663	4.867ab	63.29a
T_8	85.53ef	18.87c	33.20f	3.500	4.460cd	57.10c
T_9 (Urea)	78.63g	14.92f	36.50cd	3.633	4.733abc	57.73c
T_{10} (Control)	72.12h	14.05f	34.00ef	3.500	4.140e	55.89c

In case of lentil (*Lens culinaris)*, maximum dry weight was produced by the rhizobial strain BL153 but statistically similar result was also produced by the mixed culture of BL129, BL153, BL640 at vegetative stage (Table-13). At harvest stage, the highest number of pod/plant, 100 seed weight and seed yield were observed in the treatment five (Table-13) and similar result also observed for the treatment seven.

Table-13: Effect of rhizobial bio-fertilizers on growth and yield of lentil

Treatments	At flowering stage		At harvest stage			
	Nodule weight (mg)	Plant weight (gm)	Pod/plant (nos)	Seed/pot (nos)	100 seed weight (gm)	Seed yield / 10 plant (gm)
T_1(BL99)	50.07de	5.227c	130.2f	1.633	1.980ab	52.84cd
T_2 (BL129)	48.80e	6.180b	143.0d	1.643	1.967abc	54.54ab
T_3 (BL640)	51.08d	6.118b	153.8c	1.657	1.887abc	52.22cd
T_4 (BL27)	51.67d	6.460b	165.9a	1.660	1.963abc	54.48ab
T_5 (BL153)	66.77b	8.357a	169.5a	1.687	2.060a	55.58a
T_6 (BL99+100+174)	55.53c	6.377b	144.6d	1.667	1.953bc	54.61ab
T_7 (BL129+153+640)	69.23a	8.717a	159.7b	1.687	1.983ab	54.33ab
T_8 (GL28+70+13)	54.93c	6.830b	135.1e	1.677	1.867c	53.68bc
T_9 (Urea)	41.77f	6.450b	129.9f	1.637	1.943bc	51.58d
T_{10} (Control)	40.67f	4.233d	107.9g	1.630	1.863c	49.38e

Horticulture Division

Research Highlights

SPICES

Turmeric

A high yielding advanced turmeric genotype BHL-1 has been registered as Binahalud-1 in 2019 for its better rhizome yield and other important agronomic characters.

Chili

The mutant BL-11 performed better in respect of pungency and higher yield potential than Binamorich-1.

Garlic

Ten M_4 mutants with higher yield potential and bold clove size have been selected.

Onion

Three genotypes of onion appeared promising with high seed and bulb yield than other mutants.

Ginger

Seven M_3 populations having high yield potential and moderately tolerant to rhizome rot of zinger have been screened.

Black Cumin

Sixteen germplasm recieved from the Ministry of Agriculture (MoA) were grown at BINA, HQs farm in Rabi season. At harvest, seeds of all these germplasm were collected and have been preserved as breeding materials for future research programme. Moreover, large numbers of M2 variants, developed from different local cultivars were grown in BINA HQs farm.

VEGETABLES

Bottle gourd

Three M_5 mutants of bottle gourd have been selected having the highest number of fruits per plant, lower disease and insect susceptibility, broad leaves as well as good cooking quality.

Brinjal

Two high yielding advanced mutants of brinjal moderately tolerant to brinjal shoot and fruit borer and phomopsis blight have been selected for further yield trial at different locations of Bangladesh. To create mutant tolerant to waterlogged condition, seeds of some local genotypes of brinjal were irradiated with different doses of gamma rays and the seeds were sown at BINA HQs farm, Mymensingh in Kharif season.

Carrot

The mutant $V_1D_{75}P_{17}$ and $V_2D_{75}P_{18}$ derived from irradiating the seeds of *Brasilia agroflora* and *Prima agroflora* respectively with 75 Gy dose of gamma rays produced the highest seed yield.

Okra

Three desirable lines of okra collected from Africa were grown at BINA HQs farm, Mymensingh to select high yield potential with long harvesting duration and soft fiber.

Cucumber

Five mutants were identified with high yield potential, moderately tolerant to cucurbit fruit fly, desirable size, shape and color. In addition, some M_1 plants harvested for next year screening.

Tomato

With a view to develop high yielding new summer varieties, seeds of five varieties have been irradiated with 75Gy, 100Gy and 150Gy dose of gamma rays. Moreover, 750g, 1.2kg and 950g, respectively breeder's seed produced of Binatomato-10, Binatomato-11 and Binatomato-12.

Furthermore, some local vegetables germplasm like sweet gourd, country bean, eggplant and sweet pepper (collected from abroad) were screened to see their inherent characteristics for further irradiation.

FRUITS

Malta

The M_1 plant $WNMD_{40}P_2$ derived from grafting the irradiated scion of Washington Naval variety on rootstock of lime, produced the highest number of fruits (268) and the highest TSS (14.2%).

Lime

The M_1 $LBD_{40}P_1$ plant produced the highest number of fruits (365).

Pomegranate

Out of eight genotypes, the tallest plant (301cm) was recorded in P_2 genotype followed by P_1 genotype (280cm) and P_3 genotype (255cm) whereas the shortest plant was recorded in B_1 genotype (172cm).

The cultivar P_2 produced the maximum number of fruits (59), length (5.5cm), breadth (5.4cm) and weight of fruit (260g) and accumulated the highest TSS (18.6%).

SPICES

Turmeric

On-farm yield trial of two advanced lines and a check variety of Turmeric

On-farm yield trials were carried out with two advance lines and a popular check variety, BARI Halud-5 at BINA HQs farm, farmer's field at Mymensingh, Magura and Khagrachari in order to assess the performances following Randomized Complete Block Design (RCBD) with three replications and individual plot size of 30 m^2 (6 m × 5 m). Recommended doses of fertilizers, cultural management and intercultural practices, production packages were followed to ensure normal plant growth and development. Data on various characters, such as plant height, number of plants $hill^{-1}$, number of leaves $hill^{-1}$, number of fingers $hill^{-1}$, fresh rhizome weight $hill^{-1}$, dry rhizome weight $hill^{-1}$ and total fresh rhizome yield were taken from randomly selected five plants. Among these genotypes, BHL-1 (Proposed Binahalud-1) showed better field performances considering rhizome yield per hectare and other important agronomic characters viz. plant height, number of plant $hill^{-1}$, number of leaves $hill^{-1}$, fresh weight of rhizome $hill^{-1}$, dry rhizome weight $hill^{-1}$ and total rhizome yield. Statistical analyses of different characters of the advanced lines and the check variety are presented in the Table 1.

Table 1. Performances of two turmeric genotypes and a check variety grown under field condition at different location during 2018-19

Genotypes	Plant height (cm)	Number of plant $hill^{-1}$	Number of leaves $hill^{-1}$	Number of fingers $hill^{-1}$	Fresh rhizome weight $hill^{-1}$	Dry rhizome weight $hill^{-1}$	Fresh rhizome yield (t ha^{-1})
BINA HQs Farm, Mymensingh							
BHL-1 (Proposed Binahalud-1)	130.3a	7.26a	30.25a	38.82b	985.6a	365.5a	31.65a
BHL-2	114.7c	6.32b	23.36b	19.98c	563.6c	140.9c	18.63b
BARIhalud-5 (Check)	122.1b	6.25b	25.68b	54.32a	764.4b	243.1b	19.65b
Mymensingh (Farmer's field)							
BHL-1 (Proposed Binahalud-1)	132.6	7.98	33.62	37.65	1065.6	393.0	33.20
BHL-2	114.7	6.86	25.31	20.35	652.4	163.2	19.38
BARIhalud-5 (Check)	123.3	7.05	26.35	57.32	785.6	255.0	23.50
Khagrachari							

BHL-1 (Proposed Binahalud-1)	131.3a	7.15a	33.62a	36.26b	1254.3a	463.7a	33.65a
BHL-2	112.4c	6.35b	20.13c	19.35c	752.4b	188.0c	20.31b
BARIhalud-5 (Check)	124.4b	7.05a	27.15b	56.32a	812.0b	264.8b	20.63b
Magura							
BHL-1 (Proposed Binahalud-1)	145.5a	8.50a	34.50a	37.26b	1105.0a	408.8a	34.15a
BHL-2	120.4c	6.95b	20.25c	21.35c	815.0c	198.0c	22.50c
BARIhalud-5 (Check)	133.5b	8.00a	28.50b	42.60a	980.0b	317.9b	26.90b

In a column, values with same letters do not differ significantly at 5% level as per DMRT.

Form the results, it was observed that the genotype BHL-1 was superior over the tested genotype with check variety BARI Halud-5. The proposed variety was also found tolerant to prevailing major diseases and insects. On the basis of superior performances of the advanced line BHL-1, it was decided to register this line as improved high yielding turmeric variety as Binahalud-1.

Chilli

Advanced yield trial of two M_6 pungent mutants of chili

With a view to identify high yielding pungent mutant of chili than Binamorich–1, the experiment was conducted with two M_6 mutants along with Binamorich-1 to observe the performance of the selected pungent mutants. Seedlings of the mutant were transplanted on 8th November, 2018 at BINA HQs farm and Kashiar char experimental field near HQ, on 11th November at BINA, sub-station farm, Magura. The experiment was laid out in RCBD with 3 replications using recommended spacing 50 cm × 40 cm. A unit plot size was 4 m × 3 m. Recommended doses of fertilizers, cultural and intercultural practices and production packages were followed to ensure normal plant growth and development. Data on various characters, such as plant height, fruit length, fruit diameter, number of fruit plant^{-1}, fruit yield and average fruit weight were taken from randomly selected five plants. Fruit yield of each plot was recorded after harvest and appropriate statistical analyses were performed for comparison of means of each character which are presented in Table 2.

Results showed significant variations among the mutants and check for most of the characters in individual location and combined over locations. On an average, it was observed that plant height ranged from 35 cm in $CM_7D_{75}P_8$ (P) to 24 cm in mother plant (Table 2). The mutant line $CM_7D_{75}P_8$ (P) produced the highest number of fruits plant^{-1} (156) and mother plant produced the lowest number of fruits (82). The mutant line $CM_7D_{75}P_8$ (P) produced the highest total yield

(33.5 tha^{-1}). Among the three locations, Kashiarchar field experiment performed better in terms of yield (30.17 tha^{-1}).

Table 2. Mean performance of chili mutants (M_6) and check variety for different yield and yield contributing characteristics

Locations	Mutant/ Variety	Plant height (cm)	Branch $plant^{-1}$ (no.)	Fruits $plant^{-1}$ (no.)	Fruit length (cm)	Fruit diameter (cm)	Yield $plant^{-1}$ (kg)	Yield (tha^{-1})
BINA HQ Farm	$CM_7D_{75}P_8$ (P)	35	8	156	14	6	1.25	33.32
	$CM_7D_{300}P_{93}$	33	7	139	13	6	1.10	31.38
	$CM_7D_{150}P_{49}$	29	8	133	14	5	1.08	30.09
	Mother	23	5	82	8	3	0.70	22.12
Kashiarchar Experimental field	$CM_7D_{75}P_8$ (P)	37	9	164	15	7	1.32	35.02
	$CM_7D_{300}P_{93}$	34	7	143	14	6	1.17	31.97
	$CM_7D_{150}P_{49}$	34	7	142	13	6	1.06	31.02
	Mother	24	6	86	10	3	0.76	23.09
Magura	$CM_7D_{75}P_8$ (P)	33	8	146	13	6	1.22	32.13
	$CM_7D_{300}P_{93}$	32	7	133	14	5	1.13	31.08
	$CM_7D_{150}P_{49}$	29	8	135	12	5	1.10	31.03
	Mother	24	6	78	8	3	0.68	21.97
Combined means over locations	$CM_7D_{75}P_8$ (P)	35	8	156	14	7	1.26	33.5
	$CM_7D_{300}P_{93}$	33	7	138	13	6	1.13	31.47
	$CM_7D_{150}P_{49}$	31	7	136	13	5	1.08	31.07
	Mother	24	6	82	9	3	0.71	22.38
Locations	BINA HQ Farm	30	7	128	12	5	1.04	29.55
	Kashiarchar Experimental field	32	7	133	13	6	1.07	30.17
	Magura	30	7	123	12	5	1.05	29.35

Garlic

Evaluation of M_4 mutants of Garlic

The experiment was conducted to observe the performance of the M_4 mutants developed from Garlic BAURasun-1, BAURasun-2, BAURasun-3, BAURasun-4 and AC-5. Cloves of the garlic were planted during 2nd week of November 2018. The experiment was laid out in row planting method using spacing 30 cm × 15 cm. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters were taken from five randomly selected plants of each mutant.

Results showed that the M_4 mutants differed with the parent variety for yield and yield attributes (Table 3, Table 4, Table 5, Table 6 and Table 7). M_4 mutants produced higher yield compared to non-irradiated mother plants of B_1D_0.

In case of BAURasun-1, yield of M_4 mutants ranged from 8.34 tha^{-1} to 11.81 tha^{-1} whereas the highest yield 11.81 tha^{-1} was produced by the $B1M_4D_{1.5}P_2$ mutant plants. The lowest yield was produced by $B_1M_4D_{2.0}P_2$ (8.34 tha^{-1}) (Table 3).

In case of BAURasun-2, yield of M_4 mutants were ranged from 8.75 to 5.17 tha^{-1}. The $B_2M_4D_{1.5}P_3$ produced the highest yield (8.75 tha^{-1}) .The lowest yield was produced by $B_2M_4D_{0.75}P_{12}$ (Table 4).

In case of BAURasun-3, yield of M_4 mutants were observed ranged from 6.17 to 10.45 tha^{-1}. The $B_3M_4D_{0.75}P_1$ mutant plant produced the highest yield (10.45 t/ha) and the lowest yield was produced by $B_3M_4D_{2.0}P_1$ (6.17 tha^{-1}) (Table 5).

In case of BAURasun-4, yield of M_4 mutants were observed ranged from 6.77 to 9.92 tha^{-1}. The $B_4M_4D_{1.5}P_2$ plant produced the highest yield (9.92 tha^{-1}) and the lowest yield was produced by B_4D_0 (6.77 tha^{-1}).

The genotype AC-5 **(Binarasun-1)** of garlic responded well to the gamma irradiation. In case of AC-5 population, yield of M_4 mutants were observed ranged from 10.48 to 8.82 tha^{-1}. The AC-$5M_4D_{0.75}P_1$ plant produced the highest yield (10.48 tha^{-1}) which was followed by AC-$5M_4D_{0.75}P_9$ (10.02 tha^{-1}) and AC-$5M_4D1P_5$ (9.97 tha^{-1}). The lowest yield was produced by AC-$5M_4$ $D_{0.75}P_8$ (8.76 tha^{-1}) and the non irradiated mother (8.28 tha^{-1}) (Table 7).

Table 3. Evaluation of M_4 mutants derived from BAURasun-1

M_4 mutants	Plant height (cm)	Leaf $plant^{-1}$ (no.)	Fresh wt. of Bulb $plant^{-1}$ (g)	Clove $bulb^{-1}$ (no.)	Clove yield $Plot^{-1}$ (kg)	Bulb yield (tha^{-1})
$B_1M_4D_{0.75}P_1$	67.56	11.15	25.91	19.47	0.88	9.20
$B_1M_4D_{0.75}P_2$	68.51	12.32	26.12	17.34	0.90	9.40
$B_1M_4D_{1.0}P_1$	58.70	8.25	21.82	30.32	1.03	10.59
$B_1M_4D_{1.0}P_2$	56.40	7.04	20.86	27.88	0.96	9.79
$B_1M_4D_{1.0}P_3$	58.90	7.15	18.60	32.03	1.10	11.43
$B_1M_4D_{1.0}P_5$	54.60	5.83	21.93	26.92	0.93	9.45
$B_1M_4D_{1.0}P_6$	49.60	6.11	21.07	27.77	0.95	9.76
$B_1M_4D_{1.0}P_7$	59.70	4.51	23.11	28.52	0.98	10.02
$B_1M_4D_{1.5}P_1$	59.80	7.26	20.75	28.62	0.98	10.06
$B_1M_4D_{1.5}P_2$	58.63	6.05	20.00	33.62	1.17	11.81
$B_1M_4D_{1.5}P_3$	51.60	6.16	20.10	23.83	0.82	8.37
$B_1M_4D_{1.5}P_5$	52.64	7.26	21.39	23.73	0.82	8.35
$B_1M_4D_{2.0}P_1$	49.90	4.62	20.21	25.86	0.91	9.37
$B_1M_4D_{2.0}P_2$	49.60	4.84	21.29	24.05	0.82	8.34
$B_1M_4D_{2.0}P_4$	51.50	6.82	18.81	26.71	0.93	9.57
$B_1M_4D_{2.0}P_5$	49.40	6.38	22.36	27.24	0.93	9.55
Parent	67.00	11.98	21.18	28.41	0.97	9.99
SD	6.47	2.39	2.05	4.08	0.10	0.95

Table 4. Evaluation of M_4 mutants derived from BAURasun-2

M_4 mutants	Plant height (cm)	Leaf plant^{-1} (no.)	Fresh wt. of bulb plant^{-1} (g)	Clove bulb^{-1} (no.)	Bulb yield plant^{-1} (kg)	Clove yield (tha^{-1})
$B_2M_4D_{0.75}P_2$	63.86	11.31	17.08	26.11	0.60	5.96
$B_2M_4D_{0.75}P_3$	61.80	12.25	17.29	27.24	0.61	6.03
$B_2M_4D_{0.75}P_4$	59.23	11.52	15.85	28.16	0.56	5.52
$B_2M_4D_{0.75}P_{11}$	56.24	10.90	16.77	23.14	0.59	5.87
$B_2M_4D_{0.75}P_{12}$	62.42	12.66	14.82	23.45	0.52	5.17
$B_2M_4D_{1.0}P_2$	53.05	10.90	16.16	29.59	0.57	5.63
$B_2M_4D_{1.0}P_3$	54.08	8.10	18.32	26.11	0.64	6.39
$B_2M_4D_{1.0}P_5$	52.02	10.90	24.18	29.59	0.85	8.44
$B_2M_4D_{1.0}P_7$	49.96	11.21	16.05	31.23	0.56	5.60
$B_2M_4D_{1.5}P_1$	48.00	10.90	24.39	25.09	0.85	8.43
$B_2M_4D_{1.5}P_3$	48.00	10.17	25.11	24.17	0.88	8.75
$B_2M_4D_{1.5}P_4$	48.51	10.28	16.05	25.09	0.56	5.60
$B_2M_4D_{1.5}P_6$	46.97	10.90	16.36	23.04	0.57	5.65
$B_2M_4D_{2.0}P_1$	49.96	12.04	24.28	24.47	0.84	8.39
$B_2M_4D_{2.0}P_3$	45.73	11.94	22.12	26.42	0.77	7.70
$B_2M_4D_{2.0}P_4$	47.90	9.86	22.33	24.17	0.78	7.79
Parent	41.76	8.82	16.36	26.11	0.57	5.71
SD	6.41	1.18	3.71	2.42	0.13	1.28

Table 5. Evaluation of M_4 mutants derived from BAURasun-3

M_4 mutants	Plant height (cm)	Leaf plant^{-1} (no.)	Fresh wt. of bulb plant^{-1} (g)	Clove bulb^{-1} (no.)	Bulb yield plant^{-1} (kg)	Clove yield (tha^{-1})
$B_3M_4D_{0.75}P_1$	68.75	9.43	23.05	29.71	1.04	10.45
$B_3M_4D_{0.75}P_2$	71.12	8.40	21.62	26.64	0.76	7.56
$B_3M_4D_{0.75}P_3$	63.14	8.91	19.98	19.67	0.70	7.00
$B_3M_4D_{0.75}P_4$	61.37	7.89	22.64	21.00	0.79	7.91
$B_3M_4D_{0.75}P_{10}$	63.24	7.68	19.26	23.97	0.67	6.74
$B_3M_4D_{1.0}P_2$	62.45	9.02	198.24	17.01	0.70	6.99
$B_3M_4D_{1.0}P_3$	59.69	8.61	20.69	24.38	0.72	7.24
$B_3M_4D_{1.5}P_1$	56.54	9.84	20.18	29.51	0.71	6.93
$B_3M_4D_{1.5}P_2$	47.58	7.07	21.21	24.18	0.72	7.20
$B_3M_4D_{1.5}P_3$	50.43	7.99	22.64	26.12	0.79	7.92
$B_3M_4D_{1.5}P_5$	48.46	8.09	21.51	27.35	0.77	7.71
$B_3M_4D_{2.0}P_1$	50.43	8.09	17.62	25.00	0.62	6.17
$B_3M_4D_{2.0}P_2$	48.07	8.30	18.75	20.49	0.66	6.56
Parent	63.43	9.02	13.52	23.97	0.58	6.78
SD	7.94	0.74	47.65	3.67	0.11	1.02

Table 6. Evaluation of M_4 mutants derived from BAURasun-4

M_4 mutants	Plant height (cm)	Leaf plant^{-1} (no.)	Fresh wt. of bulb plant^{-1} (g)	Clove bulb^{-1} (no.)	Bulb yield plant^{-1}	Bulb yield (tha^{-1})
$B_4M_4D_{0.75}P_1$	88.13	8.39	25.06	28.06	0.88	8.77
$B_4M_4D_{0.75}P_3$	85.95	8.49	25.99	23.09	0.91	9.09
$B_4M_4D_{0.75}P_4$	86.98	11.60	22.99	25.37	0.80	8.05
$B_4M_4D_{0.75}P_5$	85.95	12.74	23.19	24.12	0.81	8.12
$B_4M_4D_{0.75}P_6$	86.98	13.77	25.26	29.51	0.88	8.84
$B_4M_4D_{0.75}P_7$	84.92	12.84	27.13	21.23	0.95	9.49
$B_4M_4D_{0.75}P_8$	82.52	13.77	27.33	22.05	0.96	9.57

$B_4M_4D_{0.75}P_{10}$	81.38	13.05	27.96	22.16	0.98	9.78
$B_4M_4D_{0.75}P_{11}$	80.24	10.87	23.40	24.23	0.82	8.19
$B_4M_4D_{0.75}P_{12}$	82.52	12.22	27.44	26.51	0.99	9.60
$B_4M_4D_{0.75}P_{13}$	83.67	10.98	24.23	27.54	0.85	8.48
$B_4M_4D_{1.0}P_1$	80.24	9.32	26.30	24.44	0.92	9.23
$B_4M_4D_{1.0}P_2$	76.12	9.84	24.12	29.82	0.84	8.47
$B_4M_4D_{1.5}P_2$	70.18	8.18	19.47	27.54	0.68	9.92
Parent	98.53	5.82	14.06	20.92	0.58	6.77
SD	6.24	2.38	3.59	2.94	0.11	0.84

Table 7. Evaluation of M_4 mutants derived from AC-5 (Binarasun-1)

M_4 mutants	Plant height (cm)	Leaf plant^{-1} (no.)	Fresh wt. of bulb plant^{-1} (g)	Clove bulb^{-1} (no.)	Bulb yield plant^{-1}	Bulb yield (tha^{-1})
AC-5$M_4D_{0.75}P_1$	86.75	11.72	29.66	27.17	1.04	10.48
AC-5$M_4D_{0.75}P_2$	81.46	11.93	26.24	25.30	0.92	9.18
AC-5$M_4D_{0.75}P_4$	80.04	12.86	27.38	25.61	0.96	9.58
AC-5$M_4D_{0.75}P_6$	78.82	11.82	27.58	23.44	0.71	8.94
AC-5$M_4D_{0.75}P_7$	80.95	10.78	26.55	21.15	0.91	9.10
AC-5M4D0.75P_8	78.82	10.68	26.65	25.41	0.92	8.76
AC-5$M_4D_{0.75}P_9$	81.97	10.78	28.72	23.33	1.00	10.02
AC-5$M_4D_{0.75}P_{10}$	76.58	11.72	27.69	23.23	0.96	9.66
AC-5$M_4D_{0.75}P_{12}$	79.94	12.76	26.75	23.23	0.93	9.35
AC-5$M_4D_{0.75}P_{13}$	81.26	11.20	27.58	20.84	0.96	9.64
AC-5$M_4D_{1.0}P_1$	74.55	10.27	27.79	26.13	0.95	9.55
AC-5$M_4D_{1.0}P_2$	73.63	9.54	25.20	21.36	0.88	8.84
AC-5$M_4D_{1.0}P_4$	74.75	8.61	25.30	21.26	0.88	8.82
AC-5$M_4D_{1.0}P_5$	73.53	6.84	27.90	23.33	0.97	9.97
Parent	89.70	10.27	23.44	20.64	0.82	8.28
SD	4.62	1.58	1.52	2.11	0.08	0.58

Onion

Evaluation of M_4 mutants of Onion

The experiment was conducted to observe the performance of the M_4 mutants derived from six onion accessions (Taherpuri, Faridpuri, Onion-2, Onion-3, Spring and Indian onion-1). The experiment was followed plant progeny row method using spacing 30 cm × 15 cm. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters were taken from five randomly selected plants of each mutant.

Results showed that the mutants differed for yield and yield attributes compare to check variety (Table. 8). In case of six genotypes of onion, the M_4 mutants $TD_{50}P_1$, $TD_{75}P_1$, $TD_{100}P_1$, $FD_{50}P_3$, $O_2D_{50}P_4$, $O_3D5_0P_3$, $SD_{50}P_{13}$ and $ID_{50}P_2$ produced higher seed yield ($TD_{50}P_1$ = 3.68 g, $TD_{75}P_1$ = 3.43 g, $TD_{100}P_1$ = 3.52 g, $FD_{50}P_3$ = 3.12 g, $O_2D_{50}P_4$ = 3.01 g, $O_3D_{50}P_3$ = 3.38 g, $SD_{50}P_{13}$= 3.21 g and $ID_{50}P_2$ = 3.04 compared to their mother (Table 8).

Table 8. Evaluation of M_4 mutants of six onion genotypes

M_4 mutants	Plant height (cm)	No. of leaves plant^{-1}	No. of flowering stalks plant^{-1}	Length of stalks (cm)	No. of umbels plant^{-1}	No. of seeded fruits umbel^{-1}	Seed wt. umbel^{-1} (g)	Seed yield plant^{-1} (g)	Bulb yield tha^{-1}
TD_0P_1	51.2	5.77	2.87	48.5	3.42	96.6	0.88	3.01	1.65
$TD_{50}P_1$	52.5	5.66	3.83	51.2	3.95	109.9	1.61	3.68	1.98
$TD_{75}P_1$	50.1	5.16	3.06	48.3	3.69	101.1	1.42	3.43	1.71
$TD_{100}P_1$	55.5	5.39	3.23	51.7	3.80	103.6	1.50	3.52	1.92
FD_0P_1	48.2	5.16	2.89	46.0	2.23	77.8	0.82	2.23	1.32
$FD_{50}P_3$	51.3	5.95	3.60	49.8	3.68	99.6	1.42	3.12	1.81
$FD_{75}P_5$	48.7	5.42	3.00	47.9	2.96	86.6	1.22	3.03	1.54
$O_2D_0P_2$	49.9	5.19	2.56	44.3	2.35	75.4	0.72	1.67	0.92
$O_2D_{50}P_4$	51.3	5.66	3.27	50.5	3.21	99.8	1.34	3.01	1.59
$O_2D_{75}P_8$	49.3	6.30	3.0	46.6	2.70	88.8	1.09	2.81	1.15
$O_3D_0P_3$	45.0	5.19	2.37	44.6	2.57	81.4	0.73	2.09	1.02
$O_3D_{50}P_9$	42.8	6.98	3.36	49.1	3.54	98.2	1.28	3.38	1.68
$O_3D_{75}P_{10}$	47.2	5.48	3.23	48.2	3.21	93.9	1.06	3.21	1.41
$O_3D_{100}P_{11}$	46.5	6.10	3.21	48.7	3.18	94.4	1.14	3.27	1.49
SD_0P_1	45.3	4.31	2.61	43.8	2.62	78.1	0.71	2.62	1.01
$SD_{50}P_{13}$	49.1	6.09	3.37	49.1	3.30	96.9	1.29	3.21	1.45
ID_0P_1	41.9	4.71	2.00	40.3	2.04	67.9	0.61	1.67	0.73
$ID_{50}P_2$	49.2	6.51	3.30	49.4	3.33	92.7	1.27	3.04	1.23
$ID_{75}P_4$	45.5	4.83	3.04	47.1	3.10	79.8	1.01	2.74	1.04
$ID_{100}P_5$	45.3	5.22	3.11	46.6	3.16	81.1	1.13	2.63	1.09
SD	2.47	1.35	0.587	2.65	0.35	6.58	0.085	0.245	0.142

Note: T-Taherpuri, F-Faridpuri, O_2 –Onion-2, O_3-Onion-3, S-Spring, I-Indian onion-1

Ginger

Screening of M_3 population of Ginger

The experiment was conducted to observe the performance of the M_3 population derived from 8 ginger accessions viz. Rangpur local (Taragonj), Dinajpur local (Rajbari, khanshama), Thanchy local, Shilkhali local, Mirzapur lama, Bandarban local (Whykong,Lama), Dinajpur local (Aamgonj, Khanshama), Bandarban local (Ruma). Eight mutants including parents were planted during 3rd week of November, 2017. The experiment followed plant progeny row using spacing 40 cm × 20 cm. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters were taken from five randomly selected plants of each mutant.

Results showed that the mutants differed for yield and yield attributes. In case of eight genotypes of ginger, the M_3 population produced higher yield at 2 Gy compare to their parents (Table 9). The population under 2 Gy irradiation would be further evaluated for rhizome yield and other characters in the next year.

Table 9. Screening of M_3 population of different genotypes of Ginger

Treatment	Plant height (cm)	No. of leaves plant^{-1}	No. of tillers clump^{-1}	Wt. of old mother rhizome plant^{-1} (g)	Wt. of primary rhizome clump^{-1} (g)	Wt. of secondary rhizome clump^{-1} (g)	Yield plant^{-1}(g)	Yield (tha^{-1})
Taragonj, Rangpur (2 Gy)	32.80	23.55	13.74	10.30	326.22	105.97	111.48	19.37
Taragonj,Rangpur (0 Gy)	34.64	26.89	16.08	10.54	340.10	130.52	113.46	15.01
Rajbari, khanshama, Dinajpur (2 GY)	30.47	20.54	11.49	8.36	128.06	98.39	94.77	14.61
Rajbari, khanshama, Dinajpur(0 GY)	35.90	23.91	13.00	9.79	256.12	99.40	104.97	12.79
Thanchy (2 Gy)	36.53	25.25	16.61	11.11	316.33	86.39	117.22	20.24
Thanchy (0 Gy)	38.88	27.32	15.11	12.18	476.89	97.40	137.44	16.99
Shilkhali (2 Gy)	35.09	29.92	10.68	12.09	119.30	151.24	127.90	21.42
Shilkhali (0 Gy)	40.11	29.45	11.72	11.11	457.17	82.06	129.46	17.36
Mirzapur, Lama, Bandarban (2 Gy)	31.43	21.76	9.29	9.53	283.08	109.12	97.02	16.62
Mirzapur, Lama, Bandarban (0 Gy)	36.37	24.68	10.60	11.51	337.01	118.39	113.74	14.60
Whykong, Lama, Bandarban (2 Gy)	36.37	24.68	11.07	10.53	337.01	118.39	103.57	14.60
Whykong, Lama, Bandarban (0 Gy)	41.24	27.47	9.60	8.14	327.56	137.54	121.61	12.99
Aamgonj, Dinajpur (2 Gy)	35.09	29.92	10.68	12.09	119.30	151.24	112.64	14.27
Aamgonj, Dinajpur (3 Gy)	31.90	22.89	11.10	8.45	227.60	130.58	110.55	13.05
Aamgonj, Dinajpur (0 Gy)	40.11	29.45	11.72	11.11	457.17	82.06	121.33	11.11
Ruma, Bandarban (2 Gy)	34.30	22.61	8.51	8.17	323.52	116.35	111.71	17.07
Ruma, Bandarban (0 Gy)	36.80	26.44	9.98	12.06	323.52	135.48	119.59	16.10
SD	3.11	2.97	2.34	1.45	108.97	22.35	11.19	2.78

Black Cumin

Growing of M_2 generation of black cumin

The experiment was conducted at Kashiarchar experimental field near BINA HQ with 46 M_2 derived from irradiated seeds of three local germplasm of black cumin at different doses to screen high yield potential and better quality pod. Seeds were grown on 16th November 2018 at 30 cm apart from row to row following non replicated plant-progeny-rows. The parent germplasm also included in the experiment. Plot size for the populations of each dose germplasm^{-1} was taken as per requirement. Recommended doses of fertilizers were applied with recommended cultural and intercultural practices. Data on plant height, number of pods plant^{-1}, pod yield plant^{-1}, hundred pod weight and total yield plot-1 were recorded. On the basis of the result, thirty two M_2 population were screened which will be grown in next rabi season for further screening.

Table 10. Growing of M_2 generation of different genotypes of black cumin

Germplasm	Plant height	No. of branch/plant	No. of pod/plant	Wt. of seed/pod
K_2D_0	71.0	12	49	5.0
K_2D_{10}	70.0	15	55	5.3
K_2D_{20}	78.0	14	48	5.0
K_2D_{50}	80.0	15	58	5.9
K_2D_{100}	76.0	11	46	4.8
K_2D_{150}	76.0	11	43	4.3
K_2D_{250}	66.0	6	34	3.4
K_2D_{300}	65.0	6	27	2.5
K_3D_0	75.0	8	49	4.6
K_3D_{10}	75.0	9	52	4.9
K_3D_{20}	77.0	10	61	6.0
K_3D_{50}	73.0	8	48	5.0
K_3D_{150}	74.0	8	43	5.0
K_3D_{250}	70.0	10	37	3.8
K_4D_0	71.0	7	40	4.1
K_4D_{10}	73.0	8	48	4.6
K_4D_{20}	73.0	8	49	4.9
K_4D_{50}	76.0	10	55	5.2
K_4D_{100}	76.0	8	38	4.0
K_4D_{150}	78.0	11	28	3.0
K_5D_{20}	70.0	8	40	4.1
K_5D_{50}	71.0	8	43	4.2
K_5D_{100}	68.0	7	37	3.9
K_5D_{150}	58.0	12	30	3.0
SD	4.05	2.23	7.70	0.75

VEGETABLES

Bottle gourd

Evaluation of promising M_5 mutants of Bottle gourd

The experiment was conducted at Sutiakhali, Mymensingh and Khagrachari during Rabi season 2018-19 to evaluate the performance of promising M_5 mutants of bottle gourd. The experiment was laid out in row planting method using recommended spacing (3 plants per pit), Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such fruit length, fruit diameter, number of fruit/plant, fruit yield and average fruit weight were taken were taken from five randomly selected plants of each mutant (Table 11 and Table 12).

Results showed that BL-4$M_5D_{300}P_{4-2}$ produced the highest number of fruits (29.01 fruit plant^{-1}) in all the mutants population (Table 11). Rest of the mutants showed the number of fruit ranged from 18.65-26.94 fruit plant^{-1}. The control plant produced 18.65 fruit plant^{-1}.

Table 11. Yield attributes of elite M_5 mutants of Bottle gourd at Mymensingh

Mutant/Variety	No. of fruits plant^{-1}(no.)	Length of fruit (cm)	Diameter of fruit (cm)	Colour
BL-4(control)	18.65	44.20	36.80	Dark green with whitish spot
BL-4$M_5D_{300}P_{4-1}$	25.90	48.31	40.24	Light green
BL-4$M_5D_{300}P_{4-2}$	29.01	51.4	39.21	Light green
BL-4$M_5D_{300}P_{5-2}$	25.90	48.31	40.24	Light green
BL-4$M_5D_{300}P_{6-2}$	23.15	45.12	39.21	Light green with whitish spot
BL-4$M_5D_{300}P_{6-3}$	25.90	43.17	37.15	Light green with whitish spot
BL-4$M_5D_{150}P_{3-2}$	23.83	49.34	39.21	Dark green
BL-4$M_5D_{150}P_{3-3}$	26.94	54.48	41.28	Dark green
SD	3.10	3.81	1.53	-

Results showed that BL-4$M_5D_{300}P_{4-2}$ produced the highest number of fruits (29.65 fruit plant^{-1}) in all the mutants population. Rest of the mutants showed the number of fruit ranged from 19.06-27.53 fruit plant^{-1}. The control plant produced 19.06 fruit plant^{-1}.

Table 12. Yield attributes of elite M_5 mutants of Bottle gourd at khagrachari

Mutant/Variety	No. of fruits plant^{-1}(no.)	Length of fruit (cm)	Diameter of fruit (cm)	Colour
BL-4(control)	19.06	44.63	37.02	Dark green with whitish spot
BL-4$M_5D_{300}P_{4-1}$	26.48	48.79	40.48	Light green
BL-4$M_5D_{300}P_{4-2}$	29.65	51.90	39.44	Light green
BL-4$M_5D_{300}P_{5-2}$	26.48	48.79	40.48	Light green
BL-4$M_5D_{300}P_{6-2}$	23.30	46.71	39.44	Light green with whitish spot
BL-4$M_5D_{300}P_{6-3}$	26.48	43.60	37.37	Light green with whitish spot

BL-4$M_5D_{150}P_{3-2}$	24.36	49.82	39.44	Dark green
BL-4$M_5D_{150}P_{3-3}$	27.53	55.01	41.52	Dark green
SD	3.20	3.01	1.93	-

Brinjal

Performances of promising mutant (M_5) of brinjal

The experiment was conducted with seven mutants with their parents at Sutiakhali farmers field, Mymensingh and BINA sub-station farm at Ishwardi to observe the performance of M_5 mutants of brinjal. Seeds were sown on 12th October 2018 and transplanted on 15th November 2018. The experiment was laid out in RCBD with three replications using spacing 70cm × 60cm. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such as plant height, number of branch plant^{-1}, number of fruit plant^{-1}, fruit yield and average fruit weight were recorded from five randomly selected competitive plants of each mutant. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 13. Results showed that the mutants differed for yield and yield attributes (Table 13). The mutant line Ind$M_5D_{75}P_{29}$ showed the highest fruit yield **(**15.6 kg plant^{-1}**)** which was statistically similar to Ind$M_5D_{75}P_{38}$ **(**13.1 kg plant^{-1}**).** The rest mutants showed the fruit yield ranged from 8.4 to 4.6 kg plant^{-1}. It could be concluded that the mutants Ind$M_5D_{75}P_{29}$ contributed the highest yield (108.6 t ha^{-1}) followed by Ind$M_5D_{75}P_{38}$ (97.0 t ha^{-1}) as compared to control (51.3 t ha^{-1}).

Table 13. Yield attributes of M_5 mutants of Brinjal at HQ Mymensingh

Mutant/Variety	Plant height (cm)	Branch plant^{-1} (no.)	Fruit plant^{-1}(no.)	Total fruit wt. plant^{-1}(kg)	Yield (tha^{-1})
Ind$M_5D_{75}P_{29}$	108.2	9.2	10.6	15.6	108.6
Ind$M_5D_{75}P_{30}$	99.9	10.2	6.4	6.4	64.0
Ind$M_5D_{75}P_{38}$	90.0	9.2	8.6	13.1	97.0
Ind$M_5D_{75}P_{42}$	65.9	8.2	8.6	7.2	69.8
Ind$M_5D_{75}P_{43}$	92.9	8.2	8.5	8.4	80.5
Ind$M_5D_{75}P_{45}$	90.9	10.2	6.4	5.9	68.9
Ind$M_5D_{75}P_{49}$	77.3	9.2	4.3	4.6	63.9
Parent	90.6	7.2	5.3	4.2	51.3
SD	13.0	1.1	2.1	4.1	18.9

The mutant line Ind$M_5D_{75}P_{29}$ showed the highest fruit yield (14.2 kg plant^{-1}) at Ishwardi which was statistically similar to Ind$M_5D_{75}P_{38}$ (10.9 kg plant^{-1}) and Ind$M_5D_{75}P_{42}$ mutant (8.0 kg plant^{-1}). The rest mutants showed the fruit yield ranged from 4.0-6.9 kg plant^{-1}. It could be concluded that the mutant Ind$M_5D_{75}P_{29}$ contributed the highest fruit yield (107.3 t ha^{-1}) followed by Ind$M_5D_{75}P_{38}$ and Ind$M_5D_{75}P_{42}$ as compared to control (49.2 t ha^{-1}).

Table 14. Yield attributes of M_5 population of brinjal at Ishwardi substation farm

Mutant/Variety	Plant height (cm)	Branch plant^{-1} (no.)	Fruit plant^{-1} (no.)	Total fruit wt. plant^{-1}(kg)	Yield (t ha^{-1})
Ind$M_5D_{75}P_{29}$	94.8	8.2	9.5	14.2	107.3
Ind$M_5D_{75}P_{30}$	98.9	12.3	6.4	6.9	57.6
Ind$M_5D_{75}P_{38}$	84.9	10.2	5.4	10.9	97.6
Ind$M_5D_{75}P_{42}$	74.2	9.2	8.6	8.0	69.2
Ind$M_5D_{75}P_{43}$	91.8	12.2	7.5	4.0	64.4
Ind$M_5D_{75}P_{45}$	96.1	10.2	5.3	7.3	68.9
Ind$M_5D_{75}P_{49}$	111.3	12.2	4.3	4.4	65.5
Parent	91.7	12.3	4.3	4.1	49.2
SD	10.7	1.6	2.0	3.6	19.8

Carrot

Evaluation of M_4 mutants of Carrot

The experiment was conducted with twelve mutantsalong with the species *Brasilias agroflora* and fourteen mutants under check species *Prima agroflora*. The experiment was laid out in Randomized Complete Block Design with three replications. The size of a unit plot was 10.0 m × 1.0 m with spacing of 25 cm × 25 cm. Plot to plot distance was provided 50 cm while the block to block distance was 1.0 m. All the parameters on plant growth, yield components and quality seed of carrot were significantly influenced by mutants. The mutants $V_1D_{75}P_{17}$ produced the tallest plant (169.21 cm), maximum number of primary umbel plant^{-1} (11.92), number of secondary umbel plant^{-1} (13.44), seed yield per plant (5.91 g), seed yield per plot (199.99 g) as well as yield (901.76 kg ha^{-1}) than parents. The non irradiated plants took minimum time to 50% flowering and days required from flower to fruit set whereas irradiated plants took maximum time in both of *Brasilia agroflora* (Table 15 & 16) and *Prima agroflora* varieties (Table 17 & 18). The highest seed yield (1044.42 kg ha^{-1}) was recorded from $V_2D_{75}P_{18}$ population (Table 18) while the lowest yield (707.60 kg ha^{-1}) was recorded from $V_2D_oP_2$ population (Table 18).

Table 15. Evaluation of M_4 mutants of Carrot (*Brasilia agroflora*)

Mutants/parent	Plant height (cm)	Days to 50% flowering	Days required from flower to fruit set	No. of primary umbels plant^{-1}	No. of secondary umbels plant^{-1}
$V_1D_oP_1$	156.69	53.10	9.1	9.56	9.12
$V_1D_oP_3$	155.76	52.19	9.11	8.44	9.78
$V_1D_oP_4$	152.13	52.29	9.76	8.33	9.47

$V_1D_oP_5$	150.31	54.33	8.11	8.54	10.55
$V_1D_{50}P_8$	162.32	54.46	8.55	9.17	11.62
$V_1D_{50}P_{10}$	155.77	56.66	10.76	9.24	11.32
$V_1D_{50}P_{11}$	157.69	55.12	9.87	9.44	11.29
$V_1D_{75}P_{15}$	166.24	58.21	10.11	10.11	11.29
$V_1D_{75}P_{16}$	167.55	57.11	11.31	11.21	11.21
$V_1D_{75}P_{17}$	169.21	59.21	10.81	11.92	13.44
$V_1D_{75}P_{18}$	165.11	58.21	11.66	11.29	11.92
$V_1D_{100}P_{19}$	139.90	58.33	10.81	11.18	11.93
$V_1D_{100}P_{20}$	138.40	58.33	10.11	10.56	10.55
$V_1D_{100}P_{21}$	137.10	58.21	11.21	10.36	10.69
$V_1D_{100}P_{22}$	142.11	56.11	10.32	10.21	10.99
$V_1D_{100}P_{23}$	139.32	58.17	10.50	10.12	11.33

Legend: V_1-Carrot species (*Brasilias agroflora*)

Table 16. Evaluation of M_4 mutants of Carrot (*Brasilia agroflora*) (Cont'd)

Mutants/parent	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (g)	Yield (Kg ha^{-1})
$V_1D_oP_1$	4.11	140.21	760.19
$V_1D_oP_3$	4.51	146.21	722.46
$V_1D_oP_4$	4.61	150.29	**746.62**
$V_1D_oP_5$	4.71	148.21	772.92
$V_1D_{50}P_8$	4.66	146.32	782.67
$V_1D_{50}P_{10}$	4.62	155.91	792.77
$V_1D_{50}P_{11}$	5.02	176.72	822.16
$V_1D_{75}P_{15}$	5.55	180.17	911.77
$V_1D_{75}P_{16}$	5.61	190.32	987.66
$V_1D_{75}P_{17}$	5.91	199.98	901.76
$V_1D_{75}P_{18}$	5.12	185.36	811.11
$V_1D_{100}P_{19}$	5.21	156.16	803.69
$V_1D_{100}P_{20}$	4.41	155.46	811.29
$V_1D_{100}P_{21}$	4.21	152.44	823.23
$V_1D_{100}P_{22}$	4.12	161.24	792.16
$V_1D_{100}P_{23}$	5.12	150.19	888.18

Legend: V_1-Carrot species (*Brasilias agroflora*)

Table 17. Evaluation of M_4 mutants of Carrot (Var. *Prima agroflora*)

Mutants/ parent	Plant height	Days to 50% flowering	Days required flower to fruit set	No. of primary umbels plant^{-1}	No. of secondary umbels plant^{-1}
$V_2D_oP_2$	108.31	51.67	11.66	9.23	9.91
$V_2D_oP_3$	114.41	50.32	11.32	9.32	9.92
$V_2D_oP_4$	119.31	49.77	11.29	9.42	9.88
$V_2D_oP_5$	111.81	51.33	11.44	9.26	9.66
$V_2D_{50}P_7$	121.72	53.44	12.32	10.11	11.33
$V_2D_{50}P_{11}$	125.61	55.11	11.22	10.11	10.42
$V_2D_{50}P_{12}$	128.80	56.20	10.44	10.52	12.66
$V_2D_{75}P_{14}$	125.72	51.33	11.33	11.66	12.44
$V_2D_{75}P_{15}$	131.43	53.22	10.55	10.25	11.66

$V_2D_{75}P_{16}$	130.72	56.66	11.21	9.66	11.87
$V_2D_{75}P_{17}$	126.55	55.44	12.11	9.85	11.45
$V_2D_{75}P_{18}$	134.41	55.32	11.11	9.32	10.38
$V_2D_{100}P_{19}$	133.50	50.51	11.66	9.42	10.56
$V_2D_{100}P_{20}$	134.7	53.77	11.92	9.16	10.11
$V_2D_{100}P_{21}$	138.5	52.66	12.55	10.21	10.56
$V_2D_{100}P_{22}$	135.4	51.44	11.56	9.44	10.12
$V_2D_{100}P_{23}$	131.11	52.88	10.56	9.66	10.52
$V_2D_{100}P_{24}$	125.50	53.48	11.44	10.15	10.66

Legend: V_2-Carrot variety (*Prima agroflora)*

Table 18. Evaluation of M_4 mutants of carrot (*Prima agroflora*) (Cont'd)

Mutants/parent	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (g)	Yield (t ha^{-1})
$V_2D_oP_2$	5.32	152.33	707.60
$V_2D_oP_3$	5.11	168.92	840.23
$V_2D_oP_4$	5.4	170.33	852.44
$V_2D_oP_5$	5.11	145.44	699.9
$V_2D_{50}P_7$	5.33	156.77	801.52
$V_2D_{50}P_{11}$	4.87	170.11	852.21
$V_2D_{50}P_{12}$	4.66	163.33	809.39
$V_2D_{75}P_{13}$	5.21	187.72	817.11
$V_2D_{75}P_{14}$	5.66	193.52	802.46
$V_2D_{75}P_{15}$	5.67	195.51	841.23
$V_2D_{75}P_{16}$	5.87	218.66	911.31
$V_2D_{75}P_{17}$	5.88	204.46	1021.00
$V_2D_{75}P_{18}$	6.92	209.99	1044.42
$V_2D_{100}P_{19}$	5.96	206.21	1010.32
$V_2D_{100}P_{20}$	5.77	109.62	1010.49
$V_2D_{100}P_{21}$	5.92	201.11	1009.98
$V_2D_{100}P_{22}$	5.66	192.26	997.62
$V_2D_{100}P_{23}$	5.72	205.66	987.31
$V_2D_{100}P_{24}$	5.88	213.3	1003.3

Legend: V_2-Carrot species *Prima agroflora*

Okra

Three germplasm of okra collected from Africa were grown at BINA HQs farm, Mymensingh to select high yield potential with soft fiber and good test.

Cucumber

Evaluation of M_4 mutants of cucumber

The experiment was conducted at BINA HQs farm, Mymensingh to screen the M_4 mutants. The experiment was laid out in row planting method using recommended spacing. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such as fruit length, fruit diameter, number of fruit plant^{-1}, fruit yield and fruit weight were taken from each mutant (Table 19). Results showed that the number of fruit ranged from 14 to 20 fruit plant^{-1}. Some mutants $CM_4D_{100}P_2$, $CM_4D_{100}P_5$ and $CM_4D_{300}P_3$ produced the highest number of fruits plant^{-1} (20, 19, 18 fruit plant^{-1}) as compared to parent (12 fruit plant^{-1}). The highest yield (17.65 kg plant^{-1}) was found in $CM_4D_{100}P_2$ mutant and the lowest yield (6.58 kg plant^{-1}) was in the local plant.

Table 19. Yield attributes of M_4 mutant of cucumber at BINA farm, Mymensingh

Mutant/Variety	First flowering	First fruiting	Average length of fruit (cm)	Average diameter of fruit (cm)	No. of fruits plant^{-1}	Yield plant^{-1} (kg)
CM_4 $D_{100}P_1$	06.05.2019	14.05.2019	24.36	5.86	16	13.65
$CM_4D_{100}P_2$	07.05.2019	15.05.2019	25.45	7.42	20	17.65
$CM_4D_{100}P_3$	10.05.2019	18.05.2019	22.65	6.52	14	11.34
$CM_4D_{100}P_4$	09.05.2019	16.05.2019	21.45	6.87	15	10.32
$CM_4D_{100}P_5$	11.05.2019	20.05.2019	22.86	7.13	19	15.34
$CM_4D_{100}P_6$	06.05.2019	15.05.2019	23.51	7.18	16	10.54
$CM_4D_{100}P_8$	03.05.2019	13.05.2019	25.45	7.52	17	7.65
$CM_4D_{200}P_3$	07.05.2019	15.05.2019	21.56	7.85	14	9.52
$CM_4D_{300}P_3$	05.05.2019	14.05.2019	28.53	6.54	18	12.56
$CM_4D_{300}P_4$	07.05.2019	16.05.2019	29.54	5.34	14	7.31
Parent	10.05.2019	21.05.2019	23.28	5.16	12	6.58
SD	-	-	2.64	0.89	2.43	3.46

Growing of M_2 generation of cucumber

With view to develop high yielding cucumber mutants, dry seeds of cv. baromasi, baropatha were irradiated with 100,150 & 200 Gy doses of gamma rays using the ^{60}Co source to create genetic variability for yield improvement in summer season. One hundred seeds per dose were sown on 10 March 2018 in seedbed. The germinated seedlings were transplanted in the main field on 15 April 2018 at BINA HQs farm, Mymensingh in separate plots dose and variety wise along with a plot for un-irradiated control of each variety. Seedlings were transplanted using recommended spacing. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Finally, the M_2 plants were harvested from the survived plants and kept separately dose and variety wise to screen in the M_3 generation in next season.

Tomato

Growing of M_1 generation of tomato in summer season

Dry seeds of BARI Tomato-2, BARI Tomato 19, Durga, BINA Tomato-12 were irradiated with 100, 200 and 300 Gy doses of gamma rays using the ^{60}Co source to create genetic variability for yield improvement in summer season. One hundred fifty seeds per dose were sown on 10 March 2018 in seedbed. The seedlings were transplanted in the main field on 15 April 2018 at BINA HQs farm, Mymensingh at 35 days age. Gamma treated seedlings and variety were planted in line sowing. Seedlings were transplanted at 60 cm distance within rows of 45 cm apart. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when it is necessary. Finally, M_1 plants were harvested from the survived plants and kept separately dose and variety wise to screen the M_2 generation in next season.

Breeder Seed production of Binatomato-10, Binatomato-11, Binatomato-12, Binarashun-1 and Binamorich-1

Table20. Performance of Seed production of Binatomato-10, Binatomato-11, Binatomato-12, Binarashun-1 and Binamorich-1 varieties on seed yield grown under field condition at Mymensingh during rabi season 2018-19

Variety	Seed yield (g)
Binatomato-10	500.0
Binatomato-11	950.0
Binatomato-12	800.0
Binarashun-1	90 kg
Binamorich-1	3 kg

Maintenance of germplasm (local and exotic collection)

Sixteen germplasm of Black cumin given from MoA, four germplasm of country bean collected from abroad, five germplasm of Capsicum collected from AVRDC, three local sweet gourd germplasm and three local eggplant (kata begun) germplasm were grown separately in BINA HQ farm. After harvest seeds of all these germplasm were collected and preserved for further research. Among them, two country bean and three capsicum germplasm would be more promising as their different disirable characteristics for future breeding materials.

FRUITS

Growing of M_1 plants of Malta and Lime

Malta

The experiment was conducted with sixteen M_1 plants of malta derived from grafting the irradiated scion of Washington Naval variety on rootstock of lime and five check varieties at the BINA HQs farm, Mymensingh to create genetic variability. The experiment was laid out in row planting. The $WNMD_{40}P_2$ population showed the tallest plant (271 cm) along with maximum number of fruits (68), length of fruit (6.9 cm), breadth of fruit (6.8 cm) and minimum number of seed fruit^{-1} (5) whereas the shortest plant (226 cm), the minimum number of fruits (21), length of fruit (4.8 cm), breadth of fruit (4.3 cm) and maximum number of seed fruit^{-1} (10) were recorded in TMD_0P_1 (Table 21). Accumulated higher TSS (%) 14.2 was observed in $WNMD_{40}P_2$ than the other population.

Lime

The experiment was carried out with M_1 plants and two cheek varieties at BINA HQs farm, Mymensingh. The experiment was laid out in row planting. The M_1 ($LBD_{40}P_1$) plant produced the highest number of fruit yield (365 plant^{-1}) whereas the lowest was found in LBD_0P_2 (206 plant^{-1}). The non irradiated plants showed the fruits number ranged from 195-206.

Table 21. M_1 plants of Malta and Lime

Species	Sl. No.	Mutant line/ advance line	Planting Date	Plant height (cm)	No. of fruits $plant^{-1}$	Weight of fruit $plant^{-1}$ (g)	Length of fruit (cm)	Breadth of fruit (cm)	No. of Seed $fruit^{-1}$	% TSS
Malta	1.	TMD_0P_1	08.05.16	226	21	102	4.8	4.9	10	11.6
	2.	$TMD_{20}P_2$	08.05.16	226	58	97	5.4	5.6	8	11.1
	3.	$TMD_{20}P_3$	08.05.16	255	54	96	5.2	5.2	7	11.5
	4.	$TMD_{40}P_1$	08.05.16	235	53	102	5.1	5.3	6	10.5
	5.	$TMD_{40}P_2$	08.05.16	230	57	103	4.8	5.4	7	11.3
	6.	$TMD_{40}P_3$	08.05.16	237	55	106	4.8	5.5	8	11.4
	7.	$TMD_{40}P_4$	08.05.16	257	51	136	4.6	5.4	7	10.9
	8.	$TMD_{40}P_5$	08.05.16	237	54	141	4.6	5.3	8	11.3
	9.	$WNMD_0$ P_1	08.05.16	208	44	204	6.9	5.3	9	12.6
	10.	$WNMD_{20}P_1$	08.05.16	253	52	201	6.4	6.8	8	12.4
	11.	$WNMD_{20}P_2$	08.05.16	241	52	198	6.6	6.7	8	12.5
	12.	$WNMD_{20}P_3$	08.05.16	259	59	192	6.7	6.6	8	12.5
	13.	$WNMD_{40}P_1$	08.05.16	237	62	196	6.5	6.7	8	12.4
	14.	$WNMD_{40}P_2$	08.05.16	271	68	203	6.9	6.8	5	14.2
	15.	$WNMD_{60}P_1$	08.05.16	244	45	185	6.5	6.4	6	12.1
	16.	MMD_0 P_1	08.05.16	245	45	192	5.9	5.1	6	12.3
	17.	MMD_{20} P_1	08.05.16	255	62	192	5.7	5.3	7	11.2
	18.	BARI malta-1	08.05.16	242	87	162	5.8	6.2	9	12.6
	19.	BARI malta-1	08.05.16	244	77	165	5.7	5.9	9	12.3
	20.	MMD_{40}	08.05.16	325	101	189	5.5	5.5	6	11.6
	21.	NMD_{20}	08.05.16	295	99	192	5.6	5.6	5	13.2
Lime	22.	LBD_0P_1	08.05.16	201	192	61	4.9	4.8	6	7.3
	23.	LBD_0P_2	08.05.16	318	206	56	5.6	5.2	3	8.1
	24.	$LBD_{20}P_3$	08.05.16	321	295	58	5.7	5.3	2	7.2
	25.	$LBD_{20}P_4$	08.05.16	282	216	49	5.8	5.6	0	8.8
	26.	$LBD_{40}P_1$	08.05.16	391	365	62	6.0	5.8	0	8.9

Screening of pomegranate germplasm on growth and yield quality attributes

The experiment was conducted with seven pomegranate genotypes at BINA head quarter farm. The tallest plant (301 cm) was recorded in P_2 followed by P_1 (280 cm) and P_3 (255 cm) whereas the shortest plant was recorded in B_1 (172 cm).

The cultivar P_2 showed the maximum number of fruits (57/plant), length (5.5 cm) and breadth (5.4 cm) of fruit whereas the minimum number of fruits (5/plant), length of fruit (4.8 cm) and breadth of fruit (4.3 cm) were recorded in A_1. P_2 genotype accumulated the highest TSS (18.6%) whereas the lowest (16.3%) was recorded in B_1.

Table 22. Performance of Pomegranate on growth, yield and quality

Sl No.	Pomegranate	Planting Date	Plant height (cm)	No. of fruits plant^{-1}	Weight of Fruit plant^{-1} (g)	Length of fruit (cm)	Breath of fruit (cm)	% TSS
1.	Pomegranate (India) P1	28.11.16	280	54	255	5.8	5.5	17.5
2.	Pomegranate (India) P2	09.10.16	301	**57**	260	5.5	5.4	18.6
3.	Pomegranate (India) P3	09.10.16	255	22	260	5.6	4.5	17.2
4.	Anar (India) A1	28.11.16	240	5	200	4.8	4.3	17.1
5.	Anar (India) A2	28.11.16	248	6	239	4.9	5.4	16.5
6.	Bedana (India) B1	28.11.16	172	6	225	4.6	5.2	16.3
7.	Bedana (India) B2	28.11.16	230	13	230	4.9	5.1	17.3

Crop Physiology Division

Research Highlights

- Six lentil genotypes (LMI-3, LMM-4, LMM-6, LMM-7, LMM-9 and Binamasur-5) were evaluated under three soil moisture regimes (Control, 40 and 30% FC). Two mutants i.e LMM-9 and LMM-6 were found comparatively tolerant under water stress condition than the others.
- Seven mungbean genotypes (MM-1, MM-2, MM-5, MM-8, MM-11, MM-12 and Binamoog-8) were evaluated under three soil moisture levels (Control, 60 and 40% FC) on growth and yield, and four mutants (MM-11, MM-5, MM-8 and MM-1) showed tolerance under water stress.
- Four sesame genotypes (Rajshahi Khoyeri, Kathtil Chapai, Kistotil Chapai and Binatil-2) were treated under different water logging periods (Control, 48 and 72 hours) for morpho-physiological attributes and yield. The genotype Rajshahi Khoyeri showed tolerance to water logging.
- Six imposed debranching levels *viz*., i) control, ii) main stem (MS) only, iii) MS with 1 branch, iv) MS with 2 branches, v) MS with 3 branches and vi) MS with 4 branches in a tomato experiment, main stem with 4 branches produced the highest fruit yield plant^{-1}.
- Four tomato genotypes (TM-4, TM-8, Binatomato-7 and Binatomato-13) were tested in four locations on morphological parameters and fruit yield, and the mutant TM-8 showed the highest fruit yield followed by Binatomato-13. Among the three cherry type tomato genotype, Trumling Red showed the highest fruit yield.
- Six lentil mutants were evaluated at Ishwardi and Magura based on morphological and yield attributes and two lentil mutants (LMM-9 and LMM-6) were found promising. Seven mungbean mutants were also evaluated at Ishwardi and Magura and four mutants, MM-11, MM-12, MM-1 and MM-2 showed better seed yield than Binamoog-8.
- Ten lentil and ten mungbean genotypes were evaluated based on flowering pattern and found that high yielding genotypes in general have higher rate of flowers production and flowering duration was 15-24 days in lentil and 8-12 days in mungbean.

Effect of water stress on morphological and yield attributes of lentil genotypes

A pot experiment was carried out with six lentil genotypes to assess the effects of water stress on morphological and yield attribute. Control (60% FC), 45 and 30% FC water stress were imposed on lentil genotypes at flowering stage and continued until flowering ceased. The experiment was laid out in a Complete Randomized Design with three replications. Data on morphological yield attributes were also recorded analyzed statistically.

Results showed that plant height, number of branch plant^{-1}, number of pods plant^{-1}, straw weight, 1000-seed weight and yield plant^{-1} decreased with increasing water stress (Tables 1-3). The highest values of those parameters were found in control plants and the lowest was recorded in 30% water stress condition. Under stress condition, the highest grain yield was recorded in LMM-6 in control and the lowest was observed in LMM-7.

Table 1. Effect of different soil moisture levels on morphological and yield attributes of lentil genotypes

Treatment	Plant height (cm)	Branch plant^{-1} (No.)	Seeds pod^{-1} (No.)	Pods plant^{-1} (No.)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Straw yield. (g)
Control	24.94a	11.9a	1.77a	97.6a	25.33a	3.3a	2.37a
40% FC	21.76b	9.2b	1.71b	49.6b	23.28b	1.8b	1.21b
30% FC	19.35c	7.5c	1.73ab	29.9c	21.22c	1.0c	0.88c

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 2. Morphological and yield attributes of lentil genotypes under water stress

Genotype	Plant height (cm)	Branch plant^{-1} (No.)	Seeds pod^{-1} (No.)	Pods plant^{-1} (No.)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Straw yield. (g)
LMI-3	22.7a	9.00c	1.78a	60.48b	23.44	1.91c	1.56ab
Binamasur-5	22.9a	9.52bc	1.76a	55.41c	22.89	1.90c	1.64a
LMM-4	21.1c	9.15c	1.74ab	60.41b	23.22	1.97c	1.49b
LMM-6	22.3ab	10.48a	1.69bc	63.81a	23.44	2.50a	1.51b
LMM-7	21.6bc	9.30bc	1.66c	53.41c	23.33	1.62d	1.27c
LMM-9	21.5bc	9.78b	1.8a	60.63b	23.33	2.36b	1.47b

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 3. Interaction of lentil genotypes and water stress on morphological and yield attributes

Genotype	Treatment	Plant height (cm)	Branch plant^{-1} (No.)	Seeds pod^{-1} (No.)	Pods plant^{-1} (No.)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Straw yield. (g)
LMI-3	Control	25.78ab	11.2b	1.73bcd	85.2d	24.3cd	2.43d	2.87a
	40% FC	21.78ef	8.4fg	1.77abc	59.0e	23.7de	2.03e	1.05gh
	30% FC	20.67fg	7.3hi	1.83ab	37.2gh	22.3fg	1.26g	0.77i
Binamasur-5	Control	26.78a	11.7ab	1.87a	94.4c	25.0bc	2.73c	2.81a
	40% FC	22.56de	9.1def	1.73bcd	39.2g	22.7ef	1.72f	1.35e
	30% FC	19.33gh	7.8gh	1.67cde	32.6hi	21.0h	1.26g	0.74i
LMM-4	Control	24.33bc	12.3a	1.73bcd	103.2b	25.3bc	3.62b	2.45b

	40%FC	20.55fg	8.6fg	1.83ab	57.1e	23.3def	1.64f	1.12fg
	30% FC	18.33h	6.6i	1.67cde	20.9k	21.0h	0.65i	0.89hi
LMM-6	Control	24.44bc	12.7a	1.62e	109.0a	25.7ab	3.78b	2.17c
	40% FC	22.78de	9.9cde	1.63de	47.9f	23.7de	2.37d	1.31ef
	30% FC	19.67gh	8.9ef	1.83ab	34.6gh	21.0h	1.34g	1.07gh
LMM-7	Control	24.56bc	10.9bc	1.83ab	96.6c	26.7a	2.83c	1.80d
	40% FC	21.33ef	9.3def	1.47f	36.2gh	22.7ef	1.19g	1.09gh
	30% FC	18.89h	7.7gh	1.67cde	27.5ij	20.7h	0.83h	0.91ghi
LMM-9	Control	23.78cd	12.4a	1.83ab	97.1c	25.0bc	4.17a	2.16c
	40% FC	21.56ef	10.0cd	1.83ab	58.2e	23.7de	2.10e	1.36e
	30% FC	19.22gh	6.9hi	1.73bcd	26.6j	21.3gh	0.82h	0.89hi

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Effect of water stress on morphological and yield attributes of mungbean genotypes

A pot experiment was carried out with seven mungbean genotypes to assess the effects of water stress on morphological and yield attributes. Control (80% FC), 60 and 40% FC water stress were imposed on mungbean genotypes at 25 days after sowing and continued until flowering ceased. The experiment was laid out in a Complete Randomized Design with three replications. Five seeds were sown in a plastic pots containing 10 kg soils pot^{-1} on 12 March 2019 and at 15 days after sowing kept 2 plants pot^{-1}. At harvest, seed yield and yield related traits were recorded and collected data were analyzed statistically.

Results showed that seed yield and yield related traits decreased with increasing water stress (Tables 4-6). The highest grain weight and total dry matter was found in control plants and the lowest was recorded in 40% water stress condition. The low yield under 40% FC might be due to lower dry matter production which resulted fewer pods plant^{-1}. Amongst the varieties, the lowest seed yield reduction was observed in Binamoog-7 while the highest yield reduction was in Binamoog-9 (Table 5).

Table 4. Effect of different soil moisture levels on morphological and yield attributes of mungbean genotypes

Treatment	Plant height (cm)	Branch plant^{-1} (No.)	Seed pods^{-1} (No.)	Pods plant^{-1} (No.)	Pod length (cm)	Shoot wt. plant^{-1} (g)	Root wt. plant^{-1} (g)	TDM plant^{-1} (g)	1000-seed wt. (g)	Seed yield plant^{-1}(g)
Control	22.24a	1.29a	9.04a	9.10a	7.76a	8.05a	1.59a	9.60a	58.27ab	3.89a
60% FC	22.43a	1.05b	8.49a	6.00b	6.93b	5.88b	1.48b	7.27b	59.12a	2.48b
40% FC	17.38b	1.05b	6.65b	4.57c	5.73c	5.03c	1.46b	6.36c	56.42b	1.54c

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 5. Morphological and yield attributes of mungbean genotypes under water stress

Genotype	Plant height (cm)	Branch plant^{-1} (No.)	Seed pods^{-1} (No.)	Pods plant^{-1} (No.)	Pod length (cm)	Shoot wt. plant^{-1} (g)	Root wt. plant^{-1} (g)	TDM plant^{-1} (g)	1000-seed wt. (g)	Seed yield plant^{-1}(g)
MM-1	18.78de	1.11	7.67bc	7.00b	6.85ab	7.43a	1.32d	8.54a	53.64c	2.77b
MM-2	18.11e	1.11	8.46ab	6.89b	6.39b	5.72c	1.43c	7.17c	59.14b	2.41cd
MM-5	19.00de	1.22	8.51ab	7.89a	6.72ab	5.66c	1.64a	7.24c	55.01c	3.01a
MM-8	19.67d	1.11	9.01a	5.44c	6.89ab	6.62b	1.52bc	8.19ab	56.14c	2.90ab
MM-11	21.33c	1.11	7.61bc	5.44c	7.26a	6.48b	1.59ab	8.11ab	64.53a	2.47cd
MM-12	22.67b	1.00	8.38ab	6.33bc	7.33a	5.78c	1.49bc	7.26c	61.46b	2.54c
Binamoog-8	25.22a	1.22	6.77c	6.89b	6.21b	6.54b	1.57ab	7.70bc	55.65c	2.34d

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 6. Interaction of mungbean genotypes and water stress on morphological and yield attributes

Genotype	Treatment	Plant height (cm)	Branch plant^{-1} (No.)	Seed pods^{-1} (No.)	Pods plant^{-1} (No.)	Pod length (cm)	Shoot wt. plant^{-1} (g)	Root wt. plant^{-1} (g)	TDM plant^{-1} (g)	1000-seed wt. (g)	Seed yield plant^{-1}(g)
	Control	21.00	1.00	9.93	10.00	7.79	9.80	1.40	10.57	4.20	49.60
	60% FC	20.67	1.00	8.07	5.67	6.23	6.67	1.20	7.87	2.57	54.75
MM-1	40% FC	14.67	1.33	5.00	5.33	6.52	5.83	1.37	7.20	1.53	56.57
	Control	20.33	1.33	9.57	12.33	8.42	7.10	1.57	9.00	3.67	61.90
	60% FC	20.00	1.00	8.40	5.33	6.46	4.87	1.23	5.93	1.80	59.54
MM-2	40% FC	14.00	1.00	7.40	3.00	4.29	5.20	1.50	6.57	1.77	56.00
	Control	21.00	1.67	8.50	11.00	7.85	7.13	1.93	9.07	5.07	55.09
	60% FC	21.33	1.00	9.27	7.00	7.89	5.10	1.40	6.50	2.60	56.80
MM-5	40%FC	14.67	1.00	7.77	5.67	4.43	4.73	1.60	6.17	1.37	53.15
MM-8	Control	21.00	1.33	9.57	7.33	7.82	8.50	1.47	9.97	4.40	60.63

	60% FC	20.33	1.00	9.47	4.67	6.22	7.00	1.80	9.07	2.73	55.09
	40% FC	17.67	1.00	8.00	4.33	6.62	4.37	1.30	5.53	1.57	52.70
	Control	24.00	1.33	8.53	7.00	8.21	8.03	1.57	9.60	3.63	63.60
	60% FC	22.00	1.00	7.93	6.00	7.01	5.83	1.80	7.33	2.30	67.45
MM-11	40% FC	18.00	1.00	6.37	3.33	6.56	5.57	1.40	7.40	1.47	62.54
	Control	23.00	1.00	9.93	8.33	7.51	7.93	1.53	9.50	3.40	62.56
	60% FC	25.00	1.00	8.87	6.00	7.13	5.17	1.50	6.67	2.90	54.79
MM-12	40% FC	20.00	1.00	6.33	4.67	7.34	4.23	1.43	5.60	1.33	67.03
Binamoog-8	Control	25.33	1.33	7.23	7.67	6.75	7.83	1.67	9.50	2.83	54.53
	60% FC	27.67	1.33	7.40	7.33	7.55	6.50	1.40	7.53	2.43	65.45
	40% FC	22.67	1.00	5.67	5.67	4.33	5.30	1.63	6.07	1.77	46.97

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Identification of sesame genotypes for water logged tolerance

A pot experiment was conducted at BINA pot yard, Mymensingh during February to May 2019 to assess the effect of different duration of water logging on dry matter production and seed yield of four sesame genotypes. The water logging period was imposed at flowering starting stage and water logging period was: i) control (No water logging), ii) water logged for 48 hours and iii) water logged for 72 hours. Recommended fertilizers and cultural practices were followed. At harvest, seed yield and yield related traits were recorded. The collected data were analyzed statistically.

Results revealed that plant height, number of branches plant^{-1}, capsules plant^{-1}, number of seeds capsule^{-1}, total dry matter plant^{-1}, 1000-seed weight, seed yield plant^{-1} were significantly decreased with increasing water logging periods (Tables 7-9). Rajshahi Khoyeri produced higher seed yield under water logging condition and showed more tolerance to water logging.

Table 7. Effect of water logging period on morphological, physiological, seed yield and yield components of sesame genotypes

Treatments	Plant height (cm)	Shoot dry weight plant $^{-1}$ (g)	Root dry weight plant $^{-1}$ (g)	Total dry matter plant^{-1} (g)	Capsules plant $^{-1}$ (No.)	Seeds capsule^{-1} (No.)	Seeds plant^{-1} (No.)	1000-seed weight (g)	Seed yield plant^{-1} (g)
Control	60.1a	5.25a	1.12a	6.05a	32.67a	53.67a	1080a	3.74a	5.44a
24 hrs	51.3b	4.12b	0.97b	5.01b	25.32b	41.21b	745.2b	2.99b	4.01b
48 hrs	40.7 c	2.57c	0.84bc	3.21c	19.29c	30.62c	603.7c	2.82c	1.52c
72 hrs	40.1 d	1.51d	0.76c	2.24d	10.52d	22.19d	265.2d	1.27d	0.34d

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 8. Plant height, biomass production, yield and yield components of sesame genotypes under water logging condition

Genotype	Plant height (cm)	Shoot dry weight plant $^{-1}$ (g)	Root dry weight plant $^{-1}$ (g)	Total dry matter plant^{-1} (g)	Capsules plant $^{-1}$ (No.)	Seeds capsule^{-1} (No.)	Seeds plant^{-1} (No.)	1000-seed weight (g)	Seed yield plant^{-1} (g)
Rajshahi Khoyeri	57.67cd	4.00a	0.82a	4.33a	21.23d	48.8a	1283ab	2.34a	3.73a
Kistotil Chapai	41.67d	4.01a	0.76b	4.77a	21.57cd	46.9ab	1219ab	2.21bc	2.74ab
Kathtil Chapai	48.00bc	3.23b	1.03a	4.15ab	29.53a	45.7bc	1301a	2.32ab	3.22a
Binatil-2	52.92a	3.24b	0.77b	4.0b	28.25a	35.8c	1143ab	2.03c	2.66b

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 9. Interaction effect of water logging condition on plant height, biomass production, yield and yield components of sesame genotypes

Interaction	Plant height (cm)	Shoot dry weight plant $^{-1}$ (g)	Root dry weight plant $^{-1}$ (g)	Total dry matter plant^{-1} (g)	Capsules plant $^{-1}$ (No.)	Seeds capsule^{-1} (No.)	Seeds plant^{-1} (No.)	1000-seed weight (g)	Seed yield plant^{-1} (g)
V_1T_1	57.3bcd	6.63ab	1.12b-e	7.81a	39.0a-d	75.3a	2833a	3.01ab	8.43a
V_1T_2	46.1g-j	4.21efg	0.65cde	4.85cde	21.0hi	58.7a-d	1236ef	2.50cde	3.05d
V_1T_3	45.1g-j	3.13h-k	0.95b-e	4.11e-h	15.3ij	43.3b-j	658.7gh	2.57cd	1.69efg
V_1T_4	34.3kl	2.16j-m	0.95b-e	3.05hij	7.0k	30.7g-m	215.3i	1.70lm	0.36hij
V_2T_1	56.6cde	6.82a	1.04b-e	7.87a	37.0b-e	75.3a	2679ab	2.43c-g	6.40b
V_2T_2	41.2ijk	4.86c-f	0.92b-e	5.77bcd	23.7gh	56.6a-f	1342ef	2.64bcd	3.56d
V_2T_3	39.6ijk	2.87ijk	1.03b-e	3.91e-h	18.0hi	34.7f-m	628gh	2.43c-g	1.53f-i
V_2T_4	29.02l	1.44 lm	0.85b-e	2.33ijk	9.01k	22.0j-m	197.3i	1.6m	0.32ij
V_3T_1	67.0ab	5.62cd	1.40ab	7.04ab	42.61a	51.6b-g	2213cd	3.08a	6.79b
V_3T_2	43.3g-k	3.47ghi	1.02b-e	4.78c-f	32.7def	41.0b-k	1342ef	2.53cde	3.37d
V_3T_3	38.7jk	2.31jkl	1.27abc	3.48f-i	28.3fg	35.7e-l	1003fg	2.36c-i	2.36def
V_3T_4	43.0h-k	1.25m	0.83b-e	2.12jk	15.7ij	54.3a-f	697gh	1.73klm	1.16f-j
V_4T_1	67.0ab	5.50cd	1.2bcd	6.71ab	41.31ab	58.0a-e	2399bc	2.74abc	6.57b
V_4T_2	50.01d-i	3.68ghi	1.0bcde	4.55d-g	32.3def	39.6c-k	1288ef	2.13e-k	2.75de
V_4T_3	52.01c-h	2.54jk	0.65cde	3.3g-j	23.7gh	26.7i-m	628.7gh	2.00h-m	1.25f-j
V_4T_4	42.6h-k	1.24m	0.62de	1.89jk	15.61ij	18.6klm	295.3hi	1.68lm	0.48g-j

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT; Where, T_1=Control, T_2=24 hours water logging, T_3= 48 hours water logging, T_4= 72 hours water logging, V_1=Rajshahi Khoyeri, V_2=Kistotil Chapai, V_3=Kathtil Chapai, V4=Binatil-2

Effect of different levels of debranching on reproductive efficiency and yield of Binatomato-13

An experiment was conducted at BINA pot yard, Mymensingh during the winter season of 2018-19 to assess the effect of different levels of debranching on reproductive efficiency and yield of Binatomato-13. The debranching levels were: i) control, ii) mainstem (MS) only, iii) MS with 1 branch, iv) MS with 2 branches, v) MS with 3 branches and vi) MS with 4 branches. Control plants had 5-6 branches/plant. Recommended fertilizers and cultural practices were followed. The treatments were imposed after branch initiation and maintained up to harvest.

Results showed that all the studied parameters were statistically significant due to different levels of debranching (Table 10). The highest number of effective flower clusters, flowers and fruits/plant was recorded in the treatment of MS with 4 branches followed by the treatment MS with 3 branches. The highest contribution by branches was also recorded by the treatment MS with 4 followed by MS with 3 branches with same statistical rank. In contrast, the lowest number of effective flower clusters, flowers and fruits plant^{-1} was recorded in the treatment of MS only. The plants of MS with 2 or 3 or 4 branches produced larger fruits than the others and the control plants produced the smallest. The highest fruit yield plant^{-1} was recorded in the treatment of MS with 3 branches due to increase number of fruits and larger fruit size. On the other hand, the lowest fruit yield was recorded in MS only plant due to fewer fruits per plant. The plants of MS with 4 branches produced the second highest fruit yield.

Table 10. Effect of debranching on morphological, yield and yield attributes of tomato cv. Binatomato-13

Treatments	Effective flower clusters/ plant (no.)	Flowers /plant (no)	Fruits/ plant (no.)	Single fruit weight (g)	Fruit weight /plant (kg)	Repro-ductive effi-ciency (%)	Branch contri-bution to fruit yield (%)
Control	9.60 b	76.2 a	25.3 b	47.36 c	1.20 c	33.2 b	25.3 b
Main stem (MS) only	7.67 d	60.8 b	19.4 c	54.18 b	1.05 c	31.9 b	---
MS + 1 branch	8.33 c	63.6 b	24.3 b	58.36 a	1.37 b	38.2 a	17.6 c
MS + 2 branches	9.67 ab	78.5 a	25.7 b	59.45 a	1.53 ab	32.7 b	20.7 c
MS + 3 branches	10.3 a	79.2 a	30.4 a	58.32 a	1.71 a	38.4 a	32.1 a
MS + 4 branches	9.33 b	81.2 a	30.7 a	54.37 b	1.65 a	37.8 a	32.3 a
CV (%)	6.90	10.44	9.77	4.55	8.14	13.10	7.39

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

Morpho-physiological evaluation of tomato genotypes

The experiments were carried out with four tomato genotypes *viz.* TM-4, Binatomato-7, Binatomato-13 and TM-8 at different locations during November 2018-March 2019. The locations were BINA farm, Mymensingh, Rangpur, Magura, Ishurdi and farmers field of Mymensingh and Magura. The experiments were laid out following a randomized complete block design with three replicates having a unit plot size of 4 m × 5 m. Row to row and plant to plant distances were 50 cm. Recommended doses of fertilizers were used and proper cultural practices were done as and when necessary. Data on morphological, yield and yield attributes were recorded at harvest from 10 randomly selected plants in each plot and fruit yield was taken from the whole plot and converted into kg/ha. The collected data were analyzed statistically.

Results revealed that all the studied parameters were significantly different among the genotypes (Tables 11-16). The mutant TM-8 produced the highest number of fruits/plant with larger fruit size and gave the highest fruit yield in all locations. The second and third highest fruit yield was recorded in Binatomato-13 and TM-4, respectively.

Table 11. Morphological and yield attributes of tomato genotypes at BINA farm Mymensingh

Genotype	Plant height (cm)	Primary branch (No.)	Secondary branch (No.)	Flower cluster (No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)
TM-4	129.30 a	3.33 c	2.667 c	26.67 a	142.00 a	46.00 b	58.59 b	1516.00 c
Binatomato-7	107.40 b	3.33 c	3.333 b	22.67 b	106.30 c	43.67 b	58.21 b	1305.00 c
Binatomato-13	110.20 b	4.00 a	3.667ab	20.67 b	128.00 b	49.67 ab	67.60 a	1827.00 b
TM-8	108.00 b	3.67 b	4.000 a	22.00 b	110.30 c	52.67 a	59.89 b	2071.00 a
CV%	5.40	3.36	8.09	6.02	3.55	6.36	4.13	6.30

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 12. Morphological and yield attributes of tomato genotypes at BINA farm Rangpur

Genotype	Plant height (cm)	Primary branch (No.)	Secondary branch (No.)	Flower cluster (No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)
TM-4	107.60 c	3.00 b	2.667 c	24.67 b	114.70 b	50.33 ab	51.77 b	1821.00 b
Binatomato-7	113.10 b	3.33 b	3.333 b	34.00 a	106.30 c	43.67 c	55.57 b	1377.00 c
Binatomato-13	119.00 a	4.00 a	3.667ab	33.00 a	122.00 a	48.00 b	62.21 a	1239.00 c
TM-8	116.20 a	4.00 a	4.000 a	22.33 b	109.00 c	52.67 a	53.83 b	2240.00 a
CV%	1.30	7.19	8.09	4.71	2.01	2.56	5.85	4.37

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 13. Morphological and yield attributes of tomato genotypes at BINA farm Ishurdi

Genotype	Plant height (cm)	Primary branch (No.)	Secondary branch (No.)	Flower cluster (No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)
TM-4	107.5 a	3.33 bc	2.667 c	25.33 a	142.00 a	46.00 bc	58.59 b	1641.00 b
Binatomato-7	106.0 ab	3.00 c	3.333 b	23.00 b	102.70 d	43.67 c	55.57 b	1350.00 c
Binatomato-13	101.9 bc	4.00 a	3.667ab	20.67 c	128.00 b	49.67 ab	67.60 a	1720.00 b
TM-8	100.6 c	3.67 ab	4.000 a	22.00 bc	110.30 c	52.67 a	59.89 b	2071.00 a
CV%	1.98	5.40	8.09	4.73	2.23	4.62	4.01	7.60

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 14. Morphological and yield attributes of tomato genotypes at BINA farm Magura

Genotype	Plant height (cm)	Primary branch (No.)	Secondary branch (No.)	Flower cluster (No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)
TM-4	115.30ab	3.00b	2.667 c	22.33	114.67 b	50.33 ab	51.77 c	1821.33 b
Binatomato-7	112.40bc	3.33 b	3.333 b	22.67	106.33 c	43.67 c	55.57 b	1376.67 c
Binatomato-13	118.00a	4.00a	3.667ab	23.00	122.00 a	48.00 b	62.21 a	1239.33 c
TM-8	109.00 c	4.00a	4.000 a	22.33	109.00 c	52.67 a	53.83 bc	2240.00 a
CV%	1.85	8.06	8.09	2.45	2.22	2.76	3.23	10.03

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

\Table 15. Morphological and yield attributes of tomato genotypes at farmer's field, Mymensingh

Genotype	Plant height (cm)	Primary branch (No.)	Secondary branch (No.)	Flower cluster (No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)
TM-4	108.50 a	3.00 b	2.667 c	25.33 a	135.30 a	54.00 a	60.57 b	2035.00 ab
Binatomato-7	103.20 b	3.33 b	3.333 b	23.00 b	106.30 c	43.67 c	55.57 c	1377.00 c
Binatomato-13	104.90 b	4.00 a	3.667ab	22.67 b	128.00 b	49.67 b	73.19 a	1827.00 b
TM-8	105.70 b	4.00 a	4.000 a	22.33 b	109.00 c	52.67 ab	61.50 b	2240.00 a
CV%	1.33	7.19	8.09	3.85	2.29	3.06	2.91	5.71

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 16. Morphological and yield attributes of tomato genotypes at farmer's field, Magura

Genotype	Plant height (cm)	Primary branch (No.)	Secondary branch (No.)	Flower cluster (No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)
TM-4	105.13 a	3.00 c	2.667 c	25.33 a	135.33 a	54.00 a	60.57 b	1836.67ab
Binatomato-7	105.37 a	3.33 bc	3.333 b	23.00 b	106.33 c	43.67 c	55.57 c	1350.00 c
Binatomato-13	99.10 b	3.67 ab	3.667ab	22.67 b	128.00 b	49.67 b	73.19 a	1733.33 b
TM-8	103.47 a	4.00 a	4.000 a	22.33 b	109.00 c	52.67 ab	61.50 b	2133.33 a
CV%	2.41	0.521	0.551	1.14	6.83	3.60	3.52	377.40

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Evaluation of cherry type tomato genotypes

The experiment was carried out with two advanced cherry type tomato genotypes *viz.* Cherolla and Trumbling Red along with a check variety Binatomato-10 at 5 locations during November 2018-March 2019. The locations were BINA farm, Mymensingh, Rangpur, Magura and Ishurdi. The experiment was laid out following a randomized complete block design with three replicates having a unit plot size of 4 m × 5 m. Row to row and plant to plant distances were 50 cm. Recommended doses of fertilizers were used and proper cultural practices were done as and when necessary. Data on morphological, yield and yield attributes were recorded at harvest from 10 randomly selected plants in each plot and fruit yield was taken from the whole plot and converted into kg ha^{-1}.

Results revealed that all the studied parameters were significantly different among the genotypes (Tables 17-22). The genotype, Trumbling Red produced the highest fruit yield 95.52 tha^{-1} followed by Cherolla 87.99 and Binatomato-10 82.12 tha^{-1}, respectively.

Table 17. Morphological and yield attributes of cherry type tomato genotypes at BINA farm, Mymensingh

Genotype	Plant height (cm)	Primary branch plant^{-1}(No.)	Secondary branch plant^{-1}(No.)	Flower cluster plant^{-1}(No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)	Fruit yield (ton ha^{-1})
Trumbling Red	44.93 c	7.33 a	17.33 a	99.00 a	975.00 a	917.70a	13.97 a	2499.00 a	77.26a
Cherolla	148.20 a	4.67 b	10.33 b	92.67 b	862.00 b	766.70 b	13.25 a	2335.00 b	67.25b
Binatomato-10	116.70 b	4.33 b	3.67 c	27.33 c	162.00 c	43.33 c	10.47 b	1997.00 c	66.21b
CV%	4.27	12.24	10.09	1.12	2.93	9.87	7.40	3.80	8.26

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 18. Morphological and yield attributes of cherry type tomato genotypes at BINA farm, Ishurdi

Genotype	Plant height (cm)	Primary branch plant^{-1}(No.)	Secondary branch plant^{-1}(No.)	Flower cluster plant^{-1}(No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)	Fruit yield (ton ha^{-1})
Trumbling Red	46.53 c	7.33 a	17.33 a	99.00 a	975.00 a	835.70 a	14.63 a	2462.00 a	84.27a
Cherolla	142.60a	4.67 b	10.33 b	92.67 b	862.00 b	685.70 b	11.25 b	2518.00 a	71.26a
Binatomato-10	101.40 b	4.00 b	3.67 c	27.33 c	162.00 c	43.33 c	10.27 c	1549.00 b	69.25b
CV%	11.72	10.63	10.09	3.54	3.05	11.15	4.41	3.53	17.12

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 19. Morphological and yield attributes of cherry type tomato genotypes at BINA farm, Rangpur

Genotype	Plant height (cm)	Primary branch plant^{-1}(No.)	Secondary branch plant^{-1}(No.)	Flower cluster plant^{-1}(No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)	Fruit yield (ton ha^{-1})
Trumbling Red	43.90 c	7.33 a	17.33 a	128.70 a	1167.00 a	1102.00 a	13.06 a	24663.00 a	79.25a
Cherolla	137.20 a	4.67 b	10.33 b	96.67 b	806.30 b	760.00 b	11.25 b	2369.00 a	71.26a
Binatomato-10	103.50 b	3.67 b	3.67 c	40.00 c	178.70 c	46.00 c	10.30 c	2066.00 b	67.21b
CV%	12.06	11.51	10.09	5.81	9.76	6.88	11.83	6.53	14.25

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 20. Morphological and yield attributes of cherry type tomato genotypes at BINA farm, Magura

Genotype	Plant height (cm)	Primary branch plant^{-1}(No.)	Secondary branch plant^{-1}(No.)	Flower cluster plant^{-1}(No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)	Fruit yield (ton ha^{-1})
Trumbling Red	45.03 c	7.33 a	17.33 a	121.00 a	1167.00 a	835.70 a	12.06 b	2663.00 a	95.52a
Cherolla	137.80 a	4.67 b	10.33 b	84.33 b	806.30 b	582.30 b	13.25 a	2402.00 a	87.99a
Binatomato-10	95.97 b	3.67 b	3.67 c	34.67 c	178.70 c	45.33 c	10.30 c	2066.00 b	82.12b
CV%	8.59	11.51	10.09	3.57	9.76	4.19	7.71	11.82	10.56

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 21. Morphological and yield attributes of cherry type tomato genotypes at farmer's field, Magura

Genotype	Plant height (cm)	Primary branch plant^{-1}(No.)	Secondary branch plant^{-1}(No.)	Flower cluster plant^{-1}(No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)	Fruit yield (ton ha^{-1})
Trumbling Red	45.47 c	8.10 a	17.33 a	121.30 a	1200.00 a	835.70 a	13.06 a	2282.00 a	87.56a
Cherolla	136.90 a	5.00 b	10.33 b	88.00 b	821.30 b	628.30 b	11.25 b	2191.00 b	84.26a
Binatomato-10	100.10 b	3.67 b	3.67 c	26.33 c	158.00 c	45.33 c	10.20 c	1917.00 c	77.21b
CV%	1.27	14.33	10.09	10.48	7.12	9.98	2.25	10.01	2.18

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 22. Morphological and yield attributes of cherry type tomato genotypes at farmer's field, Mymensingh

Genotype	Plant height (cm)	Primary branch plant^{-1}(No.)	Secondary branch plant^{-1}(No.)	Flower cluster plant^{-1}(No.)	Flowers plant^{-1} (No.)	Fruits plant^{-1} (No.)	Individual fruit wt. (g)	Fruit wt. plant^{-1} (g)	Fruit yield (ton ha^{-1})
Trumbling Red	44.40 c	7.33 a	17.33 a	121.30 a	1200.00a	977.0 a	12.06 a	2387.21 a	81.25a
Cherolla	145.30 a	4.67 b	10.33 b	88.00 b	821.30 b	632.3 b	11.25 b	2262. a	77.29a
Binatomato-10	104.70 b	3.67 b	3.67 c	26.33 c	158.00 c	45.33 c	9.44 c	1867. b	71.26b
CV%	6.66	11.51	10.09	4.05	7.20	11.18	5.04	2.96	11.87

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Study of flowering pattern in ten lentil varieties

A pot experiment was carried out at BINA pot yard, Mymensingh during November 2018 to February 2019 to assess the flowering pattern and its relationship with seed yield of lentil released varieties. The experiment was laid out in a Completely Randomized Design with three replications. Flowers counts were recorded from each plant of each replication just from the date of first flowering and there after every day up to flowering ceased. At harvest, seed yield and yield attributes were recorded.

Daily flowering converted to 3-day interval had shown differential peak period (Table 23). The flowering duration range from 15 to 24 days after flowering started. The shortest flowering duration was recorded in 5 varieties viz, Binamasur-5, Binamasur-8, Binamasur-9, Binamasur-10 and BARI masur4, Binamasur-8, Binamasur-9, Binamasur-10 and BARI masur4 (25 DAF) and the longest was recorded in Binamasur-2 (24 DAF). Five varieties like Binamasur-3, Binamasur-8, Binamasur-9, Binamasur-10 and BARImasur4 showed greater number of flowers at early flowering period than the others. In contrast, Binamasur-6 and Binamasur-7 produced the lowest flowers at all growth stages. All varieties except Binamasur-2 showed its flowering peak of 9 days after flowering start (DAF), while Binamasur-2 showed flowering peak at 12 DAF. Binamasur-3 and BARImasur4 produced higher number of flowers with being the highest in BARImasur4 (419 plant^{-1}). In contrast, Binamasur-6 and Binamasur-7 produced the lower number of flowers (254 plant^{-1}). Results indicated that the genotypes which had shorter flowering duration, also showed higher reproductive efficiency (Table 24). The highest seed yield was recorded in BARImasur4 followed by Binamasur-5 might be due to higher pod production with good dry matter partitioning to economic yield. On the other hand, the lowest seed yield was recorded in Binamasur-6 might be due to poor dry matter portioning to economic yield and smaller size seeds. Binamasur-7 matured earliest (96 days after sowing) and Binamasur-4 took the longest days to maturity (116 days after sowing).

23. Flowering pattern at five-day interval of ten lentil varieties

Varieties	Days to flow-ering	Number of opened flowers at 3 days interval								Total flowers $plant^{-1}$ (no)
		Days after flowering start								
		0-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	
Binamasur-2	50 c	07.0 g	29.3 i	49.3 f	73.0 b	54.7 a	36.7 a	28.3 a	4.6	283 d
Binamasur-3	48 d	52.6 a	122 b	143 b	63.7 d	20.7 f	3.30 d	0	0	405 ab
Binamasur-4	55 ab	17.5 e	68.5 f	72.2 e	68.4bc	27.7 e	20.6 b	12.0 b	0	287 d
Binamasur-5	50 c	36.3 c	89.3 e	103 d	45.3 g	17.0fg	0	0	0	291 d
Binamasur-6	50 c	10.5 g	41.0 h	71.5 e	62.7de	39.0bc	9.6 c	0	0	234 e
Binamasur-7	53 b	12.5 f	48.5 g	72.0 e	48.5fg	37.0cd	18.0 b	0	0	237 e
Binamasur-8	49 cd	42.0 b	95.0 e	104 d	61.7de	32.3 d	0	0	0	335 c
Binamasur-9	56 a	30.5 d	130 a	156 a	64.0cd	14.3 g	0	0	0	395 b
Binamasur-10	51 c	44.7 b	112 c	129 c	51.0 f	17.0fg	0	0	0	354 c
BARImasur-4	56 a	32.5cd	102 d	134 c	106 a	44.0 b	0	0	0	419 a
CV (%)	1.56	11.18	10.90	13.18	16.45	15.48	19.6	21.54	--	15.48

Same letter (s) in a column indicates do not differ significantly at P≤ 0.05

Table 24. Variation in reproductive efficiency, days to maturity, biological yield, yield attributes and seed yield of 10 lentil varieties

Varieties	Repro-ductive efficiency (%)	Days to maturity	Biolo-gical yield (g $plant^{-1}$)	Pods $plant^{-1}$ (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed weight $plant^{-1}$ (g)	Harvest index (%)
Binamasur-2	57.2 b	106 c	11.4 a	162cd	1.70 b	2.70 cd	3.80 d	33.33 e
Binamasur-3	42.7 e	110 b	9.87 c	173 bc	1.83 a	2.17 g	3.43 e	34.75 e
Binamasur-4	54.7 b	116 a	8.87 ef	157 d	1.73 b	2.30 f	3.29 ef	37.10 cd
Binamasur-5	53.3 b	99 ef	10.2 b	175 b	1.83 a	2.50 e	4.40 b	43.14 b
Binamasur-6	49.6 cd	103 d	8.63 f	116 g	1.80 a	2.60 d	3.10 f	35.92 de
Binamasur-7	75.5 a	96 f	9.23 de	179 b	1.87 a	3.01 a	4.10 cd	44.42 b
Binamasur-8	48.7 d	109 b	8.90 e	163 cd	1.80 a	2.87 b	4.20 bc	47.19 a
Binamasur-9	33.7 f	101 e	7.40 h	133 f	1.77 ab	2.50 e	3.20 f	43.24 b
Binamasur-10	40.1 e	103 d	8.13 g	142 e	1.77 ab	2.57 de	3.87 d	47.60 a
BARImasur-4	53.0 bc	106 c	10.1 bc	222 a	1.75 ab	2.80 bc	4.90 a	48.51 a
CV (%)	12.74	1.58	9.61	11.60	2.85 ab	1.98 b	6.99	8.72

Same letter (s) in a column indicates do not differ significantly at P≤ 0.05

Study of flowering pattern in mungbean genotypes

A pot experiment was carried out at BINA pot yard, Mymensingh during March to May 2019 to assess the flowering pattern and its relationship with seed yield of 10 mungbean varieties/mutants. The experiment was laid out in a Completely Randomized Design with three replications. Flowers counts were recorded from each plant of each replication just from the date of first flowering and there after every day up to flowering ceased. At harvest, seed yield and yield attributes were recorded.

Daily flowering converted to 2-day interval had shown differential peak period (Table 25). The flowering duration range from 8 to 12 days after flowering started. The shortest flowering duration was recorded in MM-9, MM-11 and MM-12 (8 DAF, days after flowering started) and the longest was recorded in Binamoog-5 and MM-1 (12 DAF). The mutant MM-

1 produced highest number of flowers (38 plant^{-1}) followed by Binamoog-8 (32 plant^{-1}). In contrast, MM-9 produced the lowest number of flowers (13.1 plant^{-1}). Results indicated that the genotypes which had shorter flowering duration, also showed higher reproductive efficiency (Table 26). The highest seed yield 7.99 (g plant^{-1}) was recorded in MM-1 due to higher pod production. Binamoog-9 showed second highest seed yield with lower number of pods plant-1 might be due to good dry matter portioning to economic yield and larger seed size. Three mutants, MM-9, MM-11 and MM-12 matured earliest (60 days after sowing) and Binamoog-5 took the longest days to maturity (70 days after sowing).

Table 25. Flowering pattern at two-day interval of ten mungbean varieties/mutants

Mutants/ Varieties	Days to flowering	Number of opened flowers at 3 days interval						Total flowers plant^{-1} (no)
		Days after flowering start						
		0-2	3-4	5-6	7-8	9-10	11-12	
MM-1	39 b	3 c	7 b	9 a	10 b	8 a	1 b	38.0 a
MM-2	42 a	4 b	5 c	5 d	4 b	1 c	0	19.0 ef
MM-5	38 c	2 d	5 c	6 c	3.3 c	1 c	0	17.3 g
MM-8	37 c	4 b	9 a	5 d	1 e	1 c	0	20.0 de
MM-9	35 d	3 c	5 c	3.1 f	2 d	0	0	13.1 h
MM-11	35 d	6 a	6 bc	4 e	2 d	0	0	18.0 fg
MM-12	35 d	4 b	6 bc	5 d	2 d	0	0	17.0 g
Binamoog-5	40 b	4 b	5 c	4 e	4 b	3 b	2 a	22.0 cd
Binamoog-8	38 c	4 b	6 bc	8 b	13 a	1c	0	32.0 b
Binamoog-9	36 d	7 a	9 a	5.3	2 d	1 c	0	24.3 c
CV (%)	1.13	9.76	15.33	7.58	11.90	20.21	16.40	13.58

Same letter (s) in a column indicates do not differ significantly at P≤ 0.05

Table 26. Variation in reproductive efficiency, biological and seed yield in 10 mungbean varieties/mutants

Mutants/ Varieties	Repro-ductive efficiency (%)	Days to maturity	Biological yield (g plant^{-1})	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield plant^{-1} (g)	Harvest index (%)
MM-1	48.7 d	68 b	18.95 a	18.5	10.9 ab	4.95 cd	7.99 a	42.16 c
MM-2	63.2 b	65 c	10.81 e	12.0	10.8 ab	4.60 ef	4.77 cd	44.12 bc
MM-5	51.0 d	65 c	11.91 d	8.67	10.6 b	4.44 fg	3.66	30.73 f
MM-8	55.0 c	65 c	12.50 c	11.0	9.40 cd	4.85 de	4.21 e	33.68 e
MM-9	70.9 a	60 e	11.48 d	10.5	10.7 b	5.31 b	4.87 c	42.42 c
MM-11	55.6 c	60 e	10.90 e	10.0	9.11 e	5.11 bc	3.82 f	34.98 e
MM-12	64.7 b	60 e	8.50 f	11.0	8.20 f	3.82 h	2.85 g	33.53 e
Binamoog-5	63.6 b	70 a	12.20 c	14.0	9.70 cd	4.15 g	4.61 cd	37.78 de
Binamoog-8	53.1 c	66 c	14.55 b	17.0	9.80 c	5.15 bc	6.96 b	47.83 b
Binamoog-9	55.6 c	63 d	13.40 b	13.5	11.2 a	5.45 a	6.70 b	50.00 a
CV (%)	17.28	1.55	8.23	8.71	3.84	2.58 b	7.96	6.54

Same letter (s) in a column indicates do not differ significantly at P≤ 0.05

Effect of foliar application of chitosan on yield of tomato in summer season

The experiment was conducted at BINA farm, Mymensingh durng the period from March to June 2019 to investigate the effects of different levels of chitosan on yield and yield contributing characters of three tomato genotypes, Binatomato-13, Cherolla and Binatomato-7. Five concentrations *viz.*, 0, 50, 75, and 100 ppm were sprayed at vegetative and reproductive stages. In control, water was sprayed as per treatment. The experiment was laid out in pots in a completely randomized design with 3 replications. Recommended intercultural operations were done as when as required.

The foliar application of chitosan had significant effect on morphological parameters and yield (Tables 25-27). Cherolla showed better performance in most of the parameters. The highest fruit yield was found when chitosan was applied at the rate of 75 ppm. Therefore, 75 ppm chitosan may be applied to increase fruit yield of tomato.

Table 25. Effect of chitosan on morphological attributes and yield of tomato genotypes

Treatment	Plant height (cm)	Primary branches plant^{-1} (No.)	Secondary branches plant^{-1} (No.)	Flower cluster plant^{-1} (No.)	Fruit cluster plant^{-1} (No.)	Fruits plant^{-1} (No.)	Fruit yield plant^{-1} (Kg)
Control	75.67 b	4.00 b	7.33 c	8.11 b	6.00 c	46.00 b	2.04 b
50ppm	81.89 a	4.00 ab	10.22 a	9.00 b	7.22 b	60.67 a	2.05 b
75ppm	82.67 a	3.67 c	11.00 a	10.11 a	8.11 a	59.89 a	2.30 a
100 ppm	82.22 a	4.22 a	8.22 b	7.00 c	7.00 b	50.89 b	1.81 c
CV (%)	3.57	5.60	9.17	13.09	11.72	11.01	10.34

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 26. Morphological parameters and yield of tomato genotypes treated with chitosan

Genotype	Plant height (cm)	Primary branches plant^{-1} (No.)	Secondary branches plant^{-1} (No.)	Flower cluster plant^{-1} (No.)	Fruit cluster plant^{-1} (No.)	Fruits plant^{-1} (No.)	Fruit yield plant^{-1} (Kg)
Binatomato-13	65.58 c	3.75 b	7.67 b	7.58 b	5.83 b	23.92 c	1.81 b
Cherolla	105.8 a	3.83 b	12.71 a	10.58 a	9.50 a	106.20 a	2.90 a
Binatomato-7	70.50 b	4.33 a	7.17 b	7.50 b	5.92 b	33.00 b	1.45 c
CV (%)	3.57	5.60	9.17	13.09	11.72	11.01	10.34

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 27. Interaction of genotype and treatments on morphological parameters yield of tomato

Genotype × Treatment	Plant height (cm)	Primary branches plant^{-1} (No.)	Secondary branches plant^{-1} (No.)	Flower cluster plant^{-1} (No.)	Fruit cluster plant^{-1} (No.)	Fruits plant^{-1} (No.)	Fruit yield plant^{-1} (Kg)
V_1T_1	61.00 e	3.67 cd	6.66 de	8.33 cd	5.00 d	23.33 f	1.97 cd
V_1T_2	67.33 cd	3.33 de	8.00 cd	7.33 cd	6.33 cd	25.33 f	1.73 de
V_1T_3	69.67 cd	4.00 bc	9.00 c	8.33 cd	6.33 cd	26.33 ef	2.23 c
V_1T_4	64.33 de	4.00 bc	7.00 de	6.33 d	5.66 cd	20.67 f	1.30 f
V_2T_1	96.33 b	4.00 bc	9.33 c	8.66 c	6.66 c	85.33 c	2.73 b
V_2T_2	108.7 a	4.00 bc	14.60 a	11.30 b	9.33 b	117.30 a	2.79 b
V_2T_3	108.3 a	3.00 e	15.30 a	14.30 a	12.30 a	116.70 a	3.34 a
V_2T_4	109.7 a	4.33 ab	11.6 b	8.00 cd	9.66 b	105.30 b	2.73 b
V_3T_1	69.67 cd	4.33 ab	6.00 e	7.33 cd	6.33 cd	29.33 def	1.43 ef

V_3T_2	69.67 cd	4.66 a	8.00 cd	8.33 cd	6.00 cd	39.33 d	1.63 def
V_3T_3	70.00 c	4.00 bc	8.66 c	7.66 cd	5.66 cd	36.67 de	1.33 f
V_3T_4	72.67 c	4.33 ab	6.00 e	6.66 cd	5.66 cd	26.67 ef	1.40 ef
CV (%)	3.57	5.60	9.17	13.09	11.72	11.01	10.34

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Where V_1=Binatomato-13, V_2= Cherolla, V_3= Binatomao-7, T_1= Control, T_2= 50ppm, T_3= 75 ppm and T_4= 100 ppm of chitosan

Screening of lentil mutants in respect of morphological attributes and yield

The experiment was conducted during winter season of 2018-19 at two locations *viz.*, BINA farm, Magura and Ishurdi sub-stations with five lentil mutants along with a check Binamasur-8. The experiments were laid out following a randomized complete block design with three replications having a unit plot size of 1 m × 1.5 m. Row to row and plant to plant distances were 30 cm and 5-7 cm, respectively. Urea, triple superphosphate and muriate of potash were applied at the rate of 40, 120 and 80 kg/ha, respectively at the time of final land preparation. Proper cultural practices were followed as and when necessary. Data on morphological and yield attributes were recorded at harvest from 10 randomly selected plants in each plot.

Results showed that maximum mutants found shorter than check variety Binamusur-8 except LMM-9 at Magura and LMM-4 in Ishurdi (Tables 28-29). There was no variation among the mutants in respect of no. of seed plant^{-1} at both the locations and also in case of no. of branch plant^{-1} at Ishurdi location. But at Magura location two mutants were found more no. of branched plant^{-1} eg. LMM-7 and LMM-4. Maximun mutants were found bolder grain seed than check variety. Three mutants viz. LMM-6, LMM-7 and LMM-9 produced higher seed weight plant^{-1} than Binamosur-8 where mutants LMM-9 at Magura and LMM-6 at Ishurdi produced the highest due to higher number of pod plant^{-1} and larger seed size. Maximum mutants produced higher straw weight than check variety in both the locations.

Table 28. Morphological and and yield attibutes of lentil genotypes at Magura in 2018-19

Genotype	Plant height (cm)	Branches plant^{-1} (No.)	Seeds pod^{-1} No.)	Pods plant^{-1} (No.)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Straw wt. plant^{-1} (g)
LMI-3	33.87db	4.67b	1.77	60.53c	20.00cd	2.56d	1.22d
Binamasur-8	37.27b	4.13b	1.77	68.67bc	20.00cd	2.55d	1.29c
LMM-4	35.8bcd	5.00ab	1.63	73.93b	26.00a	2.42e	1.34bc
LMM-6	36.4bc	4.47b	1.67	76.93b	23.33b	2.76b	1.39b
LMM-7	34.4cd	5.80a	1.60	80.47ab	18.00d	2.67c	1.49a
LMM-9	40.87a	4.87ab	1.70	90.73a	21.00bc	3.15a	1.33bc

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 29. Morphological and and yield attributes of lentil genotypes at Ishurdi in 2018-19

Genotype	Plant height (cm)	Branches plant^{-1} (No.)	Seeds pod^{-1} No.)	Pods plant^{-1} (No.)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Straw wt. plant^{-1} (g)
LMI-3	51.53cd	8.27	1.77	171.8b	3.68bc	20.67abc	2.43b
Bina Mosor-8	55.33b	8.53	1.70	164.8bc	3.31c	19.67c	3.17ab
LMM-4	57.53a	8.67	1.60	164.2bc	4.38abc	21.67a	4.23a
LMM-6	50.20d	9.80	1.73	205.9a	5.50a	21.00ab	3.89a
LMM-7	52.20c	8.33	1.67	144.8c	3.61c	18.33d	3.59a
LMM-9	52.13c	8.27	1.57	159.7bc	4.93ab	20.33bc	3.73a

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Screening of mungbean mutants in respect of morphological attributes and yield

The experiments were conducted during Kharif-I season of 2019 at two locations *viz.,* BINA sub-stations, Magura and Ishurdi with six mungbean mutants along with a check varieties to evaluate the performance of genotypes through yield and yield attributes. The experiments were laid out following a randomized complete block design with three replications having a unit plot size of 3 m × 2.0 m. Row to row and plant to plant distances were 30 cm and 10 cm, respectively. Urea, triple superphosphate and muriate of potash were applied at the rate of 40, 120 and 80 kg/ha, respectively at the time of final land preparation. Proper cultural practices were followed as and when necessary. Data on morphological and yield attributes were recorded at harvest from 10 randomly selected plants in each plot and seed yield was taken from the whole plot and converted into kg/ha.

Data of different parameters showed significant differences among the genotypes in both the locations at $P \leq 0.01$ (Table 29 and 30). The Highest pods plant^{-1} was found in genotypes MM-8 and MM-11 (63.47 and 62.67) which was followed by other mutants and the lowest was found in check variety Binamoog-8 (48) at Ishurdi. All the mutants produced higher seed weight per plant^{-1} and 1000 seed weight than Binamoog-8 where the highest seed weight and 1000 seed weight were observed in MM-8 and MM-11. In case of Ishurdi location, MM-8 produced the highest plant height, Branch number plant^{-1}, Pod number plant^{-1}, Straw weight per plant as well as the highest seed weight per plant^{-1} where the lowest was found in MM-5. Considering both the locations, results indicated that mutants MM-8, MM-11 and MM-12 showed better performance. However, it needs more detailed study further.

Table 30. Morphological and yield attributes of mungbean genotypes at Magura in 2018-19

Variety	Plant height (cm)	Branch plant^{-1} (No.)	Seeds pod^{-1} (No.)	Pods plant^{-1} (No.)	Pod length (cm)	Seed yield plant^{-1} (g)	Straw wt. plant^{-1} (g)
MM-1	41.60cd	1.50b	11.8	20.27e	8.47a	6.80a	12.33b
MM-2	37.00d	1.10c	11.3	24.53d	6.61d	6.47a	6.80c
MM-5	36.33d	0.63d	11.0	17.87f	7.40c	4.07b	6.87c
MM-8	61.80a	2.40a	11.9	52.67a	6.67d	7.93a	17.93a
MM-11	49.27b	0.30e	11.5	24.40d	8.14ab	6.53a	7.00c
MI-12	45.80bc	1.40b	10.9	27.47c	7.61bc	7.13a	13.27b
BINA-8	49.87b	0.90c	11.1	31.93b	6.71d	6.60a	7.93c

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Table 31. Morphological and yield attributes of mungbean genotypes at Ishurdi in 2018-19

Genotype	Plant height (cm)	Branch plant^{-1} (No.)	Seeds pod^{-1} (No.)	Pods plant^{-1} (No.)	Pod length (cm)	1000-seed wt. (g)	Seed yield plant^{-1} (g)	Straw wt. plant^{-1} (g)
MM-1	46.53c	3.20c	9.93ab	56.13b	9.53b	33.1ab	3.77c	6.87b
MM-2	40.07d	3.37bc	10.03ab	58.20b	10.09a	33.3ab	3.95b	6.00c
MM-5	38.07e	3.70a	9.13c	57.47b	9.14b	32.0c	3.23e	6.83b
MM-8	48.40b	3.20c	9.83b	62.67a	8.16c	32.8b	4.03b	7.48a
MM-11	37.07f	3.50ab	10.17ab	63.47a	9.21b	33.5a	4.26a	6.77b
MI-12	50.73a	3.20c	9.90b	57.47b	9.49b	32.0c	3.75c	6.78b
BINA-8	50.93a	3.30bc	10.37a	48.00c	9.21b	30.1d	3.53d	7.45a

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT

Soil Science Division

Research Highlight

- The physico-chemical properties of the soil of Char Nilakkhia and Char Ishwardia are silty loam in texture. Soil pH is slightly acidic to alkaline in nature. Organic C content is low, total nitrogen is very low to low, available phosphorus is optimum to high, available sulphur is optimum to high, exchangeable potassium is very low to low, exchangeable calcium is low and exchangeable sodium is low. The texture of the soils of Char Vangnamari and Char Moddertek is silty loam. Soil pH is moderately to slightly acidic. The organic C of the soil is low to medium, total nitrogen is very low to low, the available phosphorus is very low to optimum, available sulphur is optimum, exchangeable potassium is very low to low, exchangeable calcium is very low to low and exchangeable sodium is optimum. The soils of these Char lands are normally erosive having low water holding capacity. Farmers of these Char lands are generally cultivate local varieties of crops. As a result, crop yields are low. Profitable crops and crop cultivation measures are recommended for these char land areas.
- The treatments containing organic matter were identical except control (no organic matter added) which ensured that organic matter played an important role and attributed to increase soil fertility and produce higher yield in T. aman and Boro rice crops.
- There was a wide variation among different chemical properties of soil in AEZs 25-27. Results of 180 collected soil samples were: pH strongly acidic to neutral; organic matter very low to low; total nitrogen low to medium; available P low to very high; available S very low to optimum and exchangeable K very low to low.
- The practice of roof top gardening may fulfill the daily needs of vegetables & fruits of a family grown in a sequence round the year in urban area; which may ultimately ensure family nutrition.
- Suitable management practices of saline soil very crucial for crop production. Combination of cowdung (5 tha^{-1}) with chemical fertilizers ($N_{140}P_{25}K_{45}S_{12}Zn_{3}B_{2}$, gypsum in two split) was found as the best, which produced the highest yield (6.11 tha^{-1}) of Binadhan-10 in Shamnagar, Satkhira.
- Thirty percent N, P, K and S fertilizer could be saved with the integrated (IPNS) use of giant mimosa green manure or sesbania geen manure in T. aman rice cultivation.
- Tweenty five percent N, P, K and S could be saved with the integrated use of giant mimosa brown manure or vermicompost-1 in boro rice cultivation.

- Over the 50yr period, the clay content decreases for most of the soil series and silt content increases for all depths sampled in 2017. Soil organic carbon decreased with the increase in soil depth. OC ranged from 0.40-2.77% at surface layer and 0.31-1.63% at deeper soil. C:N ration in 83% soil samples was less than 10 at surface layer. TN content for these soils was very low to optimum, TN decreased with the increase in soil depth, ranged from 0.048-0.335% at surface layer and 0.04-0.16% at deeper layer. 75.8% soil contains medium to very high available P at 0-10 cm depth and 44.8% at deeper soil. Available P ranged from 3.6-69.8 ppm at surface layer. About 55.1% soil contain medium to very high exchangeable K and Na, 41.3% contain medium to high exchangeable Ca.

- About 30% N, P, K and S fertilizers could be saved with the integrated (IPNS) use of giant mimosa green manure or sesbania green manure in T. aman rice cultivation.
- About 25% N, P, K and S fertilizers could be saved with the integrated use of giant mimosa brown manure or vermicompost-1 in Boro rice cultivation.
- Biofertilizer was developed for production of Felon (Cowpea) which increased 15-25% grain yield and 14-24% vegetable (Green pod) yield of Felon.
- Three Bradyrhizobial strains were found efficient in growth, nodulation and yield in of Felon from a pot experiment.
- An amount of 710 kg biofertilizers were produced for distributing to the farmers for production of pulse and oilseed crops.

Characterization and management of soils in selected char lands at Mymensingh for increasing cropping intensity and crop productivity

Among the total land areas about 0.83 million hectares are char lands in Bangladesh. The char land soils are mostly sandy loam to silty loam in nature. The soils in char land are normally erosive having low fertility and low water holding capacity. Generally, farmers of char lands cultivate local varieties of crops. As a result, crop yields are low. We have great opportunity to increase crop yields as well as enhance crop production with appropriate crop selection and management practices of crops and soils. Therefore, the objectives of this study were (i) to identify suitable crops and varieties. (ii) to develop profitable cropping patterns and piloting and (iii) to increase cropping intensity and crop yields in Char Nilakkhia and Char Ishwardia of Sadar and Char Vagnamarir and Char Moddertek of Gouripur Upazila, Mymensingh.

Soil sample collection and soil analyses:

Based on the objectives, soil survey and suitable crops across seasons have been studied (Table 1). The soil samples were collected from different depths from each of the sites and taken to the laboratory for physico-chemical analyses. The soil samples were analyzed following standard methods, viz.: particle size distribution (sand, silt and clay content) by particle size analyzer (Microtec), soil pH and EC by glass electrode, organic carbon by wet oxidation and total nitrogen by micro-Kjeldahl methods. Exchangeable calcium, potassium and sodium were determined by ammonium acetate extraction method.

Table 1. Description of sampling sites of the study areas

Sample no.	Location	Soil type	Crops/cropping pattern
1	Char Nilokkhia (Vatipara)	LL	Boro, Wheat, Legumes & pulses, Different Vegetables
2	Char Nilokkhia (Vatipara)	MHL	T.aman- Boro/Wheat, Maize, Mustard, pulaes, Citrus, Banana, Papaya, etc.
3	Char Nilokkhia (Vatipara)	MHL	T.aman- Boro/Wheat, Maize, Mustard, pulaes, Citrus, Banana, Papaya, etc.
4	Char Nilokkhia (Uttorpara)	LL	Boro, Wheat, Legumes & pulses, Different Vegetables
5	Char Ishwardia	LL	Boro, Wheat, Legumes & pulses, Different Vegetables
6	Char Vangnamari	MHL	T.aman- Boro/Wheat, Different Vegetables (year round)
7	Char Vangnamari	LL	Boro
8	Char Vangnamari	HL	T.aman-Boro/Wheat, Banana, Different Vegetables (year round)
9	Char Vangnamari	LL	Boro, Wheat, Different Vegetables

10	Char Vangnamari	MHL	T.aman-Boro/Wheat, Legumes & pulses, Different Vegetables (year round)
11	Char Vangnamari	LL	Boro, Wheat, Legumes & pulses, Different Vegetables
12	Char Moddhotek	MHL	Irrigated rice, Wheat, Mustard, pulaes, Citrus, Banana, Papaya, etc.
13	Char Moddhotek	MHL	T.aman- Boro/Wheat, Mustard, pulaes, Citrus, Banana, Papaya, etc.

(A) Char Nilakkhia and Char Ishwardia of Sadar Upazila at Mymensingh district

Soil survey and suitability of crop cultivation across the areas

The land of Char Nilakkhia and Char Ishwardia is almost flat which is formed across the old channel of Brahmaputra River. A brief of land types and cropping system of the char land areas are presented in Table 1. The nature of land is medium high to lowland. Major part of this area temporarily flooded in rainy season and some other areas flooded for medium to deeply for long duration. All the sediments of these plains are transported from the Brahmaputra River.

Farmers cultivate local varieties of transplanted amen and boro rice, wheat, maize, mustard, mungbean, groundnut, sweet potato, chilli, garlic, legumes & pulses, and different kinds of vegetables. Yield of crops is low due to improper crop and fertilizer management.

Soil properties:

The physico-chemical properties of the soil of Char Nilakkhia and Char Ishwardia of sadar upzila at Mymensingh district are presented in Tables 2 & 3. The texture of soil is silty loam (Table 2). From Table 3, soil pH is slightly acidic to alkaline in nature (4.78-738). Organic C content is low (0.685-1.411%), total nitrogen is very low to low (0.025-0.137%), available phosphorus is optimum to high (10.997-35.505ppm), available sulphur is optimum to high (24.94-68.01ppm), exchangeable potassium is very low to low (0.088-0.193meq%), exchangeable calcium is low (2.067-3.982meq%) and sodium is low (0.195-0.342meq%)).

Table 2. Sand, silt, clay and soil texture of Char Nilokkhia and Char Ishwardia of sadar upzila at Mymensingh district.

Location	Depth (cm)	%Sand	%Silt	%Clay	Texture
Char Nilokkhia (Vatipara)	0-15	27.79	68.13	4.07	Silty loam
	15+	43.32	55.48	1.19	Silty loam
Char Nilokkhia (Vatipara)	0-15	19.41	74.45	6.14	Silty loam
	15+	22.95	72.31	4.74	Silty loam
Char Nilokkhia (Vatipara)	0-15	18.58	74.57	6.84	Silty loam

	15+	17.87	73.71	8.41	Silty loam
Char Nilokkhia (Uttorpara)	0-15	16.39	72.15	11.46	Silty loam
	15-50	4.39	77.34	18.27	Silty loam
	50+	17.79	76.51	5.70	Silty loam
Char Ishwardia	0-15	22.92	69.43	7.65	Silty loam
	15+	32.73	63.45	3.82	Silty loam

Table 3. Soil pH, OC, total N, avail. P, exch. K, avail. S, exch. Ca and exch. Na of Char Nilokkhia and Char Ishwardia of sadar upzila at Mymensingh district.

Location	Depth (cm)	pH	OC (%)	TN (%)	Avail.P (ppm)	exch. K (%meq)	Avail.S (ppm)	exch. Ca (%meq)	exch. Na (%meq)
Char Nilokkhia (Vatipara)	0-15	6.50	0.685	0.025	10.997	0.088	32.87	2.067	0.195
	15+	7.63	0.564	0.013	14.139	0.064	24.94	1.820	0.189
Char Nilokkhia (Vatipara)	0-15	5.72	0.927	0.024	20.109	0.092	24.94	2.408	0.244
	15+	6.51	0.424	0.018	17.281	0.095	22.67	2.446	0.250
Char Nilokkhia (Vatipara)	0-15	4.78	1.089	0.035	35.505	0.092	68.01	2.465	0.262
	15+	6.44	0.605	0.029	16.697	0.077	29.47	2.427	0.250
Char Nilokkhia (Uttorpara)	0-15	5.74	1.411	0.137	17.595	0.174	41.94	3.204	0.275
	15-50	7.84	1.048	0.038	20.707	0.180	28.34	4.930	0.378
	50+	7.96	0.605	0.024	18.852	0.127	30.60	3.754	0.299
Char Ishwardia	0-15	7.38	1.007	0.013	16.653	0.193	49.87	3.982	0.342
	15+	7.68	0.564	0.018	12.882	0.084	21.54	2.996	0.238

Suggestions/Recommendations:

- Crops of T.aman (HYV & local), Boro (HYV & local), T.aus (Local), Mustard, Mungbean, Groundnut, Soybean, Potato, Jute, Maize, Chilli, Cauliflower, Cabbage, Onion, Garlic, Tomato, Water melon, Cucumber, Melom, etc. could be grown. Farmers could be benefited by improved management and HYV of crops, irrigation, fertilizer, etc. at this area.
- Bio-fertilizer should be used for pulse and oilseed crop cultivation.
- Profitable crops and cropping pattern can be recommended through research.
- Comprehensive agricultural development programs should be taken by different GO/NGOs and other organizations.

(B). Char Vangnamari and Char Moddertek of Gouripur Upazila of Mymensingh

Soil survey and suitability of crop cultivation across the areas

The land of Char Vangnamari and Char Moddertek is almost flat, which is formed by the old channel of Brahmaputra River. A brief of land types and cropping system of the char land areas are presented in Table 1. The land is medium high to lowlands. Major part of this area is temporarily flooded in rainy season for short period and some other areas are medium to deeply flooded for medium to long period. All the sediments of these plains are transported from the Brahmaputra River.

Farmers cultivate local varieties of transplanted aman and boro rice, wheat, maize, mustard, mungbean, groundnut, sweet potato, chilli, garlic, legumes & pulses, and different kinds of vegetables. Yield of crops is low due to improper crop and fertilizer management.

Soil properties:

The physico-chemical characteristics of the soils of Char Vangnamari and Char Moddertek are presented in Table 4 and Table 5. The texture of the soils is silty loam (Table 4). From the Table 5, soil pH is moderately to slightly acidic. The organic C of the soil is low to medium (0.403-1.974%), total nitrogen is very low to low (0.024 -0.139%), available phosphorus is very low to optimum (9.74-29.535ppm), available sulphur is optimum (18.14-27.2ppm), exchangeable potassium is very low to low (0.054-0.228me%), exchangeable calcium is very low to low (0.228-2.825me%) and exchangeable sodium is optimum (0.183-0.329me%).

Location	**Depth (cm)**	**pH**	**OC (%)**	**TN (%)**	**P (ppm)**	**K (%me)**	**S (ppm)**	**Ca (%me)**	**Na (%me)**
Char Vangnamarir	0-11	6.87	0.658	0.024	13.196	0.082	26.07	0.285	0.281
	11-50	7.70	0.403	0.022	9.740	0.103	20.40	3.034	0.305
	50+	7.96	0.242	0.015	15.082	0.107	15.87	2.996	0.317
Bhangnamarir char	0-11	6.62	0.685	0.073	17.281	0.125	26.07	2.825	0.329
	11-50	6.87	0.424	0.036	10.997	0.127	19.27	3.053	0.323
	50+	6.95	0.322	0.029	8.798	0.092	10.20	3.090	0.323
Char Vangnamari	0-14	6.27	0.806	0.056	9.740	0.084	19.27	2.245	0.226
	14-50	6.51	0.282	0.028	15.710	0.064	24.94	2.048	0.201
	50+	6.74	0.242	0.028	14.767	0.075	20.40	2.256	0.214
Char Vangnamari	0-18	5.90	1.048	0.095	22.622	0.054	18.14	0.180	0.195
	18-55	6.31	0.161	0.056	13.196	0.075	21.54	2.844	0.281
	50+	6.32	0.443	0.041	14.767	0.067	19.27	2.427	0.226
Char Vangnamari	0-14	6.48	0.403	0.071	10.054	0.079	22.67	2.237	0.220
	14+	6.66	0.645	0.066	10.683	0.088	24.94	2.446	0.220
Char Vangnamari	0-16	6.18	0.282	0.077	14.139	0.073	24.94	0.184	0.250
	16+	6.54	0.846	0.059	14.453	0.079	35.14	2.806	0.268
Moddhyotek	0-15	6.27	0.605	0.052	10.369	0.082	21.54	1.858	0.183
	15+	6.58	0.322	0.018	9.740	0.058	27.20	1.877	0.189
Moddhyotek	0-15	5.17	1.974	0.139	29.535	0.228	27.20	1.991	0.262
	11-40	6.31	0.725	0.123	14.453	0.137	23.80	2.844	0.268
	40+	6.79	0.443	0.021	15.082	0.112	22.67	2.427	0.232

Table 4. Depth-wise soil texture of Char Vangnamari and Char Moddhyotek of Gouripur upzila at Mymensingh district.

Location	Depth (cm)	%Sand	%Silt	%Clay	Texture
Char Vangnamari	0-11	11.23	80.8	7.96	Silty loam
	11-50	9.36	80.87	9.78	Silty loam
	50+	28.25	66.66	5.09	Silty loam
Char Vangnamari	0-11	11.16	80.71	8.13	Silty loam
	11-50	15.53	73.8	10.67	Silty loam
	50+	45.64	50.41	3.95	Silty loam
Char Vangnamari	0-14	8.42	81.43	10.15	Silty loam
	14-50	51	46.98	2.02	Loamy soil
	50+	45.26	52.2	2.53	Silty loam
Char Vangnamari	0-18	17.06	74.87	8.08	Silty loam
	18-55	14.19	79.42	6.39	Silty loam
	50+	36.02	60.43	3.56	Silty loam
Char Vangnamari	0-14	26.95	68.33	4.73	Silty loam
	14+	29.22	68.32	2.46	Silty loam
Char Vangnamari	0-16	44.65	52.72	2.62	Silty loam
	16+	43.38	54.23	2.38	Silty loam
Char Moddhyotek	0-15	65.9	33.24	0.85	Sandy loam
	15+	50.9	47.32	1.78	Loamy soil
Char Moddhyotek	0-15	16.36	72.4	11.24	Silty loam
	11-40	2.46	83.11	14.43	Silty loam
	40+	7.5	86.86	5.65	Silty loam

Suggestions/Recommendations:

- Crops of T.aman (HYV & local), Deep water rice, Boro (HYV & local), T.aus (Local), Mustard, Mungbean, Groundnut, Soybean, Potato, Jute, Maize, Chilli, Cauliflower, Cabbage, Onion, Garlic, Tomato, Water melon, Cucumber, Melom, etc. could be grown. Farmers could be benefited by improved management and HYV of crops, irrigation, fertilizer, etc. at this area.
- Use bio-fertilizer in pulse and oilseed crop cultivation.
- Profitable crops and cropping pattern can be recommended through research.
- Farmers training should be arranged for extension of different modern technologies to the farmers' and other comprehensive agricultural development programs should be taken by different GO/NGO and other organizations.

Field trials with major crops in Tista Meander Floodplains (AEZ-3) for sustaining soil fertility and crop productivity

Over the last few decades, enormous pressure has been exerted on the land for large population which causes depletion of plant nutrients and degradation of land resources in Bangladesh. Further integrated and balanced nutrient management practices are ensuring an increased soil fertility and sustained crop productivity. Therefore, a study was initiated to increase crop yield through the use of organic matter along with chemical fertilizers to look beyond immediate crop needs for building up of soil fertility for the future.

A field experiment was initiated at BINA sub-station farm Rangpur from Rabi season of 2014 using different organic matter treatments. Initial soil data have been recorded. After harvesting of T.aman rice (2017), the post harvest soil samples were collected and the data of N, P, K & S were reported last year. The data of T.aman (Binadhan-17) and Boro (Binadhan-5) rice are presented in Tables 6 & 7, respectively.

Transplanted aman rice (Variety - Binadhan-17) :

After havesting mungbean pod, all of the residues were added in the plots except control (T_1). T.aman rice (Variety - Binadhan-17) was planted in the same experimental plots. Fifty percent recommended dose of N, P, K and S fertilizers were applied in all plots. All TSP, MP and Gypsum were applied during final land preparation. Data of yield and different yield contributing parameters are shown in Table 6. Treatment T_4 produced the longest plant and panicle length, maximum number of effective tillers per hill, filled grains panicle^{-1}, and the highest yield of grain (5.68 t ha^{-1}) and straw (6.88 t ha^{-1}). Organic amended treatments performed better than the control treatment T_1. The results indicated that addition of organic residues were very useful to contribute in crop yield (Table 6).

Boro rice (Variety- Binadhan-5) :

After havesting, one-third of T.aman rice residues were added in all plots except T_1 treatment. Recommended 50% dose of N P, K, S fertilizers were applied in all plots. The yield and yield contributing characters of Boro rice were significantly influenced by the treatments (Table 7). Treatment T_4 produced the longest plant and panicle length, maximum number of effective tillers per hill, filled grains panicle^{-1}, and the highest yield of grain (5.63 t ha^{-1}) and straw (7.67 t ha^{-1}). Organic amended treatments performed better than the control treatment T_1. The results indicated that addition of organic residues were very useful to contribute in crop yield (Table 7).

Table 6: Effect of organic amendment on T.aman rice (Binadhan-17) at Rangpur

Treatments	Grain yield(t/ha)	Straw yield (t/ha)
T_1 = control	4.67	6.47b
T_2 = STB	5.50	7.67a
T_3 = STB +3 t PM ha^{-1}	5.33	7.40ab
T_4 = STB +5 t CD ha^{-1}	5.27	7.30ab

T_5 = 75 % STB +3 t PM ha^{-1}	5.17	7.14ab
T_6 = 75 % STB +5 t CD ha^{-1}	5.17	6.97ab
CV (%)	5.18	7.16

In a column, figures having common letter(s) do not differ significantly at 1% level of probability.

Table 7: Effect of organic amenment on Boro rice (Binadhan-5) at Rangpur

Treatments	Grain yield(t/ha)	Straw yield (t/ha)
T_1 = control	4.85b	6.08
T_2 = STB	5.67a	6.78
T_3 = STB	5.53a	6.73
T_4 = STB	5.42ab	6.63
T_5 = 75 % STB	5.20ab	6.59
T_6 = 75 % STB	5.26ab	6.64
CV (%)	5.33	6.85

In a column, figures having common letter(s) do not differ significantly at 5% level of probability.

Conclusion:

All the treatments were identical except control which ensured that organic matter could play an important role and attribute to increase soil fertility and crop productivity. The combinations of organic materials were very useful to produce higher yield in T.aman–Boro cropping pattern.

Delineation of different nutrients status in terrace soils

Critical limit (C.L.) refers to a threshold value of a nutrient in soil below which the crop will readily respond to its application. Critical limit of a nutrient in plant refers to a level at or below which plant either develops deficiency symptoms or causes reduction in crop yields as compared to optimum yields. Soil Science Division of BINA is responsible to evaluate the nutrient status of AEZ 25, 26 & 27 encompassing terrace soil. The benchmark survey was completed, and a total 180 soil samples were collected as per protocol. GPS reading were also recorded for every site of sample collection. Soil samples were collected from AEZ 25-Level Barind Tract (Manda, Naogaon; Nandigram, Bogra and Hakimpur, Dinajpur), AEZ 26-High Barind Tract (Nachol, Chapai Nawabganj and Godagari, Rajshashi) and AEZ 27- North Eastern Barind Tract (Mithapukur, Rangpur). Analysis of collected soil samples for pH, organic matter, total nitrogen, available phosphorus and sulphur were completed.

Results and Discussion:

Physico-chemical properties of soil samples collected from Manda, Naogaon varied pH 6.4-7.4 (slightly acidic to neutral), OM 0.69-1.46% (low), total N 0.064-0.139% (very low to low), available P 4.9-36.1 ppm (very low to high) and available S 12.8-41.7 ppm (low to very high). In case of Nandigram, Bogra varied pH 5.0-5.9 (strongly acidic to slightly acidic), OM 1.30-1.87% (low to medium), total N 0.098-0.163% (very low to low), available P 4.7-39.9 ppm (very low to very high) and available S 6.46-24.25 ppm (very low to optimum). In Hakimpur, Dinajpur varied pH 5.5-5.9 (slightly acidic), OM 0.85-2.09% (very low to medium), total N 0.095-0.185% (very low to medium), available P 4.2-41.4 ppm (very low to very high) and available S 6.65-29.95 ppm (very low to optimum). Results of soil samples collected from Nachol, Chapai Nawabganj varied pH 5.9-7.3 (slightly acidic to neutral), OM 0.76-1.71% (low), total N 0.074-0.157% (very low to low), available P 3.9-35.7 ppm (very low to optimum) and available S 3.3-26.3 ppm (very low to optimum). In case of Godagari, Rajshashi varied pH 5.4-7.2 (strongly acidic to neutral), OM 0.72-1.44% (very low to low), total N 0.082-0.147% (very low to low), available P 3.6-47.7 ppm (very low to very high) and available S 6.46-21.1 ppm (very low to medium). In Mithapukur, Rangpur varied pH 5.4-6.0 (strong acidic to slightly acidic), OM 0.65-1.75% (very low to medium), t1otal N 0.090-0.151% (very low to low), available P 5.4-25.2 ppm (very low to optimum) and available S 5.01-328.5 ppm (very low to optimum).

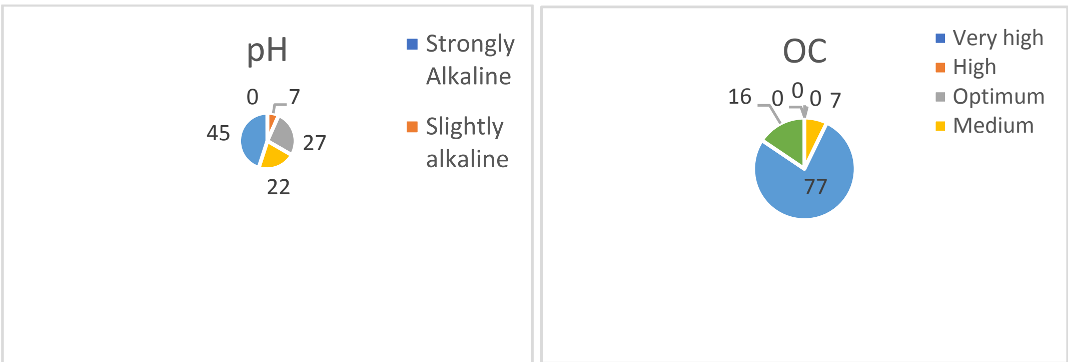


Fig. 1: Status of 180 soil samples in percentage for soil pH and organic matter.

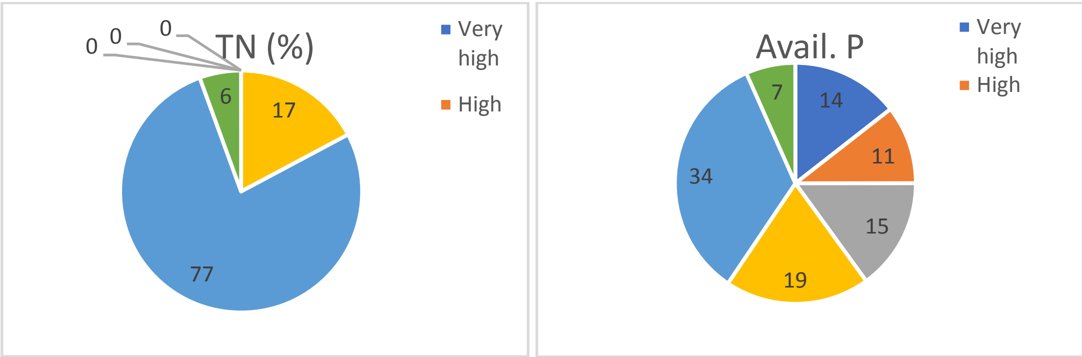


Fig. 2: Status of 180 soil samples in percentage for total nitrogen and available phosphorus.

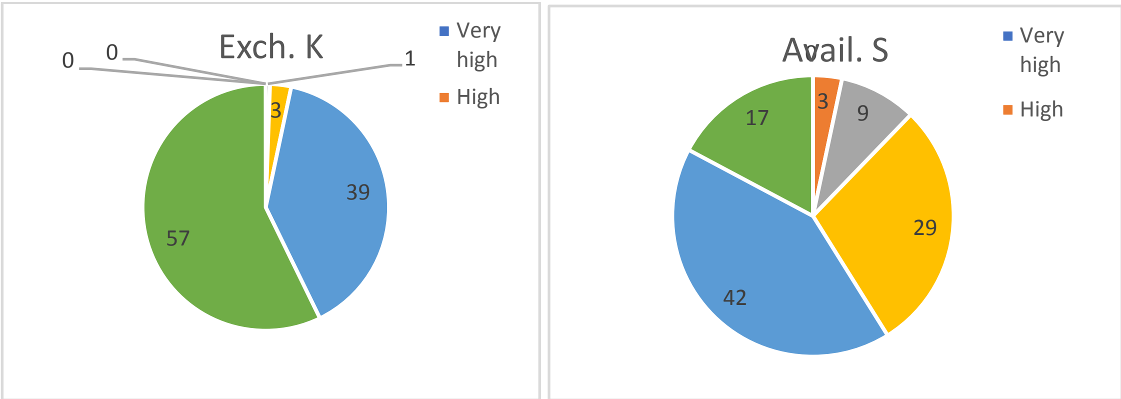


Fig. 3: Status of 180 soil samples in percentage for available sulphur and exchangeable K.

Conclusion:

There was a wide variation among different chemical properties of soil under study. Results revealed that pH (strongly acidic 45%, slightly acidic 22%, neutral 27% and slightly alkaline 7%); organic matter (very low 16%, low 77% and medium 7%); total nitrogen (very low 6%, low 77% and medium 17%); available P (very low 7%, low 34%, medium 19%, optimum 15%, high 11% and very high 14%); available S (very low 17%, low 42%, medium 29%, optimum 9%, high 3%) and exchangeable K (very low 77%, low 39%, medium 3% and optimum 1%), respectively.

Effect of different sources organic manures for vegetable and fruit production in rooftop gardening

A roof top garden is a garden on the roof of a building. Source of water and clear drainage system are a must. Regular irrigation i. e. daily watering is a must in the hot summer days. There are many benefits of roof top gardening. Apart from food supply, roof plants are beneficial for control of carbon emission and supply of oxygen to the atmosphere and filtering out harmful carbon dioxide from the atmosphere. A series of experiments (vegetables and fruits) were setup at the roof of Soil Science Division to find out suitable inorganic and organic fertilizer management practices for maximize vegetable production. The crops were vegetable (Indian Spinach, Brinjal and Chili) and fruit (mango and lemon). There were five treatments i. e T_1= Recommended Chemical fertilizer (RCF), T_2= RCF + vermicompost (3t/ha), T_3= IPNS of T_2, T_4= RCF + Eco compost (3t/ha) and T_5= IPNS of T_4. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The initial soil characters are shown in Table-8.

Results and Discussion:

The yield of vegetables differed significantly among the treatments (Table 9). The fresh weight of green chili ranges from 155.7-241.6 g/plant. The highest yield (241.6 g/plant) was obtained in treatment T_5 (IPNS of T_4) which differed from all other treatments. In case of brinjal production the value ranges from 311.6-406.6 g/plant and the highest yield (406.6 g/plant) was also obtained in treatment T_5 (IPNS of T_4) which significantly differed from all other treatments. Considering the Indian spinach production, the highest yield was recorded in treatment T_3 (IPNS of T_2) which was very close with all other treatments except T_5.

Table 8: Initial soil characteristics for roof top gardening at Soil Science Division, BINA

Locations	pH	OM (%)	Total N (%)	Available P (ppm)	Available S (ppm)	Exchangeable K (meq%)
Mymensingh	7.2	0.92	0.056	5.8	18.6	0.072
Critical limit	-	-	0.120	10.0	12.0	0.200

Table 9: Yields of crops in roof top gardening at Soil Science Division, BINA during 2018-19

Treatments	Green chili (var. Binamorich-1)		Brinjal (var. local)		Indian spinach (var. local)	
	g/plant	t/ha	g/plant	t/ha	g/plant	t/ha
T_1	155.7	5.19d	311.6	16.35c	786.8	41.31a
T_2	186.7	6.22c	332.1	17.44c	791.6	41.16a
T_3	207.0	6.89bc	372.8	19.57b	819.1	43.00a
T_4	217.8	7.03ab	380.5	19.98ab	781.3	41.01a
T_5	241.6	8.05a	406.6	21.35a	667.0	35.02b
CV%	4.55		6.15		7.12	
RCF (kg/ha)	$N_{110}P_{55}K_{100}S_{18}Zn_2B_{1.5}$		$N_{140}P_{40}K_{110}S_{18}Zn_3B_{1.5}$		$N_{120}P_{30}K_{60}S_{18}$	
D/S, D/T	22.11.2018		22.11.2018		13.06.2019	
D/H	12.03.2019		03.04.2019		-	

Means with common letter(s) are not significantly different at 5% level of probability by DMRT

Conclusion:

The practice of roof top gardening may be fulfil the daily needs of vegetables & fruits of a family grown in a sequence round the year in urban area and which will ultimately ensure family nutrition and minimize harmful effect of environment.

Monitoring and management of saline soil for increased crop production

Agriculture is a major sector of Bangladesh's economy and the coastal area of Bangladesh is suitable for growing rice where more than 30% of the cultivable land is in the coastal areas. A field experiment was conducted at farmer's field with saline soil of Shamnagar, Satkhira district to observe the effect of split application of gypsum, organic & inorganic fertilizer management and its effect on salinity. There were six treatments Viz. T_1= Recommended Chemical fertilizer, T_2= NPK+ Gypsum in two split, T_3= NPK+ Gypsum in two split + CD (5tha^{-1}), T_4= NPK+ Gypsum in three split, T_5= NPK+ Gypsum in three split + CD (5tha^{-1}), T_6= Control. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Full dose of P, K, S, Zn and B fertilizers and ⅓ of N fertilizer were applied at the time of final land preparation. The rest of N fertilizer was applied in two equal split at 20 and 50 days after transplanting. Weeding, irrigation and insecticide were applied as and when necessary. The initial soil characteristics of the experimental site are given in Table 10.

Table 10: Initial soil characteristics of the experimental site at Farmer's field, Shamnagar, Satkhira

Locations	pH	OM (%)	Total N (%)	Available P (ppm)	Available S (ppm)	Exchangeable K (meq%)
Farmer's field, Shamnagar, Satkhira	7.8	1.92	0.096	13.8	18.6	0.23
Critical limit	-	-	0.12	10.0	12.0	0.20

Results and Discussion:

Yields of Boro 2019

The yield and yield contributing characters were affected significantly due to the treatments (Table 11). The higher values of yield parameters (panicle length, tiller per hill, 1000 seeds weight) were obtained in treatment T_3. However, the grain yield of Binadhan-10 ranged from

3.27 to 6.11 t ha^{-1}. The highest grain yield (6.11 t ha^{-1}) was recorded in combination of cowdung (5 tha^{-1}) with chemical fertilizers ($N_{140}P_{25}K_{45}S_{12}Zn_3B_2$, gypsum in two split) in treatment T_3 and the lowest (3.27 t ha^{-1}) was obtained from treatment T_6 (control). The straw yield ranged from 4.14 to 6.96 t ha^{-1}. The highest straw yield (6.96 t ha^{-1}) were recorded in treatment T_5 (NPK+ Gypsum in three split + CD) and the lowest was obtained from treatment T_6. Result revealed that application of cowdung along with split application of gypsum have positive effect on production of boro rice in saline area of Bangladesh.

Table 11: Grain and straw yields (t ha^{-1}) of Boro rice Binadhan-10) at Farmer's field, Shamnagar, Satkhira during 2019

Treatments	Plant height (cm)	Panicle length (cm)	Tiller/hill (no.)	1000 seeds wt. (g)	Grain yield (t/ha)	Straw yield (t/ha)
T_1	95.1ab	26.1ab	11.3ab	24.4	5.69a	6.39ab
T_2	97.2ab	25.8ab	12.1ab	24.5	6.02a	6.57a
T_3	100.2a	26.8a	13.1a	25.3	6.14a	6.15ab
T_4	96.3ab	25.3ab	11.5ab	24.7	5.75a	6.45ab
T_5	89.9b	25.0b	10.6bc	23.7	5.84a	6.96a
T_6	78.4c	24.7b	8.2c	24.5	3.27b	4.14b
CV%	3.79	2.37	7.65	NS	13.25	12.98

Means with common letter(s) are not significantly different at 5% level of probability by DMRT
D/S-20.12.2018; D/T-21.01.2019; D/H-24.04.2019

Salinity Status

The salinity status is very important throughout the growing season. The salinity status of the experiment site ranged from 3.77 to 8.68 dSm^{-1} during the whole growing season (December/2018 to April/2019) (Table 12).

Table 12: Soil salinity level of boro rice growing period at farmer's field, Shamnagar, Satkhira during 2018-19

Period	Initial	8^{th} December	23^{th} January	10^{th} February	1^{st} March	15^{th} March	1^{th} April	13^{th} April
Salinity (dSm^{-1})	4.60	4.77	4.92	5.32	6.60	6.83	8.23	8.68

Conclusion

Combination of cowdung (5 tha^{-1}) with chemical fertilizers ($N_{140}P_{25}K_{45}S_{12}Zn_3B_2$, gypsum in two split) in treatment T_3 was found to be the best, which produced the highest yield (6.11 tha^{-1}) of Binadhan-10 in Shamnagar, Satkhira.

Reduction Of Chemical Fertilizer In Crop Production Using Organic Manures

Field experiments were conducted to reduce the chemical fertilizer with the integrated use of organic manures and chemical fertilizers in T. aman-Boro rice cropping pattern. The experiments were conducted at the BINA farm, Mymensingh in three consecutive year from 2016-17 to 2018-19. The experiment is being conducted as a part of for long term study. The reported data were for 2018-19 and average yields of three years. Six treatments were used in the experiment. The treatments used for T. aman rice (Binadhan 17) were as follows: T_1: Native soil fertility, T_2: 100% Chemical Fertilizer (CF), T_3:70%N from CF, T_4: 30% N from giant mimosa green manure + 70% N from CF and T_5:30% N from sesbania green manure + 70% N from CF and T_6: 100% PKS. The treatments of Boro rice (var. Binadhan 10) were: T_1: Native soil fertility, T_2: 100% N from chemical fertilizer (CF), T_3:75% N from CF, T_4: 25% N from Giant mimosa brown manure + 75% N from CF, T_5: 25% N from Vermicompost-1+ 75% N from CF and T_6: 100% PKS. The experiments were carried out in a Randomized Complete Block Design with three replications for each treatment. The properties of initial soil have been given in the Table 13. T. Aman rice (var. Binadhan-17) was transplanted in August and harvested in first week of November 2018 where Boro rice (Binadhan-10) was transplanted in the first week of February and harvested on the second week of May in every year. Fertilizers were applied in both the crops on the basis of soil test. In case of manure treatments, IPNS was followed i.e. chemical fertilizer N, P, K and S were balanced according to nutrients supply from organic manures. Therefore, P, K, and S were also reduced from CF treatment in T. aman or Boro rice, respectively. Nutrient contents of different organic manures have been given in Table 14. All manures were applied at 15 days before of transplanting of both the rice crops except vermicompost. Vermicompost and all inorganic fertilizers (TSP, MOP and gypsum) were applied during final land preparation except urea. Urea was applied in three equal splits. Fertilizer and manures rates have been given in Table 15.

Table 13. Properties of initial soil

Soil analysis interpretation	**Texture**	**pH**	**O.C (%)**	**Total N (%)**	**P (μgg^{-1})**	**K (meq%)**	**S (μgg^{-1})**
	Silt loam	6.8	1.1	0.12	14.0	0.145	15.0
		Neutral	Low	Low	medium	Low	Low

Table 14. Nutrient contents in different manures

Name of manures	%N	%P	%K	%S
Sesbania green manure	1.75	0.3	0.45	0.25
Giant mimosa green manure	1.8	0.4	0.8	0.30
Giant mimosa brown manures	1.65	0.35	1.1	0.2
Vermicompost-1	1.1	0.5	1.0	0.4

Table 15. Full rates (100%) of nutrients and 30% (for T. aman) or 25% (for boro rice) N equivalent manures for T. aman rice and boro rice.

	Nutrients (kg ha^{-1})				Manures (t ha^{-1})*			
Crops	N	P	K	S	30% N equivalent Sesbania green manure	30% N equivalent giant mimosa green manure	25% N equivalent giant mimosa brown manure	25% N equivalent vermicompost-1
T. aman rice	77	9	24	9	1.320	1.283	-	-
Boro rice	134	14	68	13	-	-	2.015	3.022

* Oven dry weight basis

All the yields and yield contributing characters of T. Aman rice were significantly affected by the different treatments in 2018-19 (Table 16) and as well as in average of three years (Table 17). The treatment T_5 gave maximum average grain yield (4.71 t ha^{-1}) followed by the treatment T_5 (4.59 t ha^{-1}). But the treatment T_5, T_4, and T_2 gave identical grain yields of T. Aman rice. The treatment T_1 (Native soil fertility) gave significantly minimum grain yield of T. Aman rice. Similar results were observed in case of straw yields of T. Aman rice. The result indicated that 70% N from chemical fertilizer with 30% N from either giant mimosa or sesbania green manures gave comparable yield to the sole application of 100% N from chemical fertilizer alone. Therefore, 30% N, P, K and S fertilizer could be saved with the integrated (IPNS) use of giant mimosa green manure or sesbania geen manure in T. aman rice cultivation.

Table 16. YieldS and yield contributing characters of T. Aman rice (Binadhan-17) as affected by different treatments during 2018-19

Treatments	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Plant height (cm)	Panicle length (cm)	Effective tiller $hill^{-1}$ (no.)	Filled grain $panicle^{-1}$ (no.)	unfilled grain $panicle^{-1}$ (no.)
T_1	2.6c	2.8b	80.4b	19.4b	5.9b	79.6b	44.07
T_2	4.3a	4.8a	92.0a	24.1a	10.0a	134.8a	46.67
T_3	3.7b	4.1a	94.5a	21.2a	7.4a	112.7a	42.67
T_4	4.7a	5.0a	96.9a	24.4a	10.5a	140.0a	44.67
T_5	4.9a	5.1a	96.3a	24.0a	9.9a	138.3a	52.40
T_6	2.7c	3.0b	85.5b	20.3b	6.5b	97.7b	47.00
%CV	8.59	13.35	5.35	5.2	12.94	12.42	17.45

In a column, figures having common letter(s) do not differ significantly at 5% level of probability.

Table 17. Average (three years) grain and yields of T. aman rice as affected by different treatments

Treatments	2016-17		2017-18		2018-19		Average	
	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Grain yield (tha^{-1})	Straw yield (tha^{-1})
T_1	2.49b	4.30b	2.66c	3.37b	2.6c	2.8b	2.58	3.49
T_2	4.40a	5.57a	4.57ab	5.54a	4.3a	4.8a	4.42	5.30
T_3	3.84a	5.57a	3.89b	4.93b	3.7b	4.1a	3.81	4.87
T_4	4.34a	5.33a	4.75a	5.41a	4.7a	5.0a	4.59	5.24
T_5	4.44a	5.93a	4.80a	5.55a	4.9a	5.1a	4.71	5.52
*T_6	-	-	2.76c	4.01b	2.7c	3.0b	2.73	3.50
%CV	12.08	13.35	11.08	10.37	8.59	13.35		-

In a column, figures having common letter(s) do not differ significantly at 5% level of probability. *In 2016-17 the treatment T_6 was not included.

The different treatments significantly influenced the yields and yield contributing characters of Boro rice (Binadhan-10) during 2018-19 (Table 18) and as well as on average grain yields (Table 19).The treatment T_4 (5.66.0 t ha^{-1}) gave the highest average grain yield of Boro rice followed by the treatment T_2 and $T_{5,}$. Both the manure treatments with chemical fertilizer produced statistically similar grain yield to the full dose of chemical fertilizer (100%N from CF) in average of three years. The treatment T_1 (native soil fertility) gave the lowest yield of boro rice. Similar trends were also observed in case of straw yields. The results revealed that 25% N could be saved with the integrated use of giant mimosa brown manure or vermicompost-1 in boro rice cultivation. So 25% N, P, K and S fertilizers could be reduced with integrated application of giant mimosa brown manure or vermicompost-1 for the cultivation of Boro rice.

Table 18. Yield and yield contributing characters of Boro rice (Binadhan-10) as affected by different treatments during 2018-19

Treatments	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Plant height (cm)	Panicle length (cm)	Effective tiller $hill^{-1}$ (no.)	Filled grain $panicle^{-1}$ (no.)	unfilled grain $panicle^{-1}$ (no.)
T_1	2.0c	3.0c	76.4b	19.2b	5.8c	95.7c	9.7b
T_2	5.1a	6.4a	97.4a	22.9a	10.3a	143.0b	19.5a
T_3	4.3b	5.4b	96.4a	21.4a	9.1b	126.7b	12.6b
T_4	6.0a	6.7a	101.9a	23.2a	11.9a	164.0a	15.4b
T_5	5.7a	6.2a	95.5a	22.8a	10.1a	156.0a	15.7b
T_6	2.1c	3.3c	76.4b	20.1b	6.8c	103.3c	27.06a
CV(%)	8.63	6.43	5.21	5.14	11.53	7.42	18.9

In a column, figures having common letter(s) do not differ significantly at 5% level of probability.

Table 19. Average (three years) grain and straw yields of Boro (Binadhan-10) rice as affected by different treatments

Treatments	2016-17		2017-18		2018-19		Average	
	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Grain yield (tha^{-1})	Straw yield (tha^{-1})
T_1	3.72c	4.69b	2.17c	3.06c	2.0c	3.0c	2.63	3.58
T_2	5.41a	6.82a	6.03a	6.6a	5.1a	6.4a	5.50	6.60
T_3	4.86ab	6.17a	5.1b	6.59a	4.3b	5.4b	4.75	6.05
T_4	5.33a	6.55a	5.67a	6.76a	6.0a	**6.7a**	5.66	6.67
T_5	5.24a	6.55a	5.76a	6.34b	5.7a	6.2a	5.56	6.36
*T_6	3.8bc	5.00b	2.24c	3.10c	2.1c	3.3c	2.71	3.8
%CV	9.4	8.93	12.5	16.8	8.63	6.43		

In a column, figures having common letter(s) do not differ significantly at 5% level of probability.

Assessment of land degradation situation for improving soil quality and crop productivity

An initiative has taken to know the change of soil physical and chemical properties of some selected soil series during 1967-2017. Soil samples were taken from 29 soil series of Bangladesh in 2017 from where soil samples were also taken in 1967 as in Figure and Table below.

Collection of soil samples:

Soil Samples for nutrient depletion within 50 years (1967-2017): To determine changes in soil characters, samples was collected from 43 soil series (below) of same sites/points of the previous sampling locations by SRDI (1963-1975) and BINA (1967-1996 & 2001-2003) (RSS, 1963-75 and Ali 1997). Total soil profile was collected for soil physico-chemical parameters (soil texture, soil bulk density, soil moisture, soil temperature, rainfall, soil pH, EC, SOC, N, P, K, S, Mg micronutrients, trace elements and heavy metals).

For laboratory analysis, all samples dried at room temperature, sieve (2 mm mesh sieve) and weigh. Physical and chemical analysis (soil texture, soil bulk density, soil moisture, soil temperature, rainfall, soil pH, EC, SOC, N, P, K, S, Mg, Ca, micronutrients, trace elements and heavy metals) was performed using standard analytical methods using Atomic absorption spectrophotometer, UV-visible spectrophotometer, Flame photometer etc.

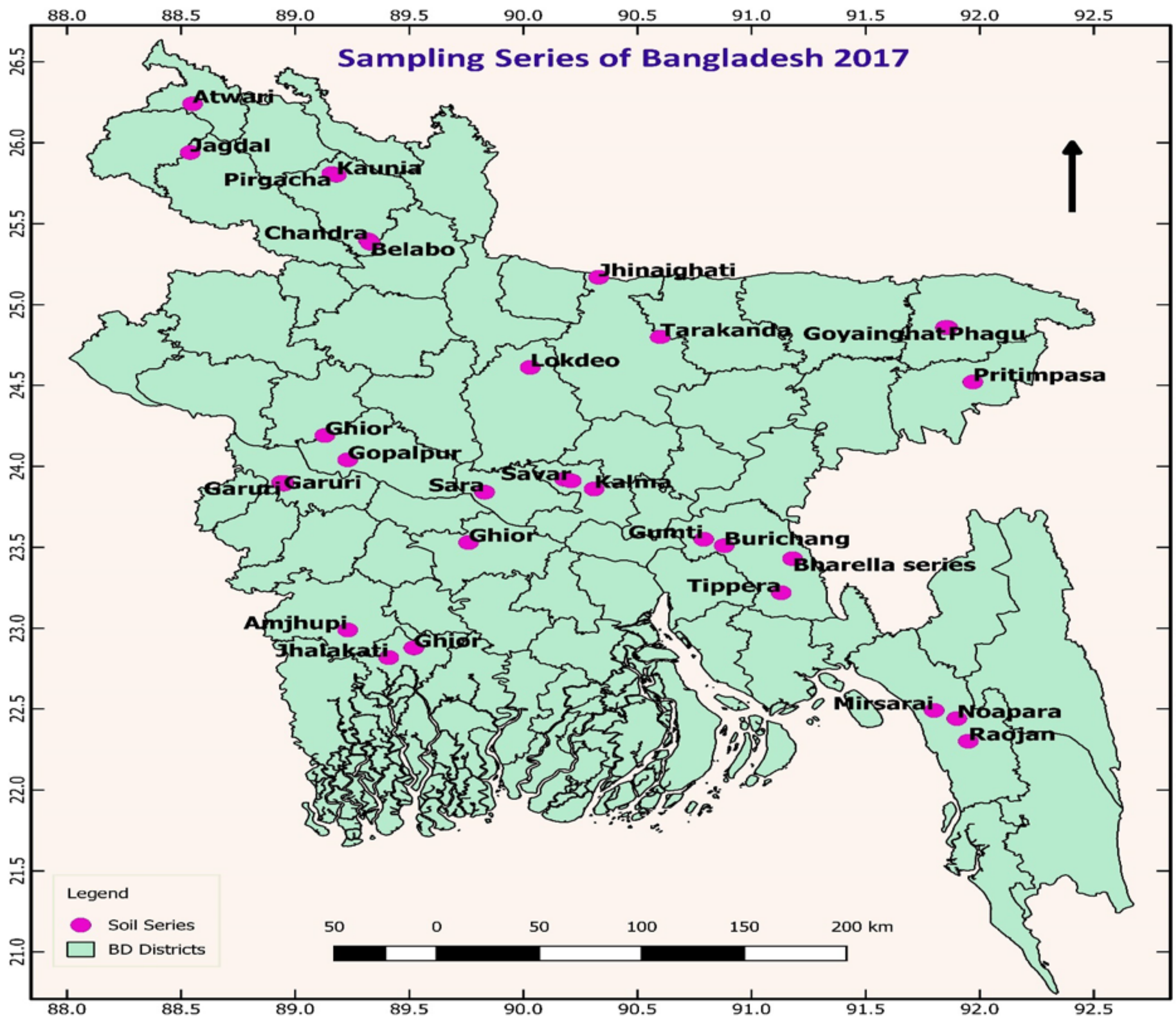


Fig.: Soil sampling series of Bangladesh during 2017

Table. Name of Soil series and their location:

Sl. No.	Series name	Location	AEZ
1	Atwari	Boda, District: Panchagarh	1
2	Jagdal	Birgonj, District: Dinajpur	1
3	Pirgacha	Rangpur Sadar, District: Rangpur	3
4	Kaunia	Rangpur Sadar, District: Rangpur	3
5	Chandra	Pirganj, District: Rangpur	3
6	Belabo	Pirganj, District: Rangpur	3
7	Ghior	Baraigram, District: Natore	5
8	Gopalpur	Kotwali, District: Pabna	12
9	Garuri	Mirpur, District: Kustia	10
10	Gopal pur	Mirpur, District: Kustia.	10
11	Garuri	Mirpur, District: Kustia	10
12	Amjhupi	Monirampur, District:Jessore	14
13	Jhalakati	Dumuria, District: Khulna	13
14	Ghior	Daulatpur, District: Khulna.	13
15	Ghior	Faridpur Sadar, District: Faridpur	12
16	Rathuria	Sibalay, District: Manikgonj	12
17	Sara	Sibalay, District: Manikgonj	12
18	Derma	Chandpara, District: Gazipur	28
19	Chhiata	Gazipur sadar. District: Gazipur.	28
20	Kalma	Savar, District: Dhaka	28
21	Noadda	Savar, District: Dhaka.	28
22	Khilgoan	Gulshan, District: Dhaka	28
23	Pagla	Savar, District: Dhaka.	28
24	Dhamrai	Dhamrai, District: Dhaka	28
25	Sonatala	Savar, District: Dhaka.	28
26	Sabhar	Dhamrai, District: Dhaka	28
27	Lokdeo	Madhupur, District: Tangail	28
28	Tarakanda	Gouripur, District: Mymensingh	09
29	Silmondi	Gouripur, District: Mymensingh	09
30	Siddhirgonj	Demra District: Dhaka.	28
31	Jalkundi	Demra, District: Narayanganj	28
32	Tippera	Laksham, District: Comilla	19
33	Burichang	Muradnagar, District: Comilla	19
34	Gumti	Daudkandi, District: Comilla	19
35	Phagu	Sylhet sadar Sylhet.	20
36	Goyainghat	Sylhet sadar, District: Sylhet.	20
37	Jhinaighati	Haluaghate, District: Mymensingh	09
38	Pritimpasa	Kulaura District: Moulvi Bazar	20
39	Bharella series	Comilla sadar, District: Comilla.	19
40	Mirsarai	Hathazari, District: Chittagong	23
41	Noapara	Raojan Chittagong.	23
42	Raojan	Patiya, District: Chittagong	23
43	Harta	Batiaghat, District: Khulna	13

Results and discussion:

Various physico-chemical properties of the 0-100 cm depths for the different soil series of Bangladesh are described below. Changes in these characters were observed in most of the soil series over the period 1967 to 2017.

Soil pH:

Table 20 illustrates the EC and pH values of the soil series and the changes in pH values at 0-10 cm and 0-100 cm soil layers during the period 1967-2017. Soil pH of the series is strongly acidic to slightly alkali. At 0-10 cm depth 31% soil was strongly acidic, 27.6% slightly acidic, 17.2% neutral and 24.1% slightly alkali. On the other hand, at 0-100 cm depth 3.4% soil was strongly acidic, 37.9% slightly acidic, 17.2% neutral and 41.4% slightly alkali. Soil pH increased in both 0-10 and 0-100 cm depth at Atwary, Jagdal, Shara, Amjhupi, Ghior, Damrai, Savar bazar, Lokdeo, Goyanghat, Pritimpasha and Mirsai by 1.2 to 31.2%. Soil pH decreased in 0-10 cm and increase in 0-100 cm depth at Pirgacha, Chandra, Belabo, Rathuria, Tipera, Burichong, Phagu and Raojan. Soil pH increased in 0-10 cm and decrease in 0-100 cm at Kaunia and Ghior. In both depths soil pH decreased at Gopalpur, Garuri, Shara, Tarakanda, Gumti and Bharella. Soil pH showed a larger decline in the 0-10 cm layers compare to 0-100 cm layers in most of the series with some exceptions, where a reverse trend was observed. At 0-10 cm layers highest soil pH increased (31.2%) in Gior series, Ganges floodplain and highest decreased (20.3%) in Tarakanda, Brahmaputra floodplain.

Changes in pH in the 0-100 cm layers varied widely within the soils from different soil series. The increased in the value of soil pH was highest (18.9%) in Amjhupi and the highest decrease (6.7%) in Gumti. Mean value for Bangladesh showed an increase of 2.2% at 0-10 cm and 5.1% at 0-100 cm soil layer over the 50 years.

Table 20: Changes in soil pH within 0-10 cm and 0-100 cm layers of the different soil series during the period 1967-2017 in Bangladesh.

Profile No.	Series	Depth (cm)	EC (dS/m)	pH		
				1967	2017	Change (%)
1	Atwary	0-10	0.06	5.8	6.1	5.3
		0-100	0.04	6.1	6.3	2.4
2	Jagdal	0-10	0.08	5.3	6.1	15.9
		0-100	0.06	5.6	6.5	15.7
3	Pirgacha	0-10	0.08	5.5	5.2	-5.1
		0-100	0.03	5.8	6.2	7.2
4	Kaunia	0-10	0.03	5.2	5.9	12.6
		0-100	0.03	6.0	6.0	-0.7
5	Chandra	0-10	0.21	5.3	5.0	-6.8

Profile No.	Series	Depth (cm)	EC (dS/m)	pH		
				1967	2017	Change (%)
		0-100	0.07	5.4	5.9	10.0
6	Belabo	0-10	0.04	5.6	5.4	-2.9
		0-100	0.04	5.4	5.6	3.1
7	Ghior	0-10	0.44	7.4	7.5	1.5
		0-100	0.39	8.2	7.8	-5.6
8	Gopalpur	0-10	0.27	8.1	7.8	-4.4
		0-100	0.31	8.2	7.8	-4.4
9	Garuri	0-10	0.48	7.9	6.7	-15.0
		0-100	0.35	7.9	7.8	-1.3
10	Gopalpur	0-10	0.23	8.2	8.1	-1.6
		0-100	0.20	8.5	8.2	-3.6
11	Shara	0-10	0.19	8.0	8.1	1.2
		0-100	0.23	8.1	8.2	2.2
12	Amjhupi	0-10	0.26	6.6	7.5	13.0
		0-100	0.27	6.7	7.9	18.9
14	Ghior	0-10	0.78	6.0	7.9	31.2
		0-100	0.67	7.2	8.2	13.2
15	Ghior	0-10	0.29	6.6	7.1	8.7
		0-100	0.18	7.4	7.9	7.8
16	Rathuria	0-10	0.22	6.6	6.1	-8.2
		0-100	0.22	7.7	7.8	1.4
17	Shara	0-10	0.19	7.7	7.3	-4.7
		0-100	0.16	8.3	8.0	-4.1
24	Damrai	0-10	0.19	5.9	6.4	8.0
		0-100	0.19	6.7	7.4	10.6
26	Savar bazar	0-10	0.27	5.6	7.0	25.4
		0-100	0.21	6.5	7.1	9.3
27	Lokdeo	0-10	0.20	5.5	6.6	20.4
		0-100	0.20	5.9	6.9	15.5
28	Tarakanda	0-10	0.43	6.4	5.1	-20.3
		0-100	0.19	6.6	6.3	-3.9
32	Tipera	0-10	0.15	6.3	5.9	-7.0
		0-100	0.12	7.0	7.4	6.9
33	Burichong	0-10	0.11	5.8	5.7	-1.4
		0-100	0.18	6.7	7.6	12.9
34	Gumti	0-10	0.07	5.4	5.2	-3.9
		0-100	0.05	6.8	6.4	-6.7
35	Phagu	0-10	0.08	5.1	4.9	-4.3
		0-100	0.09	5.4	6.4	17.7
36	Goyainghat	0-10	0.04	5.1	5.2	2.2
		0-100	0.05	6.0	6.2	4.1
38	Pritimpasha	0-10	0.02	5.1	5.6	9.2
		0-100	0.02	4.9	5.5	10.8
40	Bharella	0-10	0.26	5.8	4.8	-17.4
		0-100	0.20	6.3	6.1	-2.7
41	Mirsarai	0-10	0.13	6.1	7.4	21.6
		0-100	0.13	6.7	7.3	10.2
43	Raojan	0-10	0.33	6.2	5.6	-9.2
		0-100	0.35	6.9	7.0	0.7

Particle size distribution, organic carbon (OC) and C:N ratio in the surface 0-10 cm layers and the 0-100 cm layers of the different soil series are shown in Table 21. At 0-10 cm depth 48.3% was clay soil,10.3% Silt clay, 27.6% Silt clay loam, 10.3% Silt loam and 3.4% Sandy clay; at 0-100 cm depth 3.4% was silt, 89.7% Silt loam and 6.9% Sandy loam.

From the Table 21, considerable variation was observed in the sand, silt and clay distribution of the different soil series sampled in 1967 and 2017 in Bangladesh. The clay content decreased for all 0-10 cm depth and for 0-100 cm depth, most of the soil series and silt content increased for all 0-10 cm and 0-100 cm depth sampled in 2017.

At the series level, the status of particle size distribution in 1967 and 2017 sampled soils showed relatively higher decrease in Sand and clay content and increase in silt content. Sand content decreased in the surface 0-10 cm layers in most of the series, as Autoary, Jagdal, Pirgacha, Chandra, Belabo, Ghior, Gopalpur, Garori, Gopalpur, Shara, Amjupi, Rathuria, Shara, Saver, Logdu, Tarakanda, Tipera, Burichong, Gomoti, Fagu, Guailghat, Pritompasha, Verella, Mirsorai and Raojanseries. The surface 0-10 cm layers showed relatively lower decrease in sand content than the 0-100 cm layers with few exceptions (Table 21). A relatively higher enrichment of clay content in 0-100 cm layers was also observed in the Kaunia, Ghior, and Saver series during the period 1967-2017.

Silt content increased in both 0-10 cm and 0-100 cm layers in all soil series. (Table 21). Clay content (>30%) in the surface 0-10 cm layers in most of the series, as Jagdal, Pirgacha, Kaunia, Belabo, Ghior, Gopalpur, Garori, Shara, Amjupi, Ghior, Ghior, Rathuria, Shara, Damry, Saver, Logdu, Tarakanda, Tipera, Burichong, Gomoti, Fagu, Guailghat, Pritompasha, and Verellaseries. The surface 0-10 cm layers showed relatively higher decrease in clay content than the 0-100 cm layers with few exceptions (Table 21). A relatively higher enrichment of clay content in 0-100 cm layers was also observed in the Atwary, Bharella and Mirsarai series during the period 1967-2017. The lower clay content near the surface of many wet-cultivated soils was probably due mainly to their weathering associated with alternate flooding and drainage, as described by Brinkman (1970). Another process that can contribute to loss of clay from the surface soil was its removal in the surface water during puddling when muddy water overflows from the higher to the lower fields. An opposite process of enrichment with clay-size particles in the surface soils was sometimes brought about by irrigation with muddy water (Moormann and Breemen, 1978).

Organic carbon (OC):

Table 21 showed the concentration of OC among the soil series, organic carbon content for these soils was very low to high. At 0-10 cm depth 3.4% soil was very low, 24.1% low, 55.2% medium and 17.2% was high. Soil organic carbon decreased with the increased soil depth. At 0-100 cm depth 65.5% soil was very low, 31.0% low, 3.4% medium and there was no medium OC in 0-100 cm depth. OC ranged from 0.40 to 2.77% at surface layer. The highest OC was found in Bharella and the lowest from Gopalpur series. At deeper layer OC varied from 0.31 to 1.63%, only one sample from Atwary was medium and the rest were low to very low. Lowest OC was recorded from Shara at 0-100 cm depth.

C : N ratio:

C:N is presented in Table 21. Among the series 83% was not more than 10 and 17% was good in C:N at 0-10cm depth, at 0-100 cm depth only one series Atwari was good in C:N and the rest series was not good.

Table 21: Particle size distribution in the 0-10 cm and 0-100 cm layers in the different soil series during the period of 1967-2017 in Bangladesh

Series	Depth (cm)	Sand (%)		Silt (%)		Clay (%)		OC (%)	C: N
		1967	2017	1967	2017	1967	2017		
Atwary	0-10	37.0	15.84	46.3	72.06	16.7	12.10	2.46	9
	0-100	39.0	11.82	46.6	68.84	14.7	19.33	1.63	11
Jagdal	0-10	42.7	33.32	38.5	56.72	18.8	9.96	0.84	8
	0-100	48.0	24.56	32.5	58.44	19.5	17.00	0.33	5
Pirgacha	0-10	68.6	46.90	21.4	49.51	10.0	3.59	1.11	23
	0-100	62.0	65.67	24.0	33.65	14.1	0.68	0.32	9
Kaunia	0-10	24.9	36.63	55.9	58.47	19.2	4.90	0.67	5
	0-100	42.1	51.35	43.0	44.67	14.9	3.98	0.35	5
Chandra	0-10	54.2	8.99	31.8	78.61	14.0	12.41	1.27	7
	0-100	44.6	7.47	30.1	74.38	25.3	18.16	0.47	5
Belabo	0-10	44.6	19.86	31.5	70.58	23.9	9.54	1.19	10
	0-100	38.3	8.23	27.1	76.66	34.6	15.10	0.46	9
Ghior	0-10	12.9	2.96	38.9	77.50	48.2	19.53	1.55	8
	0-100	29.2	2.17	37.6	78.68	33.2	19.16	0.60	7
Gopalpur	0-10	9.2	8.64	59.7	83.42	31.1	7.93	0.40	6
	0-100	36.5	9.74	40.1	82.68	23.4	7.59	0.35	6
Garuri	0-10	5.1	5.28	38.7	74.31	56.2	20.41	1.35	7
	0-100	22.7	4.78	39.2	74.87	38.1	20.36	0.64	5
Gopalpur	0-10	57.0	15.21	26.8	71.73	16.2	13.05	0.87	8
	0-100	47.6	19.66	29.2	66.65	23.3	13.69	0.37	7
Shara	0-10	16.6	20.84	36.6	70.81	46.8	8.35	1.03	7
	0-100	35.1	15.03	31.5	70.77	33.4	14.20	0.50	5
Amjhupi	0-10	5.1	3.87	63.9	78.52	31.0	17.61	1.36	7
	0-100	13.8	1.63	53.3	78.29	32.9	20.09	0.48	4
Ghior	0-10	*2.7*	6.94	40.2	70.36	57.1	22.70	1.83	7
	0-100	17.5	1.13	41.6	72.22	41.0	26.65	0.76	5
Ghior	0-10	3.2	3.78	35.0	64.78	61.8	31.44	1.35	6
	0-100	5.2	16.53	45.9	69.04	48.9	14.43	0.39	6
Rathuria	0-10	19.4	1.33	46.1	79.52	34.5	19.15	1.11	7
	0-100	8.7	3.04	54.9	81.06	36.4	15.90	0.43	4
Shara	0-10	48.2	3.38	37.0	86.27	14.8	10.35	0.84	35
	0-100	26.8	10.86	50.7	82.18	22.5	6.96	0.31	8
Damrai	0-10	8.2	16.37	55.5	70.95	36.3	12.67	1.12	9
	0-100	48.9	8.16	35.8	75.78	16.3	16.05	0.50	7
Savar bazar	0-10	4.8	15.88	56.2	78.50	39.0	5.62	1.51	10
	0-100	25.8	11.20	50.6	76.33	23.6	12.47	0.56	7
Lokdeo	0-10	18.8	10.73	57.8	79.21	23.2	10.04	0.59	8
	0-100	26.1	13.34	50.9	76.35	22.9	10.30	0.32	6
Tarakanda	0-10	47.0	19.93	29.1	72.54	23.9	7.53	1.63	8

Series	Depth (cm)	Sand (%)		Silt (%)		Clay (%)		OC (%)	C: N
		1967	2017	1967	2017	1967	2017		
	0-100	61.9	27.85	23.7	66.48	14.4	5.67	0.43	6
Tipera	0-10	28.5	5.74	60.5	86.88	11.0	7.39	2.39	8
	0-100	44.6	3.09	45.2	87.75	10.2	9.16	0.63	5
Burichong	0-10	18.2	2.48	50.7	88.05	31.1	9.47	2.50	9
	0-100	19.6	8.22	52.2	82.31	28.2	9.47	0.59	4
Gumti	0-10	10.6	0.80	55.6	90.75	33.8	8.45	0.91	6
	0-100	37.9	17.15	42.7	74.90	19.4	7.95	0.43	4
Phagu	0-10	0.1	3.16	30.7	68.56	69.2	28.27	2.39	11
	0-100	17.1	2.66	36.2	68.73	46.7	28.61	0.66	5
Goyainghat	0-10	29.1	5.51	51.6	84.30	19.3	10.20	1.71	8
	0-100	24.1	2.05	51.9	76.41	24.1	21.54	0.58	4
Pritimpasha	0-10	57.6	36.62	32.6	58.32	9.8	5.07	1.27	7
	0-100	30.1	22.75	39.3	63.28	30.6	13.97	0.47	5
Bharella	0-10	31.7	15.13	46.2	72.75	22.1	12.10	2.77	8
	0-100	50.4	4.95	28.0	71.33	21.6	23.71	0.79	4
Mirsarai	0-10	40.5	16.54	37.5	67.59	22.0	15.86	1.27	19
	0-100	40.5	19.06	38.0	65.97	21.5	14.97	0.41	8
Raojan	0-10	33.3	11.19	47.1	71.54	19.6	17.27	1.75	8
	0-100	37.7	1.78	39.4	74.34	**22.9**	23.88	0.59	5

Total Nitrogen (TN):

From Table 22, among the soil series, TN content for these soils was very low to optimum at 0-10 cm depth and very low to low at 0-100 cm. At 0-10 cm depth 13.8% soil was very low, 41.4% low, 27.6% medium and 17.2% was high. TN decreased with the increased soil depth. At 0-100 cm depth 51.7% soil was very low and 48.3% was low. TN ranged from 0.048 to 0.335% at surface layer. Highest TN was found in Bharella series and the lowest from Pirgacha series. At deeper layer TN varied from 0.04 to 0.16%, the highest TN was found in Rathuria series and the lowest from Pirgacha series at 0-100 cm depth.

Available Phosphorus (AP):

From Table 22, AP content for these soils was very low to very high at surface and deeper soil. At 0-10 cm depth 6.9% soil was very low, 17.2% low, 17.2% medium, 17.2% optimum and 41.4% was very high. AP content decreased with the increased soil depth. At 0-100 cm depth 17.2% soil was very low and 37.9% was low, 13.8% medium, 13.8% optimum, 6.9% high and 10.3% was very high. AP ranged from 3.6 to 69.8 ppm at surface layer. The highest AP was found in Pirgacha series and the lowest from Pritimpasha series. At deeper layer AP varied from 1.95 to 40.37%, Highest AP was found also in Pirgacha series and the lowest from Pritimpasha series at 0-100 cm depth.

Exchangeable potassium (Ex. K):

From Table 22, exchangeable K content for these soils was very low to very high at surface and deeper soil. At 0-10 cm depth 13.8% soil was very low, 31% low, 31% medium, 6.9% optimum, 10.3% high and 6.9% was very high. At 0-100 cm depth 17.2% soil was very low and 37.9% was low, 31% medium, 10.3% optimum and 3.4% high. Exchangeable K ranged from 0.06 to 0.42 me% at surface layer, the highest exchangeable K was found in Garuri series and the lowest from Lokdeo series. At deeper layer exchangeable K varied from 0.05 to 0.37 me%, the highest me% was found in Amjhupi series and the lowest from Pritimpasha series at 0-100 cm depth.

Available sulphur (AS):

From Table 22, AS content for these soils was very low to high at surface and very low to optimum at deeper soil. At 0-10 cm depth 3.4% soil was very low, 24.1% low, 48.3% medium, 17.2% optimum, and 6.9% was high. At 0-100 cm depth 3.4% soil was very low and 34.5% was low, 58.6% medium and 3.4% optimum. AS ranged from 7.9 to 44.2 ppm at surface layer, the highest AS was found in Ghior series and the lowest from Tarakanda series. At deeper layer AS varied from 7.3 to 40.5 ppm, the highest AS was found in Amjhupi series and the lowest from Gumti series at 0-100 cm depth.

Exchangeable Na:

From Table 22, among the soil series, Exchangeable Na content for these soils was very low to very high at surface and deeper soil. At 0-10 cm depth 10.3% soil was very low, 34.5% low, 13.8% medium, 6.9% was high and 34.5% was very high. At 0-100 cm depth 10.3% soil was very low, 31% low, 10.3% medium, 17.2% was high and 31% was very high. Exchangeable Na ranged from 0.09 to 2.76 me% at surface layer. The highest exchangeable Na was found in Ghior series and the lowest from Tarakanda series. At deeper layer Exchangeable Na varied from 0.11 to 2.71 me%, Highest Exchangeable Na was found in Ghior series and the lowest from Pirgacha series at 0-100 cm depth.

Exchangeable Ca:

From Table 22, among the soil series, Exchangeable Ca content for these soils was very low to very high at surface and deeper soil. At 0-10 cm depth 41.4% soil was very low, 17.2% low, 13.8% medium, 3.4% was optimum, 3.4% was high and 20.7% was very high. At 0-100 cm depth 27.6% soil was very low, 27.6% low, 3.4% medium, 10.3% was optimum, 3.4% was high and 27.6% was very high. Exchangeable Ca ranged from 0.29 to 9.79 me% at surface layer. Highest Exchangeable Ca was found in Ghior series and the lowest from Tarakanda series. At deeper layer Exchangeable Ca varied from 0.30 to 12.15 me%. Highest Exchangeable Ca was found in Amjhupi series and the lowest from Pirgacha series at 0-100 cm depth.

Table 22: Total N (%), available P (ppm), Exchangeable K (meq%) and available S (ppm) in the 0-10 cm and 0-100 cm layers in the different soil series during the period of 1967-2017 in Bangladesh

Series	Depth (cm)	Total N (%)	Avail. P (ppm)	Avail. S (ppm)	Exch. K (me%)	Exch. Ca (me%)	Exch. Na (me%)
Atwary	0-10	0.277	13.47	22.77	0.08	1.128	0.24
	0-100	0.150	10.66	21.03	0.08	1.13	0.27
Jagdal	0-10	0.101	68.16	21.01	0.08	0.941	0.18
	0-100	0.060	20.03	21.77	0.09	1.35	0.21
Pirgacha	0-10	0.048	106.84	16.08	0.33	0.564	0.17
	0-100	0.040	40.37	17.74	0.13	0.30	0.11
Kaunia	0-10	0.126	50.11	21.0	0.18	0.75	0.24
	0-100	0.070	32.16	19.3	0.12	0.75	0.20
Chandra	0-10	0.173	34.56	25.2	0.37	0.56	0.24
	0-100	0.090	13.54	20.5	0.16	1.03	0.22
Belabo	0-10	0.123	32.71	18.5	0.09	0.56	0.24
	0-100	0.060	6.54	15.1	0.13	0.79	0.23
Ghior	0-10	0.204	22.73	44.2	0.19	0.52	0.34
	0-100	0.090	6.10	25.5	0.24	8.71	0.40
Gopalpur	0-10	0.061	9.74	21.3	0.14	8.47	0.23
	0-100	0.060	5.53	26.0	0.18	8.80	0.30
Garuri	0-10	0.207	42.29	19.4	0.42	6.52	0.81
	0-100	0.120	11.05	13.2	0.25	8.07	0.89
Gopalpur	0-10	0.110	16.61	12.5	0.19	8.381	0.87
	0-100	0.060	8.94	26.5	0.15	7.97	0.84
Shara	0-10	0.138	11.48	20.2	0.11	7.56	0.94
	0-100	0.100	7.03	19.5	0.16	8.30	0.90
Amjhupi	0-10	0.187	22.68	27.4	0.23	9.79	0.94
	0-100	0.110	6.03	40.5	0.30	12.15	0.95
Ghior	0-10	0.281	43.74	19.4	0.38	8.97	2.76
	0-100	0.140	13.81	20.9	0.37	11.25	2.71
Ghior	0-10	0.224	12.69	11.8	0.33	8.39	0.84
	0-100	0.060	6.60	13.8	0.16	8.80	0.88
Rathuria	0-10	0.161	29.35	21.7	0.17	3.64	0.41
	0-100	0.160	9.18	18.2	0.20	6.83	0.67
Shara	0-10	0.124	20.87	25.0	0.14	3.64	0.46
	0-100	0.060	7.33	17.8	0.13	5.46	0.61
Damrai	0-10	0.121	4.74	17.1	0.08	2.22	0.14
	0-100	0.070	5.02	21.6	0.09	2.65	0.15
Savar bazar	0-10	0.149	11.09	10.5	0.07	1.58	0.21
	0-100	0.080	8.90	16.7	0.08	2.16	0.29
Lokdeo	0-10	0.076	16.51	9.2	0.06	1.15	0.19

Series	Depth (cm)	Total N (%)	Avail. P (ppm)	Avail. S (ppm)	Exch. K (me%)	Exch. Ca (me%)	Exch. Na (me%)
	0-100	0.060	15.05	13.1	0.05	1.84	0.28
Tarakanda	0-10	0.202	32.20	7.9	0.07	0.29	0.09
	0-100	0.060	15.86	9.4	0.05	1.07	0.17
Tipera	0-10	0.286	8.94	24.9	0.21	4.39	0.67
	0-100	0.110	5.57	16.2	0.10	4.77	0.65
Burichong	0-10	0.285	14.35	31.9	0.13	2.50	0.42
	0-100	0.110	6.46	21.2	0.06	2.17	0.40
Gumti	0-10	0.161	35.88	16.4	0.16	3.14	0.75
	0-100	0.100	14.73	7.3	0.13	3.27	0.72
Phagu	0-10	0.213	4.99	33.5	0.25	1.67	0.37
	0-100	0.120	7.94	21.7	0.16	2.42	0.53
Goyainghat	0-10	0.225	26.13	18.3	0.16	0.91	0.59
	0-100	0.130	16.39	17.9	0.11	1.73	0.49
Pritimpasha	0-10	0.176	3.59	33.5	0.08	0.83	0.32
	0-100	0.100	1.95	21.5	0.05	0.83	0.18
Bharella	0-10	0.335	26.27	39.2	0.187	5.03	0.79
	0-100	0.150	11.32	25.9	0.18	5.09	0.68
Mirsarai	0-10	0.066	4.96	26.2	0.07	1.64	1.66
	0-100	0.050	32.03	25.8	0.06	1.58	1.72
Raojan	0-10	0.208	8.08	32.7	0.17	1.09	0.81
	0-100	0.110	5.87	25.4	0.18	1.77	1.19

Requirement of Zn and B application for mustard - Boro - T. *Aman* cropping pattern

Experimental sites

One cropping pattern experiments viz. mustard-boro-T. *Aman* was set up at BINA substation in Rangpur Sadar. The objective was to evaluate the effects of different micronutrients on the crops and cropping pattern. Soil properties descriptions are given in Table 23 below.

Table 23. Soil morphological, physical and chemical properties of the experimental site

Soil properties	BINA substation farm
AEZ (UNDP and FAO, 1988)	Tista Meander Floodplain
General soil type	Non-calcareous Brown Floodplain soil
Soil series	Gangacchhara
Topography	Medium high land
Drainage	Well drained
Flood level	Above flood level
Sand (%) (2- 0.05 mm)	57.9
Silt (%) (0.05 - 0.002mm)	21.3
Clay (%) (<0.002 mm)	20.8
Soil texture	Sandy loam
pH	5.28
OM (%)	0.83
Total N (%)	0.04
Ex. K (cmol kg^{-1})	0.13
P (µg g^{-1})	30.40

S (μg g^{-1})	23.05
Zn (μg g^{-1})	0.62
B (μg g^{-1})	0.17

There were six treatments (T_1: Zn_0B_0, T_2: Zn_2B_1, T_3: $Zn_2B_{1.5}$, T_4: Zn_2B_2, T_5:$Zn_4B_{2.5}$, T_6: Zn_6B_3) for the first crop, (mustard), six treatments (T_1: Zn_0B_0, T_2:Zn_0B_0, T_3:Zn_2B_0, T_4:Zn_2B_0, T_5: Zn_0B_0, T_6: Zn_0B_0) for the second crop (Boro rice) and finally 10 treatments (T_1: Zn_0B_0, T_2: Zn_0B0, T_3: Zn_2B_0, T_4: Zn_0B_0, T_5: Zn_2B_0, T_6: Zn_0B_0. T_7: Zn_2B_0, T_8: Zn_0B_0, T_9: Zn_2B_0, T_{10}:Zn_0B_0) for the third crop (T. *Aman* rice). Subscripts of Zn and B represent kg ha^{-1}. Each treatment replicated three times. Thus, taking into account of the 10 treatments for the third crop (T. *Aman* rice) of both experiments in 1-year crop cycle, 10 plots were prepared in each block. The treatments were randomly distributed to the plots within a block. Thus, the numbers of plots were thirty (3 x 10 = 30). N, P, K & S (recommended and equal rates for all plots), rates based on soil test. The Zn-B treatments were imposed on the first, second and third crops, as shown above. The rates of micronutrients were 0 (control), 2, 4, 6 kg ha^{-1} for Zn and 0, 1, 1.5, 2, 2.5 and 3 kg ha^{-1} for boron as mentioned by subscripts of Zn and B. The elements were added as $ZnSO_4.7H_2O$ and H_3BO_3, respectively. Other nutrients viz. N, P, K & S were used at recommended rates for all plots; rationale was followed for the second and third crops to complete 1-crop cycle. After completion of 1 year crop cycle, effects of Zinc and Boron on the yield of crops are presented. The objective is to see the direct and residual effects of Zn and B on crops as to determine the requirement of Zn and B for the cropping patterns.

Result of Zn and B application on mustard

Seed yield of mustard (1st crop):

From Table 24, the seed yield ranged from 1.66 -1.89 t ha^{-1} over the treatments. Treatment T_6 (Zn at 6 kg ha^{-1} and B at 3 kg ha^{-1}) recorded the highest yield (1.89 t ha^{-1}). In terms of seed yield, the treatments can be ranked in the order: T_6> T_5> T_3> T_4> T_2> T_1.

Stover yield of Mustard (1st crop): Straw yield of mustard ranged from 4.26 – 5.14 t ha^{-1}. Treatment $T_{6.1}$ (Zn at 6 kg ha^{-1} and B at 3 kg ha^{-1}) and T_4 (Zn at 2 kg ha^{-1} and B at 2 kg ha^{-1}) with NPKS gave the maximum stover yield (5.14 t ha^{-1}) which corresponded to the maximum seed yield over the control yield (1.89 t ha^{-1}). In terms of stover yield, the treatments were found nonsignificant.

Table 24. Effect of Zn and B on Mustard

Treatment	Plant height (cm)	Branchs/ plant	Pod length (cm)	Seeds/ pod	No. of pods/ plant	Grain yield (t/ha)	Stover yield (t/ha)
T_1	89.67	3.60	3.9	16.0	102	1.66 d	4.26
T_2	95.70	3.73	4.0	17.4	110	1.76 c	4.47

T_3	89.03	3.87	4.3	18.1	111	1.80 bc	4.69
T_4	93.07	3.80	4.4	16.8	111	1.89 a	5.13
T_5	93.80	3.77	4.4	19.0	122	1.86 ab	4.95
T_6	95.20	3.27	4.4	17.8	125	1.89 a	5.14
CV%	7.79	4.27	4.11	3.97	8.20	2.99	3.89

In a column. mean followed by common letter(s) do not differ significantly at 5% level by DMRT

Result of Zn and B application on boro rice

Grain yield of boro rice (2nd crop):

From Table 25, the grain yield ranged from 5.30 – 6.63 t ha^{-1} over the treatments. Treatment $T_{4.2}$ (Zn 2 kg ha^{-1} and B 2 kg ha^{-1} applied to mustard and only Zn 2 kg ha^{-1} applied to boro rice) produced the maximum seed yield (6.63 t ha^{-1}).

Straw yield of boro rice (2nd crop):

The grain yield ranged from 6.00 – 6.92 t ha^{-1} over the treatments. Treatment $T_{4.2}$ (Zn 2 kg ha^{-1} and B 2 kg ha^{-1} applied to mustard and only Zn 2 kg ha^{-1} applied to boro rice) produced the maximum straw yield (6.92 t ha^{-1}) and $T_{3.2}$ (Zn 2 kg ha^{-1} and B 1.5 kg ha^{-1} applied to mustard and only Zn 2 kg ha^{-1} applied to boro rice).

Table 25. Effect of Zn and B on Boro rice

Treatment	Plant height (cm)	Tillers/ hill	Panicle length (cm)	No. of grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)
$T_{1.1}$	85.00 b	10.17	21.60	105.40	5.30 c	6.37
$T_{2.1}$	93.00 a	11.90	21.90	125.10	5.62 bc	6.30
$T_{3.2}$	97.97 a	11.43	23.07	123.67	5.80 b	6.92
$T_{4.2}$	98.93 a	12.43	23.00	134.77	6.63 a	6.92
$T_{5.1}$	96.70 a	11.93	22.40	116.93	5.77 b	6.35
$T_{6.1}$	91.60 ab	12.40	22.33	123.13	5.37 bc	6.00
CV%	7.58	8.03	9.05	4.43	5.64	2.48

In a column. mean followed by common letter(s) do not differ significantly at 5% level by DMRT.

Result of Zn and B application on T. *Aman* rice

Grain yield of T. *Aman* rice (3rd crop):

From Table 26, the grain yield ranged from 3.40 – 4.85 t ha^{-1} over the treatments. Treatment $T_{4.2.1}$ (Zn 2 kg ha^{-1} and B 2 kg ha^{-1} applied to mustard and only Zn 2 kg ha^{-1} applied to boro rice) produced the maximum seed yield (4.85 t ha^{-1}).

Straw yield of T. *Aman* rice (3rd crop):

The grain yield ranged from 4.76 – 6.13 t ha^{-1} over the treatments. Treatment $T_{4.2.2}$ (Zn 2 kg ha^{-1} and B 2 kg ha^{-1} applied to mustard and Zn 2 kg ha^{-1} applied to every boro and T. *A*man rice) produced the maximum straw yield (6.13 t ha^{-1}).

Table 26. Effect of Zn and B on T. *Aman* rice

Treatment	Plant height (cm)	Panicle length (cm)	Tillers/ hill	No. of grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)
$T_{1.1.1}$	80.53	19.73	8.13	99.40	3.40 g	4.59 abc
$T_{2.1.1}$	84.40	19.67	8.87	116.93	4.30 cd	5.96 abc
$T_{2.1.2}$	85.07	20.27	9.13	118.67	4.18 cde	5.26 ab
$T_{3.2.1}$	86.20	20.07	8.67	123.60	3.94 def	5.75 abc
$T_{3.2.2}$	83.00	20.33	8.80	117.87	4.70 ab	5.90 ab
$T_{4.2.1}$	84.33	20.53	8.20	123.93	4.85 a	5.99 ab
$T_{4.2.2}$	83.47	20.67	8.87	126.13	4.40 bc	6.13 a
$T_{5.1.1}$	80.67	19.53	8.27	122.93	4.11 cde	5.59 bc
$T_{5.1.2}$	80.07	19.53	8.80	113.13	3.88 ef	5.39 bc
$T_{6.1.1}$	78.33	19.20	8.27	114.27	3.69 fg	4.76 c
CV%	4.33	3.05	8.09	8.88	5.39	9.29

In a column. mean followed by common letter(s) do not differ significantly at 5% level by DMRT.

Field performance of Rhizobial inoculant on growth, nodulation and yield of Felon at different locations of country

Field experiments were conducted at BINA HQ Farm Mymensingh, Sunamgonj, Magura and Khagrasori substations to see the performance of felon Rhizobial biofertilizer on growth, nodulation and yield of felon in Rabi season of 2018-2019. There were two treatments viz. Inoculated and uninoculated. The experiments were laidout in randomized complete block design (RCBD) with three replications. Phosphorus, Potassium, Sulphur, Zinc and Boron were applied as basal application @ 20, 50, 18, 2 and 4 kg/ha. BARI felon-1 was used as test crop cultivar in the study. Data on growth and nodulation were recorded at vegetative stage of felon. Green pod yield was recorded at optimum fruit growth as vegetable up to end of pod grown. Data on grain yield was recorded at ripening stage. Result showed that significant increase of plant growth, nodulation and yield were recorded due to application of Rhizobial biofertilizer over uninoculated control (Table 27-30). Plant height was increased significantly due to Rhizobial inoculant application at all the locations. Nodule number was increased 4 to 5 times due to inoculation at all locations. The highest nodule number was recorded 22 per plant. Nodule dry weight was recorded the highest with an amount of 125 mg/plant. Rhizobial inoculant resulted as highest nodule producing inoculant at both locations. Significant higher grain and vegetable (green pod) yield were recorded with Rhizobial Inoculants at all locations. The highest grain yield (1120 kg/ha) as well as vegetable yield (6156 kg/ha) were found with Rhizobial biofertilizer at Sunamgonj. Yield contributing parameters like pod length, seed per pod and 100 seed weight were found significantly higher over uninoculated control at all four locations.

Conclusion:

Felon rhizobial inoculant increased 15-25% grain yield and 14-24% vegetable (Green pod) yield of felon.

Table. 27. Effect of Rhizobial inoculants on yield and yield attributes of felon at Mymensingh

Treatments	Plant height (cm)	Nodule number (No./ plant)	Nodule dry weight (g /plant)	Grain yield (kg/ha)	Vegetable (Green pod) yield (kg/ha)
Uninoculated	60.52 b	1.33 b	4.19 b	890 b	4899 b
Inoculated	69.88 a	14.00 a	86.37 a	1080 a	5943 a
Sig. level	*	**	**	*	*
CV(%)	3.16	15.00	6.92	5.49	5.11

In a column, having similar letter(s) do not differ significantly as per DMRT.

Table. 28. Effect of Rhizobial inoculants on yield and yield attributes of felon at Sunamgonj

Treatments	Plant height (cm)	Nodule number (No./plant)	Nodule dry weight (g /plant)	Grain yield (kg/ha)	Vegetable (Green pod) yield (kg/ha)
Uninoculated	38.83 b	0.92 b	3.67 b	842 b	4623 b
Inoculated	52.03 a	22.45 a	125.00 a	1120 a	6156 a
Sig. level	*	**	**	*	*
CV(%)	5.07	9.80	10.23	6.00	6.65

In a column, having similar letter(s) do not differ significantly as per DMRT.

Table. 29. Effect of Rhizobial inoculants on yield and yield attributes of felon at Magura

Treatments	Plant height (cm)	Nodule number (No./ plant)	Nodule dry weight (g /plant)	Grain yield (kg/ha)	Vegetable (Green pod) yield (kg/ha)
Uninoculated	41.63 b	3.97 b	14.40 b	880 b	4831 b
Inoculated	49.60 a	20.80 a	109.23 a	1049 a	5787 a
Sig. level	*	**	**	*	*
CV(%)	3.40	11.17	6.42	4.82	4.48

In a column, having similar letter(s) do not differ significantly as per DMRT.

Table 30. Effect of Rhizobial inoculants on yield and yield attributes of Felon at Magura

Treatments	Plant height (cm)	Nodule number (No./plant)	Nodule dry weight (g/plant)	Grain yield (kg/ha)	Vegetable (Green pod) yield (kg/ha)
Uninoculated	70.37 b	4.07 b	12.97 b	863 b	4734 b
Inoculated	79.87 a	18.80 a	90.83 a	1001 a	5816 a
Sig. level	*	**	**	*	*
CV(%)	3.58	7.25	12.74	3.96	5.31

In a column, having similar letter(s) do not differ significantly as per DMRT.

Performance of different bradyrhizobial inoculant strains on nodulation, growth and yield of Felon in pot condition

A pot experiment was conducted for screening of Bradyrhizobial inoculant strains for efficient biofertilizer production for felon production. There were eight treatments viz. Inoculant strains FRS-1, FRS-2, FRS-3, FRS-6, FRS-8, FRS-14, FRS-18 along with one uninocualted control. The pot experiment was laid out in a randomized complete block design with four replications. at peat processing complex at BINA in December 2018. An amount of 25 kg soil was used in each pot. Phosphorus, potassium, zinc and boron were applied with doses of 25, 9, 1 and 2 mg P, K, Zn and B/kg soil as basal application in the form of TSP, MoP, Zinc oxide and boric acid. Nine plants were maintained in each pot. Irrigation and weeding were done as and when necessary. Nodulation data were recorded at vegetative stage. Data on grain yield was recorded at ripening time. Yield attributing parameters were recorded after harvest of crop. Result showed significant increase in nodule formation, plant height, shoot dry weight with inoculated treatments over uninoculated control treatments (Table 31). Inoculant strains FRS-18 showed the highest plant height, shoot dry weight, nodule number and dry weight (Table 32). Strain FRS-2, FRS-14 and FRS-18 recoded better grain weight per plant as well as grain yield per pot. Pod length, seeds per pod and 100 seed weight were also found better in the said strains inoculated.

Conclusion: These three strains may be tested for their performance in field condition in the next year.

Table 31. Effect of Rhizobial inoculant strains on growth and nodulation of felon in pot condition

Treatments	Plant height (cm)	Shoot dry weight (g/plant)	Nodule number (No./plant)	Nodule dry weight (g/plant)
Control	26.63 d	7.41 d	3.88 d	17.88 e
FRS-1	33.25 ab	8.91 c	13.88 b	78.35 c
FRS-2	34.50 ab	10.14 ab	15.38 b	90.93 b
FRS-3	29.25 c	9.05 bc	9.50 c	58.95 d
FRS-4	29.63 c	9.11 bc	10.50 c	60.97 d
FRS-6	30.38 c	9.97 abc	10.75 c	67.05 d
FRS-8	32.63 b	10.64 a	13.75 b	92.72 b
FRS-14	35.38 a	10.59 a	19.50 a	112.9 a
CV(%)	3.37	5.51	9.32	6.15

In a column, having similar letter(s) do not differ significantly as per DMRT.

Table 32. Effect of Rhizobial inoculant strains on yield and yield attributing characters of Felon in pot condition

Treatments	Grain wt./plant (g)	Grain yield (g/ pot)	Pod length (cm)	Seeds/pod (No.)	100 seed wt. (g)
Control	4.41 e	34.80e	12.73 c	10.90 c	11.45 b
FRS-1	6.57 abc	52.54 abc	14.07 ab	12.38 ab	12.41 a
FRS-2	7.16 a	57.28 a	14.88 ab	12.82 ab	12.35 a
FRS-3	5.73 d	45.85 d	14.05 ab	12.25 b	12.55 a
FRS-4	6.36 bcd	50.64 bcd	13.70 bc	12.40 ab	12.64 a
FRS-6	6.14 cd	48.65 cd	14.18 ab	12.75 ab	12.54 a
FRS-8	7.11 a	57.13 a	15.02 a	13.02 ab	12.70 a
FRS-14	6.92 ab	55.23 ab	15.10 a	13.20 a	12.66 a
Sig. level	**	**	**	**	**
CV(%)	5.01	5.27	3.90	3.10	2.92

In a column, having similar letter(s) do not differ significantly as per DMRT.

Production and distribution of BINA biofertilizers in 2018-2019

An amount of 710 kg biofertilizers were produced for production of soybean, mungbean, lentil, groundnut and chickpea, among this amount 449 kg were distributed to farmers, scientists, research students and other agriculture practitioners (Table 33). The highest amount of biofertilizer produced and distributed was of soybean followed by mungbean and lentil this year.

Table 33. Biofertlizers production and distribution at BINA in 2018-2019.

Sl. No	Crop	Production (kg)	Distribution (kg)
1	Soybean	280.00	263.00
2	Mungbean	202.00	114.00
3	Lentil	158.00	52.00
4	Chickpea	40.00	10.00
5	Groundnut	30.00	10.00
	Total	710.00	449.00

Effect of *Bradyrhizobium* in combination with micronutrients on blackgram production in pot condition

A field experiment was conducted for evaluating the influence of bradyrhizobial strains on nodulation and growth of blackgram cultivar in the glass house of Soil Science Division, BINA, Mymensingh in November 2017. There were thirteen treatments i.e. T_1=control, T_2= Strain 1, T_3= Strain 2, T_4= Strain 3, T_5= Strain 1+(Zn+ Fe+ Mo) @1.5 kg ha^{-1}, T_6= Strain 1++(Zn+ Fe+ Mo) @3 kg ha^{-1}, T_7= Strain 2 +(Zn+ Fe+ Mo) @1.5 kg ha^{-1}, T_8= Strain 2+ (Zn+ Fe+ Mo) @3 kg ha^{-1}, T_9= Strain 3+(Zn+ Fe+ Mo) @1.5 kg ha^{-1} and T_{10}= Strain 3+(Zn+ Fe+ Mo) @3 kg ha^{-1}. Treatments were replicated three times. Symbiotic efficiency of the bacterial strains examined in pot condition. Nodule number, nodule dry weight, plant height, root length and shoot dry weight mungbean were influenced significantly due to inoculation. After 32 DAS of blackgram the data was collected. The highest nodulation, nodule dry weight, root length and shoot dry weight were recorded in the treatment T_{10} followed by T_9 and T_8 , T_{10} followed by T_9 and T_8 , T_{10} followed by T_9 and T_8 and T_{10} followed by T_9 and T_8.

Table 34. Effect of *Bradyrhizobium* in combination with micronutrients on the nodule number, nodule weight and growth of blackgram during 32 DAS

Treatments	Nodule no $plant^{-1}$ (No.)	Nodule fresh weight (gm $plant^{-1}$)	Nodule dry weight (mg $plant^{-1}$)	Plant height (cm)	Root length (cm)	shoot fresh weight (mg $plant^{-1}$	shoot dry weight (gm $plant^{-1}$)
T_1=control	44.33 i	0.125 j	45.67 j	19.67 j	8.33 h	5.43 h	0.97 i
T_2= Strain 1	53.67 h	0.138 i	48.33 i	20.33 i	9.33 g	5.77 g	1.09 h
T_3= Strain 2	56.00 g	0.148 h	50.00 h	22.33 h	9.33 g	6.44 f	1.17 g
T_4= Strain 3	63.00 fg	0.163 g	57.67 g	22.60 g	9.83 f	7.287 e	1.29 f
T_5= Strain1+(Zn+Fe+ Mo) @1.5 kg ha^{-1}	63.67f	0.219 f	58.33 f	23.33 h	9.83 f	7.66 de	1.36 e
T_6=Strain 1+(Zn+Fe+ Mo) @3 kg ha^{-1}	77.00e	0.226 e	65.67 e	23.50 df	10.50 e	7.93d	1.46 de
T_7= Strain 2+(Zn+ e+Mo) @1.5 kg ha^{-1}	81.67d	0.242 d	74.67 d	23.67 df	10.90 d	8.54 c	1.53 d
T_8=Strain2+(Zn+ Fe+ Mo) @3 kg ha^{-1}	86.67c	0.269 c	78.67 c	24.00 c	11.00 c	8.57c	1.63 c
T_9=Strain3+(Zn+ Fe+ Mo) @1.5 kg ha^{-1}	89.00 b	0.308 b	93.00 b	26.00 b	11.77 b	9.32 b	1.76 b
T_{10}= Strain2+(Zn+ Fe+ Mo) @3 kg ha^{-1}	97.67a	0.335 a	98.00 a	27.00 a	12.00 a	10.89 a	2.13 a
CV	11.47 %	2.83%	7.73 %	12.39 %	16.98 %	10.12 %	15.20 %
Level of sigficance	**	**	**	NS	*	**	NS

After 52 DAS of blackgram the highest nodulation was recorded in the treatment T_{10} followed by T_9 and T_8 ; the highest nodule dry weight was recorded in the treatment T_{10} followed by T_9 and T_8 ; the highest root length was also recorded in treatment T_{10} followed

by T_9 and T_8 . The highest shoot dry weight was recorded in treatment T_4 followed by T_2 and T_3.

Table 35. Effect of *Bradyrhizobium* in combination with micronutrients on the nodule number, nodule weight and growth of blackgram during 52 DAS

Treatments	Nodule no plant^{-1} (No.)	Nodule fresh weigh	Nodule dry wt. (mg plant^{-1})	Plant height (cm)	Root length (cm)	shoot fresh weight (mg plant^{-1})	shoot dry weight (gm plant^{-1})
T_1=control	49.33 j	0.122 i	47.67 j	12.33 i	7.53 h	7.53 i	1.32 h
T_2= Strain 1	59.33 i	0.158 h	54.33 i	22.33 h	8.5 fg	15.51 c	4.93 b
T_3= Strain 2	75.00 h	0.165g	60.00 h	23.00 g	8.67 f	15.79 b	4.52 c
T_4= Strain 3	76.67 g	0.242 f	60.33 g	24.33 ef	9.00 e	18.57 a	5.62 a
T_5= Strain1+(Zn+Fe+ Mo) @1.5 kg ha^{-1}	82.67f	0.247 f	61.00 f	24.00 f	9.33de	11.70 h	2.23
T_6=Strain 1+(Zn+Fe+ Mo) @3 kg ha^{-1}	90.00 e	0.269 e	72.00 e	25.67 e	9.00 e	12.08 g	2.59 g
T_7= Strain 2+(Zn+ e+Mo) @1.5 kg ha^{-1}	96.33 d	0.280 d	78.67 d	26.33 d	9.5 d	13.40 f	2.62 f
T_8=Strain2+(Zn+ Fe+ Mo) @3 kg ha^{-1}	105.67 c	0.295 c	85.76 c	26.33 c	10.00 c	12.12 e	2.70 e
T_9=Strain3+(Zn+ Fe+ Mo) @1.5 kg ha^{-1}	10b8.33	0.324 b	87.33b	28.83 b	10.33 b	12.14 e	2.61f
T_{10}= Strain2+(Zn+ Fe+ Mo) @3 kg ha^{-1}	112.67 a	0.341a	100.00 a	29.33 a	12.50 a	13.96 d	3.99 d
CV	10.24 %	2.83%	12.35 %	12.61 %	15.20 %	13.12 %	18.72 %
Level of sigficance	**	**	**	NS	*	**	NS

After harvest the highest pod length, seed per pod, pod per plant, seed weight per10 plant and pod weight per 10 plant were recorded in the treatment T_{10} followed by T_9 and T_8.

Table 36. Effect of *Bradyrhizobium* in combination with micronutrients on the Pod length, Seed./ Pod , Pod / plant and Seed weight growth of blackgram during harvest

Treatments	Pod length	Seed. Pod (No)	Pod / plant	Seed wt./10 plant	Pod wt./ 10 plant
T_1=control	4.02	5.47	9.80	10.77	17.87
T_2= Strain 1	4.16	5.97	10.15	16.35	24.83
T_3= Strain 2	4.19	6.11	10.32	16.86	25.97
T_4= Strain 3	4.27	6.13	10.35	17.40	26.89
T_5= Strain1+(Zn+Fe+ Mo) @1.5 kg ha^{-1}	4.27	6.15	10.35	19.33	30.10
T_6=Strain 1+(Zn+Fe+ Mo) @3 kg ha^{-1}	4.24	6.19	10.37	21.22	32.39
T_7= Strain 2+(Zn+ e+Mo) @1.5 kg ha^{-1}	4.27	6.25	10.36	22.97	33.47

T_8=Strain2+(Zn+ Fe+ Mo) @3 kg ha^{-1}	4.35	6.37	10.62	24.88	37.16
T_9=Strain3+(Zn+ Fe+ Mo) @1.5 kg ha^{-1}	4.36	6.35	12.40	26.18	38.97
T_{10}=Strain2+(Zn+Fe+Mo) @3 kg ha^{-1}	4.42	6.37	13.15	31.97	46.89

Effect of *Bradyrhizobium* in combination with micronutrients on lentil production in field condition

A pot experiment was conducted for evaluating the influence of bradyrhizobial strains on nodulation and growth of blackgram cultivar in the BINA farm, Mymensingh in November 2018. There were thirteen treatments with RCBD degine i.e. T_1=control, T_2= Strain 1, T_3= Strain 2, T_4= Strain 3, T_5= Strain 1+(Zn+ Fe+ Mo) @1.5 kg ha^{-1}, T_6= Strain 1++(Zn+ Fe+ Mo) @3 kg ha^{-1}, T_7= Strain 2 +(Zn+ Fe+ Mo) @1.5 kg ha^{-1}, T_8= Strain 2+ (Zn+ Fe+ Mo) @3 kg ha^{-1}, T_9= Strain 3+(Zn+ Fe+ Mo) @1.5 kg ha^{-1} and T_{10}= Strain 3+(Zn+ Fe+ Mo) @3 kg ha^{-1}. Treatments were replicated three times. Symbiotic efficiency of the bacterial strains examined in field condition. All treatments showed better nodulation and growth of blackgram compared to uninoculated control in field condition. Nodule number, nodule dry weight, plant height and shoot dry weight of lentil was influenced significantly due to inoculation. After 32 DAS of lentil, the data was collected. The highest nodulation was recorded in the treatment T_{10} followed by T_9 and T_8 ; the highest nodule dry weight was recorded in the treatment T_{10} followed by T_9 and T_8 ; the highest plant height was recorded in treatment T_{10} followed by T_9 and T_8. The highest shoot dry weight was recorded in treatment T_{10} followed by T_9 and T_8

Table 37. Effect of *Bradyrhizobium* in combination with micronutrients on the nodule number, nodule weight and growth of lentil during 32 DAS

Treatments	Nodule no of 5 plant	Nodule dry wt. (mg $plant^{-1}$)	Plant height 5 plant (cm)	shoot fresh wt. 5 plant (mg $plant^{-1}$)	shoot dry wt 5 plant (mg $plant^{-1}$)
T_1=control	8.00 j	52.67	11.46	2.87	0.78
T_2= Strain 1	20.00 i	111.67	13.27	3.35	1.00
T_3= Strain 2	21.00 h	114.33	14.1	3.82	1.13
T_4= Strain 3	23.33 g	117.00	14.4	4.11	1.18
T_5=Strain1+ (Zn+Fe+ Mo) @1.5 kg ha^{-1}	23.67 f	119.00	14.93	4.26	1.18

T_6= Strain1+(Zn+Fe+ Mo) @3 kg ha^{-1}	25.00 e	119.33	15.33	4.48	1.21
T_7= Strain 2+(Zn+Fe+Mo) @1.5 kg ha^{-1}	25.67 d	120.67	15.33	4.60	1.25
T_8= Strain2+(Zn+Fe+ Mo) @3 kg ha^{-1}	28.67 c	121.33	15.40	4.85	1.30
T_9= Strain3+(Zn+Fe+ Mo) @1.5 kg ha^{-1}	32.33 b	125.00	15.60	5.82	1.42
T_{10}=Strain3+(Zn+Fe+ Mo) @3 kg ha^{-1}.	35.67a	129.67	16.40	7.22	1.73

After 52 DAS of blackgram the data were collected. The highest nodulation was recorded in the treatment T_{10} followed by T_9 and T_8; The highest nodule number, nodule weight and growth of blackgram were recorded in the treatment T_{10} followed by T_9 and T_8.

Table 38. Effect of *Bradyrhizobium* in combination with micronutrients on the nodule number, nodule weight and growth of lentil during 52 DAS

Treatments	**Nodule no plant^{-1} (No.)**	**Nodule dry wt. (mg plant^{-1})**	**Plant height (cm)**	**Shoot fresh wt**	**Shoot dry wt (gm plant^{-1})**
T_1=control	7.00	53.33	22.80	6.37	2.15
T_2= Strain 1	22.33	121.67	23.00	7.21	2.45
T_3= Strain 2	24.67	123.33	23.67	9.03	2.89
T_4= Strain 3	27.00	124.33	24.07	10.35	3.01
T_5=Strain1+(Zn+Fe+Mo) @1.5 kg ha^{-1}	24.67	124.33	24.27	12.73	3.26
T_6=Strain1+(Zn+Fe+ Mo) @3 kg ha^{-1}	28.33	133.33	25.4	14.49	4.12
T_7= Strain 2+(Zn+ e+Mo) @1.5 kg ha^{-1}	35.67	130.33	26.13	15.48	3.44
T_8=Strain2+(Zn+Fe+ Mo) @3 kg ha^{-1}	39.00	134.33	26.40	15.92	4.20
T_9=Strain3+(Zn+Fe+ Mo) @1.5 kg ha^{-1}	40.67	134.33	24.40	16.98	3.77
T_{10}=Strain3+(Zn+Fe+Mo) @3 kg ha^{-1}.	43.33	137.33	24.93	19.36	4.26

After harvest the highest Plant height, Shoot fresh weight, pod per plant, seed weight per10 plant and pod no. per 10 plant were recorded in the treatment T_{10} followed by T_9 and T_8 .

Table 39. Effect of *Bradyrhizobium* in combination with micronutrients on the Plant height, Shoot fresh weight, pod per plant, Seed weight per10 plant and pod no. per 10 plant of lentil during final harvest

T_1=control	**Plant height (cm**	**Shoot fresh wt (10 plant)**	**Shoot dry wt (10 plant)**	**Shoot dry wt plant^{-1}**	**Pod no. plant^{-1}**
T_1=control	31.22	88.33	12.58	1.26	59.20
T_2= Strain 1	31.34	102.67	14.14	1.41	61.37
T_3= Strain 2	31.45	114.00	21.38	2.13	66.13
T_4= Strain 3	31.56	132.00	22.77	2.28	66.43
T_5=Strain1+(Zn+Fe+Mo) @1.5 kg ha^{-1}	32.22	162.33	29.46	2.95	73.57
T_6=Strain 1+(Zn+Fe+ Mo) @3 kg ha^{-1}	32.33	176.67	30.58	3.06	76.40
T_7= Strain 2+(Zn+Fe+Mo) @1.5 kg ha^{-1}	33.11	183.67	32.64	3.62	81.30
T_8=Strain2+(Zn+ Fe+ Mo) @3 kg ha^{-1}	33.22	201.00	34.58	3.72	85.43
T_9=Strain3+(Zn+ Fe+ Mo) @1.5 kg ha^{-1}	33.56	218.00	37.19	3.37	86.27
T_{10}=Strain3+(Zn+Fe+ Mo) @3 kg ha^{-1}.	34.78	247.67	46.24	3.46	90.93

Plant Pathology Division

Research Highlights

- Among the mutants/lines tested in aus season, five showed moderately resistant and 4 showed moderately susceptible reaction to bacterial blight and whereas four mutants/lines showed moderately resistant and 5 showed moderately susceptible reaction to sheath blight.

- Three mutants/lines showed moderately resistant and 8 showed moderately susceptible reaction to bacterial leaf blight in aman season. Six mutants/lines showed moderately resistant and 9 showed moderately susceptible reaction to sheath blight.

- Among the 16 mutants/lines tested, all the mutants and advanced lines were found to be moderately resistant to bacterial blight during boro season. Three mutants/lines were showed moderately resistant and 13 moderately susceptible reactions to sheath blight.

- Among 43 entries of wheat, BWM-5 and BWM-6 were found tolerant to blast.

- Six rapeseed mutants and a check variety, BARI Sarisha-17 were tested against alternaria blight under natural field condition in Mymensingh and Rangpur. All the mutants of rapeseed were susceptible to alternaria blight.

- Three mutants of soybean (SBM-02, SBM-05, SBM-07) along with two check varieties (Binasoybean-4 and BARIsoybean-5) were tested against collar rot (Sclerotium rolfsii) and cercospora leaf spot in Mymensingh and Noakhali. All the mutants and the check varieties showed susceptible reaction to collar rot and cercospora leaf spot.
- Four sesame mutants were found to be moderately resistant to yellow mosaic.

- Fourteen mutants of groundnut along with the check variety were moderately resistant to collar rot and also to cercospora leaf spot.

- Two advanced mutants of chickpea were evaluated against root rot (Fusarium sp.) and botrytis gray mould (Botrytis sp.) at Magura and Chapainobabgong. All the mutants were susceptible to root rot and moderately susceptible to botrytis gray mould.

- Six advanced mutants along with two check varieties of lentil were evaluated against root rot (Fusarium sp.) and stemphylium blight (Stemphylium sarciniformis) at Magura, Chapai and Ishurdi. All the mutants were susceptible to root rot. The mean severity of stemphylium blight ranged from 4-5. All the mutants were found moderately susceptible to susceptible to stemphylium blight.

- Two tomato mutants (TM-4 and TM-8), three lines (Cherolla, Lupitas and Trumbling Red) along with two check varieties, Binatomato-7 and Binatomato-10 were evaluated against late blight and early blight under natural field condition. Two mutants (TM-4 and TM-8) showed moderately resistant reaction to late blight and early blight.

- Experiments were conducted to control collar rot disease (Sclerotium rolfsii) of soybean and chickpea using BINA-biofungicide (based on Trichoderma harzianum). The disease reduction over control was 57% in soybean and 59% in chickpea.

- Application of biocontrol agent Trichoderma with seed and soil reduced the collar rot disease of groundnut significantly and also increased pod yield.

- An experiment was conducted in the laboratory of Plant Pathology Division to evaluate five fungicides (Bavistin 50 WP @ 0.2%, Dithane M-45 @ 0.2%, Simon gold 50 WP @ 0.4%, Antracol 70 WP @ 0.2%, Secure @ 0.2%) against four major soilborne pathogens: Sclerotium rolfsii, Fusarium oxysporum, Rhizoctonia solani and Macrophomina phaseolina following food poison technique. The highest growth inhibition was found in Bavistin 50 WP (70.3-75.4%) followed by Dithane M-45 (69.9-73.0%) for the four fungi.

- An experiment was carried out in the laboratory of Plant Pathology Division, BINA to see the effect of different storage containers (tin container, plastic container, polythene bag and cloth bag) on seed associated fungi of jute (Corchorus olitorious, var. O-9897) and onion (Allium cepa, var. BARI Piaj-1). Among the storage containers, tin container showed better performance than others in aspect of the prevalence of seed associated fungi.

- Development of blast at different growth stages of wheat was evaluated. The highest blast incidence and severity was recorded at heading to maturing stage.

- Eight non-chemical fungicides were evaluated against wheat blast. All fungicides showed higher incidence and severity of disease.

- Five fungicides including control were evaluated against wheat blast Nativo and Trooper showed higher reduction of wheat blast at laboratory and pot condition.

- Nine fungicides including control were evaluated against wheat blast Nativo, Filia Trooper and SunFighter treated plants had lower blast severity at all the growth stage even at pre-harvesting stage (10.5, 25.5, 10.6 and 20.8%).

Rice

Evaluation of mutants/advanced lines of rice for bacterial blight and sheath blight during aus season

Eight mutants and two lines of rice along with two varieties were assessed against bacterial leaf blight (*Xanthomonas oryzae* pv. *oryzae*) and sheath blight (*Rhizoctonia solani*) resistance in Aus season of 2018 under inoculated field condition. The experiments were conducted in a randomized block design with three replications at BINA farm, Mymensingh. The unit plot size was 2 m x 2 m. The distance between lines and hills were 20 cm and 15 cm, respectively. Twenty five days old seedlings were transplanted in the field. The fertilizers were applied as per recommendations. Ten hills in each plot were inoculated at the booting stage with 72 hours old culture of *X. oryae* pv. *oryzae* by clipping method. Similarly, ten hills in each plot were inoculated at the booting stage with seven days old culture of *R. solani*. Plants were assessed for bacterial leaf blight and sheath blight severity after two and three weeks of inoculation, respectively following the scale developed at IRRI (2013).

All the plants of mutants/parents were infected with bacterial leaf blight. Mean severity of BLB was ranged from 2.5 to 5.7 (Table 1). Among the mutants/lines, five showed moderately resistant and 4 showed moderately susceptible reaction to bacterial blight. Mean severity of ShB were ranged from 2.5-6.0 (Table 1). Four mutants/lines showed moderately resistant and 5 showed moderately susceptible reaction to sheath blight.

Table 1. Mean incidence and severity of bacterial leaf blight and sheath blight in some advanced mutants of rice during aus season of 2018 at Mymensingh

Mutant/variety	Bacterial leaf blight			Sheath blight		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
N_1/250/P-7-3-1-2-2	93.3	3.3	MR	100.0	5.8	MS
N_1/250/P-6-2-6-1	86.7	3.4	MR	100.0	3.3	MR
N_{10}/250/P-2-3-5(1)	100.0	2.7	MR	100.0	3.4	MR
N_4/250/P-2(5)-11-2	100.0	5.1	MS	100.0	6.0	MS
N_{10}/300/P-2-3-5-1	100.0	5.6	MS	100.0	5.7	MS
N_{10}/300/P-2-3-5-2	100.0	5.7	MS	100.0	5.9	MS
N_4/350/P-4(5)	100.0	5.3	MS	100.0	4.5	MS
N_{10}/350/P-5-4	80.0	2.5	MR	100.0	2.9	MR
SSS	70.0	2.8	MR	100.0	2.5	MR
BRRI dhan56	86.7	4.1	MS	86.7	3.2	MR
BR-26	100.0	3.5	MS	100.0	4.7	MS
SH-1	83.3	5.5	MS	100.0	3.1	MR
TN-1	100.0	6.8	S	100.0	6.4	MS

MR = Moderately resistant, MS= Moderately susceptible, S= Susceptible

Evaluation of mutants/advanced lines of rice for sheath blight and bacterial blight during aman season

Seven mutants, 10 advanced lines of rice along with four varieties and one susceptible check variety were assessed against sheath blight (*Rhizoctonia solani*) and bacterial leaf blight (*Xanthomonas oryzae* pv. *oryzae*) resistance in aman season of 2018 under inoculated field condition. The experiments were conducted in a randomized block design with three replications at BINA farm, Mymensingh. The unit plot size was 2 m x 2 m. The distance between lines and hills were 20 cm and 15 cm, respectively. Thirty days old seedlings were transplanted in the field. The fertilizers were applied as per recommendations. Ten hills in each plot were inoculated at the booting stage with *X. oryae* pv. *oryzae* by clipping method. Similarly, ten hills in each plot were inoculated at the booting stage with seven days old culture of *R. solani*. Plants were assessed for bacterial leaf blight and sheath blight severity after two and three weeks of inoculation, respectively following the scale (0-9) developed at IRRI (2013).

All the plants of mutants, lines and varieties were infected with bacterial leaf blight and sheath blight. Mean severity of BLB was ranged from 2.4 to 8.5 (Table 2). Among the mutants/lines, 3 showed moderately resistant and 8 showed moderately susceptible reaction to bacterial leaf blight. Mean severity of ShB were ranged from 1.7-8.1 (Table 2). Six mutants/lines showed moderately resistant and 9 showed moderately susceptible reaction to sheath blight. Moderately resistant mutants/lines will be tested in inoculation condition in next year.

Table 2. Mean incidence and severity of bacterial leaf blight and sheath blight in some advanced mutants/lines of rice during aman season of 2018 at Mymensingh

Mutant/variety	Bacterial leaf blight			Sheath blight		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
MARF-12	100.0	6.3	MS	100.0	6.5	S
MARF-62	100.0	7.0	S	100.0	5.4	MS
MARF-75	100.0	5.6	MS	100.0	5.1	MS
MARF-76	100.0	6.2	MS	100.0	5.0	MS
MARF-78	100.0	5.2	MS	100.0	5.0	MS
MARF-82	100.0	3.6	MS	100.0	4.3	MS
MARF-86	100.0	3.6	MS	86.7	2.7	MR
RM-Kas-80(c)-1	90.0	3.2	MR	93.3	1.7	MR
N_1/250/P-2-3-5(1)	100.0	5.0	MS	100.0	2.8	MR
N_1/300/P-6-3-5(2)	90.0	2.5	MR	83.3	2.3	MR
N_{10}/300/P-2-3-5-2	80.0	3.8	MS	80.0	7.3	S
SSB-3	100.0	3.0	MR	83.3	2.3	MR

SSB-4	100.0	7.4	S	100.0	4.0	MS
IRBB-60	100.0	6.5	S	100.0	2.5	MR
MV-10	100.0	7.2	S	100.0	5.2	MS
MV-20	100.0	6.8	S	100.0	6.1	MS
MV-40	100.0	6.9	S	100.0	5.1	MS
Binadhan-7	100.0	6.7	S	100.0	3.8	MS
Binadhan-16	100.0	6.5	S	100.0	5.1	MS
Binadhan-17	100.0	6.5	S	100.0	4.9	MS
BRRI dhan49	100.0	2.9	MR	63.3	2.4	MR
TN-1	100.0	8.5	HS	100.0	8.1	HS

MR = Moderately resistant, MS= Moderately susceptible, S= Susceptible, HS= Highly susceptible

Evaluation of some promising mutants/advanced lines of rice for bacterial blight and sheath blight during boro season

Three promising mutants and 13 advanced lines along with 3 varieties were assessed against bacterial leaf blight and sheath blight during boro season of 2018-19 under inoculated field condition. The experiments were conducted in a randomized complete block design with three replications at BINA farm, Mymensingh. The unit plot size was 2 m x 2 m and spacing between rows and hills were maintained 20 cm and 15 cm, respectively. Forty days old seedlings were transplanted. The fertilizers were applied as per recommended doses. The inoculation and assessment were carried out similar to previous experiments conducted in Aman season.

Mean incidences and severities of bacterial leaf blight and sheath blight were differ significantly among the mutants/lines. Mean incidences and severity of BLB were ranged from 23.3-100% and 1.6-6.1, respectively (Table 3). All the mutants and advanced lines were found to be moderately resistant to bacterial blight. Mean severity of ShB were ranged from 2.3-7.0 (Table 3). Among the mutants/lines, three were showed moderately resistant and 13 moderately susceptible reactions to sheath blight.

Table 3. Mean incidence and severity of bacterial blight and sheath blight of some mutants/advanced lines of rice during boro season of 2018-19 at Mymensingh

Mutant/lines/variety	Bacterial leaf blight			Sheath blight		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
RM (2)-50(C)-2-1-1	50.0	2.1	MR	100.0	4.4	MS
N_{10}/300/P-2-3-5-2	50.0	2.0	MR	100.0	3.6	MS
RM-40(c)-4-2-8	90.0	2.7	MR	100.0	5.8	MS
Magic-12	96.7	3.1	MR	100.0	5.5	MS
Magic-23	83.3	1.9	MR	100.0	6.0	MS

Magic-27	100.0	2.4	MR	100.0	5.0	MS
Magic-62	100.0	2.7	MR	100.0	5.6	MS
Magic-72	23.3	2.2	MR	100.0	3.1	MR
Magic-78	66.7	2.4	MR	100.0	4.1	MS
Magic-82	40.0	1.6	MR	93.3	3.2	MR
Magic-86	53.3	1.6	MR	100.0	5.1	MS
SSB-2	53.3	2.0	MR	100.0	2.3	MR
E-02	100.0	2.0	MR	100.0	5.2	MS
THDB	70.0	2.4	MR	100.0	4.9	MS
B-10	83.3	2.4	MR	100.0	4.8	MS
SH-1	100.0	3.3	MR	100.0	4.8	MS
Binadhan-10	93.3	3.5	MS	100.0	3.8	MS
Binadhan-14	86.7	1.9	MR	100.0	5.6	MS
BRRI dhan28	83.3	5.2	MS	100.0	5.3	MS
BRRI dhan29	30.0	1.6	MR	100.0	3.9	MS
TN-1	100.0	6.1	S	100.0	7.0	S

MR= Moderately resistant, MS= Moderately susceptible, S= Susceptible

Wheat

Evaluation of some mutants (M_3) of wheat against blast at Meherpur and Mymensingh during 2018-19

Thirty three mutants derived from exotic varieties and germplasms of wheat including susceptible check were assessed against blast in winter season of 2018-19 under inoculated field condition. To maintain temperature and moisture, the whole experimental field was covered by polythene sheet. The experiment was conducted in a randomized block design (CRD) with three replications at BINA farm, Mymensingh. Line to line distance was 20 cm and block to block 1m. The fertilizers were applied as recommendations dose. Inoculum was sprayed at booting stage with conidia suspension of *Magnaporthe oryzae* Triticum (Mot) collected from infected field of Meherpur by spray along method. Plants were assessed for blast incidence and severity after one week to pre-ripening of inoculation. The experiment at Meherpur was done under natural condition. Severity scale for infection on wheat heads was assessed following the scale from 0 to 4 according to the procedure described by Ma *et al*., (2014) (Figure 1) where 0 = No lesions; 1 = 25% or less; 2 = 26-50%; 3 = 51-75%; and 4 = 76-100% infected area

No lesions 25% or less 26-50% 51-75% 76-100%

Figure 1. Disease severity (DS) in wheat spike

Mean incidence and severity of blast at BINA farm ranged from 0.0 -100% and 0.0-100% respectively. The lower incidence and severity were found in the entry. BWM-5 and BWM-6 (Table 4). At Meherpur, mean incidence and severity of blast ranged from 0.0-57.8% and 0.0-61.7%, respectively. Disease incidence and severity were low in Meherpur under natural condition (Table 5).

Table 4. Incidence and severity of blast in thirty three entries of wheat inoculated with spores of *Magnaporthe oryzae* Triticum at pre-heading stage at BINA farm, Mymensingh

Entries	Disease Incidence (%)	Disease Severity (%)
BARRI Gom 26	100	100
BWM 1	35.65	9.06
BWM 2	33.77	2.00
BWM 3	17.95	1.53
BWM 4	77.22	94.33
BWM 5	0.00	0.00
BWM 6	2.18	0.13
BWM 7	27.71	4.86
BWM 8	93.34	86.33
BWM 9	40.98	4.86
BWM 10	71.62	69.66
BWM 11	90.05	75.33
BWM 12	57.63	44.66
BWM 13	53.63	49.66
BWM 14	83.75	14.33
BWM 15	52.98	7.13
BWM 16	40.92	11.66
BWM 17	41.89	6.00
BWM 18	51.17	20.86
BWM 19	37.19	6.06
BWM 20	20.07	2.26

BWM 21	15.64	1.93
BWM 22	29.40	4.86
BWM 23	30.19	4.66
BWM-250-21	97.9	83.0
BWM-200-25	87.7	76.3
BWM-200-29	100	100
BWM-200-30	100	100
BWM 40	100	95.47
BWM 41	100	97.67
BWM 42	100	96.33
BWM 43	100	97.53
BWM 44	100	93.13
LSD (0.05)	**7.2**	**3.5**

Table 5. Incidence and severity of blast in thirty three entries of wheat inoculated with spores of *Magnaporthe oryzae* Triticum at pre-heading stage in Meherpur

Entries	Disease incidence (%)	Disease severity (%)
BARI Gom 26	57.83	61.67
BWM 1	8.113	1.0
BWM 2	0.00	0.00
BWM 3	0.00	0.00
BWM 4	5.733	1.0
BWM 5	0.00	0.00
BWM 6	0.00	0.00
BWM 7	0.00	0.00
BWM 8	11.80	1.33
BWM 9	0.00	0.00
BWM 10	29.87	1.0
BWM 11	28.27	1.67
BWM 12	0.00	0.00
BWM 13	0.00	0.00
BWM 14	10.67	1.33
BWM 15	0.00	0.00
BWM 16	0.00	0.00
BWM 17	0.00	0.00
BWM 18	0.00	0.00
BWM 19	0.00	0.00
BWM 20	0.00	0.00
BWM 21	0.00	0.00
BWM 22	0.00	0.00
BWM 23	6.27	1.0
BWM-150-21	44.2	3.7
BWM-150-25	12.3	2.3
BWM-250-29	11.4	1.7
BWM-150-30	17.5	1.3
BWM 40	18.77	21.67
BWM 41	42.70	58.33
BWM 42	51.63	50.0
BWM 43	32.87	3.67
BWM 44	12.73	2.33
LSD (0.05)	**5.3**	**7.2**

Figure 2. Samples of wheat blast collected from infected wheat field in Meherpur sadar

Fig. 3. Field view of the experiment at BINA farm, Mymensingh

Fig. 4. MoT inoculated M3 population under polythene shed in BINA farm, Mymensingh

Fig. 5. Field view of the experiment of wheat at Meherpur

Evaluation of some selected mutants (M_2) and germplasms against blast at BINA farm, Mymensingh

Forty-two selected materials including susceptible check (BARI Gom-26) of wheat were assessed against blast in winter season of 2018-19 under inoculated field condition. To maintained temperature and moisture, the whole experimental field was covered by polythene shed. The experiment was conducted in a randomized block design (RBD) with three replications at BINA farm, Mymensingh. Forty-two entries each were sown in three replication. Line to line distance was maintained 20 cm and block to block 1 m. The fertilizers were applied as recommendation dose. Inoculum was applied at booting stage with conidia suspension of MoT collected from infected field of Meherpur by spray along method. Plants were assessed for blast incidence and severity after one week of inoculation to pre-ripening stage.

Mean incidence of blast ranged from 0.0 -27.5, 0.0-39.8, 0.0-55.4, 0.0-75.6 and 7.7-90.0, respectively at 85, 100, 105, 110 and 115 DAS (Table 6). The lower incidence was found in the entries BSG-10, BSG-19 and BSM-18 at all the growing stage.

Mean severity of blast at BINA farm ranged from 0.0 -58.9, 0.0-85.0, 0.0-85.0, 0.0-90.6 and 18.3-95.0, respectively at 85, 100, 105, 110 and 115 DAS (Table 7). The lower seventy were found in the entries BSG-9, BSG-18 and BSM-18 at all the growth stage. Blast incidence of wheat (Mutants M2) BINA farm.

Table 6. Blast incidence of wheat mutants at BINA farm, Mymensingh

Treatments	Percent incidence of disease at different days after sowing (DAS)				
	95 DAS	100 DAS	105 DAS	110 DAS	115 DAS
BSG-1	27.51	34.11	55.39	70.59	89.11
BSG-2	3.34	14.36	22.31	38.18	57.54
BSG-3	1.60	13.40	17.68	17.64	47.00
BSG-4	0.00	3.93	7.58	9.67	78.78
BSG-5	0.00	0.00	2.35	3.60	26.34
BSG-6	0.21	1.04	2.82	5.717	26.23
BSG-7	0.33	0.37	4.96	11.06	27.77
BSG-8	4.05	15.35	16.38	32.83	60.72
BSG-9	0.00	1.85	1.80	5.07	36.08
BSG-10	0.00	0.00	0.00	0.00	7.73
BSG-11	6.65	39.78	52.05	75.20	90.00
BSG-12	6.44	38.35	44.70	63.50	90.00
BSG-13	1.90	0.00	2.49	34.37	17.45
BSG-14	0.00	0.00	16.66	40.15	45.92
BSG-15	0.00	0.00	8.00	5.55	16.37

BSG-16	0.50	6.09	8.69	15.44	42.84
BSG-17	0.00	6.72	10.16	17.86	33.34
BSG-18	0.00	0.00	0.00	4.540	24.07
BSG-19	0.00	0.00	0.00	7.740	15.35
BSG-20	0.00	0.00	0.00	22.36	24.88
BSG-21	0.00	0.00	0.00	12.77	42.93
BSG-22	0.00	0.00	0.00	7.983	19.49
BSG-23	0.00	0.00	0.00	10.03	29.54
BSG-24	4.54	13.63	18.18	27.27	28.44
BSM-1	3.22	1.48	8.45	25.58	58.69
BSM-2	3.36	6.41	19.98	43.74	63.93
BSM-3	1.33	7.46	21.00	38.44	56.77
BSM-4	0.00	1.92	9.07	27.62	65.53
BSM-5	2.19	4.79	26.04	42.81	67.38
BSM-6	3.05	14.35	32.32	72.52	75.29
BSM-7	0.313	13.63	28.67	47.72	70.02
BSM-8	3.22	12.95	27.84	57.54	74.90
BSM-9	1.54	15.11	38.67	67.34	65.38
BSM-10	0.55	11.01	24.83	48.33	60.13
BSM-11	1.05	13.60	30.17	75.55	70.85
BSM-12	5.88	8.08	28.34	42.68	19.27
BSM-13	0.58	7.52	13.18	62.58	76.51
BSM-14	0.00	4.76	4.76	19.05	19.38
BSM-15	0.00	1.28	5.44	36.99	70.62
BSM-16	0.00	6.63	17.58	42.98	73.16
BSM-17	0.58	10.07	33.62	57.04	77.36
BSM-18	0.00	6.66	6.66	9.52	9.52
Level of sig.	**	**	**	**	**
$LSD_{(0.05)}$	0.16	0.71	1.33	2.81	6.12
CV (%)	4.89	5.48	5.17	5.36	7.73

*= Significant at 5% level of probability

Table 7. Blast severity of wheat mutants at BINA farm, Mymensingh

Treatments	Percent severity of diseases at different days after sowing (DAS)				
	95 DAS	100 DAS	105 DAS	110 DAS	115 DAS
BSG-1	58.33	85.00	85.00	90.67	95.00
BSG-2	0.00	31.33	20.00	20.00	28.33
BSG-3	0.00	25.67	25.00	25.00	51.67
BSG-4	0.00	3.33	28.33	33.33	50.00
BSG-5	0.00	0.00	15.00	38.33	26.67
BSG-6	0.00	6.667	15.00	65.00	25.00
BSG-7	0.00	33.33	20.00	40.00	51.67
BSG-8	0.00	10.00	28.33	66.67	35.00
BSG-9	0.00	2.00	20.00	25.00	38.33
BSG-10	0.00	0.00	0.00	0.00	23.33
BSG-11	0.00	33.33	36.67	80.00	95.00
BSG-12	0.00	35.00	31.67	81.67	95.00
BSG-13	0.00	0.00	5.00	50.00	18.33
BSG-14	0.00	0.00	5.00	48.33	40.00
BSG-15	0.00	0.00	7.33	28.33	30.00
BSG-16	0.00	10.67	33.33	30.00	51.67
BSG-17	0.00	1.33	46.67	36.67	40.00
BSG-18	0.00	0.00	0.00	23.33	23.33
BSG-19	0.00	0.00	0.00	56.67	18.33

BSG-20	0.00	0.00	0.00	15.00	23.33
BSG-21	0.00	0.00	0.00	15.00	36.67
BSG-22	0.00	0.00	0.00	8.33	23.33
BSG-23	0.00	0.00	0.00	13.33	36.67
BSG-24	15.00	13.33	15.00	23.33	31.67
BSM-1	5.00	6.67	23.33	31.67	60.00
BSM-2	15.00	25.00	30.00	31.67	71.67
BSM-3	5.00	21.67	28.33	35.00	66.67
BSM-4	0.00	6.67	18.33	25.00	73.33
BSM-5	6.67	38.33	38.33	45.00	70.00
BSM-6	8.33	36.67	46.67	61.67	80.00
BSM-7	1.67	6.66	36.67	41.67	61.67
BSM-8	10.33	20.33	31.67	43.33	65.00
BSM-9	8.33	21.67	43.33	53.33	65.00
BSM-10	4.33	41.67	33.33	55.00	65.00
BSM-11	8.33	41.67	36.67	48.33	66.67
BSM-12	5.00	6.66	13.33	25.00	41.67
BSM-13	3.33	5.00	23.33	35.00	65.00
BSM-14	0.00	1.67	3.33	15.00	23.33
BSM-15	0.00	48.33	13.33	28.33	63.33
BSM-16	2.66	10.00	26.67	30.00	70.00
BSM-17	5.00	6.66	23.33	48.33	65.00
BSM-18	0.00	1.66	1.67	3.33	10.00
Level of sig.	*	*	*	*	*
$LSD_{(0.05)}$	1.03	2.65	5.23	5.74	6.819
CV (%)	16.4	10.74	14.31	4.45	8.51

*= Significant at 5% level of probability.

Mustard

Field evaluation of rapeseed mutants/lines against alternaria blight

Six rapeseed mutants and a check variety, BARI Sarisha-17 were tested against alternaria blight (*Alternaria brassicae*) under natural field condition at BINA farm, Mymensingh and BINA substation farm, Rangpur during the winter season of 2018-19. The experiments were conducted in a randomized complete block design with three replications. The unit plot size was 3m × 2m. The recommended doses of fertilizer were applied and normal cultural practices were followed. The severity scale 0-5 was followed for assessing the disease at early pod maturity stage.

Table 8. Response of mutants/lines/varieties of rapeseed to alternaria blight at Mymensingh during winter season of 2018-19

Mutants/variety	Leaf area diseased (%)	Disease severity (0-5)	Disease reaction
RM -03	36.2	4	
RM -11	38.3	4	
RM -13	33.0	4	
RM-15	39.0	4	Susceptible
RM-18	39.1	4	
RM-20	39.0	4	
BARI Sarisha-17	38.0	4	

Table 9. Response of mutants/lines/varieties of rapeseed to alternaria blight at Rangpur during winter season of 2018-19

Mutants/variety	Leaf area diseased (%)	Disease severity (0-5)	Disease reaction
RM -03	32.3	4	
RM -11	35.3	4	
RM -13	31.1	4	
RM-15	37.4	4	Susceptible
RM-18	33.5	4	
RL-20	35.2	4	
BARI Sarisha-17	36.0	4	

The disease incidence of alternaria blight ranged from 33.0-39.1% and 31.1-37.4% at Mymensingh and Rangpur, respectively. All the mutants of rapeseed and the check variety BARI Sarisha-17 were susceptible to alternaria blight (Table 8 and 9).

Soybean

Field evaluation of soybean mutants against collar rot and cercospora leaf spot

Three mutants of soybean (SBM-02, SBM-05, SBM-07) along with two check varieties (Binasoybean-4 and BARIsoybean) were tested against collar rot (*Sclerotium rolfsii*) and cercospora leaf spot disease. The evaluation for collar rot disease was done under inoculated condition and data of cercospora leaf spot were recorded from natural field condition. The unit plot size was 2.0 m × 2.0 m. The experiment was conducted in randomized complete block design with three replications at BINA farm, Mymensingh and Farmer's field at Noakhali. Seeds were sown on first week of January, maintaining row to row distance 75 cm and line to line distance 30 cm. The fertilizer was applied as per recommended doses. Twenty seedlings of thirty days old were inoculated with 10 days old culture of *Sclerotium rolfsii* in each plot. With appearance of visible symptoms, observation on disease parameter was made following (0-9) scale. In Mymensingh, the mean incidence of collar rot ranged from 63.4-83.4% and cercospora leaf spot ranged from 40.0-68.3% (Table 10). All the mutants and the check varieties showed susceptible reaction to collar rot. The mutant SBM-05 showed tolerant reaction and the rest of mutants and the check varieties showed moderately susceptible reaction to cercospora leaf spot.

Table 10. Disease reaction of three mutants of soybean against collar rot and cercospora leaf spot at Mymensingh in rabi season of 2018-19

Mutants/ varieties	Collar rot			Cercospora leaf spot		
	Disease incidence (%)	Disease severity (0-9)	Disease reaction	Disease incidence (%)	Disease severity (0-9)	Disease reaction
SBM-02	83.0	9	S	53.3	7	MS
SBM-05	83.4	9	S	40.0	5	T
SBM-07	80.9	9	S	56.6	7	MS
Binasoybean-4	75.9	9	S	48.3	7	MS
BARIsoybean-5	63.4	9	S	68.3	7	MS

MS= moderately susceptible, S= susceptible, T= tolerant

In Noakhali, the mean disease incidence of collar rot ranged from 52.7-97.8% and cercospora leaf spot ranged from16.6-28.3% (Table 11). All the mutants and the check varieties showed susceptible reaction to collar rot and moderately resistant reaction to cercospora leaf spot disease.

Table 11. Disease reaction of three mutants of soybean against collar rot and cercospora leaf spot at Noakhali in rabi season of 2018-19

Mutants/ varieties	Collar rot			Cercospora leaf spot		
	Disease incidence (%)	Disease severity (0-9)	Disease reaction	Disease incidence (%)	Disease severity (0-9)	Disease reaction
SBM-02	74.0	9	S	16.6	3	MR
SBM-05	72.0	9	S	28.3	3	MR
SBM-07	97.8	9	S	23.3	3	MR
Binasoybean-4	52.7	9	S	18.3	3	MR
BARIsoybean-5	73.3	9	S	20.6	3	MR

Sesame

Evaluation of sesame mutants against yellow mosaic

Four mutants of sesame along with two varieties were assessed against yellow mosaic at BINA sub-station, Ishurdi in 2019 under natural field condition. The experiments were conducted in a randomized complete block design with three replications. The seeds were sown in rows 30 cm apart on 25 March. The incidence of the disease was recorded at maximum pod maturing stage following the scale (0-5).

The stem rot disease was not observed and the yellow mosaic incidences were very low. The mean incidence of yellow mosaic ranged from 1.0 to 1.4%, the maximum disease infection was recorded in sesame mutant, SM-001 (Table 12).

Table 12. Mean incidences of stem rot in some advanced mutants of sesame at Ishurdi in 2019

Mutants/variety	Incidence (%)
SM-001	1.4
SM-002	1.0
SM-006	1.1
SM-058	1.2
Binatil-2	1.1
Binatil-3	1.2

Groundnut

Field evaluation of advanced mutants of groundnut against foot and root rot and cercospora leaf spot

Fourteen mutants of groundnut along with Binachinabadam-4 were evaluated for their resistance to foot and root rot (*Sclerotium rolfsii*) and cercospora leaf spot (*Cercospora arachidicola*) diseases under natural condition at Mymensingh in 2019. The experiments were conducted in a randomized complete block design with three replications. The unit plot size was 2.0m x 1.2m. Spacing between rows and plants within rows were 40 cm and 15 cm, respectively. Seeds were sown on 9 January 2019. The disease severity was assessed following the scale 0-5 for cercospora leaf spot.

Mean root rot incidences ranged from 11.6 to 21.7% (Table 13). All the mutants along with the check variety were moderately resistant to the disease. Mean cercospora leaf spot incidences and severities ranged from 28.5 to 72.6% and 2.1 to 3.3. All the mutants showed moderately resistant reaction to cercospora leaf spot.

Table 13. Disease reaction of mutants/varieties of groundnut to foot and root rot and cercospora leaf spot at Mymensingh during 2019

Mutants/varieties	Foot and root rot		Cercospora leaf spot		
	Incidence (%)	Disease reaction	Incidence (%)	Severity (0-5)	Disease reaction
B_6-282-11	12.7	MR	40.3	2.8	MR
B_6-282-50	15.7	MR	48.6	2.2	MR
B_6-282-53	18.4	MR	28.5	2.5	MR
B_6-282-56	14.1	MR	39.7	2.5	MR
B_6-282-62	15.6	MR	43.3	2.3	MR
B_6-282-63	13.3	MR	47.0	2.7	MR
B_6-282-64	11.9	MR	43.7	2.6	MR
B_6-282-65	11.9	MR	36.7	2.6	MR
B_6-282-66	15.8	MR	41.3	2.3	MR
B_6-282-67	14.3	MR	51.2	2.7	MR
B_6-282-68	13.9	MR	46.7	2.2	MR
B_6-282-70	11.6	MR	61.7	2.9	MR
B_6-282-77	14.2	MR	56.7	2.1	MR
B_6-282-80	13.6	MR	41.7	2.2	MR
Binachinabadam-4	21.7	MR	72.6	3.3	MS

MR= Moderately resistant, MS= Moderately susceptible

Lentil

Evaluation of lentil mutants against root rot and stemphylium blight

Six advanced mutants along with two check varieties of lentil were evaluated against root rot (*Fusarium* sp.) and stemphylium blight (*Stemphylium sarciniformis*) at Magura, Chapainawabganj and Ishurdi during the winter season of 2018-19. The experiments were conducted in randomized complete block design with three replications. The seeds were sown in rows on 2nd week of November 2018. Distance between rows and seeds were 30 cm and 5 cm, respectively.

The mean incidence of root rot was found 100%. All the mutants were susceptible to root rot. The mean severity of stemphylium blight ranged from 3-4. All the mutants were found moderately susceptible to susceptible to stemphylium blight (Table 14).

Table 14. Disease reaction of root rot and stemphylium blight on lentil mutants at Magura and Ishurdi

Mutants/ varieties	Root rot		Stemphylium blight	
	Disease incidence (%)	Disease reaction	Disease severity (0-5)	Disease reaction

LM-118-9	100		4	S
LM- 138-3	100		4	S
LM-206-5	100		4	S
LM-185-2	100	S	3	MS
Utfala	100		4	S
Binamasur-8	100		3	MS
LSD $_{(P\geq0.05)}$	**5.2**		**0.7**	**-**

MS = Moderately Susceptible, S = Susceptible

Chickpea

Evaluation of chickpea mutants against root rot and botrytis gray mould

Two advanced mutants along with two check varieties of chickpea were evaluated against root rot (*Fusarium* sp.) and botrytis gray mould (*Botrytis* sp.) at Magura and Chapainawabganj during the winter season of 2018-19 under inoculated condition of root rot and natural condition of botrytis gray mould. The experiments were conducted in randomized complete block design with three replications. The seeds were sown in rows on last week of November, 2018. Distances between rows and seeds were 30 cm and 5 cm, respectively.

The mean severity of root rot and botrytis gray mould ranged from 40.5-80.0% and score 5, respectively. All the mutants were susceptible to root rot and moderately susceptible to botrytis gray mould (Table 15). BGM incidence was 100%.

Table 15. Diseases incidence and severity of root rot and botrytis gray mold on some mutants of chickpea

Mutants/ varieties	**Root rot**		**Botrytis gray mould**	
	Disease incidence (%)	**Disease reaction**	**Disease severity (1-9)**	**Disease reaction**
CPM-200	80.0	S	5	MS
CPM-300	50.4	S	5	MS
Binasola-8	40.5	S	5	MS
BARI Chola-7	50.2	S	5	MS
LSD $_{(P\geq0.05)}$	9.5	-	0.7	**-**

MS= Moderately susceptible, S= Susceptible

Mungbean

Evaluation of some promising mungbean mutants against cercospora leaf spot and yellow mosaic

Four promising mutant along with one variety of mungbean were assessed for their resistance to cercospora leaf spot (*Cercospora sp.*) and yellow mosaic at BINA sub-station Magura in kharif-1 season of 2019 under natural field condition. The experiment was conducted in a randomized complete block design with three replications. The seeds were sown on 25 March and the unit plot size was 3m × 3m. The recommended doses of fertilizer were applied and normal cultural practices were followed. The incidence and severities of CLS and yellow mosaic were recorded at pod ripening stage.

The mean incidences of cercospora leaf spot ranged from 2.3 to 4.4% (Table 16). The mean severity of CLS ranged from 1.7-3.5. Mean incidences of yellow mosaic ranged from 1.7 to 12.3.

Table 16. Mean incidence and severity of yellow mosaic and cercospora leaf spot of mungbean mutants at Magura in 2018

Mutants/variety	Yellow mosaic incidence (%)	Cercospora leaf spot	
		Incidence (%)	Severity (0-8)
MBM-427-87-3	2.2	3.2	1.9
MBM-656-51-2	1.7	3.7	2.4
MBM-07-Y-2	12.3	4.4	2.1
MBM-07(g)-2	2.8	2.3	1.7
BARI Mung-6	2.0	4.4	3.5

Tomato

Evaluation of tomato mutants against late blight and early blight

Two tomato mutants (TM-4 and TM-8), three lines (Cherolla, Lupitas and Trumbling Red) along with two check varieties were evaluated against late blight and early blight under natural field condition at BINA farm, Mymensingh and BINA sub-station, Magura during rabi season of 2018-19. The experiments were conducted in a randomized complete block design with three replications. The unit plot size was 2m × 2m. Thirty days old seedlings were transplanted in the field. The fertilizers were applied as per recommendations and normal cultural practices were followed. Diseases incidence and severity for tomato late blight and early blight were recorded at an interval of 7 days to the maturity of fruits on visual assessment of symptomatic leaves, petioles, fruits and stems. The severity scale (0-6) and (0-5) was followed for assessing late blight and early blight, respectively.

The mean incidence of late blight ranged from 48.8 to100% in Mymensingh and 23.3 to 47.3% in Magura, respectively (Table 17). In Mymensingh, both the mutants showed moderately resistant reaction, two lines showed moderately susceptible and one line showed tolerant reaction against late blight. But in Magura two lines (Lupitas and Trumbling Red) showed tolerant reaction and the rest of the lines showed moderately resistant reaction against late blight.

Table 17. Mean incidence and severity of late blight of tomato at Mymensingh and Magura during rabi season of 2018-19

Mutants/lines/ varieties	Mymensingh			Magura		
	Disease incidence (%)	Disease severity (0-6)	Disease reaction	Disease incidence (%)	Disease severity (0-6)	Disease reaction
TM-4	68.1	2.7	MR	32.3	1.7	MR
TM-8	66.6	2.6	MR	29.4	1.8	MR
Cherolla	93.3	4.1	MS	23.3	3.2	T
Lupitas	100.0	4.0	MS	26.8	3.1	T
Trumbling Red	48.8	3.0	T	28.3	2.1	MR
Binatomato-7	100.0	2.4	MR	47.3	1.7	MR
Binatomato-10	60.7	2.2	MR	39.4	2.0	MR

MR = Moderately resistant, MS = Moderately susceptible, T= Tolerant

The mean incidence of early blight ranges from 25.2 to 50.0% in Mymensingh and 18.3 to 66.3% in Magura, respectively (Table 18). In both locations (Mymensingh and Magura) all the mutants, lines and varieties showed moderately resistant reaction against early blight.

Table 18. Mean incidence and severity of early blight of tomato mutants at mymensingh and magura during rabi season of 2018-19

Mutants/ varieties/lines	Mymensingh			Magura		
	Disease incidence (%)	Disease severity (0-5)	Disease reaction	Disease incidence (%)	Disease severity (0-5)	Disease reaction
TM-4	26.67	2.26	MR	36.87	1.77	MR
TM-8	28.34	2.33	MR	28.9	1.74	MR
Cherolla	39.17	2.34	MR	51.67	2.39	MR
Lupitas	50.00	2.40	MR	51.48	2.28	MR
Trumbling Red	37.50	2.25	MR	18.33	2.13	MR
Binatomato-7	31.67	2.40	MR	33.33	2.17	MR

Binatomato-10	25.28	2.17	MR	66.37	1.64	MR

MR = Moderately resistant

Biological control of collar rot disease of soybean and chickpea using BINA-biofungicide

Experiments were conducted to control collar rot disease (*Sclerotium rolfsii*) of soybean and chickpea at BINA farm, Mymensingh using BINA-biofungicide (based on *Trichoderma harzianum*). Experiments were done in randomized complete block design with three replications during winter season of 2018-19. The unit plot size was 2m × 1.5m. The recommended doses of fertilizer were applied. Inter cultural operation and irrigation were applied when necessary. The data were collected on collar rot incidence of soybean and chickpea.

The incidence of collar rot in BINA-Biofungicide treated plots of soybean and chickpea were 24.6% and 22.5%, respectively, where the incidence of disease in untreated plots (control) were 57.3% and 55.1%, respectively. The incidence of collar rot in BINA-biofungicide treated plots were lower than the untreated plots (control). The disease decreased over control was 57% in soybean and 59% in chickpea (Table 19 and 20). The grain yield of soybean and chickpea in BINA-biofungicide treated plots was also higher than untreated plots (control).

Table 19. Effect of BINA-Biofungicide on disease incidence (%) of collar rot of soybean

Treatments	Collar rot disease incidence (%)	Disease decreased over control (%)	Grain yield (t/ha)
BINA-Biofungicide	24.6	57.1	2.20
Control	57.3	-	1.50
LSD $_{(P\geq0.05)}$	5.8		

Table 20. Effect of BINA-Biofungicide on disease incidence (%) of collar rot of chickpea

Treatments	Collar rot disease incidence (%)	Disease decreased over control (%)	Grain yield (t/ha)
BINA-Biofungicide	22.5	59.2	1.60
Control	55.1	-	0.90
LSD $_{(P\geq0.05)}$	7.6		

Management of foot and root rot groundnut

Field experiment was conducted to find out environment friendly management strategy for foot and root rot (*Sclerotium rolfsii*) of groundnut (Binachinabadam-7) under inoculated condition at Mymensingh in 2019. The experiment was conducted in a randomized complete block design with three replications. The unit plot size was 2.0m x 2.0m. Spacing between rows and plants within rows were 40 cm and 10 cm, respectively. Seeds were sown on 24 January 2019. Inter cultural operations and irrigations were applied when necessary. The disease incidences were recorded at 15 days interval from germination to maturity.

Mean foot and root rot incidences ranged from 55.2 to 77.7% (Table 21). The lowest disease incidence was recorded in provex treated plot. The pod yield of groundnut was the highest in the plot applied Trichoderma as seed dressing and also applied at soil.

Table 21. Mean incidences of foot and root rot and yield of groundnut (var. Binachinabadam-7) as affected by different treatment at Mymensingh during 2019

Treatments	Incidence (%)	Plant height (cm)	Branch plant^{-1} (No.)	Pod plant^{-1} (No.)	Pod weight plant^{-1} (g)	Yield (kg ha^{-1})
T_1 (Provex)	55.2	83.3	3.76	16.0	6.8	1670
T_2 (Trichoderma seed)	68.9	85.0	4.45	19.6	8.9	1830
T_3 (Trichoderma soil)	73.6	73.3	4.13	28.5	8.8	1490
$T_2 + T_3$	62.8	79.8	3.56	19.9	8.3	1880
T_5 (Control)	77.7	76.5	3.36	15.5	6.4	1390

In vitro evaluation of five fungicides against four major soilborne pathogens

An experiment was conducted in the laboratory of Plant Pathology Division, BINA during August-November, 2018 to evaluate five fungicides against four major soilborne pathogens: *Sclerotium rolfsii, Fusarium oxysporum, Rhizoctonia solani* and *Macrophomina phaseolina*. The fungicides which were used in the experiment were: Bavistin 50 WP @ 0.2%, Dithane M-45 @ 0.2%, Simon gold 50 WP @ 0.4%, Antracol 70 WP @ 0.2%, Secure @ 0.2%. Food poison technique was followed for *in vitro* evaluation of the selected fungicides. The experiment was carried out in a completely randomized design (CRD) with five replications. Inhibition of radial growth of the fungi was computed by measuring colony diameter of fungi on control plates and treated plates.

Table 22. Growth inhibition (%) of four fungi by five different fungicides

Treatments	Fungal growth inhibition (%)			
	S. rolfsii	***F. oxysporum***	***R. solani***	***M. phaseolina***
Bavistin 50 WP	75.4a	70.3a	72.1a	74.7a
Dithane M-45	73.0a	71.4a	69.9a	72.0a
Simon gold 50 WP	38.2b	38.9b	36.7b	38.0b
Antracol 70 WP	37.5b	38.0b	37.7b	38.1b
Secure	40.2b	37.8b	36.8b	39.3b

In a column figures with same letter do not differ significantly

All the fungicides inhibited the growth of four fungi (*S. rolfsii*, *F. oxysporum*, *R. solani* and *M. phaseolina*) (Table 22). The highest growth inhibition was found in Bavistin 50 WP following by Dithane M-45 for the four fungi. In Bavistin 50 WP the growth inhibition ranged from 70.3-75.4% while in Dithane M-45 the growth inhibition ranged from 69.9-73.0%.

Effect of different storage containers on seed associated fungi of jute and onion

An experiment was carried out in the laboratory of Plant Pathology Division, BINA to see the effect of different storage containers on seed associated fungi of jute (*Corchorus olitorious*, var. O-9897) and onion (*Allium cepa*, var. BARI Piaj-1). Four different types of container like tin container, plastic container, polythene bag and cloth bag were used to store jute and onion seeds for 75 days. Observation/recording of seed associated fungi following the standard blotter method was done at every 15 days during the experimental period. The seeds in petridishes (placed on three layers of moistened filter paper, Whatman No. 1) were incubated at 22 ± 2^0C for eight days. The seeds were examined under stereo microscope at 25x magnification to observe the presence of seed borne fungi. Most of the seed associated fungi were identified by observing the growth characters on the incubated seeds on blotter paper.

The seed associated fungi were *Colletotrichum corchori*, *Macrophomina phaseolina*, *Fusarium* spp. and *Aspergillus niger* in jute while in onion these were *Alternaria porri*, *Fusarium* spp., *Aspergillus niger* and *Curvularia lunata.* The prevalence of the fungi increased with storage time in both jute and onion seeds. Among the storage containers, tin container showed better performance than plastic container, polythene bag and cloth bag in aspect of the prevalence of seed associated fungi (Table 23 and 24).

Table 23. Prevalence of fungi associated with jute seeds stored in different container during the storage period

Fungi	Containers	Prevalence of fungi (%)					
		Before storage	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
Colletotrichum corchori	Tin container	12.3	12.3c	12.5c	12.4c	12.7c	12.8c
	Plastic container	12.3	13.8b	13.9b	14.2b	14.5b	14.6b
	Polythene bag	12.3	13.9b	14.1b	14.5b	14.6b	14.7b
	Cloth bag	12.3	14.0a	15.5a	15.8a	16.0a	16.3a
Macrophomina phaseolina	Tin container	10.1	10.4c	10.5c	10.7c	10.7c	10.8c
	Plastic container	10.1	11.8b	12.5b	12.8b	12.7b	12.9b
	Polythene bag	10.1	12.3b	12.4b	12.3b	12.5b	12.8b
	Cloth bag	10.1	13.5a	13.7a	13.8a	13.9a	13.9a
Fusarium spp.	Tin container	11.6	11.9c	12.0c	12.4c	12.5c	12.5c
	Plastic container	11.6	13.8b	13.2b	13.4b	13.8b	13.8b
	Polythene bag	11.6	13.7b	13.8b	13.7b	13.8b	14.0b
	Cloth bag	11.6	14.9a	14.9a	15.2a	15.3a	15.6a
Aspergillus niger	Tin container	5.5	5.8c	6.0c	6.2c	6.2c	6.5c
	Plastic container	5.5	7.0b	7.0b	7.1b	7.1b	7.3b
	Polythene bag	5.5	7.3b	7.5b	7.5b	7.7b	7.7b
	Cloth bag	5.5	8.7a	8.8a	8.8a	8.5a	8.5a

Table 24. Prevalence of fungi associated with onion seeds stored in different container during the storage period

Fungi	Containers	Prevalence of fungi (%)					
		Before storage	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
Alternaria porri	Tin container	9.3	9.5c	10.1c	10.1c	10.3c	10.3c
	Plastic container	9.3	11.6b	11.7b	11.7b	11.9b	11.9b
	Polythene bag	9.3	11.4b	11.5b	11.3b	11.6b	11.5b
	Cloth bag	9.3	13.5a	13.7a	13.9a	13.0a	13.1a
Fusarium spp.	Tin container	10.1	10.2c	10.5c	10.6c	10.8c	10.9c
	Plastic container	10.1	12.3b	12.4b	12.4b	12.5b	12.4b
	Polythene bag	10.1	12.1b	12.2b	12.4b	12.4b	12.4b
	Cloth bag	10.1	13.8a	14.5a	14.8a	14.9a	14.9a
Aspergillus niger	Tin container	12.6	12.8c	12.6c	12.9c	12.8c	12.8c
	Plastic container	12.6	13.5b	14.8b	14.9b	14.8b	14.8b
	Polythene bag	12.6	13.6b	14.8b	14.8b	14.9b	14.8b
	Cloth bag	12.6	15.7a	15.9a	15.9a	16.2a	16.4a
Curvularia Lunata	Tin container	5.3	5.7c	5.7c	5.8c	6.0c	6.0c
	Plastic container	5.5	7.6b	7.8b	7.8b	7.7b	7.9b
	Polythene bag	5.5	7.7b	7.8b	7.8b	7.6b	7.8b
	Cloth bag	5.5	8.8a	8.9a	9.0a	9.1a	9.3a

Study on blast development at different growth stages of wheat (BARI Gom 26) under inoculated condition

A pot experiment was conducted to evaluate the development of blast at different growth stages of wheat. The experiment was done in CRD with four replications at BINA farm during the winter season of 2018-19. Fifteen seeds were sown in each pot on 9 November 2018. The inoculum of blast (*Magnaporthe oryzae* triticum) collected from blast hotspot of Meherpur district and inoculated on susceptible variety of wheat (BARI Gom-26) at four growing stages i.e. seedling stage, growing stage, heading stage and maturing stage.

The mean incidence and severity of blast was ranged from 5-100% and 3-60%, respectively. The highest blast incidence and severity was recorded at heading stage to maturing stage (Fig 6).

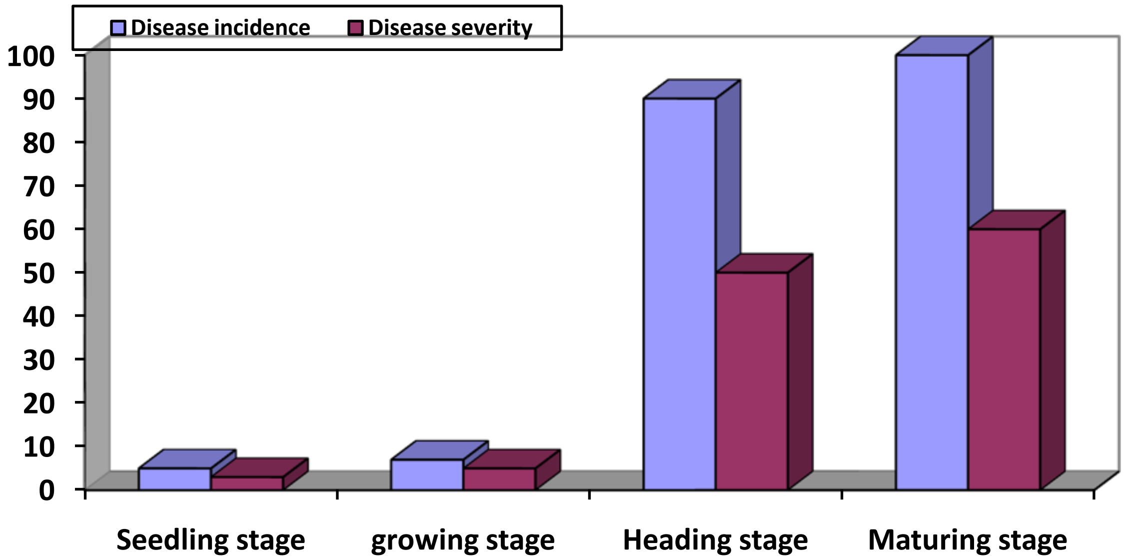


Fig. 6. The mean disease incidence and severity of blast at different growth stages of wheat

(BARI Gom 26)

Evaluation of different organic and inorganic means in controlling blast of wheat

A pot experiment was carried out in the research farm of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during 2018-19 following CRD with 3 replications. The experiment was done to evaluate the efficacy of fungicide, some organic and inorganic substances in the control of wheat blast caused by *Magnaporthe oryzae* Triticum (MoT). Soil was collected from the field laboratory of the Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh and dried. Decomposed cow dung from the Dairy Farm of Bangladesh Agricultural University, Mymensingh was added to it. The dried soil was mixed uniformly with well-decomposed cow dung at 2:1 (soil : cow dung) and sterilized with formalin (40%) at the rate of 5 ml formalin diluted with 20 ml of water for 4kg soil. The formalin treated soils were covered with polythene sheet for 48-hrs and then exposed to 48-hrs aeration before pot filling with 16kg/pot. A total of 24 pots were filled with the treated soil. Twenty seeds per pot of wheat cv. BARI Gom26 was sown on 15th November 2018. The treatments used in this study were: T_o: Control (distilled water spray), T_1: Nativo (tebuconazole + trifloxystrobin) @ 0.6 g L^{-1} , T_2: Trichoderma–suspension as biofungicide 250 g L^{-1}, T_3: Trichoderma–extract as biofungicide 5.0 g L^{-1}, T_4: Rin powder as detergent 1.0 g L^{-1}, T_5: Dutura leaf extract as botanical fungicide 1.0 g L^{-1}, T_6: NaCl (Inorganic substance) 3.0 g L^{-1}, T_7: NaCl (Inorganic substance) 5.0 g L^{-1}. Wheat spikes of different varieties infected with blast were collected from different regions of Meherpur district. Infected spikelets and other parts of spikes were processed for the isolation of MoT. Moist chamber technique and agar plate methods were used for the isolation of MoT.

Moist Chamber Technique: One or two blotter (filter paper what man no. 4) papers of size 9 cm soaked in sterile water were placed in 9 cm sterile plastic petridishes to prepare the moist chamber. Infected spike parts were cut into small pieces of 2-3 cm size to prepare inocula. 3-4 inocula were placed in the moist chamber maintaining equal distance. The moist chambers were incubated at room temperature (25+10c).

Agar plate method: Inocula were surface disinfected in 10% Clorox for 1-2 minutes followed by 2-3 times washing in sterile water. 3-4 inocula were placed aseptically on PDA and oat meal agar plates. The plates were incubated at room temperature (25+ 10c). Any fungal growth seen out of inocula was subject to microscopic observation for identification. Any fungal growth identified as MoT was transferred to agar plates for culture. All available literatures were consulted for identification of MoT.

Preparation of MoT spore suspension: The inocula in moist blotter yielded the blast pathogen which upon transfer to agar plate showed very poor growth. So, spore suspension of blast pathogen was prepared out of the collected blast affected spikes. Infected wheat spikes were smashed and vigorously shaken in a beaker of sterile water. Suspension of MoT spores thus obtained was checked under microscope for MoT through preparation of slides. Spore density was 5 x 10^6 ml^{-1} as calculated in Hemocytometer count. The germination ability of the spores was checked through continued microscopic observation of the slide prepared and of spore suspension prepared (Fig.7).

Fig.7. Microscopic view of spore germination of *Magnaporthe oryzae* triticum

Application of spore suspension onto foliage: Spore suspension was sprayed onto the foliage of wheat plants with an atomizer @ 100 ml pot^{-1} each pot carried 15 plants.

Inoculation of wheat plants with MoT: Three times inoculation were done with MoT into wheat plants at the age of 54, 59 and 70 days. After inoculation, the plants were kept covered for 24-48 h to maintain high humidity and temperature.

Sprayin of organic and inorganic substances: Fungicides were prepared in water as per treatment or based on the selective dose of treatment. The prepared suspensions or dilution of different treatments were sprayed individually by hand sprayer. First spray was done after 60 days of seeds sowing. The second, third and fourth spray were done after 70, 80 and 90 days of seeds sowing. All exposed surface of the plant including leaves, buds twigs and branches were sprayed. Control plants were sprayed with water. Data on disease incidence and severity were taken after 70, 80 and 90 DAS.

The incidence of blast at 70, 80 and 90 DAS was ranged from 0.0-2.6, 3.5-22.9 and 6.9-78.8, respectively. All the treatments except Nativo @ 0.6 g L^{-1} showed statistically identical higher incidence of diseases at 80 and 90 DAS as well as the treatment Nativo showed higher reduction in incidence of disease and showed least incidence at 70 (0.0%), 80 (3.5%) and 90 (6.9%) DAS (Table 25).

Table 25. Effect of fungicides on incidence of blast in wheat cv. BARI Gom-26 at different days after sowing

Treatment	Disease incidence		
	70 DAS	80 DAS	90 DAS
Control (Distilled water)	2.63	20.36	73.60
Nativo @ 0.6 g L^{-1}	0.00	3.49	6.92
Tricho-suspension 250 g L^{-1}	0.00	18.68	76.40
Trichoderma extract 5 g L^{-1}	0.82	20.94	67.75
Rin powder 1.0 g L^{-1}	0.77	17.60	74.47
Dutura seed powder 1.0 g L^{-1}	1.66	18.57	75.87
NaCl (inorganic substance) 3.0 g L^{-1}	0.85	22.44	73.32
NaCl (inorganic substance) 5.0 g L^{-1}	0.00	22.99	78.78
Level of sig.	*	*	*
LSD(0.05)	0.59	5.68	9.15
CV (%)	35.18	17.88	7.97

DAS = Days After Sowing, *= Significant at 5% level of probability

The severity of blast at 70, 80 and 90 DAS was ranged from 0.0-0.7, 3.3-28.0 and 8.3-73.3, respectively. All the treatments except Nativo @ 0.6 g L^{-1} showed statistically identical higher incidence of diseases at 80 and 90 DAS as well as the treatment Nativo showed higher reduction in severity of diseases and showed least incidence at 70 (0.0%), 80 (3.3%) and 90 (8.3%) DAS (Table 26).

Table 26. Effect of fungicides on diseases severity in wheat cv. BARI Gom-26 at different days after sowing

Treatment	Disease severity at different days after sowing		
	70 DAS	80 DAS	90 DAS
Control (Distil water)	0.33	28.00	73.33
Nativo @ 0.6 g L^{-1}	0.00	3.33	8.333
Tricho-suspension 250 g L^{-1}	0.00	23.67	61.67
Trichoder extract 5 g L^{-1}	0.67	22.33	61.67
Rin powder 1.0 g L^{-1}	0.33	20.67	51.67
Dutura seed powder 1.0 g L^{-1}	0.33	23.00	65.00
NaCl (inorganic substance) 3.0 g L^{-1}	0.33	22.33	63.33
NaCl (inorganic substance) 5.0 g L^{-1}	0.00	24.67	63.33
Level of sig.	*	*	*
LSD(0.05)	0.09sss	4.19	6.08
CV (%)	21.6	11.4	6.2

*= Significant at 5% level of probability, DAS = Days After Sowing

Evaluation of chemical fungicides in controlling blast of wheat

The experiment was conducted in both laboratory and in pot of Bangladesh Institute of Nuclear Agriculture following CRD with four replications to evaluate the efficacy of fungicides in the control of wheat blast caused by *Magnaporthe oryzae triticum* (MoT). The laboratory experiment was done for the analysis of radial mycelia growth of Mot on PDA through poison technique with following five fungicides -

Table 27. Name of fungicides and their concentration used

Sl. No.	Fungicides used	Chemical name/active ingredient	Labeled Dose	Concentration/ Dose used
1.	Nativo	Tebuconazole 50%+Trifloxystrobin 25% w/w WG(75WG)	0.4 g/L	0.04% = 400 ppm
2.	Trooper	Tricyclazole 75 WP	0.75 g/L	0.075% = 750 ppm
3.	Two-in-one	(Hexaconazole 3% + Tricyclazole 22%) 25 SC	1 ml/L	0.1% = 1000 ppm
4.	Opponent	(Tebuconazole 50% + Trifloxystrobin 25%) 75 WG	0.4 g/L	0.04% =400 ppm
5.	Azonil	(Azoxystrobin 6% + Chlorothalonil 50%) 56 SC	1 ml/L	0.1%=1000 ppm

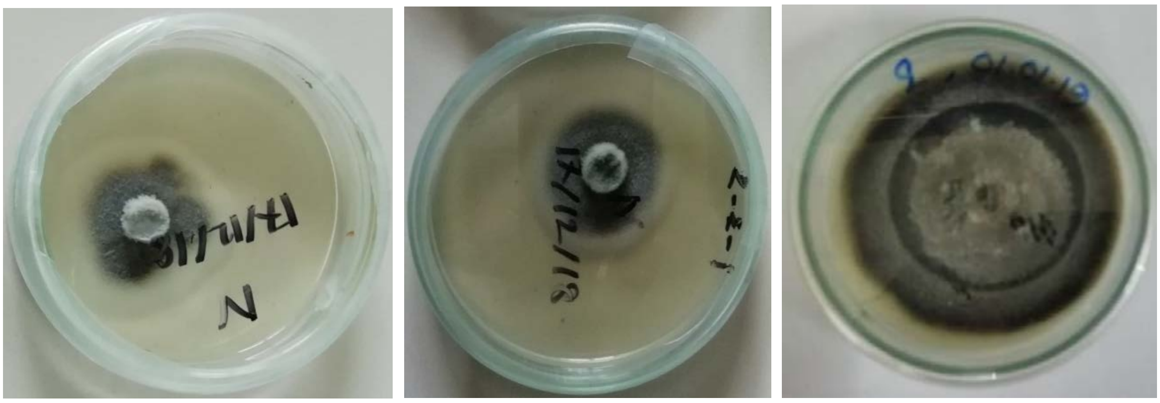
On PDA, out of five fungicides Nativo and Trooper completely inhibited (100%) the mycelia growth of MoT after 20 days of inoculation. Two in One, Opponent and Azonil arrested the growth of MoT by 5, 80 and 82% respectively (Table 28, Fig 8). In the control plate, the fungus had profuse growth and it took 20 days to cover the whole of the plate though. All the five fungicides were selected for trial in pot experiment.

Table 28. *In vitro* mycelial growth inhibition of *M. o. Triticum* by fungicides

Fungicides	Concentration used (%)	Mycelial growth (mm) with days			
		24h	48h	3 days	20 days
Trooper	0.075	0.00	0.00	0.00	0.00 (100%)
Two-in-one	0.10	0.00	10.00	12.00	49.50 (5%)
Nativo	0.04	0.00	0.00	0.00	0.00 (100%)
Opponent	0.04	0.00	3.00	4.00	18.00 (80%)
Azonil	0.10	0.00	2.50	3.00	16.20 (82%)
Control	0.00	10.0	20.0	25.00	90.0
LSD (0.05)		1.0	3.2	2.5	3.5

Data in parentheses are per cent reduction of mycelial growth over control

Trooper Two-in-one Nativo



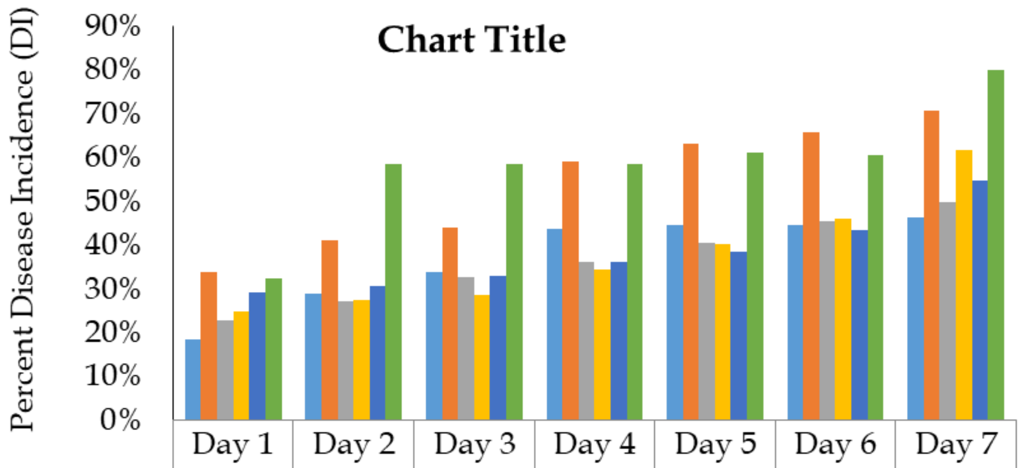
Oponent Azonil Control

Fig 8. Growth of MoT on PDA poisoned with five different fungicides

In pot, fungicides were sprayed at pre-heading stage after 48h of inoculation with spores of *M. o. Triticum*. Symptoms appeared approximately 4 days after inoculation in untreated (control) plants. The treated plants also showed blast infection after same days. Both blast incidence and severity were recorded for 7 days intervals.

Blast incidence varied from 18.6 – 33.9% from the first day of the disease appearance for different fungicides which increased with time and on the 7th day 46 – 80% DI was recorded (Figure 4). In the untreated plants, DI was 32.4% on the 1st day of disease appearance which flared up to 80% on the 7th day. All plants were infected (Figure 5)

Trooper, Nativo and Azonil treated plants had lower blast incidence. The DI in these plants had a slow rise upto <55% on the 7th day. These three fungicides showed similar efficacy in reducing blast incidence (Figure 4).



	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Trooper	18.57%	29.05%	33.98%	43.78%	44.73%	44.73%	46.48%
Two-in-one	33.91%	41.33%	44.11%	59.07%	63.19%	65.97%	70.75%
Nativo	23.02%	27.30%	32.65%	36.37%	40.64%	45.58%	49.85%
Opponent	25.08%	27.69%	28.62%	34.43%	40.40%	46.21%	61.87%
Azonil	29.19%	30.76%	33.14%	36.28%	38.71%	43.67%	54.90%
Control	32.38%	58.57%	58.57%	58.57%	61.27%	60.79%	80.00%

Fig . 9. Blast disease incidence (%) on wheat after post inoculation of MoT

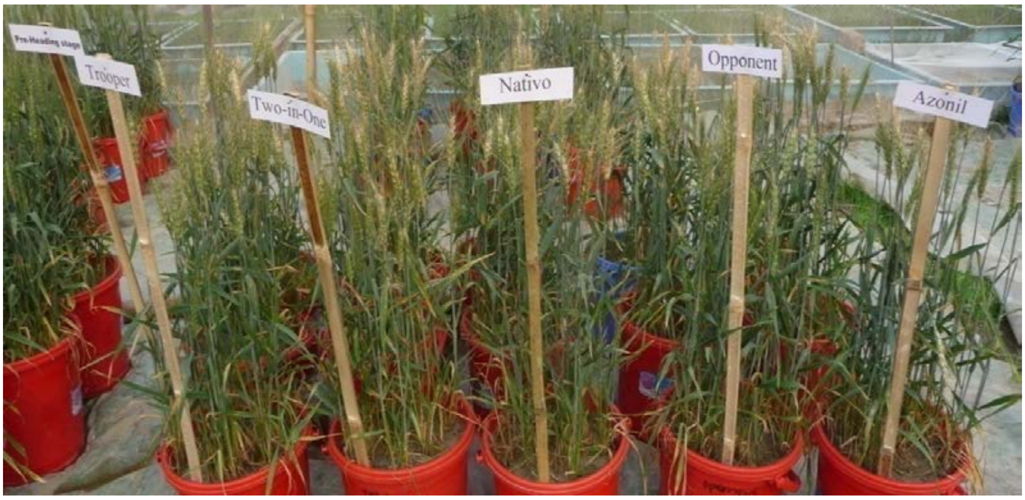
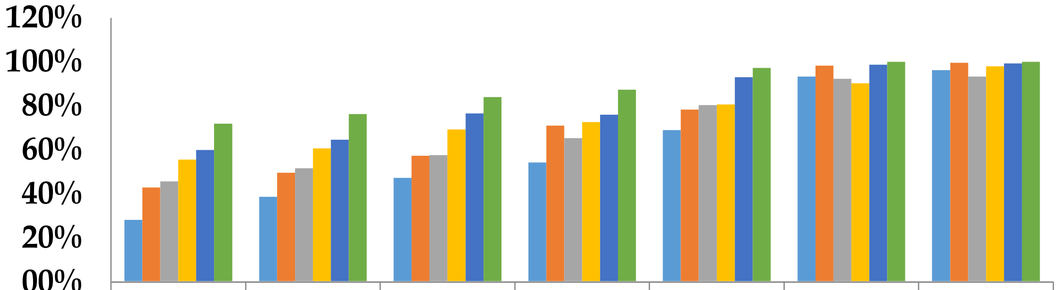


Figure 10. Wheat plants (var. BARI Gom 26) treated with five different fungicides

Effect of different treatments showed significant on disease severity of wheat blast. The results are presented in Figure 6. On the first day, among the fungicides the highest disease severity (60.00%) was found in Azonil, while the lowest disease (28.27%) was found in Trooper. On day 7 the highest severity (100%) was found in control, while the lowest severity (93.33%) was found in Nativo.

Trooper and Nativo treated plants had lower blast severity. The DS in these plants had a slow



	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Trooper	28.27%	38.67%	47.33%	54.33%	69.00%	93.33%	96.33%
Two-in-one	43.00%	49.67%	57.33%	71.00%	78.33%	98.33%	99.67%
Nativo	45.67%	51.67%	57.67%	65.33%	80.33%	92.33%	93.33%
Opponent	55.67%	60.67%	69.33%	72.67%	80.67%	90.33%	98.00%
Azonil	60.00%	64.67%	76.67%	76.00%	93.00%	98.67%	99.33%
Control	72.00%	76.33%	84.00%	87.33%	97.33%	100.00%	100.00%

Fig. 11. Blast disease severity (%) on wheat plants of var. BARI Gom-26 post-inoculation treated with five different fungicides.

Wheat plants inoculated with MoT but not treated with fungicides had 80% DI and 100% DS (Fig 12a). Uninoculated plants and also not treated did not show any blast disease symptoms. (Fig 12b).

7a 7b

Fig 12. (a) Inoculated but not treated wheat plants and (b) uninoculated plants did not develop any blast disease.

Effect of fungicides against blast when sprayed at the end of footing, pre-heading and pre-maturing stage of wheat

The experiment was conducted in pot under controlled condition at BINA farm following CRD with four replications during 2018-19 to evaluate the effect of time spraying of fungicides in controlling the wheat blast. Three time inoculation was done at seedling stage, booting stage and heading stage. All fungicides were sprayed at three times i.e. end of the booting stage, 7 days after 1st spray and 10 days after 2nd spray. The incidence of blast were ranged from 0-20%, 1.1-100%, 5.2-100% and severity of blast were ranged from 0.0-5.5, 2.1-80.5,10.5-100% at pre-heading, maturing and pre-harvesting stage. Nativo, Filia, Trooper and SunFighter treated plants had to lower blast incidence at all the growth stage even at pre-harvesting stage (5.7,10.4, 5.2 and 5.5).The severity of blast at pre-heading, maturing pre-harvesting stage were ranged from 0-5.5, 2.1-80.5 and 10.5-100%, respectively . Nativo, Filia Trooper and SunFighter treated plants had lower blast severity at all the growth stage even at pre-harvesting stage (10.5, 25.5, 10.6 and 20.8%).(Table 29).

Table 29. Blast incidence and severity when fungicides sprayed at the end of booting stage, 7 days after spike initiation and 10 days after 2nd sprayed

Treatments	Pre-heading stage		Maturing stage		Pre-harvesting stage	
	DI (%)	DS (%)	DI (%)	DS (%)	DI (%)	DS (%)
Control	20	5.5	100	80.5	100	100
Nativo	0.0	0.0	1.2	2.2	5.7	10.5
Filia	0.0	0.0	2.1	5.5	10.4	25.5
Seltima	3.2	1.2	30.5	40.5	70.5	90.9
Keicin	3.5	1.3	40.7	45.6	75.6	90.7
Adephen	5.3	2.5	70.2	50.8	85.4	95.8
Diaben	5.2	2.4	75.5	60.8	80.5	95.5
Trooper	0.0	0.0	1.1	2.1	5.2	10.6
Sunfighter	0.0	0.0	2.5	3.3	5.5	20.8
LSD (0.05)	2.1	1.0	3.5	5.5	7.5	17.5

DI = Disease incidence, DS= Disease severity

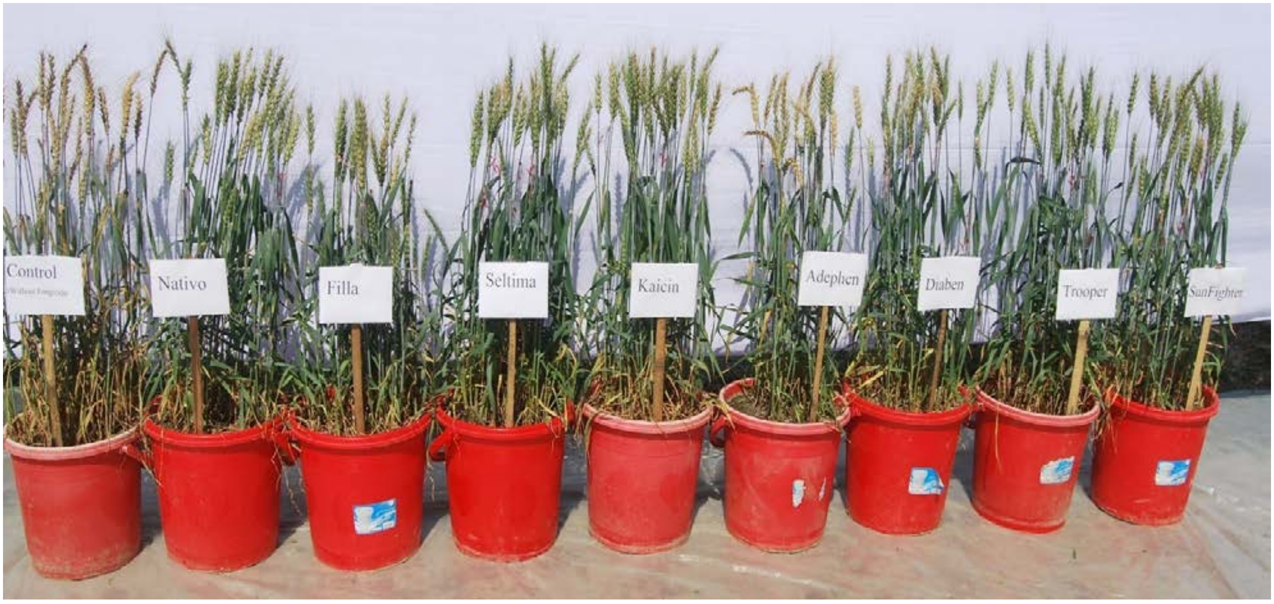


Fig. 13. Blast incidence and severity reduced at maturing stage for spraying fungicide at the end of booting then after 7 days and 10 days of 2nd spray.

Molecular analysis of wheat entries against blast pathogen (*Magnaporthe oryzae trichum*)

A modified mini-prep DNA extraction method developed at International Rice Research Institute (IRRI), The Philippines, was followed in this experiment. The simplified mini scale procedure for DNA isolation in PCR analysis of this method was done in the Biotechnology Lab., Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The quality of the isolated DNA in the protocol was sufficient for PCR analysis. The steps followed in PCR-based DNA marker analysis are given below:

Extraction of DNA

Two to three spike samples from each plant were used and ground in a small pestle and mortar to collect DNA. Strict hygiene was maintained during the DNA extraction by autoclaving all glassware, micropipette tips, PCR tubes, distilled water, reagents and buffer solutions also cleaned by 70% ethanol. DNA was extracted using the mini preparation CTAB method.

Quantification of DNA

Before PCR amplification it is important to know the concentration of genomic DNA because different DNA extraction methods produce DNA of different purity. It is necessary to optimize the amount of DNA to achieve reproducibility and strong signal in PCR assay. Excessive genomic DNA may result smears or lack of clearly defined bands in the gel. On the other hand, too little DNA will give non-reproducible patterns (Williams *et al.*, 1993). For quantification of DNA concentration two methods can be applied 1) Use of spectrophotometer and 2) Use of different known concentration of λ (Lambda) DNA as 0.5 µl, 1.0 µl, 2.0 µl etc. For this study Nano Drop TM spectrophotometer was used.

PCR analysis for M3 survey

Primer selection

MoT3, the selective primer for *Magnaporthe oryzae* Triticum was selected.

Primer Name	Seq[a]	Sequence		Annealing temperature (°C)	Target species
MoT3	WB12	Forward	GTCGTCATCAACGTGAC	62	*Magnaporthe Oryzae* Triticum
		Reverse	ACTTGACCCAAGCCTCG		

The sequence and size of the selected specific primer used for M$_3$ survey

Polymerase chain reaction (PCR)

The PCR cocktail including DNA had total volume of 10 µl /reaction based on a wheat protocol (Pieck *et al.*, 2013) was placed in the PCR tubes and run in the DNA thermal cycler.

Documentation of the DNA samples

After staining, the gel was taken out carefully from the staining tray and placed on high performance ultraviolet light box (UV-trans-illuminator) of GEL Doc for checking the DNA bands. The DNA was observed as band and saved the records.

Scoring of Bands

The pattern of bands obtained after amplification with the primers was scored.

Quantification of DNA

The DNA isolated from infected spikes of M3 mutants of wheat was quantified through Nano Drop^{TM} spectrophotometer. It was found that DNA concentration varied from 463.13 ng/µl to 2227.46 ng/µl (Table 30). The lowest concentration was found in BWM 10 and highest concentration in BWM 13. The amount in each M3 family was adjusted to 50 ng/µl.

Table 30. The concentration of DNA of 25 M3 families of wheat spike sample

Sl. No.	Treatments	DNA Concentration (ng/µl)	Absorbance Ratio	
			A260/280	A260/230
1.	BARI Gom 26	1703.40	1.77	1.16
2.	BWM 1	1177.69	1.91	1.22
3.	BWM 2	1823.75	1.56	1.01
4.	BWM 3	1367.13	1.81	1.09
5.	BWM 4	1470.98	1.45	0.96
6.	BWM 5	1982.76	1.60	1.06
7.	BWM 6	2131.95	1.77	1.18
8.	BWM 9	1389.20	1.79	0.99
9.	BWM 10	463.13	1.89	1.38
10.	BWM 11	2084.65	1.63	0.91
11.	BWM 12	1506.92	1.73	1.15
12.	BWM 13	2227.46	1.59	0.94
13.	BWM 14	1004.55	1.75	1.02
14.	BWM 15	1349.14	1.81	1.31
15.	BWM 16	1135.56	1.63	0.94
16.	BWM 17	1183.09	1.86	1.35
17.	BWM 18	975.71	1.81	1.14

18.	BWM 19	1013.81	1.88	1.37
19.	BWM 20	1176.57	1.88	1.46
20.	BWM 21	1321.19	1.83	1.15
21.	BWM 22	1874.09	1.92	1.41
22.	BWM 23	1128.59	2.00	1.55
23.	BWM 34	1607.45	1.68	1.11
24.	BWM 37	1555.28	1.72	1.10
25.	BWM 42	1342.12	1.24	1.01

PCR based detection of *Magnaporthe oryzae* Triticum using specific primer

Genomic DNA was extracted from 25 infected M3 wheat spike samples, representative of a total of 48 entries. The DNA concentration was found between 463.13 ng/µl (BWM 10) to 2227.46 ng/µl (BWM 13). A working DNA solution 100 ng/µl was prepared for each sample. Molecular analysis in PCR was done with MoT3 marker produced typical bands of MoT (361 bp) in all the entries except for the entry 5 and entry 6 (Figure 24).

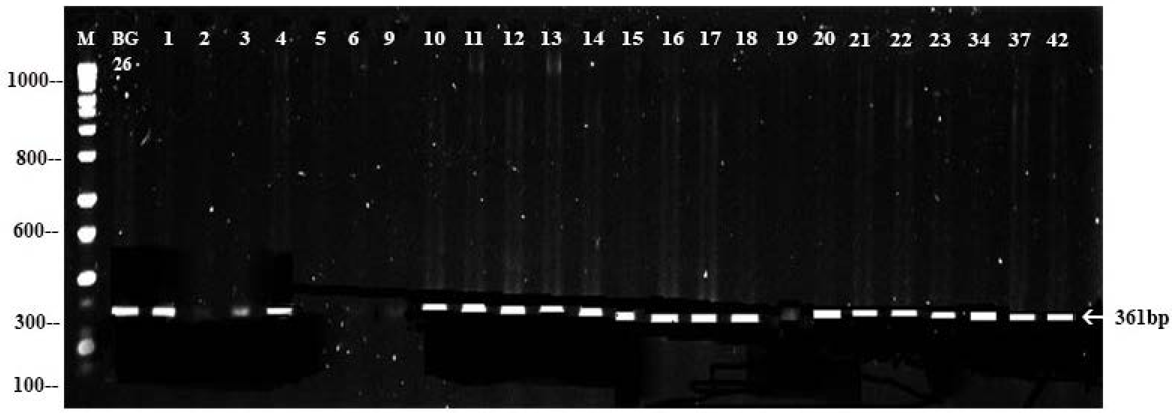


Figure 14. Agarose gel electrophoresis of DNA of wheat blast infected spikes of M3 population amplified with primer MoT3. Lane M-1000bp DNA ladder. Lane 1: BARI Gom 26, Lane 2: BWM 1, Lane 3: BWM 2, Lane 4: BWM 3, Lane 5: BWM 4, Lane 6: BWM 5, Lane 7: BWM 6, Lane 8: BWM 9, Lane 9 to Lane 22: BWM 9- BWM 23, Lane 23: BWM 34, Lane 24: BWM 37, Lane 25: BWM 42. An amplificn size of 361 bp was found in all the entries except 5 & 6.

The size of the band confirms the infection of M3 population by *Magnaporthe oryzae* Triticum (MoT).

In general, disease incidence and severity on the M3 plants were reflected on the presence or absence of banding on agarose gel except in few cases. The MoT infection was recorded on all the M3 families except the entry no. BWM 5 while molecular detection of MoT infection by MoT3 primer was confirmed on 23 M3 families. Entry no. BWM 6 which showed very low blast infection in the inoculated field did not produce MoT band. The primer detected the expression of the disease as an amplification of 361 bp semi-quantitatively. It showed that semi-quantitative detection of disease which varied in different M3 families of wheat. For quantitative expression of *Magnaporthe oryzae* Triticum, Real Time PCR study is recommended.

Entomology Division

Research Highlights

- IPM components with (Collection of rolled leaves + Virtako 40WG) was effective against leaf roller of rice.

- The management approaches with (Collection of egg mass + Virtako 40WG) was effective against stem borer of rice.

- The management approaches with [Pheromone trap (Helico-lure) + Spraying of HNPV] was effective against pod borer of chickpea.

- The management approaches with neem seed crust was effective against jassid of okra.

- The management approaches with (Advantage 20EC) was effective against thrips of garlic.

- Four advanced lines of rice were found tolerant and one was moderately tolerant to brown plant hopper under artificial infested condition.

- Three advanced lines of rice were found moderately susceptibility to brown plant hopper under artificial infested condition.

- Pod borer infestation of mungbean ranged from 2.50 to 8.51% and the lowest number of pod borer infestation was recorded in the mutant MBM-656-51-2.

- The lowest percentage of pod borer infestation was observed in the sesame mutant SM-001 at Magura.

Effectiveness of various management practices against the leaf roller (*Cnaphalocrosis medinalis*) of rice

The experiment was laid out with four treatments against leaf roller of rice under field condition during Kharif season of 2018-19 at BINA farm, Mymensingh. The treatments were: T_1 = Light trap + perching, T_2 = Collection of rolled leaves + Virtako 40WG, T_3 = Granular insecticide (Diazon 10G) and T_4 = Control. The tested variety was Binadhan-20. Data were recorded during maximum tillering and heading stage and analyzed statistically.

IPM components with (Collection of rolled leaves + Virtako 40WG) was the most effective (Infestation 3.18%) against leaf roller of rice. The highest was found in the control plots (12%) (Table 1).

Table 1. Percent infestation of rice leaf roller with four different treatments

	Treatments	Rolled leaves (%)
i.	Light trap + Perching	6.25
ii.	Collection of rolled leaves + Virtako 40WG	3.18
iii.	Granular insecticide (Diazon 10G)	4.31
iv.	Control	12.00

Effectiveness of different management approaches against the yellow stem borer of rice

The experiment was laid out with four treatments against yellow stem borer of rice under field condition during Kharif season of 2018-19 at BINA farm, Mymensingh. The treatments were: T_1 = Use of perching, T_2 = Collection of egg mass + Virtako 40WG, T_3 = Granular insecticide (Diazon 10G) + Cartap (Santap 50SP) and T_4 = Control. The tested variety was Binadhan-17. Data were recorded during maximum tillering and heading stage and analyzed statistically.

The management approach (Collection of egg mass + Virtako 40WG) was the most effective against stem borer of rice. The highest was found in the control plots (3.0%) (Table 2).

Table 2. Percent infestation of rice yellow stem borer with four different treatments

	Treatments	White head (%)
i.	Use of perching	2.5
ii.	Collection of egg mass + Virtako 40WG	0.5
iii.	Granular insecticide (Diazon 10G) + Santap 50SP	1.0
iv.	Control	3.0

Effectiveness of different management approaches against pod borer of chickpea

The experiment was laid out with three treatments against pod borer of chickpea under field condition during rabi season of 2018-19 at Ishurdi. The treatments were: T_1 = Pheromone trap (Helico-lure) + Spraying of HNPV, T_2 = Virtako 40WG + Spraying of HNPV, T_3 = Control. The variety was Binasola-8. Data were recorded during fruiting stage and analyzed statistically.

The management approaches with Pheromone trap (Helico-lure) + Spraying of HNPV was effective against pod borer of chickpea. The highest was found in the control plots (7.14%) (Table 3).

Table 3. Percent infestation of pod borer with three different treatments

	Treatments	Pod borer infestation (%)
i.	Pheromone trap (Helico-lure) + Spraying of HNPV	1.27
ii.	Virtako 40WG + Spraying of HNPV	1.51
iii.	Control	7.17

Evaluation of different management approaches against jassied of okra

The experiment was laid out with four treatments against jassid of okra under field condition during kharif season of 2018-19 at BINA farm, Mymensingh. The treatments were: T_1 = Bioneem plus, T_2 = Neem seed crust, T_3 = Success 2.5SC and T_4 = Control. Data were recorded during maximum vegetative stage and analyzed statistically.

The management approaches with (Neem seed crust) was effective against jassid of okra. The highest was found in the control plots (53.20) (Table 4).

Table 4. Mean number of jassid of okra with four different treatments

	Treatments	No. of jassid
i.	Bioneem plus	21.73
ii.	Need seed crust	10.66
iii.	Success 2.5SC	20.20
iv.	Control	53.20

Evaluation of different management approaches against thrips of garlic

The experiment was laid out with four treatments against thrips of garlic under field condition during rabi season of 2018-19 at BINA Farm Mymensingh. The treatments were: T_1 = White sticky trap (WST), T_2 = Yellow sticky trap (YST), T_3 = Advantage 20EC and T_4 = Control. Data were recorded during maximum vegetative stage and analyzed statistically.

The management approaches with (Advantage 20EC) was effective against thrips of garlic. The highest was found in the control plots (29.0) (Table 5).

Table 5. Mean number of thrips of garlic with four different treatments

	Treatments	No. of thrips
i.	White sticky trap (WST)	12.06
ii.	Yellow sticky trap (YST)	13.80
iii.	Advantage 20EC	7.80
iv.	Control	29.00

Evaluation of different advanced rice lines against brown plant hopper under artificial infested condition

Five advanced mutants of rice, viz. P-019, P-026, P-034, P-047 and P-033 were tested along with one resistant check (T27A) and susceptible check (TN1) against brown plant hopper under artificial infested condition. The experiment was laid out in a completely randomized block design with three replications. Data were recorded during seedling stage and analyzed statistically.

All the advanced lines of rice were found tolerant and rest one was moderately tolerant to brown plant hopper (Table 6).

Table 6. Mean infestation of different mutant/lines of rice to brown plant hopper

Mutants/lines	Damage scale (0-9)	Level of resistance
P-019	1	T
P-026	3	MT
P-034	1	T
P-047	1	T
P-033	1	T
TN1 (Susceptible check)	7	S
T27A (Resistant check)	1	T

MT=Moderately Tolerant, T= Tolerant, S=Susceptible

Susceptibility of different mutants of deep water rice to brown plant hopper

Three advanced lines of rice, viz. LD-200-1-3-2, LD-200-1-3-3 and Kasalath were tested along with resistant check (T27A) and a susceptible check (TN1) against brown plant hopper under artificial infested condition. The experiment was laid out in a completely randomized block design with three replications. Data were recorded during seedling stage and analyzed statistically.

Three advanced lines of rice were found moderately susceptibility to brown plant hopper under artificial infested condition (Table 7).

Table 7. Mean infestation of different lines of rice to brown plant hopper

Mutants/lines	Damage scale (0-9)	Level of resistance
LD-200-1-3-2	5	MS
LD-200-1-3-3	5	MS
Kasalath	5	MS
TN1 (Susceptible check)	7	S
T27A (Resistant check)	1	T

MS=Moderately susceptible, T= Tolerant, S=Susceptible

Effect of gamma radiation for controlling fruit fly (*Bactrocera cucurbitae*) of cucurbit vegetables

Seven thousand four hundred sterile pupae were released in 600 sq. m of bitter gourd cultivated field during kharif season of 2018-19 at Sutiakhali, Sadar, Mymensingh. Sterile fruit fly were released in the bitter gourd field at six times with fifteen days interval. Data were recorded during fruiting stage and analyzed statistically.

Total number of infested and uninfested bitter gourd were 11 and 188, respectively. The mean fruit infestation was found 5.52% (Table 8).

Table 8. Percent infestation of infested and uninfested bitter gourd and number of released sterile fruit fly at Sutiakhali, Sadar, Mymensingh.

Date of fly released	No. of released sterile fruit fly (Pupae) in the bitter gourd field	No. of uninfested bitter gourd	No. of infested bitter gourd	% infestation
10-03-19	1100	28	2	
26-03-19	1500	31	1	
11-04-16	1200	26	1	5.52
26-04-19	1400	36	2	
12-05-19	900	40	3	
28-05-19	1300	27	2	
Total	7400	188	11	

Screening of different summer mungbean mutants/lines against jassid, pod borer and hairy caterpillar

Two advanced mutants of mungbean viz. MBM-477-87-3, MBM-656-51-2 and one check variety BARImoog-6 were evaluated against pod borer under field condition. The experiments were set up in a randomized complete block design with three replications during the year 2018-19 at two farmers field Natore and Kushtia. No protective measures were taken to control these pests. Data on percent pod infested by pod borer were collected from 10 randomly selected plants per plot. All the data were analyzed statistically.

Pod borer infestation of mungbean ranged from 2.50 to 8.51% although there was no significant difference among the tested lines/mutants (Table 9). The lowest number of pod borer infestation was recorded in the line MBM-656-51-2.

Table 9. Mean infestation of different lines of mungbean to pod borer

Mutants/lines	Pod borer infestation (%)	
	Natore	Kushtia
MBM-656-51-2	2.50	6.43
MBM-477-87-3	2.82	8.06
BARImoog-6	4.67	8.51
$LSD_{0.05}$	**NS**	**NS**

Susceptibility of different mutants of sesame to leaf roller, pod borer and hairy caterpillar

Two advanced mutants/lines of sesame viz. SM-001 and SM-006 with check varieties Binatil-2 and Binatil-3 were evaluated against sesame pod borer. The experiment was laid out randomized complete block design with three replications at BINA substation farm, Magura. The experiment was exposed to natural infestation. Data on percent pod infested by pod borer were collected from 10 randomly selected plants per plot and were analyzed statistically.

The lowest percentage of pod borer infestation was observed in the mutant SM-001 (0.07%) at Magura (Table 10).

Table 10. Mean infestation of different lines of sesame to pod borer

Mutants/lines	Pod borer infestation (%)
SM-001	0.07b
SM-006	2.32a
Binatil-2	0.24ab
Binatil-3	0.34ab
$LSD_{0.05}$	1.98

Agricultural Engineering Division

Research Highlights

- The rice mutants N_4/250/P-2(2) and N_4/250/P-2(6)-26 produced lower yield under severe water stress (85% depletion ASM) compared to normal irrigated condition.

- Strip tillage and irrigation at early stage produced the highest yield ofMungbean.

- The yield of sesame under drainage spacing of 150 cm, 200 cm, 100 cm and no drain were 1049.2 t/ha, 869.31 t/ha, 1101.8 t/ha and 485.2 t/ha,respectively.

- Twelve sesame mutants survived under natural rainfall. Ten mutants survived under 48 hrs artificial water logging condition (in pot) at flowering stage. Five mutants survived under natural rainfall as well as 48 hrs artificial water logging (under field condition) at pre-flowering stage.

- Mean recharge rate at Ishwardi was found as 53.7 mm/year under tracer technique and 46.2 mm/year under water balance method, which correspond to 5.14% and 4.42% of yearly rainfall, respectively.

- Application of 30% excess gypsum (in addition to recommended dose) produced the highest seed yield. In an another management by application of 25% excess Gypsum and Potassium (K) and foliar application of Sodium Silicate (100 ppm, at 45 DAS) and one irrigation at early stage also produced the highest seed yield under the prevailing climatic condition (having rainfall at vegetative and pod formation stage).

- In lysimeter study, the highest yield (6.9t/ha) was recorded in treatment T_5 and T_6 (Continuous saturation (0-3 cm) + 68 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering l) + 10 kg/ha Si (basal) + addition of PK (30%) at booting/flowering stage + Washout (change standing water) at 25 days interval).
    - In the field, the highest yield (4.03t/ha) was recorded in treatment T_5 (Continuous saturation + 68 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering l) + 10 kg/ha Si (basal) + No ridge + Washout (change standing water) at 25 days interval).

- From pumping test, recovery data and aquifer material distribution K value has been determined. From recovery data, K value was found as 31.4 $m^{3/}m^2$/day and from aquifer materials size distribution, K value was found as 35-45 $m^{3/}m^2$/day.

- At Nachol and Niamatpur upazila, the magnitude between maximum and minimum depth to water-table is decreasing over time, meaning that the recharge rate is decreasing. The long-term trend shows a sharp decreasing trend (38 cm/year) at Niamatpur.

- At Nachol and Niamatpur upazila, the water samples of 50 DTW/STWs are within permissible limit for irrigation and drinking purposes.

- In Barind area, among the existing (Boro-Aman-Fallow) and four introduced cropping patterns, the “T. Aman-Mustard-T. Aus” pattern yielded 2nd highest rice-equivalent yield (as well as net profit), and 41.8% irrigation water savings and 7% lower yield compared to “T. Aman-Mustard-Boro”.

Project 1. Drought Screening and Irrigation and Drainage Management for Field Crops

Exp.01. Evaluation of some Aus mutants (M4) for different 'soil moisture stress'/'drought tolerance level' (in Pot culture)

Objective: **To study the response of rice mutants to different level of soil moisture stress**

Methods

The experiment was conducted in container (size: 1.5 m x 1 m x 0.28 m) at BINA HQ, Mymensingh. The scheduled treatments were: T_1 = Control (normal irrigation, 3 days AWD); T_2= Supplemental irrigation when ASM drops below 85% (throughout the growing season); T_3= Up to booting stage, irrigation at 0.85 ASM; then for the remaining period, irrigation at 0.60 PASM; T_4 = Irrigation at 0.85 ASM (throughout the growing season), treatment beginning at 17 days after transplanting. Treatments were imposed after 3 weeks from transplanting) except $T_{4.}$, Here, “AWM” means alternate wetting and drying, “ASM” means “available soil moisture”.

The cultivars were: V_1 = N_4/250/P-1(2) and V_2 = N_4/250/P-2(6)-26. Three series of container (3 replicates) were used. The design was RCBD, with split-plot. The seedlings of 22 days old were transplanted on 12 April 2018, and harvested on 28 June 2018. The statistical analysis was performed using statistical software of IRRI, “STAR”.

Results

The mean effects of irrigation treatments and cultivars on yield and yield attributing characters are summarized in Table 1.1. The cultivars showed insignificant difference in all parameters. The irrigation treatments showed significant difference in grain yield, tiller/plant, plant height and seed/panicle.The mutants produced lower yield under soil moisture stress, but survived until the soil moisture drops around wilting point. Interaction effects of irrigation treatments and cultivars on grain yield showed insignificant difference (Table1.2).Irrigation frequency, total irrigation, water savings and water footprint under different treatments are shown in Table 1.3. Under severe water stress condition (T_4), to produce 1 kg of rice, 460.3 Litter water was required, while normal irrigated plot (T_1) required 525.5 litter/kg.

Table 1.1. Mean effects of irrigation treatments and cultivars on yield and yield attributing characters of rice cultivars

Treatment	Plant height (cm)	Tiller/ plant	Panicle length (cm)	seed/ panicle (Fill grain)	Un fill grain (No.)	Grain yield (gm/m^2)	1000 grain wt. (gm)	Straw yield (gm/m^2)
T_1	106.4 a	11 a	25	142 a	19	406 a	23.3	473
T_2	90.1 b	8 b	23	97 b	20	273 b	19.7	354
T_3	88.9 b	7 b	24	95 b	22	250 b	18.9	308
T_4	88.4 b	7 b	24	99 b	23	309 b	17.6	414
F-test at (5%)			NS		NS		NS	NS
Cultivars								
V_1	92.6	8	24	107	22	313	20.4	399

V_2	94.3	9	24	110	20	306	19.3	357
F-test at (5%)	NS	NS	NS	NS	NS	NS	NS	NS

Note: Means with the same letter are not statistically different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test [Appropriate test statistic is selected by the software automatically].

Table1.2. Interaction effects of irrigation treatments and cultivars on grain yield of rice

Treatment	**Grain yield of different cultivars (gm/m^2)**	
	V_1	**V_2**
T_1	416	395
T_2	273	304
T_3	254	249
T_4	309	278
F-test at (5%)	***NS***	***NS***

Table1.3. Irrigation frequency, total irrigation, water savings and water footprint under different Treatments

Irri. Treat -ment	**Irri. up to establishment, (cm)**	**No. of irri. after treatment started (no.)**	**Total irrigation amount (cm)**	**Water savings, comp. to T1 (%)**	**Irri. date (days after transplanting, (DAT)**	**Yield reduction (%)**	**WF, L/kg**
T1	17.5	5	38.8	-	12,25,38,51,60	-	525.5
T2	17.0	3	31.2	19.6	29,43,56	32.8	521.0
T3	17.5	3	30.8	20.6	40,49,57	38.4	533.0
T4	17.0	3	31.2	19.6	31,42,55	23.9	460.3

Conclusion

Both the cultivars produced lower yield under water stress condition compared to normal irrigated condition.

Exp.2. Studies on the effect of different tillage practices and irrigation management on Mungbean production under conservation agriculture practice

Objectives:

-To study the effect of different tillage practices on water use in mungbean cultivation
- To develop appropriate irrigation application rate for conservation and conventional tillage practices on mungbean production.

Methods

The experiment was conducted at BINA substation Magura. The scheduled treatments were: T_1 = Strip tillage with previous crop residue retention; T_2 = Minimum tillage (1 pass by power tiller and 1 pass by Seeder and followed by laddering); T_3=.Control /Full tillage (4 pass by power tiller followed by laddering and seed broadcasting by hand). The sub-plot treatments were: I_1 = Control (Farmer's practice /no irrigation); I_2 = Irrigation at early stage; I_3 =Irrigation at early stage and flowering stage. The test cultivar was Binamug-8. Three replicates were used. The design was RCBD, with split-plot.

The seeds were sown on 20th March 2019, and harvested on 19th June 2019. Agronomic data were collected throughout the whole period of the mungbean growing season. The statistical analysis was performed using statistical software Statistix 10. Rainfall amount during the mungbean production periodare summarized in Figure 2.1.

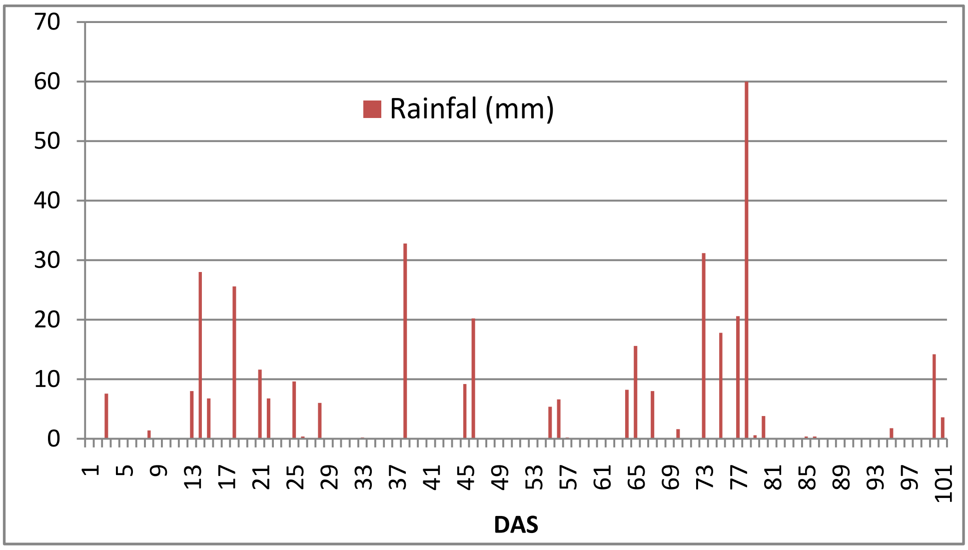


Figure 2.1. Rainfall during the mungbean growing period

Results

There was rainfall at vegetative, pod formation and ripening stages of the crop which affected the treatment effect and crop yield. Due to high rainfall at ripening stage, second harvesting from the field could not be done. The result is formulated on the basis of first harvest.As a result, the yield is less than the normal production.

The mean effects of tillage and irrigation treatment on yield and yield attributing characters of mungbean cultivar are summarized in Table 2.1. The tillage treatments showed significant difference in seed yield. The irrigation treatments also showed significant difference in seed yield. The interaction effect between tillage and irrigation treatments showed significant difference in grain yield. The mean effects of treatments and cultivars on yield and yield attributing characters of mungbean cultivar is summarized in Table 2.1and Table 2.2.

Table 2.1. Mean effects of irrigation treatments and cultivars on yield and yield attributing characters of mungbean cultivar.

Tillage	Plant Height (cm)	Branch/ Plant	Pod/ Plant	Pod Length (cm)	Seed/ Pod	Yield (kg/ha)
T1	67.7	1.8	15.3	8.1	10.9	581.7
T2	62.6	1.8	16.2	8.1	11.6	519.4
T3	59.7	1.8	16.2	8.3	12.8	507.4
LSD	NS	NS	NS	NS	NS	29.2
Irrigation						
I1	63.1	1.8	15.7	8.3	11.8	534.7
I2	64.6	1.8	16.1	8.1	11.7	547.2
I3	61.9	1.9	15.9	8.1	11.9	526.6
LSD	NS	NS	NS	NS	NS	29.8

Table 2.2. Interaction effect between tillage and irrigation

Tillage	Yield (kg/ha)		
	Irrigation I_1	Irrigation I_2	Irrigation I_3
T_1	572.79	609.72	562.5
T_2	517.36	527.08	513.89
T_3	513.89	504.86	503.47

Conclusion

It was difficult to maintain treatments properly due to excess rainfall. There was rainfall at vegetative, pod formation and ripening stages of the crop which affect the treatment effects and crop yield.However, from the results of first harvest, the strip tillage (T_1) and irrigation at early stage (I_2) showed the highest seed yield.

Exp. 3. Response of sesame cultivars to different drainage provisions

Objective

To find out the effect of different drainage spacings on sesame yield.

Methods

The experiment was carried out at BINA HQ, Mymensingh during the period from March 2018 to June 2018. The test varietieswere V_1 = Binatil-2, V_2 = Binatil-3, V_3 = Binatil-4.The experimental design was RCBD, with 3 replications. The plot size was 30 m × 17 m. The imposed drainage treatments were:

T_1 = Control (normal flat land, no special drain)
T_2= 100 cm wide beds and 30 cm drain (10 cm depth) between the beds
T_3 = 150 cm wide beds and 30 cm drain (10 cm depth) between the beds
T_4=200 cm wide beds and 35 cm drain (10 cm depth) between the beds

The rainfall during experimental period (March to May 2019) is shown in Figure3.1. During the period of experiment, total 456.80 mm rainfall was occurred specially vegetative and flowering stage of sesame. In addition, a strong storm (Foni) hit during the pod filling period. The statistical analysis was performed using statistical software of IRRI, “STAR”.

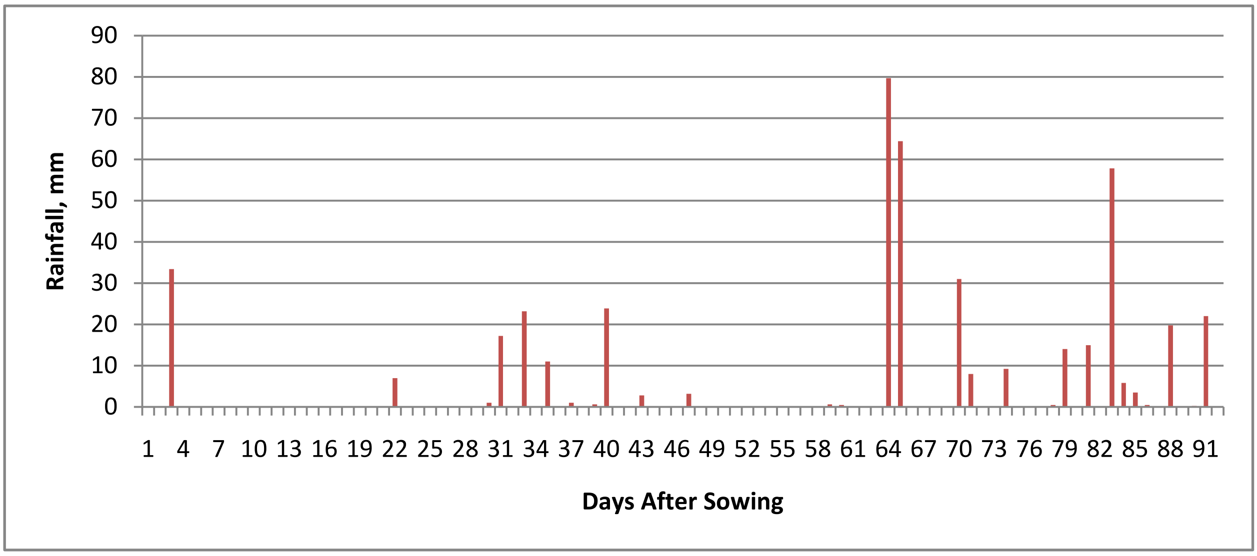


Figure 3.1.Rainfall distribution during experiment period (March-2019 to May-2019)

Results

The mean effects of drainage treatments and cultivars on yield of sesame are summarized in Table 3.1. The drainage treatments demonstrated significant effect on seed yield. The highest yield (1101.8 kg/ha) was obtained in T_2 (100 cm wide beds and 30 cm drain between the beds) followed by T_3 (150 cm spacing), and the treatment T_1 (normal flat land, no special drain) produced the lowest (485.2 kg/ha). The cultivars showed significant difference in grain yield.The cultivar V_2 (Binatil-3) produced the highest yield (935.2kg/ha) followed by V_1 (Binatil-2) and V_3 (Binatil-4).Interaction effects of drainage treatments and cultivars on grain yield of sesame are shown in Table. 3.2. Under normal condition (no water-logging), yield of Binatil-2, Binatil-3 and Binatil-4 ranges from 1000 to 1400 kg/ha. In this experiment, yield ranged from 485.2 to 1101.8 kg/ha under excess rainfall as well as strong storm (Foni).

Table 3.1. Mean effects of drainage treatments and cultivars on yield of sesame cultivars

Treatment	Grain yield (kg/ha)
T_1	485.2 b
T_2	1101.8 a
T_3	1049.2 a
T_4	869.31 a
F-test at (5%)	
Cultivars	
V_1	934.0 a
V_2	935.2 a

V_3	759.9 b
F-test at (5%)	

Means with the same letter are not significantly (statistically) different at 5% probability level byTukeys's Honest Significant Difference (THSD) test.

Table 3.2. Interaction effects of drainage treatments and cultivars on grain yield of sesame.

Treatment	Grain yield of different cultivars (Kg/ha)		
	V_1	V_2	V_3
T_1	582.3	443.1	430.0
T_2	993.3	1248.4	1163.5
T_3	1150.3	1167.9	829.5
T_4	1009.9	861.4	716.5
F-test at (5%)	NS	NS	NS

Conclusion

The highest yield was obtained in 100 cm wide beds accompanied by 30 cm drain between the beds, followed by 150 cm spacingaccompanied by 30 cm drain between the bed.

Project 2.Development of Sesame cultivar tolerant to water-logging

Exp.4. Evaluation of M_4 generation of sesame mutants

Objective: To develop water-logged tolerant sesame cultivar

Methods:
The growing season was March, 2019 – June, 2019. The growing environments were artificial water-logging under control in Lysimeter and pot (shed by polythene), and in the field under natural rainfall condition.

Results:
Some mutants (M_2) which appeared to be water-log tolerant but long crop duration (125-145 days), radiated again in different doses (350 to 700 Gray; 52 nos. samples) and produced M_2R_1 population in 2018. Including some M_3 and newly produced (M_2R_1 andM_2R_2) materials, 117populations were sownin the first week of March 2019 in Lysimeter and field, and successfully produced seeds (M_4 and M_2R_2 Population) under natural rainfallas well as artificial water logging condition. Characteristics of some mutants survived under different conditionsare given in Table 4.1.

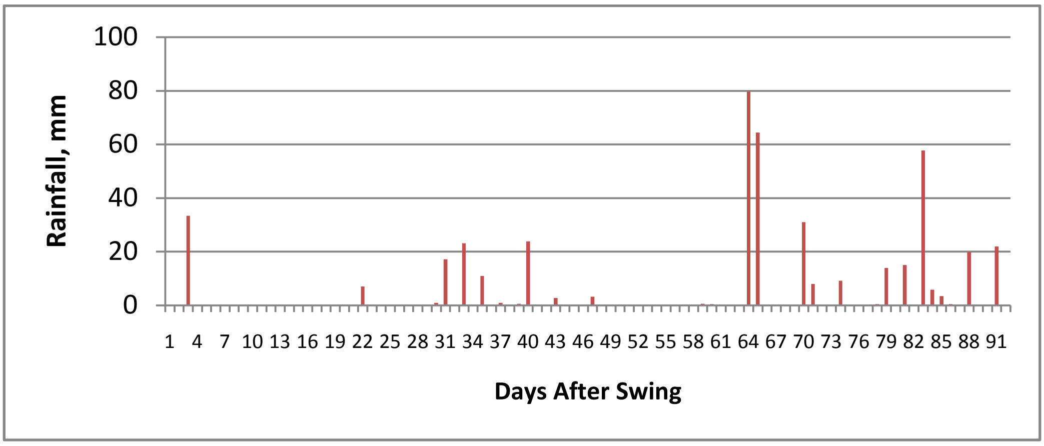


Figure 4.1. Rainfall distribution during the growing season (March-May 2019)

Table 4.1. Main features of some harvested mutants under different condition.

Mutant/Plant ID	Plant ht., cm	Branch/ plant	Days to maturity	Condition
K/C/450/P_1/M_4	110-130	3-4	90-95	Under natural rainfall with 200 cm bed and 30 cm drain between beds *[12 nos under this category]*
K/C/450/P_2/M_4	110-130	2-3	90-95	
K/C/450/P_3/M_4	110-130	2-4	85-95	
K/C/600/P_1/M_4	110-130	2-4	85-92	
K/C/600/P_2/M_4	110-120	2-3	85-92	
K/C/600/P_3/M_4	100-120	3-4	85-92	
K/C/600/P_5/M_4	110-130	2-4	85-92	
K/C/700/P_1/M_4	90-100	2-4	85-90	
W/M/K/700/P_1/M_4	90-100	3-4	85-90	
W/M/K/700/P_2/M_4	90-100	3-4	85-90	
W/P/K/700/P_1/M_4	80-100	3-4	85-90	
D/K/S/450/P_1/M_4	100-130	4-5	100-110	
228M_2R_2/P_2	100-110	2-3	83-86	Under artificial water logging with control condition (pot) at flowering stage (about 48 hr) *[10nos under this category]*
218M_2R_2/P_2	100-120	2-4	85-86	
239M_2R_2/P_3	100-110	2-4	88	
235M_2R_2/P_5	100-120	2-4	88	
234M_2R_2/P_2	100-110	2-3	88	
243M_2R_2/P_2	100-120	2-3	88	
221M_2R_2/P_2	100-120	2-3	88	
201M_2R_2/P_1	100-130	2-4	90-95	
244M_2R_2/P_1	100-130	2-4	90-95	
W/M/K/700/P_2/M_4	80-90	2-3	85-88	Under natural rainfall and artificial water logging at field condition *[5nos under this category]*
225M_2R_3/P_1	80-90	2-3	82-85	
243M_2R_3/P_4	80-90	2-3	82-85	
243M_2R_3/P_5	80-90	2-3	82-85	
242M_2R_2/P_1	80-90	2-3	88-92	
239M_2R_2/P_3	80-90	2-3	83-85	

Conclusion:

Twelve mutants survived under natural rainfall. Ten mutants survived under 48 hrs artificial water- logging condition at flowering stage. Five mutants survived under natural rainfall and 48 hrs artificial water logging condition at pre-flowering stage.

Project 3. Studies on groundwater recharge at Ishwardi Area using tracer and other advance techniques for sustainable use of groundwater

Exp. 5: Quantifying natural groundwater recharge using tracer technique and water balance method.

Objective: To quantify natural groundwater recharge from rainfall

5.1 Methodology for recharge estimation using tracer technique

The study was conducted in a rice field of Iswardisub-station. Before the beginning of rainy season (in March), a rice field (medium land) was selected for tracer application. To prepare the 'Test tracer plot', a square of 1.5 m × 1.5 m was first selected and marked. At the outer edge, a 0.6 m deep small hole (6 inch wide) was dugged. A continuous polythene sheet was placed in the hole, and then the soil was covered. This was done to eliminate the lateral flow of water and chloride from the 'Test' unit. Within the test plot, chloride ion solution [prepared by dissolving analytical grade KCL in distilled water, with sufficient concentration, about 250 ppm, so that it can be traced easily] was applied/pushed at 20 cm soil depth by 'siring/hand-pump', at the centre and four mid-corner (Fig.5.1). At each point, the amount was about 25 ml. The tracer was applied at 20 cm soil depth to avoid surface runoff of the applied tracer.

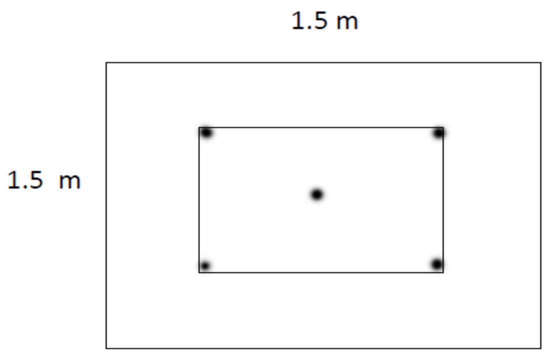


Figure 5.1. Schematic of tracer test unit (indicating tracer application point)

Infiltration of precipitation/rainfall transports the tracer downward. At the end of rainy season (in October 2018), a trench was dugged at the centre of the 'test plot' and samples were collected up to 200 cm, at 10 cm interval. The chloride concentration of the collected samples was determined by Mohr method (Doughty,1929; Harris, 2007), using micro-burette

having 0.01 mm readable facility. The subsurface distribution of applied tracer was determined from the concentration graph of chloride.
The vertical distribution of the tracer was used to estimate the velocity (v), and the recharge rate (R) was calculated as (Chand et al.2005; Scanlon et al., 2002; Ali, 2017):

$$R = v\theta = \frac{\Delta z}{\Delta t}\theta \quad (1)$$

Where, Δz is the depth of the tracer peak, Δt is the time between tracer application and sampling, and θ is the average volumetric water content.

In this year (2018), tracer was applied at 3 sites of the same field.

5.2 Water Balance Method

A simplified form of water balance equation (Yin et al., 2011) was used to estimate recharge:

$$P = R_0 + R + ET_a + \Delta SM \qquad (2.1)$$

where: P = rainfall (mm), R_0= surface runoff (mm), R = recharge, ET_a = actual evapo-transpiration (mm), and ΔSM= change in soil moisture (mm) for the specified time interval. For the yearly consideration (i.e. March and Nov.), the change in soil moisture can reasonably be neglected in water balance equation (Yin et al., 2011). Thus, re-arranging the above equation, the recharge (R) can be expressed as:

$$R = P - (R_0 + ET_a) \qquad (2.2)$$

5.3 Runoff estimation

The USDA-SCS runoff equation is (USDA-SCS, 1985):

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (2.3)$$

Where: Q= runoff (mm), P = rainfall (mm), S= potential maximum retention after runoff begins (mm). The potential retention (*S*) can range from zero on smooth, impervious surface to infinity in deep gravel.

Ali (2015), Ali (2016), and Ali(2017a) found for Mymensingh region that the runoff calculated using SCS method, when introduced in equation (2.2), produced negative results, i.e., the runoff plus ET_a becomes higher than the rainfall, which is impractical. Similar characteristics of SCS-R_0 was also observed for Ishwardi region [Ali (2017b), Ali (2018), and Ali (2019)]. When ET_a was deducted from rainfall, the results were found realistic; and it is logical to deduct the ET_a loss for longer time interval of runoff estimation.

In the present study a, modified form of USDA-SCS method (Ali, 2017c) was used [subtracting the 'actual evapotranspiration (ET_a)' from 'Rainfall (P)' in equation (2.3)]:

$$Q = \frac{[(P - ETa) - 0.2S]^2}{(P - ETa) + 0.8S} \qquad (2.4)$$

Based on the field condition during the monsoon rainfall (i.e. grassy/cropped), the 'S' value was considered as 3.0 cm; and monthly values of runoff (and hence monthly recharge) was calculated.

5.4ET$_a$ calculation

Daily reference crop evapotranspiration (ET_0) was calculated using '*ET_0 Calculator*' software of FAO (FAO, 2012). Traditionally, actual crop evapotranspiration (ET_a) is calculated as:

$$ET_a = ET_0 \times K_c \times K_s = (ET_0 \times K_c) \times K_s = ET_p \times K_s \qquad (2.5)$$

where: ET_0 is the reference crop evapotranspiration (mm), K_c is the crop coefficient, K_s is the soil moisture stress factor (or dryness factor), ET_p is the potential crop evapotranspiration.

From daily values, monthly values of ET_a were calculated. Based on the 'dryness (or water deficit)' and 'wetness (or water surplus)' condition (i.e. P - ET_p, P is the rainfal), the monthly actual crop evapotranspiration (ET_{am}) was calculated as (Ali, 2017):

$$ET_{am} = ET_{mp}, \quad \text{If } P_m > ET_{mp} \quad (\text{i.e. } K_s = 1)$$
$$= P_m, \quad \text{If } P_m < ET_{mp} \qquad (2.6)$$

where: P_m is the monthly rainfall, ET_{mp} is the monthly potential evapotranspiration.
Thus, the equation (2.2) deduced as:

$$R = P - R_0 - ET_{am} \qquad (2.7)$$

Where, all the values are in monthly time scale.

5.5Perspectives of recharge estimation using Water-table Fluctuation method:

The recharge estimation using Water-table Fluctuation (WTF) method is only applicable to unconfined aquifer (Scanlon et al., 2002; Heely and Cook, 2002; Goes, 1999; Ali and Mubarak, 2017). In our study area, the aquifer is confined, and hence recharge could not be estimated using WTF method.

Results

Year 2018

The distribution of rainfall throughout the year is depicted in Fig. 5.2. The pattern of tracer concentration is depicted in Fig. 5.3.

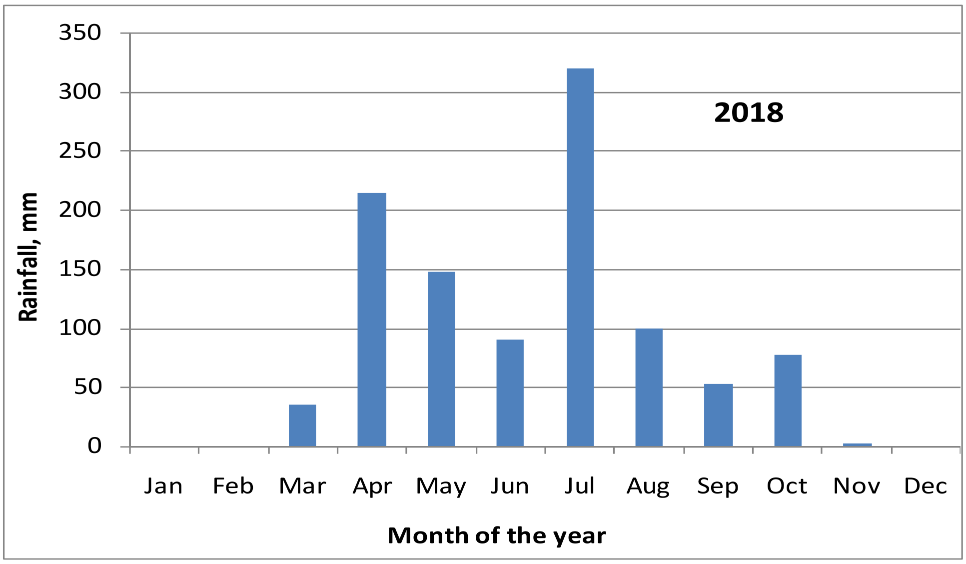
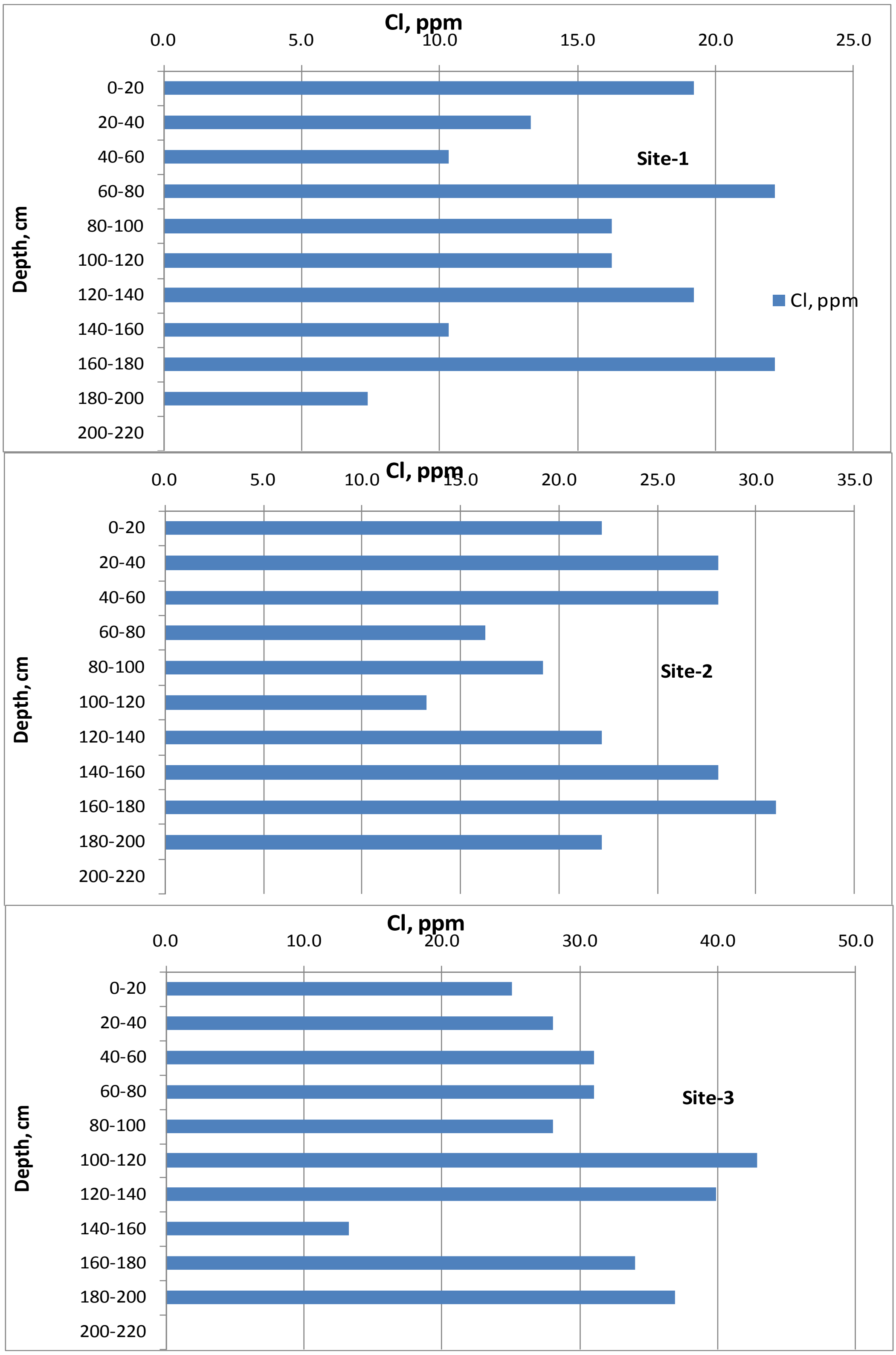


Fig5.2. Rainfall distribution at Ishwardi throughout the year (2018)



Fiure5.3. Tracer concentration profile at different sites (2018)

The recharge rate found using tracer and water balance method for the year 2018 at 3 spots/sites are summarized in Table 5.1.

Table 5.1. Recharge rates under different methods and years (2018)

Sites	Rainfall, mm	Recharge rate, $mm.yr^{-1}$		Recharge rate, % of rainfall	
		Tracer	Water balance	Tracer	Water balance
1		42.9			
2	1041	66.3	33.2		3.2
3		66.3			
Average		58.5		5.6	

The recharge rate found using tracer technique ranged from 42.9 mm to 66.3 mm (average 58.5 mm) under the rainfall of 1041 mm, which in terms of percentage of rainfall, is 5.6%. Using water balance method, the recharge rate was found as 33.2 mm, which in terms of percentage of rainfall, was 3.2%.

Average recharge of two years

The recharge rate during 2017 and 2018 under different methods are tabulated in Table 5.2. When averaged over years, the recharge rate under tracer technique was found as 53.7 mm/year; and 46.2 mm under water balance method.

Table 5.2. Recharge rates under different methods and years

Year	Rainfall, mm	Recharge rate, mm/yr		Average recharge rate, mm/yr		Recharge rate, % of rainfall	
		Tracer	Water balance	Tracer	Water balance	Tracer	Water balance
2017	1050	48.9	59.2	53.7	46.2	5.14	4.42
2018	1041	58.5	33.2				

Conclusion

Mean recharge rate at Ishwardi was found as 53.7 mm/year under tracer technique and 46.2 mm/year under water balance method, which correspond to 5.14% and 4.42% of rainfall, respectively.

Project 4. Development of appropriate irrigation management strategy for increasing yield in saline area

Exp. 6. Irrigation management and chemical amendment for soybean cultivars under saline condition

Objectives:

-To identify critical stage of soybean with respect to salinity

-To develop appropriate irrigation management practice for higher yield of soybean

Methods

The experiment was conducted in the farmer's field at Noakhali. The scheduled treatments were: T_1 = Control (farmer's practice/ no irrigation) ; T_2 = One irrigation at early/*vegetative stage*(20-22 DAS) ; T_3= One irrigation at *flowering stage* (45 DAS) ; T_4 = One irrigation *at early stage* + one irrigation at *floweringstage*; T_5 = One irrigation *early stage* + one irrigation at *pod formation stage* (65 DAS); T_6 = No irrigation, w*ith seed priming (18 hrs soaking in water, and then drying for 8 hrs)* + 30% excess Gypsum; T_7 = No irrigation + Foliar application of *Salicylic Acid* (100 ppm, 20 DAS) + Sodium Silicate (100 ppm, at 45 DAS ; T_8 = 25% excess Gypsum and K + One irrigation at *early stage* + Foliar application of Sodium Silicate (100 ppm, at 45 DAS); T_9 = Foliar application of *Salicylic Acid* at 20 DAS + One irrigation at *flowering stage* + Sodium Silicate at 60 DAS (100 ppm)

The varieties were, V_1 = Binasoybean-3; V_2 = Binasoybean-4; V_3= BARI Soybean 6 (as Check). Three replicates were used. The main plot size was 5 m × 2 m and total area was 814 m^2 (37 m × 22 m) The design was RCBD, with split-plot. The seeds were sown on 20th January 2019, and harvested on 15th April 2019. The experiment was conducted at two sites.Salinity data of the soil, yield and agronomic data were collected throughout the whole period of the soybean growing season from two farmer's field of field at Noakhali.The statistical analysis was performed using statistical software of IRRI, "STAR".Totalrainfall;Temperature and humidity of the experimental site during the soybean production periodare summarized in Figure 6.1 and Figure 6.2

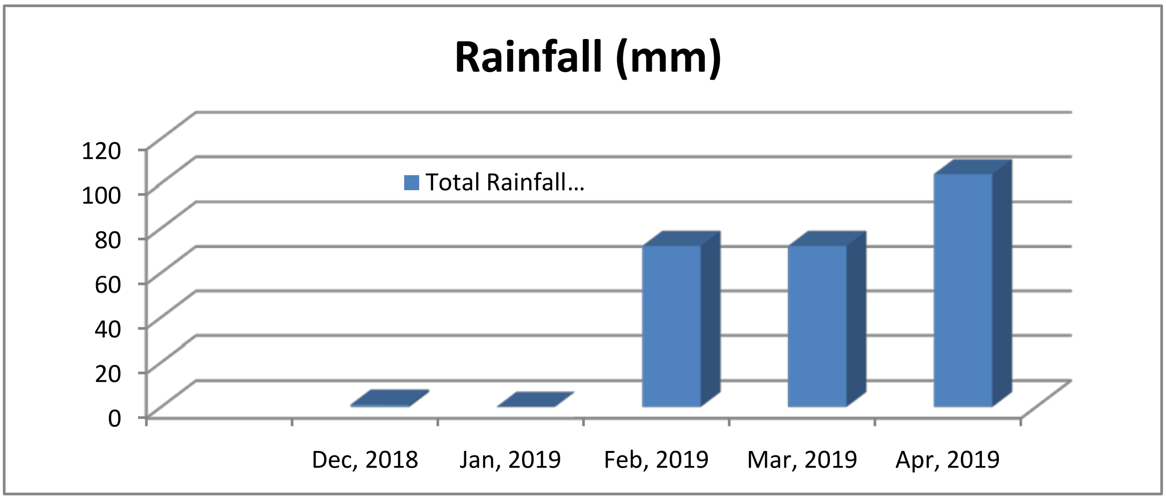


Figure 6.1 Rainfall during the soybean production period

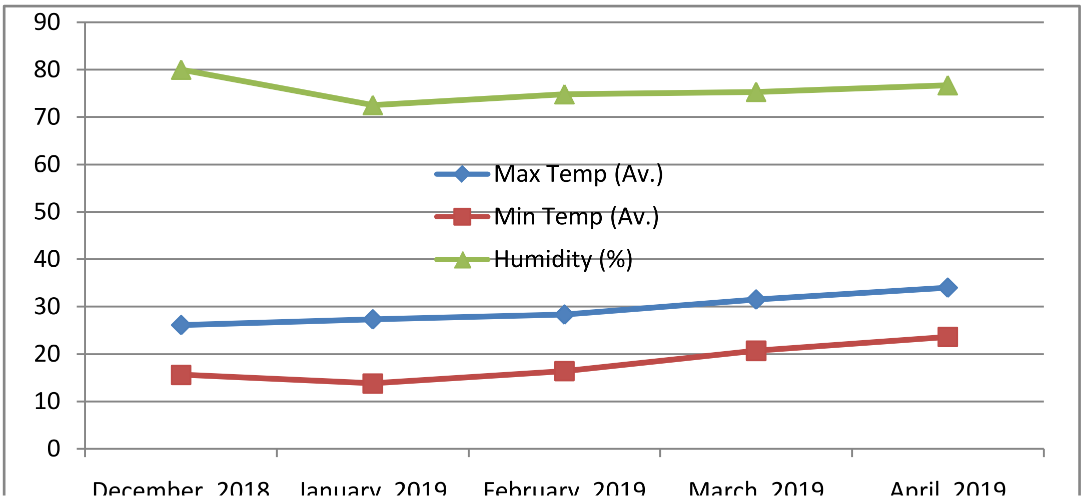


Figure 6.2. Temperature and humidity during the soybean production period

Result and Discussion

There was rainfall at vegetative, pod formation and ripening stages of the crop which might affect the treatment effects.The mean effects of treatments and cultivars on yield and yield attributing characters of soybean cultivars are summarized in Table 6.1 and Table 6.2.

In case of Location 1(Table 5.1) cultivars showed significant difference except branch/ plant and pod/ plant. The treatments showed significant difference in all yield attributing characters exceptgrain yield. The interaction effect of treatment and variety was significant. The Salinity of soil during the soybean production period (location 1) is summarized in Table 6.2 and Figure 6.3**.**

Table 6.1. Mean effects of irrigation treatments and cultivars on yield and yield attributing characters of soybean cultivars (location 1)

Treatment	Plant height (cm)	Branch/ plant	Pod/ plant	Grain yield (gm/m^2)
T_1	67.2889	2.6	45.6444	0.263
T_2	61.7555	2.5333	38.1333	0.268
T_3	66.3222	2.6222	38.2889	0.246
T_4	74.6889	2.1111	36.8889	0.273
T_5	61.1333	1.6222	26.3111	0.283
T_6	64.8222	1.57778	30.1777	0.277
T_7	72.3778	1.4666	30.8666	0.247
T_8	72.7999	1.6222	39.7555	0.261
T_9	68.4666	2.0444	35.8222	0.253
F-test at (5%)	S	S	S	NS
Cultivars				
V_1	76.4629	1.9851	33.9185	0.2585
V_2	60.4814	2.0814	37.9185	0.284
V_3	66.2740	2.3330	35.4592	0.2522
F-test (5%)	S	NS	NS	S

Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 6.2. Salinity of soil during the soybean production period (location 1)

Treatments	Soil Ec(dS/m)		
	Early Stage	Flowering Stage	Pod Formation stage
T1	0.223	1.589	0.496
T2	0.188	0.489	0.583
T3	0.389	1.498	0.56
T4	0.288	1.851	0.256
T5	0.306	1.227	0.601
T6	0.244	2.25	0.44
T7	0.413	2.83	0.437
T8	0.291	2.2	0.271
T9	0.981	1.857	0.843

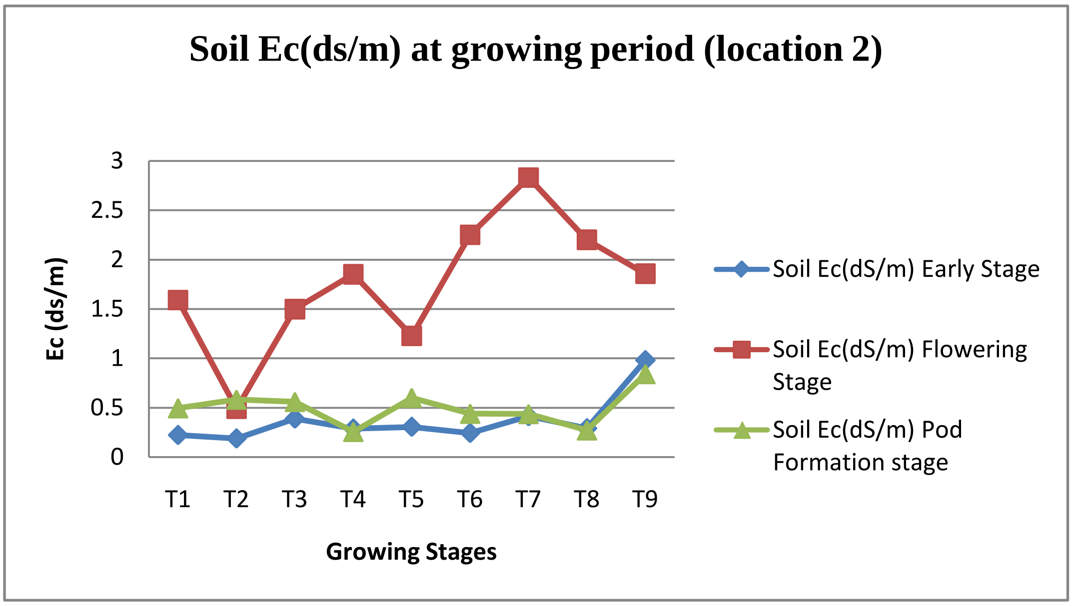


Figure 6.3. Salinity of soil during the soybean production period (Location 1)

In case of location 2(Table 6.3) cultivars showed significant difference except pod/ plant. The treatments showed significant difference in all yield attributing characters exceptgrain yield. The interaction effect of treatment and variety was significant. Salinity of soil during the soybean production period (location 1)is shown in Table 6.4 and Figure 6.4.The cultivars produced reasonable yield under the prevailing weather condition.

Table 6.3. Mean effects of irrigation treatments and cultivars on yield and yield attributing characters of soybean cultivars (location 2)

Treatment	Plant height (cm)	Branch/ plant	Pod/ plant	Grain yield (g/m^2)
T_1	54.20	2	49.6	0.2604
T_2	47.733	1.5	34.8	0.2578
T_3	53.466	1.26	50.57	0.2763
T_4	42.40	1.86	33.03	0.2785
T_5	40.40	1.23	36.90	0.2581
T_6	46.50	1.5	40.43	0.2851
T_7	47.766	1.56	26.98	0.2733
T_8	46.233	1.36	32.63	0.2861
T_9	51.433	1.2	33.8	0.2556
F-test at (5%)	S	S	S	NS
Cultivars				
V_1	53.211	1.388	39.755	0.2631
V_2	44.188	1.70	37.125	0.2804
V_3	45.977	1.411	36.033	0.2828
F-test (5%)	S	S	NS	S

Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 6.4. Salinity of soil during the soybean production period (location 2)

Treatments	Soil Ec(dS/m)		
	Early Stage	Flowering Stage	Pod Formation stage
T1	0.223	1.12	0.4
T2	0.188	1.008	0.751
T3	0.389	1.802	0.549
T4	0.288	1.494	0.695
T5	0.306	1.4	1.01
T6	0.244	1.532	0.909
T7	0.413	1.18	0.524
T8	0.291	1.54	0.726
T9	0.981	1.05	0.45

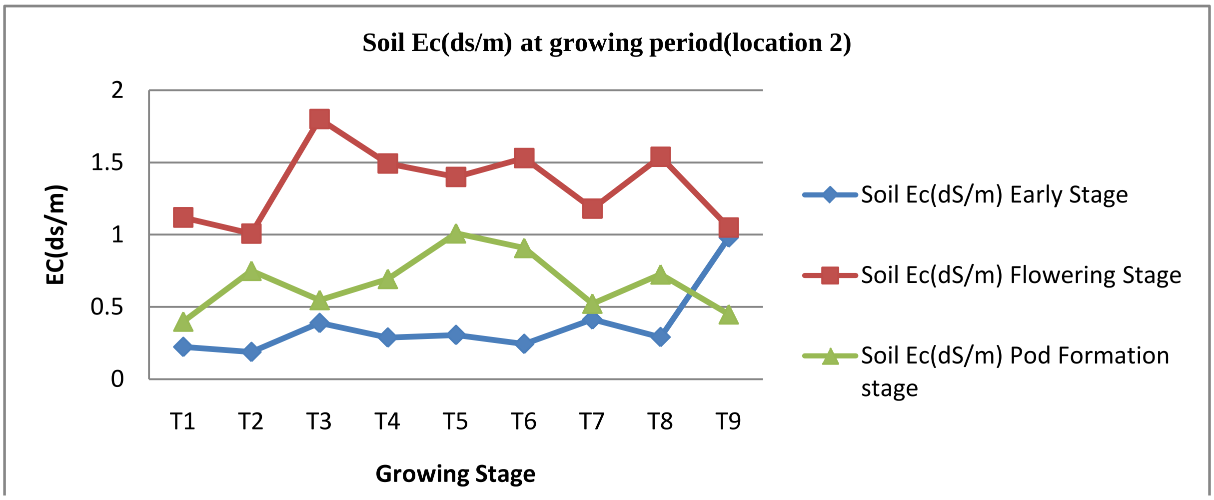


Figure6.4. Salinity of soil during the soybean production period (Location 2)

Table 6.5.Mean yield of soybean cultivars over location

Treatment	Location 1 Grain yield (t/ha)	Location 2 Grain yield (t/ha)	Mean
T_1	2.63	2.60	2.62
T_2	2.68	2.58	2.63
T_3	2.46	2.76	2.61
T_4	2.73	2.79	2.76
T_5	2.83	2.58	2.71
T_6	2.77	2.85	2.81
T_7	2.47	2.73	2.60
T_8	2.61	2.86	2.74
T_9	2.53	2.56	2.55
Cultivars			
V_1	2.59	2.63	2.61
V_2	2.84	2.80	2.82
V_3	2.52	2.83	2.68

When averaged over locations, The treatment T_6 showed the highest yield and for cultivar, V_2 (Binasoybean-4) produced the highest yield.

Conclusion

Application of 30% excess gypsum (in addition to recommended dose) produced the highest seed yield. In an another management by application of 25% excess Gypsum and Potassium (K) and foliar application of Sodium Silicate (100 ppm, at 45 DAS) and one irrigation at early stage also produced the highest seed yield under the prevailing climatic condition (having rainfall at vegetative and pod formation stage). Also in the last year experiment (with having rainfall at vegetative, pod formation and ripening stages) seed priming for 18 hrs and then drying for 8 hrs + 30% excess gypsum application (in addition to recommended dose) produced the highest seed yield.To confirm the result, the experiment will be repeated in the next year.

Expt.7. Effects of Irrigation Management and amendments in Boro rice under Saline condition (Lysimeter and Field study, Satkhira)

Objective: - To identify appropriate irrigation and other management practices for higher yield in saline area

Method

The experiment was carried out at BINA Sub-stationSatkhira (Lysimeter and field) during the period from 7 January 2018 to 19 May 2018. To objective was to identify appropriate irrigation and other management practices for higher yield in saline area. The test variety was Binadhan-10.Recommended dose for Binadhan-10 is Urea, TSP, MoP, Gypsum, and Zinc - 217, 110, 70, 45, and 4.5 kg/ha.The experimental design was RCBD, with 3 replications. The imposed irrigation treatments were:

T1= Continuous ponding (3-5 cm) + 150 kg/ha Gypsum (basal) + 10 kg/ha Si (basal) + planting in ridge [ridge (30 cm) + Furrow (30 cm, 3 line)]

T2= Continuous saturation (0-3 cm) + 68 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering) + No Si + No ridge (normal/Recom. density)

T3= Continuous ponding (3-5 cm) + 150 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering) + 10 kg/ha Si (basal) + No ridge

T4= Continuous saturation (0-3 cm) + 150 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering) + 10 kg/ha Si (basal) + No ridge

T5= Continuous saturation (0-3 cm) + 68 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering l) + 10 kg/ha Si (basal) + No ridge + Washout* (change standing water) at 25 days interval

T6= Continuous saturation (0-3 cm) + 68 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering l) + 10 kg/ha Si (basal) + addition of PK (30%) at booting/flowering stage + Washout (change standing water) at 25 days interval

T7= Continuous saturation (0-3 cm); with recommended fertilizer, no amendment.

*Washout" of salt by irrigation at 25 days interval (or, when soil salinity exceeds 10 dS/m)

The seedlings were transplanted on 7 February 2018 at Lysimeter and field at Satkhira sub-station. After establishment, treatments were followed. The total rainfall and Temperature and sunshine hour at growing period are given in the Figure 7.1 and Figure7.2.

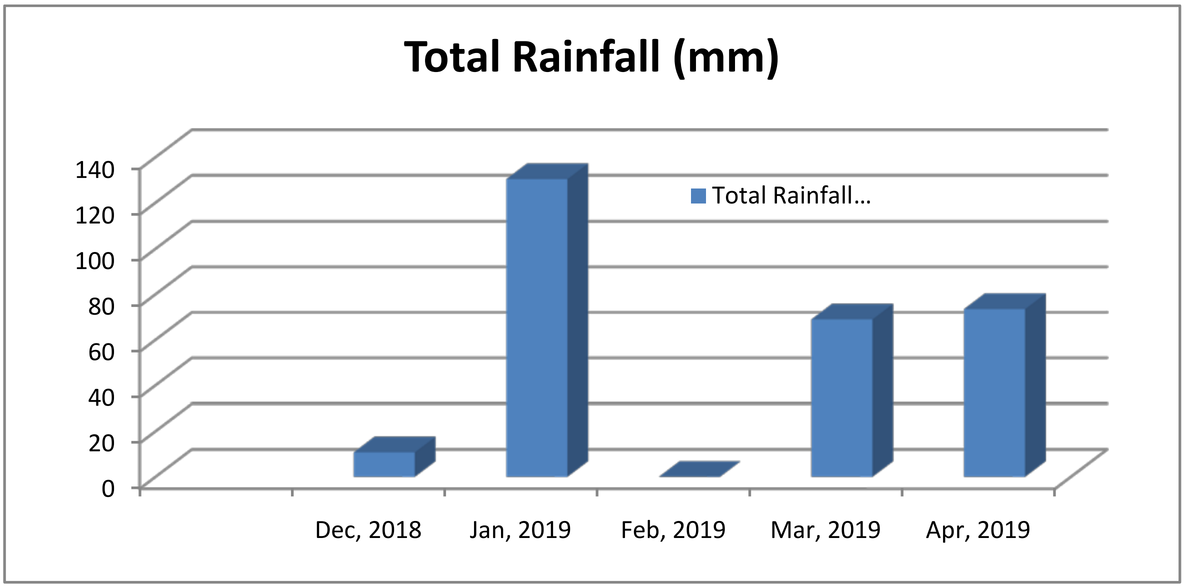


Figure 7.1. Rainfall during the rice production period

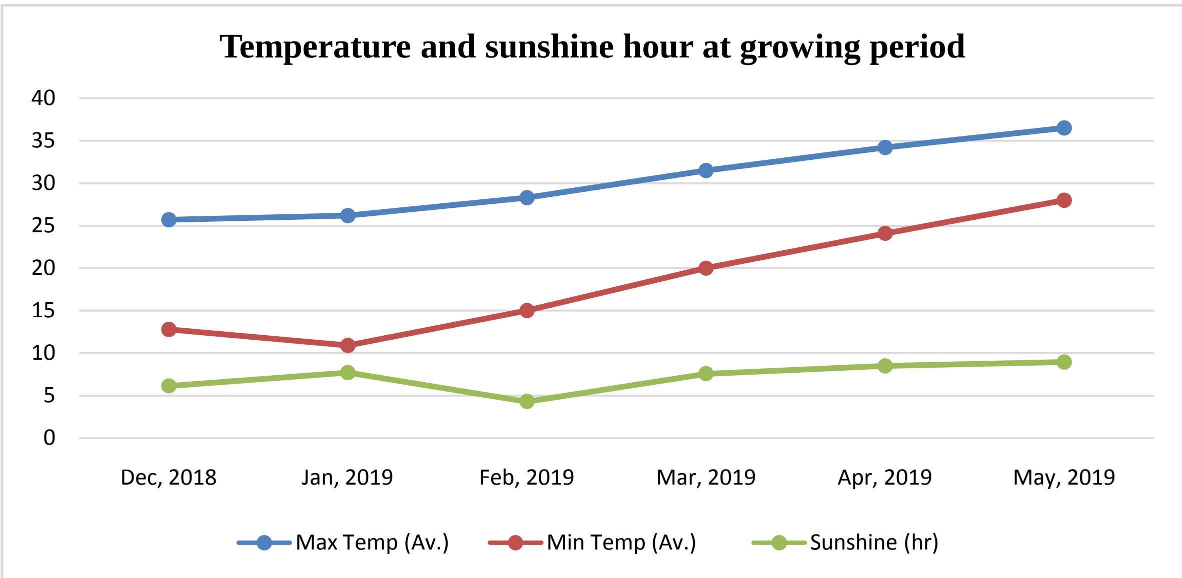


Figure 7.2. Temperature and humidity during the rice production period

Result and Discussion

In Lysimeter study, the treatments showed insignificant difference in all yield attributing characters except grain yield. It was difficult to maintain treatments properly due to excess rainfall (Fig. 7.1). The highest yield (6.93t/ha) was recorded in treatment T_6.

Table 7.1. Mean effects of Irrigation Management and amendments on yield and yield attributing characters of Binadhan-10 under Saline condition (Lysimeter study)

Treatment	Plant height (cm)	Panicle Length (cm)	Tiller/ plant	seed/panicle (Filled grain) (no.)	Unfilled grain (no.)	Grain yield (t/ha)
T_1	106.5	23.5	9.2	113.8	7.7	3.47b
T_2	106.5	24.2	11	128.2	6.3	6.7a
T_3	104.7	23.7	9.8	118.3	9.2	6.53a
T_4	107.3	23	10.3	121.3	9.7	6.37a
T_5	108.7	26	11.3	113.8	8.8	6.90a
T_6	103.2	25.7	10.5	109.3	7.2	6.93a
F-test at (5%)	NS	NS	NS	NS	NS	S

Note: Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.Means with the same letter are not significantly different.

In case of field study, the treatments showed significant difference in grain yield and all yield attributing characters except unfilled grain numbers. The highest yield (4.03t/ha) was recorded in treatment T_5. Table 7.2 showed the effects of treatments on Binadhan-10 under Saline condition.

Table 7.2. Mean effects of Irrigation Management and amendments on yield and yield attributing characters of Binadhan-10 under Saline condition (Field study)

Treatment	Plant height (cm)	Panicle Length (cm)	Tiller/ plant	seed/panicle (Filled grain) (no.)	Unfilled grain (no.)	Grain yield (t/ha)
T_1	104.5ab	28.1a	12a	145.7a	7	2.17d
T_2	106.8a	27.3ab	11a	13ab	7	2.57c
T_3	107.8 a	27.9ab	7.7b	129.7ab	7.7	1.77e
T_4	101.5b	26.3b	7b	118.7b	7.7	1.87de
T_5	104.7ab	26.2b	8.3b	118.3b	6	4.03a
T_6	104.3ab	26.4ab	7.3b	111b	4	2.57c
T_7	108.07a	27.7ab	11.7a	121.7b	9.3	3.10b
F-test at (5%)	S	S	S	S	NS	S

Note: Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test. Means with the same letter are not significantly different.

Conclusion

In field study, the treatments showed significant difference in grain yield and all yield attributing characters except unfilled grain numbers. It was difficult to maintain treatments properly due to excess rainfall. The highest yield (4.03t/ha) was recorded in treatment $T_{5.}$ In lysimeter study, the treatments showed insignificant difference in all yield attributing characters except grain yield. The highest yield (6.93t/ha) was recorded in treatment T_6.

Project6. Groundwater resources management for sustainable crop production in northwest hydrological region of Bangladesh (*NATP-2 funded project*)

Exp.8. Determination of aquifer hydraulic properties (by pumping test)

The objective was to generate information for safe groundwater withdrawal rate.

Method:

Pumping test was done at Niamatpurupazila (of Naogaon district) following standard procedure (e.g. time-drawdown, distance- drawdown, recovery data).

Two observation wells were installed in line at 150 ft and 300 ft from the test (production) well (hereafter called 1st and 2nd observation well), at the same depth of the test well. The well was pumped at a constant rate until steady state condition reached (~48 hours). The water levels in the wells were checked and recorded at specific time interval.

The discharge rate of the pump was measured with V-notch and cut-throat flume in the vicinity of the outlet.

Distance-drawdown

The horizontal distance between each observation well and the pumping well should was measured. The vertical elevation of a fixed reference point on each observation well and on the pumping well (e.g., "top of casing") was established.

To examine the expected influence of the pumping well, one well (submersible drinking well of the villager) at about 500 ft apart, and one observation well of BMDA at about 800 ft apart from the test well were monitored.

Time- drawdown

The water level at the observation wells were monitored at different time intervals.

Recovery data recording

Once the pumping had stopped, the recovery of the water level (i.e. rising water level) was monitored at specific time intervals (2 min. interval for the first 10 minutes, 5 minutes interval for the next 30 min., etc.) until the water level returns to about 80 percent of its original level.

Determination of aquifer hydraulic properties

The following methods were used for calculating aquifer hydraulic properties:

- Theis drawdown
- Cooper-Jacob drawdown
- Theis recovery

Theis method

Theis (1935) derived the following discharge-drawdown relationship, called Theis equation:

$$s = \frac{Q}{4\pi T} W(u)$$

Where,

$$W(u) = -0.577216 - \ln(u) + \sum_{i=1}^{\infty} (-1)^{i+1} \frac{u^i}{i.\,i!}$$

and,

$$u = \frac{r^2 S}{4Tt}$$

Where, T is the transmissivity of the aquifer, t is the time since pumping started, and Q is the pumping rate.

The steps in Theis curve analysis are as follows:

- Plot log drawdown (s) versus log time (t) on the same scale of matching (master) curve
- Overlay plotted and master curve (keeping axes parallel)
- Identify a match point and record values of S, T, u, and W(u)
- Solve for T as:

$$T = \frac{Q}{4\pi T} W(u)$$

- Solve for S as:

$$S = \frac{4uTt}{r^2}$$

- Derive K as:

$$K = \frac{T}{b}$$

Where, b is the thickness of the aquifer.

Cooper-Jacob Method

Cooper and Jacob (1946) observed that as the variables decreases with time ($u^i/i.i! \longrightarrow 0$), and thus the term W(u) can be approximated by:

$$W(u) = -0.577216 - \ln(u)$$

The Theis equation then becomes:

$$s = \frac{Q}{4\pi T}\left(-0.5772 - ln\frac{r^2S}{4Tt}\right) = \frac{Q}{4\pi T}\left(ln\frac{4Tt}{r^2S} - 0.5772\right)$$

In terms of $\log_{10}$ (As the term lnX = 2.303 $\log_{10}$X), the above eqn. can be expressed as:

$$s = \frac{2.3Q}{4\pi T} log_{10}\left(\frac{2.25Tt}{r^2S}\right)$$

There are 3 types of solution approaches using Cooper-Jacob simplification:

- Time-drawdown
- Distance-drawdown, and
- Recovery

Determination of aquifer hydraulic properties (by pumping test)

Pumping test has been performed at Niamatpur (during January 12-15, 2019). The analysis of the data is going on. The static water level in the observation well was found as 33.23 m (109 ft).

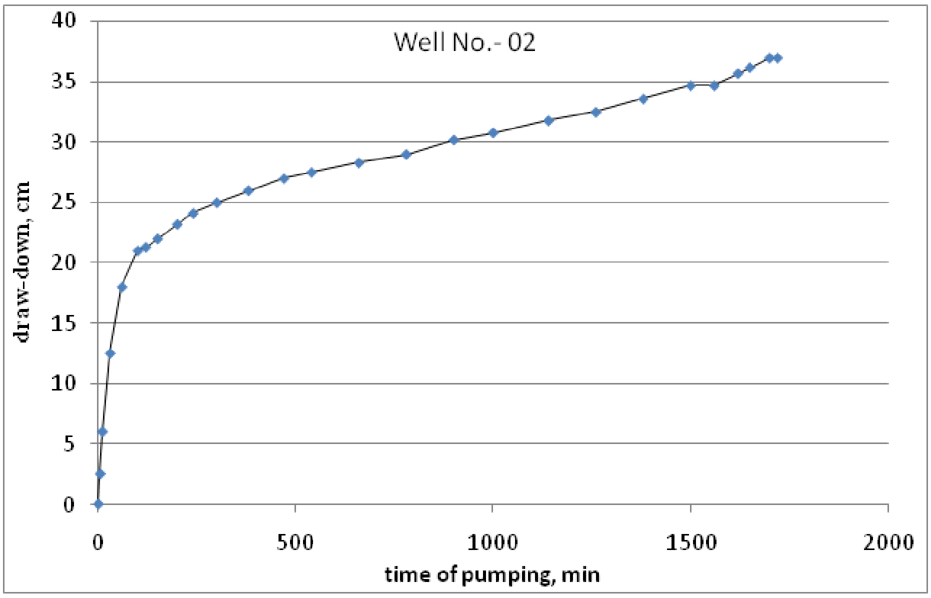


Figure 8.1 Pattern of drawdown during the course of pumping

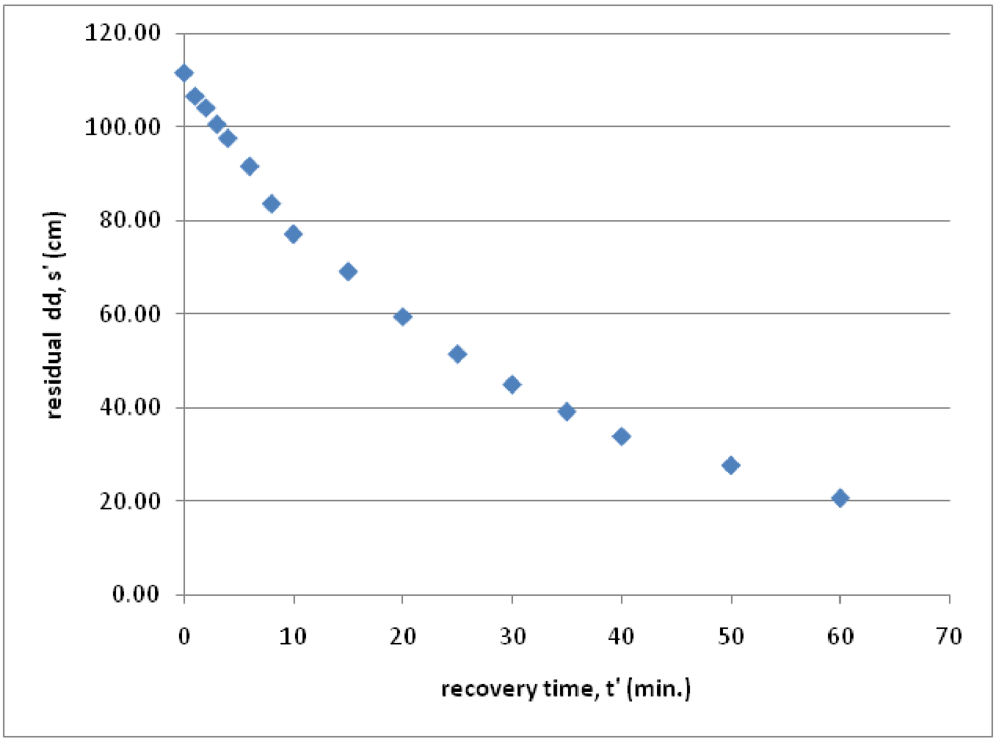
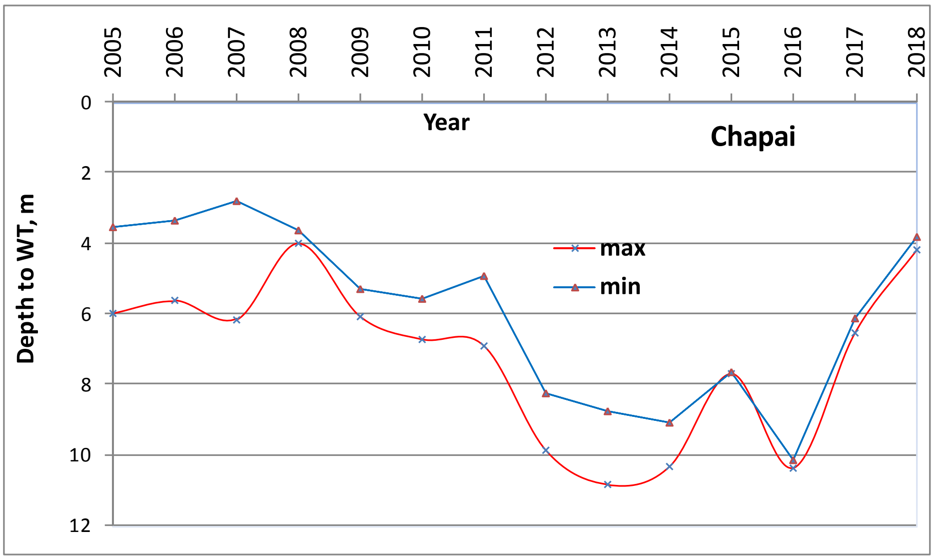


Figure 8.2. Pattern of residual drawdown during recovery period

Exp.9. Water-table trend analysis using non parametric method.

9.1 BADC (digital) data

Data were taken from BADC publications - data of digital water-level recorder. The patterns of maximum and minimum water-table at Chapai and Naogaon are depicted in Figure 9.1.1 and Figure 9.1.2, respectively. The fluctuating pattern does not necessarily follow the rainfall pattern. It is also revealed that the trend is declining and the magnitude between maximum and minimum depth to water-table is decreasing over time, meaning that the recharge rate is decreasing.



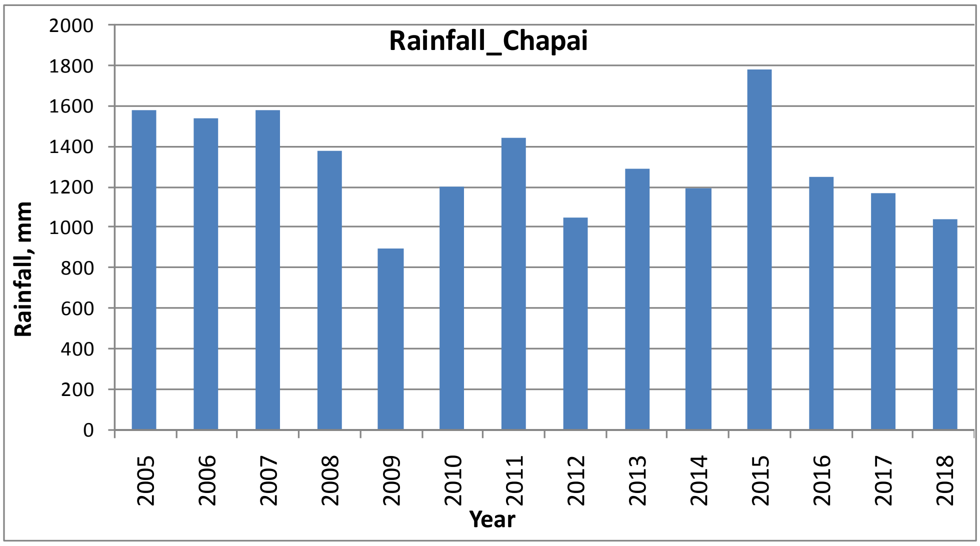


Figure 9.1.1. Water-table and rainfall pattern at Chapainawabgonj

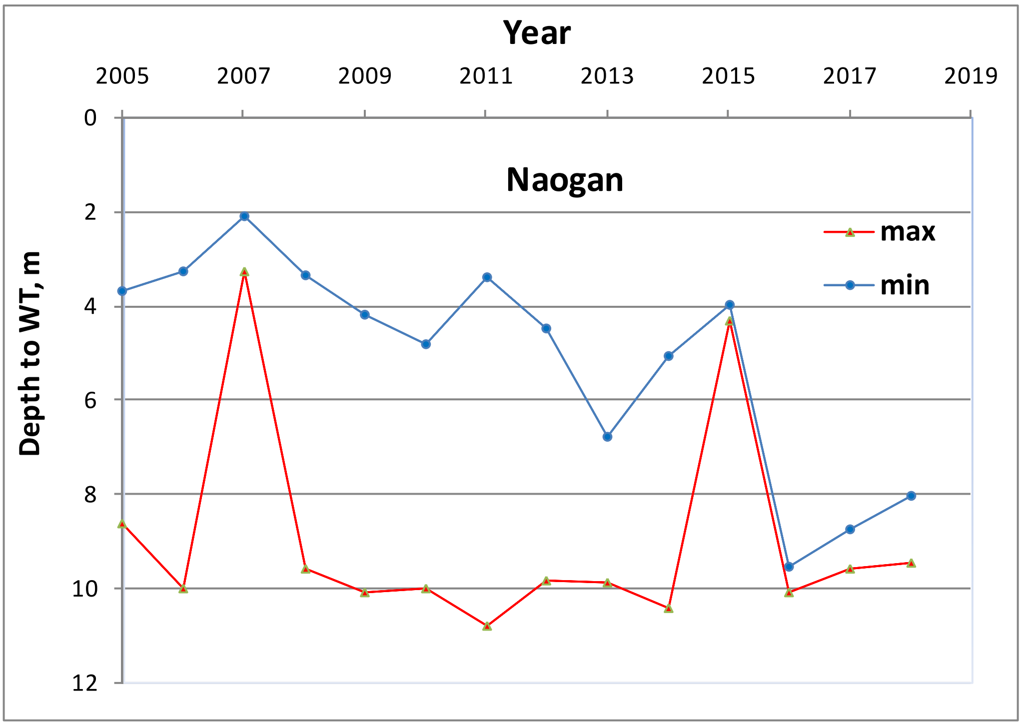


Figure 9.1.2. WT pattern at Naogaon

9.2 BMDA data

Figure 9.2.1 shows the pattern of yearly maximum and minimum depth to water-table at Niamatpur. The long-term trend shows a sharp decreasing trend (38 cm/year).

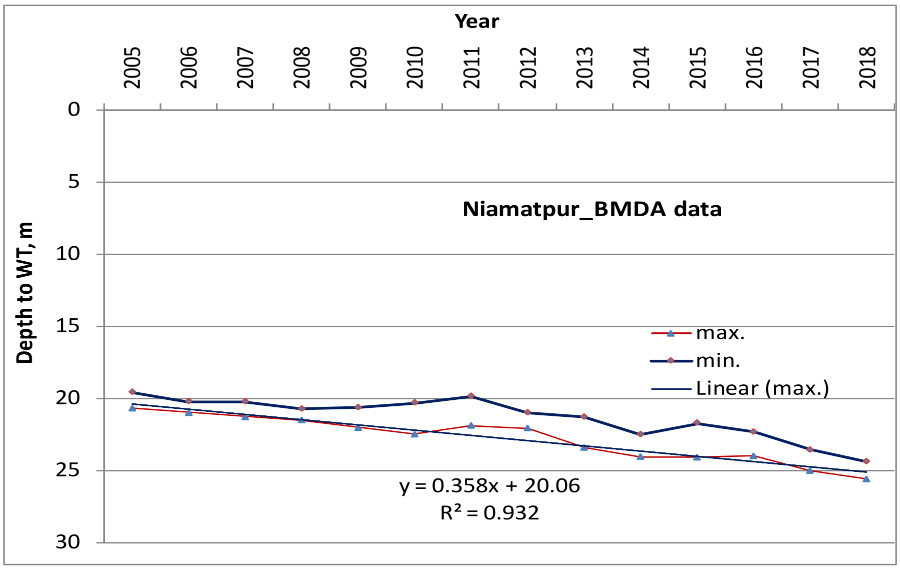
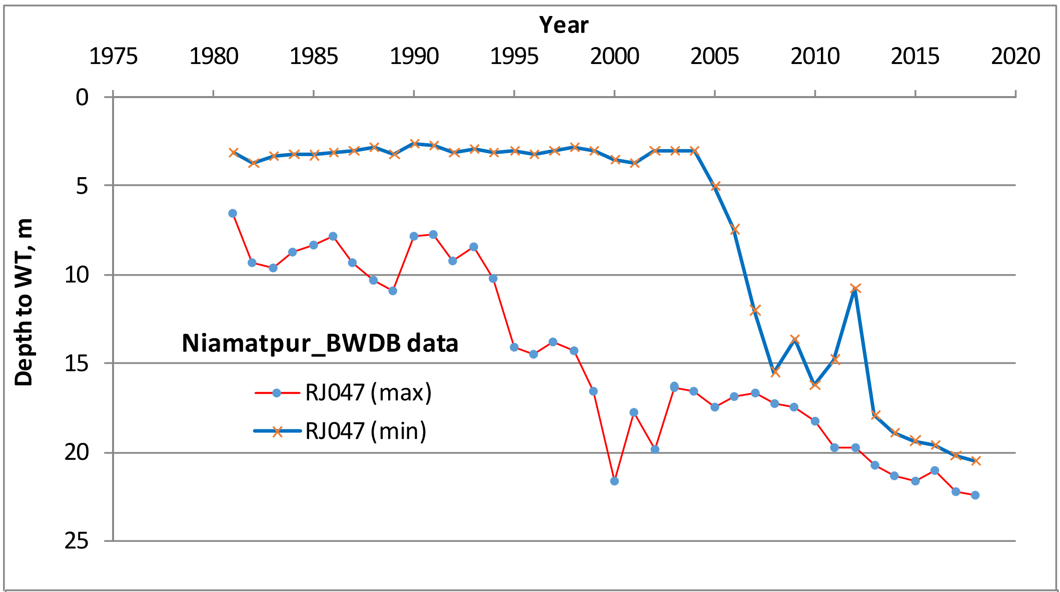


Figure 9.2.1. WT pattern at Niamatpur

9.3 BWDB data

The patterns of maximum and minimum water-table at Niamatpur and Nachol are depicted in Figure 9.3.1 and Figure 9.3.2, respectively. Here also, similar to that of BADC data, the magnitude between maximum and minimum depth to water-table is decreasing over time, meaning that the recharge rate is decreasing.



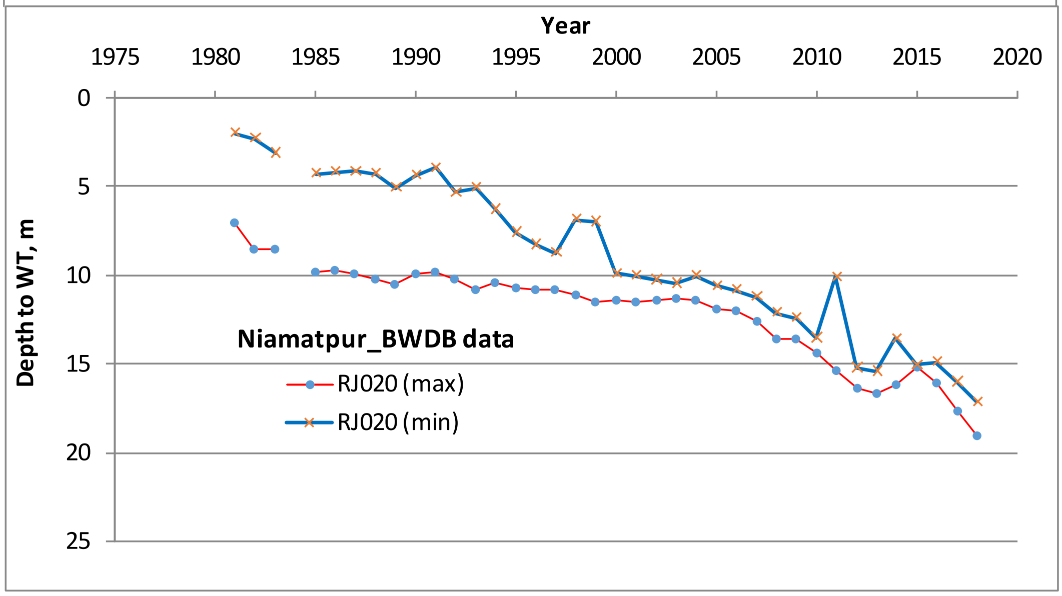


Figure 9.3.1. WT pattern of 2 wells at Niamatpur

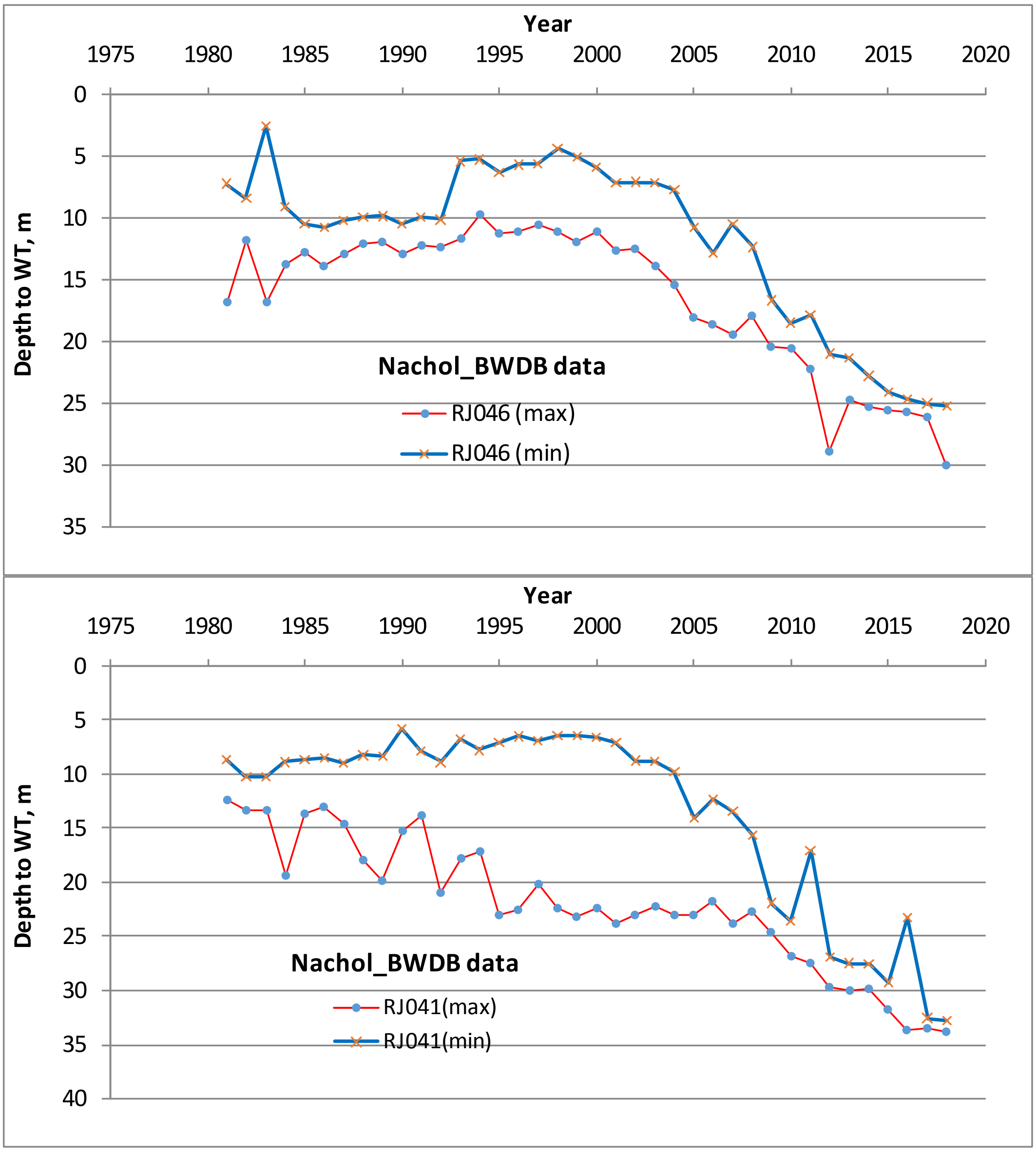


Figure 9.3.2. WT pattern of 2 wells at Nachol

Exp.10 Estimation of groundwater recharges using tracer technique and water balance method

10.1 Methodology for recharge estimation using tracer technique

The study was conducted in a rice field of Nacholupazila. Before the beginning of rainy season (in March), a rice field (medium land) was selected for tracer application, and followed the same procedure as that of Experiment 5.

The vertical distribution of the tracer was used to estimate the velocity (v), and the recharge rate (R) was calculated as (Chand et al.2005; Scanlon et al., 2002; Ali, 2017):

$$R = v\theta = \frac{\Delta z}{\Delta t}\theta \quad (1)$$

Where, Δz is the depth of the tracer peak, Δt is the time between tracer application and sampling, and θ is the average volumetric water content.

10.2 Water Balance Method

A simplified form of water balance equation (Yin et al., 2011) was used to estimate recharge:

$$P = R_0 + R + ET_a + \Delta SM \qquad (2.1)$$

where: P = rainfall (mm), R_0= surface runoff (mm), R = recharge, ET_a = actual evapo-transpiration (mm), and ΔSM= change in soil moisture (mm) for the specified time interval. Re-arranging the above equation, the recharge (R) can be expressed as:

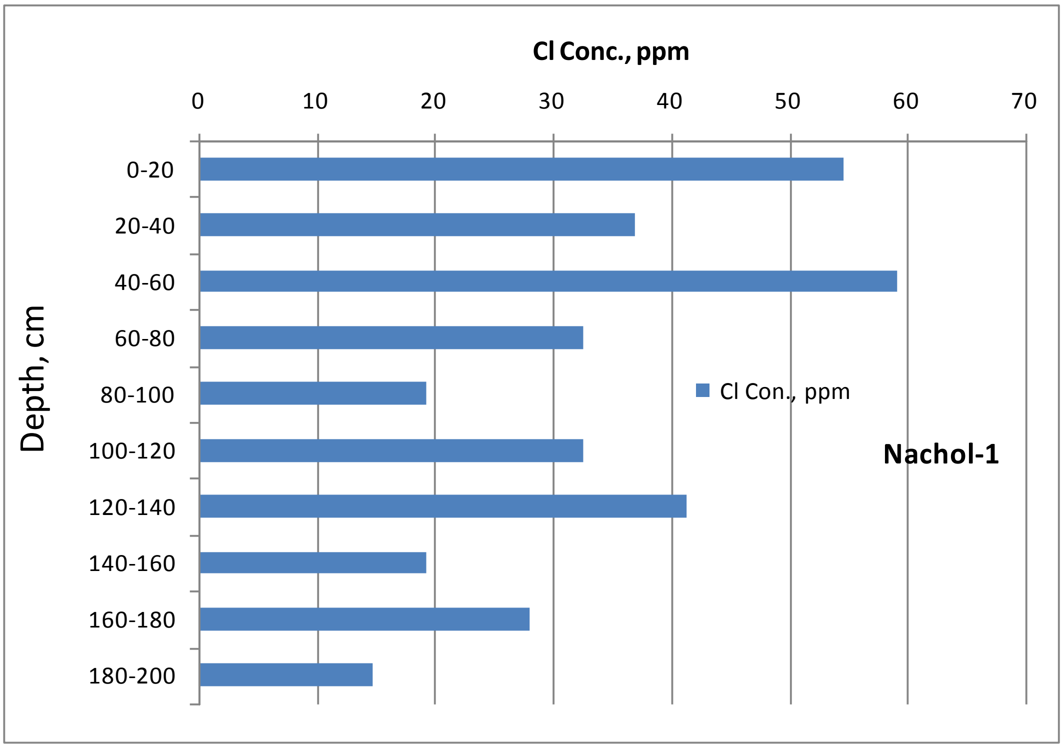
$$R = P - (R_0 + ET_a) \qquad (2.2)$$

10.3 Estimation of groundwater recharge (by tracer technique and water-balance method)

Here also, Tracer Method and Water balance method followed same as described in Exp 5.

Tracer concentration profile at two locations is depicted in Figure 10.3.1 and the monthly rainfall distribution of the year 2018 (total 1450 mm) is depicted in Figure 10.3.2. From tracer technique, the yearly recharge was found as 180 mm (12.4 % of rainfall).

From water balance method, the yearly recharge was found as 96.5 mm (6.7% of rainfall). Monthly recharge estimates are tabulated in Annexure-3.



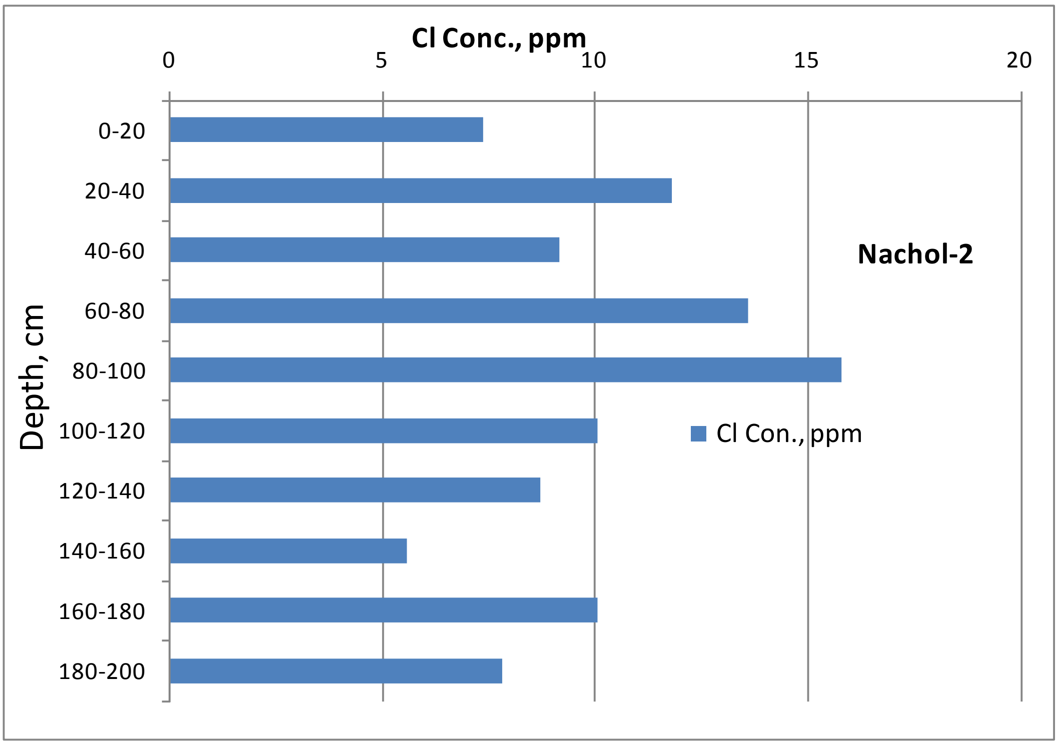


Figure 10.3.1. Concentration profile of tracer

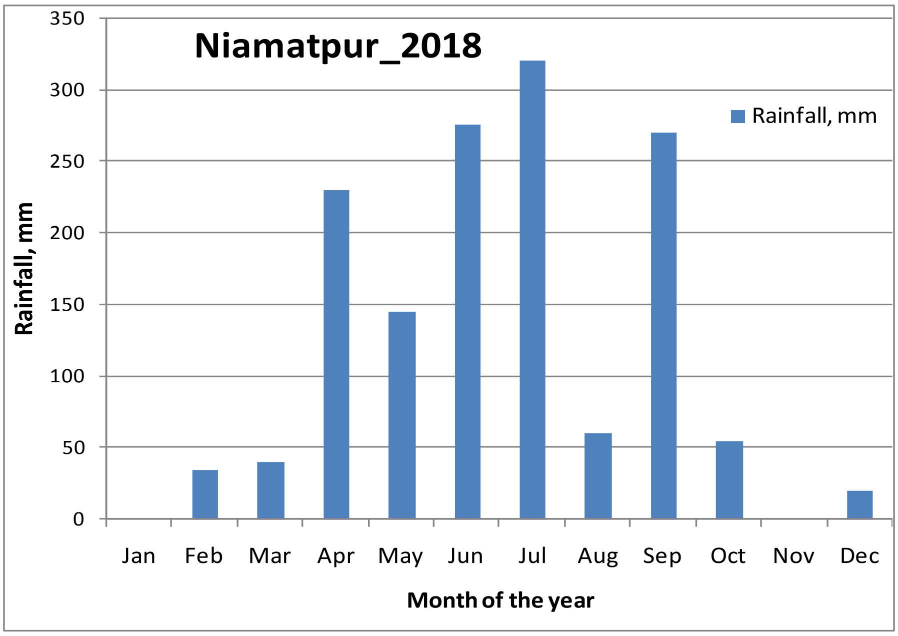


Figure 10.3.2. Monthly rainfall distribution at Niamatpur

Exp.11.Studies on Water Quality for irrigation and drinking purposes

Methods

The objective was to investigate the quality of water and make suggestion for different uses. Sampling schedule was: (1) At the beginning of the irrigation season (end of January), and (2) At the peak irrigation season (middle of April). Samples were collected from 50 DTWs covering the major irrigated area of Nachol and Niamatpurupazila (Figure 11.1). Analysis was performed by Multi-parameter Photometer for anions and cations. Interpretation was made comparing with national/FAO/WHO guideline.

Figure 11.1. Location map of the sampling DTWs (based on GPS data, using googlemap)

Water quality status at Nachol and Niamatpur

The results of quality parameters tested are summarized in Table 11.1. All parameters are within acceptable limit for irrigation and drinking (according to GOB(1997)) except chromium in few samples, which will be monitored in the next sampling.

Table 11.1. Quality parameters of water collected from different DTWs.

Sample no.	pH	Ec µs/m	NO3 (mg/L)	Fluoride (mg/L)	PO_4 (mg/L)	Zn (mg/L)	SO_4 (mg/L)	Cr (µg/L)
1	8.22	803.4	0.02	0.43	0.48	0	5	10
2	8.09	597.6	0.03	0.37	0.35	0	0	0
3	8.2	505.3	0.02	0.71	0.26	0	0	0
4	8.44	533.6	0.02	2	0.31	0	0	0
5	8.14	633.4	0.02	0.82	0.38	0	5	0
6	8.2	706.8	0.06	0.51	0.21	0	5	0
7	8.25	707.9	0.02	0.97	0.2	0	0	0
8	8.07	779.7	0.02	0.9	0.28	0	5	3
9	8.42	684.3	0	0.61	0.34	0	5	0
10	8.26	568.5	0.01	0.67	0.25	0	5	0
11	8.42	657.4	0.03	0.64	0.43	0	5	0
12	8.09	586.9	0	0.36	0.47	0	0	0
13	7.96	501.7	0.04	0.53	0.24	0	0	0
14	8.01	558.1	0.04	0.9	0.36	0	5	0
15	8	591.3	0	1.1	0.37	0	5	0
16	8.28	580.9	0.03	0.57	0.25	0	0	0
17	8.09	637.7	0.04	0.71	0.27	0	0	0
18	8.12	652.3	0.05	1.05	0.32	0	5	0
19	8.3	717.5	0.03	1.56	0.21	0	5	0
20	8.44	641.3	0.01	1.09	0.17	0	5	0
21	8.48	535.8	0.01	1.49	0.67	0	0	0
22	8.46	533.2	0	0.8	0.15	0	0	0
23	8.32	642.8	0.06	0.74	0.32	0	0	0
24	8.04	686.2	0.03	0.84	0.31	0	15	0
25	8.01	659.7	0	0.72	0.24	0	15	3

26	7.89	753.6	0.02	0.3	0.36	0	5	0
28	8.11	713.9	0.01	0.18	0.39	0	0	0
29	8.21	714.2	0.01	0.36	0.29	0	0	0
30	8.15	610.6	0.01	0.12	0.61	0.3	5	0
31	8.18	607.8	0.02	0	0.4	0	0	0
32	8.16	728.6	0.03	0.03	0.21	0	10	0
33	8.13	840.7	0.02	0.34	0.36	0.06	5	0
34	8.15	734.1	0.02	0.22	0.3	0	5	0
36	8.24	518.9	0.03	0.26	0.38	0	0	0
37	8.07	542.6	0.04	0.29	0.27	0	5	0
38	8.03	531.9	0.04	0.34	0.39	0	0	0
39	8.19	610.5	0.06	0.24	0.31	0	0	0
41	8.17	663.3	0.05	0.04	0.35	0	0	0
42	8.19	537.5	0.03	0.27	0.33	0	0	0
43	8.15	516.9	0	0.14	0.33	0	10	0
44	8.09	510.8	0.03	0.36	0.38	0	5	0
45	8.21	570.8	0	0.54	0.31	0	10	0
46	8.04	419	0.05	0.21	0.22	0	0	0
47	8.12	402.4	0.01	0.14	0.32	0	0	0
48	7.98	369.5	0.01	0.13	0.45	0	0	0
49	8.12	457.7	0.01	0.16	0.37	0	0	0
50	7.84	478.8	0.03	0.18	0.31	0	10	0
GOB permis. Limit for irrigation	6.0-8.5	1200	10 (as N_2)	NYS	15	10	1000	NYS
GOB permis. Limit for drinking	6.5-8.5	600-1000	10	NYS	6	5	400	NYS

“NYS” means ‘Not yet standardized’.

Exp. 12. Cropping pattern study for identifying water-saving pattern

Objective: To identifying water-saving and economic cropping pattern

Methodology:

Based on the survey data, Nacholupazila of Chapai Nawabganj district, and Niamatpurupazila of Naogaon district were selected. Details of each location are presented in Table 12.1.

Table 12.1. Locational description of the selected sites

Location No.	Village	Union	Upazila	District
1	Sirajpur (Uttor Para)	Rosulpur	Niamatpur	Naogaon
2	Verendi Bazar	Rosulpur		
3	Chairman Para	NacholPauroshova	Nachol	Chapai Nawabganj
4	Jonakipara	Nachol		

Existing major cropping patterns and new interventions:

The existing cropping patterns of the sites are presented in Table 12.2. From the survey data it is revealed that the major cropping patterns practiced by the farmers are:Aman-Boro-Fallow(Pattern-5)

Table 12.2 Major cropping patterns at the study sites

Sl No.	Cropping Pattern	Percentage
1	Aman-Boro-Fallow	51
2	Aman- Wheat-Fallow	19
3	Aman-Mustard-Boro	8
4	Aman-Lent-Fallow	8
5	Aman-Mustard-Fallow	8
6	Aman-Lent-Boro	3
7	Aman-pea-Fallow	2
8	Aman-Mustard-pea	1

Along with local existing cropping pattern, different 'low water demanding'/ 'water-wise' cropping patterns (including technological intervention, such as new drought tolerant Aman variety, drought tolerant broadcast Aus variety) were tried to find out an economic and water-efficient cropping pattern based on the available resources. The following new (proposed) cropping patterns were selected for trial in the area (Table-12.2).

Table 12.2 Details of cropping pattern selected for intervention

Major crop for pattern	Cropping sequence	Pattern No.
Aus based	Aus- Aman – Rabi (Mustard)	Pattern-1
	Aus - Aman – Rabi (Lentil)	Pattern-2
	Aus - Aman – Rabi (Wheat)	Pattern-3
Boro based	Boro - Aman – Rabi (Mustard)	Pattern-4
Boro based	Boro - Aman –Fallow	Pattern-5 *(control)*

Economic Analysis:

Economic analyseswas performed using full production cost. For each pattern, the crops other than rice was transformed to equivalent rice. The BCR was calculated for each pattern (Table 12.3).

Table 12.3 Cropping pattern wise rice-equivalent yield, no. of irrigation required, irrigation amount, irrigation saving, net income and BCR

Cropping Pattern	Rice-eqivalent yield (t/ha)	No. of irrigation required	Irri. Amount, (seasonal total) cm	Net Income (tk/ha)	BCR	Irrigation Saving %	Yield Reduction %
P-1 (T.Aman-Mustard-T.Aus)	14.56	11	57	105437	1.47	41.84	7.06
P-2 (T.Aman-Lentil-T.Aus)	14.43	10	53	96733	1.43	45.92	7.85
P-3 (T.Aman-Wheat-T.Aus	13.73	12	61	95303	1.42	37.76	12.32
P-4 (T.Aman-Mustard-Boro)	15.66	18	98	119134	1.51	-	-
P-5 (T.Aman-Fallow-Boro)	12.10	20	106	82101	1.42		

Result:

Cropping pattern wise rice-equivalent yield, no. of irrigation required, irrigation amount, irrigation saving, net income and BCR are presented in Table 12.3.All the new cropping patterns yielded higher REY with reduced water compared to farmer's existing pattern, P-5(T. Aman- Fallow-Boro). The higher cost benefit ratio indicated the superiority of the improved patterns over the existing pattern.The pattern P-4 (T. Aman-Mustard-Boro) with AWD in Boro, yielded the highestREY (as well as net profit)with 98 cm seasonal irrigation water. The pattern P-1 (T. Aman-Mustard-T. Aus) yielded the 2nd highest REY (as well as net profit) with 41.84% irrigation watersavingscompare to P-4 (T. Aman-Mustard-Boro); but sacrificing 7.06% yield.

Conclusion:

From water-saving and economic pint of view, improved pattern *T.Aman – Mustard-T.Aus (Pattern-1)*is superior to existing and other studied patterns.

Agronomy Division

Research Highlights

- In Aus season, among different transplanting time, April 15 produced maximum yield (4.41 t ha^{-1}) by NERICA mutant, N_4/350/P-4(5) in Chapainawabgonj followed by BRRI dhan48 (4.31 t ha^{-1}).
- In Aman season, among different transplanting time, July 30 produced maximum yield (4.86 t ha^{-1}) by the mutant, RU-Kas-60(C)-1 at 20 cm×15 cm spacing in Mymensingh.
- In Aman season, the effect of combined application of different levels of silicon and plant growth retardants, the cultivar Chinishail produced the maximum yield (2.78 t ha^{-1}) at silicon 7.5 kg ha^{-1} and plant growth retardants 600 ppm.
- In Boro season, the mutant, RM-40(C)-4-2-8 was evaluated under four transplanting time at Rangpur. The highest grain yield (5.88 t ha^{-1}) was produced at January 15 transplanting.
- In Boro season, among different tillage, plough land at 20 cm depth with 60 cm disc by 5 times and application of FYM (5 t ha^{-1}) gives the maximum yield 6.68 t ha^{-1} in saline prone area in Satkhira.
- In Aus season, among different establishment method, the application of super mix (herbicide) in transplanting method Binadhan-19 produced the maximum yield (4.58 t ha^{-1}) in Mymensingh.
- In Boro season, among herbicide treatments, the highest grain yield (5.49 t ha^{-1}) was obtained with the application of serious followed by super mix (5.36 t ha^{-1}).
- Study on determination of optimum seed rate for growth and yield of lentil lines/variety, LM-118-9 produced the highest seed yield (1.96 t ha^{-1}) at 30 kg ha^{-1} seed rate at Ishurdi followed by LM-138-3 (1.92 t ha^{-1}) at Chapainawabganj.
- Study on determination of optimum sowing date and spacing for growth and yield of mungbean lines/variety, MBM-656-51-2 produced maximum seed yield (843 kg ha^{-1}) at 25 cm row spacing followed by BARI Mung-8 (828.6 kg ha^{-1}) sowing at Feb. 18 in both locations.
- Among different sesame mutant line SM-003 produced maximum seed yield (1.19 t ha^{-1}) at 30 cm line spacing in Chapainawabganj.
- Among different mustard mutant line RM-10 produced the highest seed yield (1.73 t ha^{-1}) at 20 cm line spacing followed by RM-07 produced the highest seed yield (1.66 t ha^{-1}) at same spacing in Rangpur.
- Among different wheat mutant line/variety Morocco Gom-1 produced the highest grain yield 4.42 t ha^{-1} which is followed by BARI Gom28 (4.18 t ha^{-1}) in Rangpur.

Effect of date of transplanting on the yield and yield contributing characters of NERICA rice mutants/variety in Aus season at drought prone areas

The experiment was conducted at drought prone areas of BINA Sub-station, Ishurdi and Chapainawabganj. Two advanced mutant lines N_4/350/P-4(5) and N_{10}/350/P-(4) were evaluated compared with one check variety BRRI dhan48 with four transplanting dates were March 15, March 30, April 15 and April 30 during aus season 2018. The objective was to evaluate the yield performances of mutant lines as affected by different dates of transplanting. Twenty five days old seedlings were transplanted in a randomized complete block design with three replications. The unit plot size was 3 m×4 m. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were compared with LSD.

The effect of dates of transplanting on grain yield of March 30 was the highest (3.51 t ha^{-1}) whereas April 30 produced the lowest grain yield 2.19 t ha^{-1} (Table 1). Among the NERICA mutant lines/varieties, BRRI dhan48 produced the highest grain yield (4.15 t ha^{-1}) followed by N_{10}/350/P-(4) produced (3.65 t ha^{-1}). The interaction effect of date and variety showed that N_{10}/350/P-(4) produced the maximum yield (4.02 t ha^{-1}) at March 30 followed by BRRI dhan48 (3.55 t ha^{-1}) at same date. The interaction effect of date and location showed that in April 15 produced the maximum seed yield (3.96 t ha^{-1}) in April 15 followed by Chapainawabganj at March 15 (3.69 t ha^{-1}). The interaction effect of variety and location the mutant line N_4/350/P-4(5) produced maximum yield (3.31 t ha^{-1}) in Chapainawabganj followed by BRRI dhan48 at Ishurdi (2.99 t ha^{-1}). The interaction effect of date, variety and location showed that transplanting at April 15, mutant line N_4/350/P-4(5) produced maximum yield (4.41 t ha^{-1}) in Chapainawabganj followed by BRRI dhan48 at Ishurdi (4.31 t ha^{-1}) March 15. The data recorded on crop duration from transplanting to maturity revealed that the advanced mutant line N_4/350/P-4(5) required the least average 106 days and the BRRI dhan48 required maximum average 116 days (Table 1).

Table 1. Effect of date of transplanting on the yield and yield contributing characters of NERICA rice mutant/variety in Aus season at drought prone area

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Location(s):									
Ishurdi (L_1)	79.9	11.2	9.8	21.6	85.1	34.9	21.1	3.03	4.17
Chapainawabgonj(L_2)	86.3	13.1	11.6	22.5	72.1	26.5	21.8	2.75	4.09

T value	*	NS	NS	NS	*	*	NS	NS	NS
March 15 (D_1)	87.1	12.1	10.5	21.9	86.4	32.6	21.6	3.36	4.32
March 30 (D_2)	90.1	10.9	9.7	22.1	92.6	22.9	21.5	3.51	4.53
April 15 (D_3)	80.6	10.3	9.1	23.2	73.4	31.7	21.3	2.50	3.89
April 30 (D_4)	74.6	15.1	13.5	21.0	62.0	35.4	21.4	2.19	3.61
$LSD_{0.05}$	3.9	0.9	1.0	NS	10.3	3.7	NS	0.33	0.46
Mutants/Variety :									
N_4/350/P-4(5) (V_1)	79.8	12.5	11.1	21.7	80.6	33.7	21.1	3.48	4.98
N_{10}/350/P-(4) (V_2)	85.6	12.3	11.1	21.6	80.7	30.4	21.9	3.65	4.56
BRRI dhan48 (V_3)	83.8	11.6	9.9	22.8	74.5	27.9	21.3	4.15	5.64
$LSD_{0.05}$	1.5	0.6	0.6	NS	5.0	3.5	0.3	0.68	0.28
Dates ×Mutant/Variety :									
D_1V_1	84.2	12.6	10.5	21.7	93.4	35.2	20.9	3.19	4.44
D_1V_2	91.7	12.4	11.2	22.2	86.2	35.6	22.3	3.64	4.72
D_1V_3	85.4	11.5	9.9	21.8	79.5	27.1	21.4	3.26	4.26
D_2V_1	84.9	10.6	9.4	22.1	93.3	31.4	21.0	2.97	4.04
D_2V_2	93.2	10.6	9.6	22.3	101.1	20.7	22.1	4.02	4.45
D_2V_3	92.4	11.4	10.1	21.9	83.4	16.8	21.3	3.55	4.85
D_3V_1	79.0	10.3	9.4	22.0	74.0	30.6	21.1	2.53	3.40
D_3V_2	81.7	10.4	9.2	21.1	73.3	31.6	22.2	2.67	3.74
D_3V_3	81.1	10.2	8.7	26.3	72.9	32.8	20.6	2.30	3.69
D_4V_1	71.3	16.4	14.9	21.1	61.7	37.6	21.4	2.03	3.73
D_4V_2	76.0	15.9	14.3	20.7	62.1	33.6	21.1	2.26	3.94
D_4V_3	76.5	13.1	11.1	21.1	62.1	35.1	21.9	2.28	4.00
$LSD_{0.05}$	3.0	1.1	1.2	4.1	10.1	6.9	0.6	0.30	0.56
Dates ×Location :									
D_1L_1	86.1	11.9	9.6	20.8	82.9	37.9	20.8	2.76	3.90
D_1L_2	91.3	10.3	9.2	21.9	92.2	31.3	21.3	3.69	4.69
D_2L_1	76.0	12.0	9.8	23.4	98.6	14.0	21.5	2.89	5.12
D_2L_2	66.3	12.5	11.4	20.2	89.8	36.2	21.2	2.77	4.07
D_3L_1	88.0	12.4	11.4	23.0	89.9	27.4	22.3	3.96	4.35
D_3L_2	89.0	11.5	10.2	22.3	93.1	14.6	21.7	3.33	4.31
D_4L_1	85.3	10.6	9.2	22.9	71.1	29.3	21.4	2.12	3.20
D_4L_2	82.9	17.8	15.6	21.7	34.2	34.7	21.7	1.60	3.71
$LSD_{0.05}$	5.5	1.3	1.4	NS	14.5	5.3	0.8	0.48	0.65
Mutant/Variety×Location :									
V_1L_1	76.8	11.5	10.0	20.9	86.8	40.2	20.7	2.89	4.08
V_1L_2	81.5	11.4	10.3	20.7	88.2	31.3	22.0	3.31	4.30
V_2L_1	81.4	10.7	9.2	23.2	80.3	33.1	20.6	2.89	4.13
V_2L_2	82.9	13.5	12.2	22.6	74.4	27.2	21.4	2.48	3.88
V_3L_1	89.8	13.3	11.9	22.4	73.1	29.5	21.9	2.99	4.22
V_3L_2	86.2	12.4	10.7	22.4	68.7	22.8	22.0	2.80	4.16
$LSD_{0.05}$	2.1	0.8	0.9	NS	7.1	4.9	0.4	0.21	0.40
Dates×Mutant/Variety×Location :									
$L_1D_1V_1$	86.3	12.5	9.2	21.0	92.7	37.1	20.2	2.98	4.27
$L_2D_1V_1$	87.5	13.1	11.5	20.5	81.0	37.0	22.0	2.87	3.85
$L_1D_1V_2$	84.5	10.3	8.2	20.8	74.9	39.5	20.1	2.43	3.58
$L_2D_1V_2$	84.2	10.4	9.1	21.9	90.0	48.7	20.6	3.09	4.09
$L_1D_1V_3$	96.5	9.6	8.6	22.5	105.6	24.4	22.6	4.31	5.05
$L_2D_1V_3$	93.1	10.8	9.9	21.3	80.9	20.9	20.6	3.68	4.94
$L_1D_2V_1$	74.4	10.1	9.2	20.9	77.5	34.9	20.8	2.80	3.93
$L_2D_2V_1$	76.3	9.7	9.0	19.7	73.4	32.2	22.3	3.23	4.27
$L_1D_2V_2$	77.2	10.3	8.7	29.7	76.0	34.9	20.4	2.62	3.85
$L_2D_2V_2$	62.3	13.0	12.3	19.7	87.1	40.1	21.3	2.67	4.03
$L_1D_2V_3$	65.7	13.0	12.1	20.1	92.9	31.4	21.1	2.82	4.05
$L_2D_2V_3$	70.9	11.5	9.8	20.9	89.4	37.1	21.2	2.84	4.14
$L_1D_3V_1$	82.1	12.7	11.7	22.3	94.1	33.2	21.6	3.40	5.21
$L_2D_3V_1$	95.8	11.7	10.9	23.9	91.3	34.3	22.6	4.41	5.19
$L_1D_3V_2$	86.2	12.7	11.5	22.9	84.2	14.6	22.8	4.08	4.95
$L_2D_3V_2$	85.5	10.7	9.7	22.3	96.6	14.1	21.4	2.85	3.98

$L_1D_3V_3$	89.8	11.7	10.6	22.1	96.7	17.0	21.7	3.73	4.66
$L_2D_3V_3$	91.7	12.1	10.3	22.5	86.0	12.6	22.0	3.42	4.29
$L_1D_4V_1$	83.7	10.6	9.5	23.2	70.4	26.3	21.4	2.26	2.88
$L_2D_4V_1$	87.1	11.1	9.5	22.5	73.1	30.9	22.1	2.11	3.20
$L_1D_4V_2$	85.0	10.2	8.6	22.9	69.7	30.7	20.8	1.98	3.53
$L_2D_4V_2$	80.3	19.9	17.6	22.5	36.4	35.1	21.4	1.38	3.43
$L_1D_4V_3$	86.3	18.7	16.6	21.3	31.3	35.8	21.2	1.70	3.84
$L_2D_4V_3$	82.1	14.7	12.5	21.4	34.9	33.2	22.5	1.72	3.85
$LSD_{0.05}$	4.2	1.6	1.7	5.9	14.2	9.8	0.8	0.42	0.79
CV%	6.5	10.1	9.8	16.0	10.9	19.3	5.5	11.1	11.53

Effect of different row spacing and dates of transplanting on yield and yield contributing characters of Kasalath rice mutant/variety in T. Aman season

The experiment was conducted in BINA HQ farm Mymensingh. One advanced mutant line was evaluated compared with one check variety with three row spacing and three dates of transplanting during Aman season at Mymensingh. The objective was to evaluate the yield performances of mutant line as affected by different levels of spacing and dates of transplanting. Three levels of spacing were 20 cm×15 cm, 20 cm×20 cm and 20 cm×25 cm. The advanced mutant line was RU-Kas-60(C)-1, and the check variety Binadhan-11. Twenty five days old seedlings were transplanted in a split-split plot design with three replications. The unit plot size was 3 m×4 m. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were compared with LSD.

Among different dates of transplanting July 30 was the highest (4.71 t ha^{-1}) whereas Aug 15 transplanting produced the lowest grain yields (4.18 t ha^{-1}) (Table 2). Among the mutant line/variety, RU-Kas-60(C)-1 produced the highest grain yield (4.39 t ha^{-1}). The grain yield of 20 cm×15 cm spacing was the highest (4.54 t ha^{-1}) whereas 20 cm×25 cm spacing produced the lowest grain yields (3.89 t ha^{-1}). The interaction effect of date and variety showed that RU-Kas-60(C)-1 produced the maximum yield (4.34 t ha^{-1}) transplanting at July 30. The interaction effect of date and spacing transplanting at July 30 produced the maximum yield (4.64 t ha^{-1}) at 20 cm×15 cm spacing. The interaction effect of variety and spacing showed that RU-Kas-60(C)-1 produced maximum yield (4.63 t ha^{-1}) at 20 cm×15 cm spacing. The interaction effect of date, variety and spacing showed that the mutant line RU-Kas-60(C)-1 produced maximum yield (4.86 t ha^{-1}) at 20cm×15cm spacing in July 30 transplanting. The data recorded on crop duration from transplanting to maturity revealed that Binadhan-11 required the least average 116 days and the advanced mutant line RU-Kas-60(C)-1 required maximum average 122 days (Table 2).

Table 2. Effect of different spacing and dates of transplanting on the yield and yield contributing characters of Kasalath rice mutant/variety in aman season

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Dates of transplanting:									
July 15 (D_1)	105.8	9.9	8.7	28.1	125.6	29.0	22.6	4.32	5.46
July 30 (D_2)	102.3	9.2	8.3	25.9	139.7	17.1	22.5	4.71	5.45
Aug. 15 (D_3)	98.7	15.6	9.5	23.9	120.5	22.4	21.9	4.18	5.50
$LSD_{0.05}$	3.0	NS	0.8	1.5	NS	3.1	NS	NS	NS
Mutant/Varieties:									
RU-Kas-60(C)-1 (V_1)	107.6	13.2	8.8	26.5	136.5	23.5	22.2	4.39	5.39
Binadhan-11 (V_2)	97.0	9.9	8.9	25.4	120.7	15.1	22.4	4.14	5.56
T value	*	*	NS	NS	*	*	NS	NS	NS
Row spacing:									
20cm×15cm (S_1)	101.7	14.2	7.9	25.4	122.3	24.0	22.3	4.54	5.82
20cm×20cm (S_2)	102.4	10.1	9.1	26.0	126.1	21.4	22.3	4.16	5.47
20cm×25cm (S_3)	102.7	10.5	9.4	26.5	137.4	23.1	22.4	3.89	5.12
$LSD_{0.05}$	NS	NS	0.7	0.5	6.2	NS	NS	0.06	0.08
Dates × Mutant /Variety:									
D_1V_1	110.6	9.8	8.6	29.1	131.6	29.3	22.8	4.15	5.38
D_1V_2	100.9	9.9	8.8	27.1	119.6	28.7	22.4	4.08	5.53
D_2V_1	104.5	9.4	8.6	25.5	149.6	19.0	22.5	4.34	5.35
D_2V_2	100.2	9.0	8.0	26.3	129.7	15.2	22.4	4.21	5.56
D_2V_1	107.6	20.4	9.1	25.0	128.2	22.1	21.3	4.22	5.43
D_2V_2	89.9	10.8	9.9	22.9	112.8	22.8	22.4	4.13	5.58
$LSD_{0.05}$	2.3	NS	1.4	1.1	14.2	10.1	NS	NS	0.20
Dates × Spacing:									
D_1 S_1	105.2	8.7	7.6	27.9	118.0	32.2	22.5	4.44	5.81
D_1 S_2	105.9	10.0	9.1	28.2	121.4	27.7	22.7	4.11	5.45
D_1 S_3	106.1	10.8	9.3	28.2	137.3	27.1	22.6	3.80	5.12
D_2 S_1	101.2	8.3	7.4	25.1	129.4	16.4	22.4	4.64	5.77
D_2 S_2	102.6	9.2	8.3	25.9	137.2	15.4	22.6	4.21	5.48
D_2 S_3	103.2	10.1	9.1	26.8	152.4	19.5	22.5	3.78	5.11
D_3 S_1	98.6	15.5	8.6	23.3	119.4	23.5	22.0	4.56	5.89
D_3 S_2	98.8	11.0	10.1	24.1	119.7	21.1	21.5	4.17	5.49
D_3 S_3	98.9	10.4	9.8	24.5	122.4	22.6	22.1	3.80	5.13
$LSD_{0.05}$	2.2	5.6	1.2	0.9	10.8	9.7	NS	0.10	0.14
Mutant/Variety × Spacing:									
V_1 S_1	107.3	19.2	7.9	26.0	127.5	26.0	22.1	4.63	5.83
V_1 S_2	107.5	10.5	9.4	26.5	136.4	23.6	22.1	4.16	5.36
V_1 S_3	107.9	9.9	9.0	27.1	145.6	20.8	22.4	3.79	4.97
V_2 S_1	96.1	9.1	7.9	24.9	117.1	22.0	22.5	4.46	5.81
V_2 S_2	97.4	9.7	8.8	25.5	115.8	19.2	22.4	4.16	5.59
V_2 S_3	97.6	11.0	9.9	25.8	129.2	25.4	22.4	3.80	5.27
$LSD_{0.05}$	1.8	NS	1.0	0.7	8.8	NS	NS	0.08	0.12
Dates × Mutant/Variety × Spacing:									
D_1V_1 S_1	110.5	8.6	7.8	29.1	121.8	32.9	22.5	4.55	5.80
D_1V_1 S_2	110.7	10.2	9.0	28.9	131.1	30.6	23.0	4.13	5.36
D_1V_1 S_3	110.6	10.5	9.0	29.3	141.9	24.4	22.9	3.77	4.98
D_1V_2 S_1	99.9	8.8	7.5	26.7	114.3	31.5	22.5	4.33	5.81
D_1V_2 S_2	101.2	9.9	9.1	27.5	111.7	24.8	22.4	4.08	5.54
D_1V_2 S_3	101.7	11.2	9.7	27.1	132.7	29.7	22.3	3.83	5.25
D_2V_1 S_1	104.0	10.1	9.5	24.8	138.5	20.1	22.3	4.86	6.34
D_2V_1 S_2	104.5	9.7	8.7	25.4	153.3	17.6	22.7	4.17	5.33

$D_2V_1\,S_3$	105.0	10.3	9.6	26.4	157.1	19.5	22.7	3.77	4.92
$D_2V_2\,S_1$	98.5	8.4	7.4	25.5	120.3	12.7	22.5	4.62	5.73
$D_2V_2\,S_2$	100.6	8.7	7.8	26.3	121.1	13.3	22.6	4.24	5.63
$D_2V_2\,S_3$	101.5	9.9	8.7	27.2	147.7	19.6	22.3	3.79	5.30
$D_3V_1\,S_1$	107.3	10.9	8.3	24.0	122.1	25.0	21.6	4.67	5.89
$D_3V_1\,S_2$	107.3	11.6	10.6	25.3	124.7	22.7	20.7	4.16	5.39
$D_3V_1S_3$	108.0	8.8	8.4	25.7	137.7	18.5	21.7	3.83	5.02
$D_3V_2\,S_1$	89.8	10.1	8.9	22.6	116.7	21.9	22.3	4.44	5.89
$D_3V_2\,S_2$	90.3	10.4	9.5	22.8	114.7	19.6	22.3	4.17	5.59
$D_3V_2\,S_3$	89.7	12.1	11.3	23.3	107.1	26.7	22.5	3.77	5.25
$LSD_{0.05}$	3.1	2.1	1.7	1.3	15.3	13.7	NS	0.14	0.20
CV%	5.1	11.1	10.3	6.4	9.6	14.6	2.99	4.56	6.80

Determination of lodging resistance, growth and yield of selected local T. Aman aromatic rice cultivars by application of silicon and plant growth retardant

The experiment was conducted at BINA HQs farm Mymensingh during Aman season 2018. Two local cultivars Tulsimala and Chinishail were evaluated with five levels of silicon and plant growth retardants combination, Control, silicon 2.5 kg ha^{-1}, plant growth retardants 200 ppm(S_1P_1), silicon 5 kg ha^{-1}, plant growth retardants 400 ppm (S_2P_2), silicon 7.5 kg ha^{-1}, plant growth retardants 600 ppm (S_3P_3) and silicon 10 kg ha^{-1}, plant growth retardants 800 ppm (S_4P_4). The objective was to evaluate the lodging resistance, growth and yield of selected local aromatic rice varieties. Twenty-five day old seedlings were transplanted in a Randomized Complete Block Design with three replications. The unit plot size was 3 m×4 m. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were compared with LSD.

The effect of combined application of different levels of silicon and plant growth retardants significantly increases the lodging resistance and yield of rice. The effect of combined application of silicon 7.5 kg ha^{-1}, plant growth retardants 600 ppm gives the maximum yield 2.73 t ha^{-1}. The interaction effect of cultivar with silicon and plant growth retardants the cultivar Chinishail produced the maximum yield (2.78 t ha^{-1}) silicon 7.5 kg ha^{-1}, plant growth retardants 600 ppm (Table 3).

Table 3. Yield and yield contributing characters of selected local T. Aman aromatic rice cultivars by application of silicon and plant growth retardant

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains Panicle^{-1} (no.)	1000 Seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Cultivars									
Tulsimala(V_1)	102.3	12.8	12.0	26.0	132.8	5.3	24.2	5.8	9.3
Chinishail(V_2)	100.9	13.0	12.0	26.8	137.6	4.9	24.2	6.6	9.8

T value	NS	NS	NS	1.8	17.0	NS	1.4	0.4	0.9
Silicon and plant growth retardant levels :									
Control (S_0P_O)	114.0	10.5	9.0	22.0	102.2	14.8	10.6	2.15	7.10
2.5 kg ha^{-1},200 ppm (S_1P_1)	112.6	11.4	10.7	21.1	104.8	16.2	10.6	2.43	6.88
5 kg ha^{-1},400 ppm (S_2P_2)	115.1	9.8	8.8	22.0	110.7	16.9	10.5	2.64	6.48
7.5 kg ha^{-1},600 ppm (S_3P_3)	115.4	10.8	10.2	22.9	122.3	17.5	10.5	2.73	6.06
10 kg ha^{-1},800 ppm (S_4P_4)	115.5	11.4	10.6	24.0	117.9	13.6	10.5	2.72	5.65
$LSD_{.05}$	NS	NS	1.6	2.1	NS	3.7	0.3	0.15	0.46
Variety × Silicon and plant growth retardant levels :									
$V_1S_0P_O$	123.4	10.3	8.1	22.6	113.6	18.7	10.8	1.82	7.14
$V_1S_1P_1$	120.7	12.5	11.1	22.3	135.1	18.3	10.8	2.07	6.72
$V_1S_2P_2$	124.3	8.9	7.9	22.4	128.7	16.9	10.4	2.31	6.33
$V_1S_3P_3$	125.5	10.8	10.3	22.3	125.1	19.5	10.5	2.57	5.97
$V_1S_4P_4$	125.3	11.0	10.6	21.3	106.5	14.7	10.5	2.55	5.42
$V_2S_0P_O$	104.6	10.7	9.9	21.4	90.8	10.9	10.4	2.11	7.07
$V_2S_1P_1$	104.5	10.3	10.4	19.9	74.5	14.1	10.4	2.29	7.03
$V_2S_2P_2$	106.0	10.6	9.8	21.6	92.8	16.9	10.5	2.41	6.63
$V_2S_3P_3$	105.3	10.9	10.0	23.5	119.5	15.5	10.5	2.78	6.15
$V_2S_4P_4$	105.7	11.8	10.7	26.7	129.2	12.4	10.5	2.71	5.89
$LSD_{.05}$	14.9	5.0	2.2	3.2	38.3	5.2	0.4	0.22	0.65
CV(%)	7.6	9.8	13.0	5.4	10.0	9.1	2.3	5.23	5.92

Effect of date of transplanting and row spacing on the yield and yield contributing characters of mutant line RM-40(c)-4-2-8 in Boro season

The experiment was conducted at BINA HQs farm and BINA sub-station, Rangpur during Boro season 2018-19. The mutant line, RM-40(c)-4-2-8 was evaluated compared with two check varieties Binadhan-18, BRRI dhan28 with four dates of transplanting and spacing. The objective was to evaluate the yield performances of mutant line as affected by different dates of transplanting and spacing. Three different dates of transplanting were January 15, February 1 and February 15 in Mymensingh and four dates of transplanting at BINA sub-station, Rangpur. Three row spacing were 20cm×15cm, 20cm×20cm, 20cm×25cm in both location. Thirty five day old seedlings were transplanted in a split-split plot designed with three replications. The unit plot size was 3 m×4 m. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were compared with LSD. The results of transplanting and spacing are discussed below separately.

Mymensingh

The effect of dates of transplanting on grain yield showed that of Jan. 15 transplanting produced the highest grain yield (5.13 t ha^{-1}) whereas Feb. 15 transplanting produced the lowest grain yields (4.61 t ha^{-1}). The mutant line, RM-40(c) -4-2-8 produced the highest grain yield (5.67 t ha^{-1}) followed by BRRI dhan28 (4.26 t ha^{-1}). Among different row spacings, (20cm×15cm) produced the highest grain yield (5.25 t ha^{-1}). The interaction effect of date and variety showed that mutant line, RM-40(c)-4-2-8 produced the maximum yield (5.87 t ha^{-1}) at January 15 transplanting followed by Feb. 1 (5.74 t ha^{-1}). The interaction effect of date, variety and spacing showed that the mutant line, RM-40(c)-4-2-8 produced maximum yield (6.12 t ha^{-1}) at 20cm×15cm spacing in Jan. 15 transplanting. The data recorded on crop duration from transplanting to maturity revealed that BRRI dhan28 required the least average 125 days and the Binadhan-18 required maximum average 131 days (Table 4).

Table 4. Effect of date of transplanting on the yield and yield contributing characters of Boro rice mutant/varieties at BINA HQs farm mymensingh

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Dates of transplanting :									
January 15 (D_1)	111.8	12.7	11.2	25.2	127.3	32.4	21.4	5.13	6.35
February 01 (D_2)	109.0	13.3	11.7	25.3	127.9	32.4	21.4	5.06	6.62
February 15 (D_3)	98.0	11.0	9.9	24.6	120.9	30.0	21.4	4.61	6.54
$LSD_{0.05}$	3.3	1.2	1.3	0.6	NS	NS	NS	NS	NS
Mutant/Varieties :									
RM-40(c) -4-2-8 (V_1)	118.8	11.8	10.6	27.2	140.9	30.9	19.7	5.67	7.35
Binadhan-18 (V_2)	102.3	12.7	11.0	25.5	118.0	33.2	22.1	4.23	5.91
BRRI dhan28 (V_3)	97.7	12.5	11.1	22.4	117.2	30.7	22.5	5.26	6.25
$LSD_{0.05}$	1.8	1.2	NS	0.4	8.0	NS	0.2	0.23	0.38
Spacings:									
20cm×15cm (S_1)	105.8	11.5	10.1	25.2	123.4	32.7	21.4	5.45	6.87
20cm×20cm (S_2)	106.2	12.4	10.9	24.9	128.4	31.8	21.5	5.01	6.51
20cm×25cm (S_3)	106.8	13.2	11.7	25.0	124.4	30.3	21.3	4.69	6.13
$LSD_{0.05}$	NS	1.3	0.3	NS	4.5	NS	NS	0.07	0.17
Dates × Varieties :									
D_1V_1	120.9	12.7	11.2	27.1	148.5	29.0	19.4	5.87	7.65
D_1V_2	111.7	11.8	10.5	25.6	117.6	36.8	22.4	3.97	5.46
D_1V_3	102.7	13.7	11.8	22.9	116.0	31.4	22.5	5.12	5.92
D_2V_1	121.2	13.1	12.0	27.3	142.5	33.7	19.6	5.74	7.56
D_2V_2	103.3	13.8	11.3	25.7	121.2	32.9	22.1	4.35	5.89
D_2V_3	102.6	13.0	11.8	22.7	120.0	30.6	22.5	5.11	6.41
D_3V_1	114.4	9.7	8.6	27.0	131.8	30.0	20.0	5.56	6.84
D_3V_2	91.9	12.4	11.1	25.1	115.2	29.9	21.7	4.36	6.36
D_3V_3	87.8	10.9	9.8	21.8	115.7	30.0	22.5	4.96	6.43
$LSD_{0.05}$	3.1	0.8	1.3	0.7	13.8	NS	0.4	0.39	0.65
Dates × Spacings :									
D_1 S_1	111.2	11.9	10.2	25.4	128.0	34.6	21.5	5.61	6.81
D_1 S_2	112.2	12.7	11.3	25.0	128.2	32.8	21.6	5.06	6.42
D_1 S_3	111.9	13.6	11.9	25.1	125.8	29.9	21.2	4.72	5.80
D_2 S_1	108.9	12.4	10.8	25.7	124.6	32.0	21.4	5.41	6.94
D_2 S_2	109.0	13.3	11.6	25.0	131.4	33.7	21.6	4.99	6.59
D_2 S_3	109.1	14.2	12.7	25.1	127.8	31.6	21.2	4.80	6.33
D_3 S_1	97.2	10.1	9.3	24.5	117.6	31.5	21.5	5.34	6.87
D_3 S_2	97.6	11.1	9.8	24.7	125.5	28.8	21.2	4.98	6.52
D_3 S_3	99.3	11.8	10.5	24.8	119.6	29.6	21.5	4.56	6.25

$LSD_{0.05}$	1.0	0.2	0.5	0.7	7.8	NS	NS	0.12	0.29
Varieties × Spacings :									
$V_1 S_1$	118.2	10.8	9.7	27.1	138.4	32.4	19.7	5.86	7.76
$V_1 S_2$	118.9	11.9	10.8	27.1	145.3	31.0	19.8	5.63	7.35
$V_1 S_3$	119.3	12.8	11.3	27.3	139.1	29.4	19.5	5.51	6.93
$V_2 S_1$	102.0	11.9	10.1	26.0	113.7	34.2	22.2	4.56	6.21
$V_2 S_2$	102.1	12.7	10.8	25.3	122.4	33.8	22.1	4.24	5.86
$V_2 S_3$	102.8	13.4	12.0	25.2	117.8	31.6	21.9	3.88	5.64
$V_3 S_1$	97.1	11.7	10.4	22.6	118.0	31.4	22.4	5.65	6.64
$V_3 S_2$	97.8	12.5	11.1	22.3	117.3	30.5	22.5	5.06	6.32
$V_3 S_3$	98.3	13.4	11.8	22.5	116.3	30.1	22.5	4.69	5.80
$LSD_{0.05}$	NS	0.4	0.5	0.7	7.8	NS	0.4	0.12	0.29
Dates × Varieties × Spacings :									
$D_1V_1 S_1$	121.1	11.9	10.3	27.2	151.7	33.7	19.3	6.12	8.06
$D_1V_1 S_2$	121.1	12.6	11.5	26.9	145.7	26.0	19.6	5.70	7.84
$D_1V_2 S_3$	120.4	13.5	11.7	27.3	148.1	27.3	19.4	5.48	7.06
$D_1V_2 S_1$	110.5	11.1	9.4	26.4	116.7	40.7	22.7	4.51	6.07
$D_1V_2 S_2$	112.5	11.9	10.7	25.4	121.7	37.1	22.4	3.89	5.48
$D_1V_2 S_3$	112.2	12.6	11.5	25.1	114.3	32.7	22.0	3.50	4.84
$D_1V_3 S_1$	102.1	12.7	10.9	22.7	115.7	29.4	22.4	5.50	6.31
$D_1V_3 S_2$	102.9	13.6	11.8	22.8	117.3	35.2	22.7	5.17	5.94
$D_1V_3 S_3$	103.2	14.7	12.5	23.1	115.0	29.7	22.3	4.68	5.52
$D_2V_1 S_1$	120.1	11.9	10.9	27.4	140.2	34.3	19.5	5.92	8.02
$D_2V_1 S_2$	121.3	13.2	12.0	27.3	147.1	34.5	20.0	5.58	7.48
$D_2V_2 S_3$	122.1	14.2	13.3	27.3	140.2	32.3	19.3	5.32	7.19
$D_2V_2 S_1$	103.2	13.2	10.6	26.5	110.2	32.3	22.3	4.51	6.16
$D_2V_2 S_2$	102.8	13.7	10.9	25.3	129.7	35.3	22.3	4.35	5.78
$D_2V_2 S_3$	103.8	14.4	12.3	25.4	123.7	31.0	21.7	4.19	5.75
$D_2V_3 S_1$	103.5	12.0	11.0	23.3	123.3	29.3	22.4	5.40	6.65
$D_2V_3 S_2$	102.9	13.1	11.9	22.3	117.3	31.3	22.4	5.04	6.53
$D_2V_3 S_3$	101.5	13.9	12.4	22.5	119.3	31.3	22.7	4.88	6.05
$D_3V_1 S_1$	113.5	8.6	8.0	26.7	123.3	29.3	20.4	5.94	7.21
$D_3V_1 S_2$	114.3	9.9	8.9	27.1	143.1	32.3	19.8	5.50	6.74
$D_3V_2 S_3$	115.5	10.7	9.1	27.2	128.8	28.5	19.8	5.24	6.56
$D_3V_2 S_1$	92.3	11.5	10.4	25.0	114.3	29.7	21.7	4.67	6.41
$D_3V_2 S_2$	90.9	12.5	10.9	25.2	116.0	29.0	21.5	4.47	6.33
$D_3V_2 S_3$	92.3	13.2	12.1	25.2	115.3	31.0	22.0	3.93	6.34
$D_3V_3 S_1$	85.7	10.3	9.4	21.7	115.0	35.5	22.3	5.41	6.97
$D_3V_3 S_2$	87.5	10.9	9.7	21.7	117.3	25.1	22.4	4.98	6.48
$D_3V_3 S_3$	90.1	11.5	10.4	22.0	114.7	29.3	22.7	4.49	5.84
$LSD_{0.05}$	1.7	0.6	0.9	5.2	13.5	10.2	0.7	0.20	0.50
CV%	4.1	10.6	11.4	7.2	10.7	9.4	2.1	7.5	9.7

Rangpur

The effect of dates of transplanting on grain yield of January 15 transplanting was the highest (5.98 t ha^{-1}) whereas Feb. 15 transplanting produced the lowest grain yields (4.07 t ha^{-1}) (Table 05). Among the mutant lines/varieties, the mutant RM-40(c) -4-2-8 produced the highest grain yield (4.88 t ha^{-1}) followed by Binadhan-18 (4.81 t ha^{-1}). Among different levels of spacing, (20cm×15cm) produced the highest grain yield (4.94 t ha^{-1}). The interaction effect of date and variety showed that BRRI dhan28 produced the maximum yield (6.2 t ha^{-1}) at January 15 followed by the mutant RM-40(c)-4-2-8 (5.48 t ha^{-1}). The interaction effect of date and spacing transplanting date at January 15 produced the maximum yield (6.06 t ha^{-1}) at

20cm×15cm which followed by same transplanting date produced (5.74 t ha^{-1}) at 20cm×20cm. The interaction effect of variety and spacing the mutant RM-40(c)-4-2-8 produced maximum yield (5.09 t ha^{-1} followed by Binadhan-18 (4.98 t ha^{-1}) at same spacing 20cm×15cm. The interaction effect of date, variety and transplanting date at January 15 the mutant RM-40(c)-4-2-8 produced maximum yield (5.88 t ha^{-1}) at 20cm×15cm spacing. The data recorded on crop duration from transplanting to maturity revealed that BRRI dhan28 too earliest maturity (125 days) while Binadhan-18 took maximum maturity (131 days) (Table 5).

Table 05. Effect of date of transplanting on the yield and yield contributing characters of Boro rice mutants/variety at BINA Sub-station, Rangpur

Treatments	Plant height (cm)	Total tillers $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	1000 seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Dates of transplanting :									
January 3 (D_1)	104.4	11.4	10.4	24.0	142.0	23.3	21.3	4.84	6.00
January 15 (D_2)	112.8	13.6	11.8	25.4	153.2	13.5	21.5	5.98	7.01
February 1 (D_3)	110.8	12.2	10.7	24.2	129.2	16.9	21.5	4.22	5.70
February 15 (D_4)	113.1	11.1	9.8	25.2	145.1	20.6	21.4	4.07	5.32
$LSD_{0.05}$	NS	0.7	0.7	0.7	5.9	9.2	NS	0.22	0.19
Mutants/Variety :									
RM-40(c) -4-2-8 (V_1)	118.1	11.6	10.4	26.8	166.6	15.4	19.7	4.88	6.10
Binadhan-18 (V_2)	107.0	11.9	10.6	24.5	125.0	22.0	22.2	4.81	6.00
BRRI dhan28 (V_3)	105.8	12.7	11.2	22.8	135.6	18.4	22.4	4.60	5.93
$LSD_{0.05}$	NS	0.8	0.6	0.7	7.5	4.1	NS	0.18	NS
Spacings:									
20cm×15cm (S_1)	109.7	10.8	9.7	24.6	143.7	18.8	21.4	4.94	6.15
20cm×20cm (S_2)	110.8	12.3	11.0	24.6	142.1	18.3	21.4	4.74	5.96
20cm×25cm (S_3)	110.4	13.0	11.4	24.9	141.3	18.6	21.5	4.66	5.92
$LSD_{0.05}$	NS	0.7	0.5	NS	NS	NS	NS	0.35	0.19
Dates × Mutants /Variety:									
D_1V_1	116.1	10.8	9.8	25.2	168.1	22.5	19.5	5.48	6.43
D_1V_2	100.3	11.3	10.4	25.5	121.3	27.1	22.2	5.33	6.27
D_1V_3	96.9	12.0	10.9	21.3	136.7	20.5	22.2	3.80	5.30
D_2V_1	119.9	14.3	12.4	27.4	179.0	8.2	19.8	5.59	6.74
D_2V_2	108.5	12.7	11.2	25.2	138.7	14.7	22.3	5.68	7.15
D_2V_3	110.1	13.7	11.9	23.4	141.8	17.6	22.5	6.20	7.15
D_3V_1	115.8	9.6	9.0	25.8	144.9	15.1	19.9	4.17	5.61
D_3V_2	110.4	14.0	11.7	23.9	117.5	20.1	22.2	4.06	5.42
D_3V_3	106.2	13.1	11.4	23.0	125.2	15.4	22.4	4.44	6.08
D_4V_1	120.5	11.6	10.2	28.8	174.3	15.8	19.5	4.38	5.62
D_4V_2	108.7	9.8	8.9	23.5	122.3	26.0	22.3	3.88	5.15
D_4V_3	110.1	11.9	10.4	23.4	138.6	20.1	22.3	3.96	5.21
$LSD_{0.05}$	2.7	1.5	1.1	1.4	15.0	8.0	0.5	0.17	0.65
Dates × Spacing :									
$D_1 S_1$	103.3	9.6	8.9	24.4	145.4	22.5	21.2	4.94	5.86
$D_1 S_2$	104.0	11.6	10.7	23.6	142.0	23.6	21.3	4.69	6.07
$D_1 S_3$	106.0	12.8	11.6	24.1	138.6	24.0	21.4	4.58	6.07
$D_2 S_1$	112.2	13.0	11.4	25.5	156.7	13.5	21.5	6.06	7.24
$D_2 S_2$	113.3	13.5	11.8	25.4	152.9	13.6	21.6	5.74	6.81
$D_2 S_3$	113.0	14.2	12.3	25.1	149.9	13.4	21.6	5.17	6.99
$D_3 S_1$	110.2	10.9	9.7	23.6	127.8	19.7	21.6	4.59	5.93

D_3 S_2	111.8	12.6	11.2	24.3	131.2	14.5	21.2	4.16	5.65
D_3 S_3	110.4	13.1	11.2	24.8	128.6	16.4	21.6	3.92	5.53
D_4 S_1	113.1	9.7	8.9	24.9	144.7	19.6	21.2	4.42	5.58
D_4 S_2	113.9	11.6	10.3	25.1	142.5	21.7	21.4	4.12	5.30
D_4 S_3	112.3	11.9	10.4	25.8	148.1	20.6	21.5	3.67	5.09
$LSD_{0.05}$	2.8	1.4	0.9	0.8	12.0	4.4	0.5	0.16	0.39
Mutants/Variety × Spacing:									
V_1 S_1	118.0	10.7	9.7	26.8	170.5	14.3	19.5	5.09	6.29
V_1 S_2	117.8	11.4	10.3	26.2	164.6	15.9	19.7	4.75	5.97
V_1 S_3	118.5	12.6	11.1	27.4	164.7	16.0	19.8	4.79	6.05
V_2 S_1	106.0	10.6	9.5	24.4	128.2	22.4	22.2	4.98	6.21
V_2 S_2	107.2	12.4	10.9	24.4	124.6	20.9	22.2	4.91	5.96
V_2 S_3	107.8	12.8	11.3	24.8	122.2	22.5	22.4	4.69	5.82
V_3 S_1	105.2	11.2	9.9	22.6	132.3	19.8	22.4	4.74	5.96
V_3 S_2	107.3	13.2	11.7	23.2	137.3	18.2	22.2	4.57	5.94
V_3 S_3	105.0	13.6	11.8	22.6	137.1	17.3	22.5	4.49	5.90
$LSD_{0.05}$	2.4	1.2	0.8	0.7	10.0	3.8	0.4	0.28	0.34
Dates × Mutants/Variety× Spacing :									
D_1V_1 S_1	116.5	8.9	8.4	25.5	174.0	18.7	19.1	5.82	6.03
D_1V_1 S_2	113.6	10.7	9.7	23.0	156.9	24.7	19.6	5.67	6.72
D_1V_2 S_3	118.1	12.8	11.3	27.1	173.4	24.1	19.7	5.32	6.53
D_1V_2 S_1	99.3	9.3	8.5	25.4	124.3	27.4	22.1	5.27	6.40
D_1V_2 S_2	100.6	11.8	10.9	25.5	122.9	24.8	22.3	5.37	5.91
D_1V_2 S_3	101.0	12.8	11.9	25.5	116.7	29.0	22.2	5.37	6.50
D_1V_3 S_1	94.2	10.7	9.7	22.1	137.9	21.4	22.3	4.00	5.14
D_1V_3 S_2	97.8	12.5	11.5	22.1	146.3	21.2	22.1	3.80	5.58
D_1V_3 S_3	98.8	12.9	11.7	19.7	125.8	18.8	22.2	3.60	5.18
D_2V_1 S_1	118.9	14.1	12.3	27.5	182.3	9.3	19.8	5.88	7.13
D_2V_1 S_2	120.2	13.7	12.2	27.4	179.3	7.9	20.2	4.97	6.25
D_2V_2 S_3	120.6	15.1	12.9	27.2	175.3	7.5	19.6	5.53	6.83
D_2V_2 S_1	106.9	11.7	10.5	25.3	145.3	15.3	22.2	5.37	7.16
D_2V_2 S_2	109.0	13.2	11.3	25.1	141.3	14.9	22.1	5.67	7.14
D_2V_2 S_3	109.5	13.2	11.9	25.4	129.5	13.9	22.5	5.30	7.16
D_2V_3 S_1	110.9	13.2	11.4	23.8	142.5	16.1	22.5	5.70	7.43
D_2V_3 S_2	110.7	13.6	12.0	23.7	137.9	17.9	22.4	5.78	7.03
D_2V_3 S_3	108.7	14.2	12.2	22.8	144.9	18.8	22.7	5.67	6.98
D_3V_1 S_1	115.2	10.3	9.4	25.9	149.8	17.3	20.2	4.67	5.89
D_3V_1 S_2	116.6	9.4	9.1	25.9	143.9	13.0	19.5	4.03	5.43
D_3V_2 S_3	115.7	9.1	8.6	25.7	141.1	15.1	19.9	3.80	5.52
D_3V_2 S_1	109.3	11.9	10.1	23.9	118.9	19.7	22.3	4.33	5.77
D_3V_2 S_2	110.1	14.5	12.2	23.3	115.5	19.1	22.2	4.13	5.65
D_3V_2 S_3	111.9	15.5	12.8	24.5	118.1	21.5	22.3	3.70	4.83
D_3V_3 S_1	106.1	10.5	9.6	21.1	114.9	22.1	22.4	4.77	6.14
D_3V_3 S_2	108.7	14.0	12.2	23.6	134.1	11.3	22.0	4.30	5.85
D_3V_3 S_3	103.7	14.7	12.3	24.1	126.6	12.6	22.7	4.27	6.24
D_4V_1 S_1	121.1	9.3	8.7	28.3	176.0	12.0	19.1	5.03	6.09
D_4V_1 S_2	120.9	11.9	10.3	28.5	178.1	18.0	19.7	4.33	5.46
D_4V_2 S_3	119.6	13.4	11.4	29.7	168.9	17.4	19.7	3.77	5.30
D_4V_2 S_1	108.5	9.6	8.8	23.1	124.1	27.4	22.2	4.37	5.50
D_4V_2 S_2	109.1	10.0	9.3	23.6	118.5	24.8	22.2	3.87	5.15
D_4V_2 S_3	108.6	9.8	8.7	23.8	124.3	25.7	22.5	3.40	4.79
D_4V_3 S_1	109.5	10.3	9.1	23.3	133.9	19.4	22.2	3.87	5.14
D_4V_3 S_2	111.9	12.9	11.3	23.2	130.8	22.2	22.4	4.17	5.31
D_4V_3 S_3	108.8	12.5	10.9	23.8	151.1	18.8	22.4	3.83	5.18
$LSD_{0.05}$	4.8	2.4	1.6	1.5	21.0	7.7	0.8	0.56	0.68
CV%	5.4	12.3	9.2	5.7	10.6	25.2	2.2	7.43	10.96

Improving the yield of Boro rice through tillage and farmyard manure under salinity condition at Farmer's field, Haroddah, Satkhira

The experiment was conducted at Farmer's field of Haroddah, Satkhira during boro season, 2018-19. The objective was to find out the suitable management of tillage and application of farmyard manure for increasing yield of rice under natural salinity condition. The experiment was laid out as split plot design with three replications. The unit plot size was 5 m×4 m. Thirty five days old seedlings were transplanted at 2/3 seedlings hill^{-1}. Binadhan-10 was observed under four tillage operation by tractors i.e., Control (power tiller operated) (T_0), Plough land 20 cm depth with 60 cm disc in 3 times (T_1), Plough land 20 cm depth with 60 cm disc in 4 times, (T_2). Plough land 20 cm depth with 60 cm disc in 5 times (T_3). Gypsum 200 kg ha^{-1} and other recommended dose of fertilizers were applied. The recorded yield and yield component data were analyzed using the Analysis of Variance Technique. The mean differences were judged by LSD test.

Among the effect of tillage, plough land at 20 cm depth with 60 cm disc in 5 times had significant effect on most of the plant parameters and produced the highest grain yield (6.36 t ha^{-1}). Among the effect of FYM, application of FYM at 5 t ha^{-1} had significant effect on most of the plant parameters and produced the highest grain yield (5.89 t ha^{-1}). The interaction effect of tillage (plough land 20 cm depth with 60 cm disc 5 times) and application of FYM (5 t ha^{-1}) had significant effect on most of the plant parameters and produced the highest grain yield (6.68 t ha^{-1}) (Table 6).

Table 6. Effect of tillage and farmyard manure application on yield and yield contributing characters of boro rice under salinity condition during 2018-19 at Farmer's field Haroddah, Satkhira

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Tillage:									
Control (T_0)	110.8	9.8	8.5	25.1	98.8	12.1	23.6	5.17	6.76
Plough 3 times (T_1)	110.7	12.1	9.8	25.6	107.4	8.8	23.6	5.43	7.05
Plough 4 times (T_2)	108.9	12.9	10.3	25.6	110.9	7.0	23.8	5.87	7.62
Plough 5 times (T_3)	109.1	13.0	10.7	25.5	114.3	7.1	23.7	6.63	8.04
T value	NS	0.7	0.7	NS	5.5	2.6	NS	0.67	0.27
Fertilizer:									
Control (C_0)	106.7	11.5	9.4	25.2	110.7	8.2	23.6	4.53	7.20
FYM 2.5 t ha^{-1} (C_1)	110.4	11.9	9.8	25.6	111.0	8.1	23.5	5.10	7.25
FYM 3.75 t ha^{-1} (C_2)	109.1	11.9	9.8	25.6	111.4	9.1	23.6	5.56	7.40
FYM 5.0 t ha^{-1} (C_3)	112.0	11.9	9.9	25.5	110.2	9.4	23.9	5.89	7.36
FYM 6.25 t ha^{-1} (C_4)	110.2	11.8	9.8	25.3	104.5	8.9	23.7	5.81	7.47

FYM 7.5 t ha^{-1} (C_5)	110.9	12.6	10.2	25.5	101.3	8.9	23.6	5.73	7.52
$LSD_{.05}$	NS	0.3	0.5	0.4	NS	NS	NS	0.87	NS
Tillage × Fertilizer:									
T_0 C_0	108.0	9.5	7.9	24.7	96.0	11.0	23.3	4.42	6.23
T_0 C_1	110.0	9.3	8.2	25.5	104.3	10.1	23.5	5.46	6.78
T_0 C_2	111.4	10.1	8.6	25.8	99.9	12.5	23.1	5.13	6.68
T_0 C_3	112.4	9.7	8.9	24.7	104.0	14.7	24.0	5.28	6.47
T_0 C_4	112.4	9.7	8.6	24.7	101.7	12.0	23.9	5.24	6.86
T_0 C_5	110.9	10.4	9.0	25.0	100.9	12.3	23.6	5.68	6.98
T_1 C_0	109.0	11.7	9.5	25.5	93.0	8.4	23.9	4.58	6.32
T_1 C_1	112.5	12.3	10.1	25.9	109.1	8.3	23.0	5.33	6.71
T_1 C_2	110.1	11.9	9.8	25.4	113.2	10.1	24.0	5.48	7.10
T_1 C_3	113.1	12.2	9.4	25.8	110.0	6.2	23.7	5.47	7.14
T_1 C_4	110.1	11.6	9.3	25.4	113.2	9.9	23.8	5.52	7.36
T_1 C_5	109.2	13.0	10.5	25.4	110.0	10.2	23.3	5.58	7.28
T_2 C_0	107.0	12.5	9.8	25.7	97.7	11.7	24.0	4.57	6.98
T_2 C_1	107.7	12.7	10.6	25.7	116.8	6.7	23.6	5.61	7.54
T_2 C_2	106.9	12.7	10.2	25.5	115.7	7.1	23.9	5.83	7.76
T_2 C_3	112.0	12.6	10.7	25.4	116.3	6.9	24.1	5.88	7.74
T_2 C_4	109.0	12.9	10.1	25.8	118.7	7.4	23.7	5.82	7.79
T_2 C_5	111.0	13.9	10.3	25.6	120.0	7.2	23.4	5.79	7.51
T_3 C_0	102.9	12.4	10.6	25.0	94.2	13.2	23.2	4.68	6.91
T_3 C_1	111.3	13.3	10.2	25.4	113.9	7.2	24.1	6.39	7.99
T_3 C_2	108.0	13.0	10.6	25.5	116.7	6.8	23.6	6.61	8.06
T_3 C_3	110.3	13.1	10.5	25.9	110.6	9.8	23.8	6.68	8.08
T_3 C_4	109.2	12.9	11.2	25.4	116.2	6.3	23.5	6.28	7.86
T_3C_5	112.7	13.1	11.2	25.9	118.3	5.9	23.9	6.06	7.33
$LSD_{0.05}$	3.1	0.6	1.1	0.8	4.9	4.3	NS	0.81	0.18
CV(%)	2.7	6.8	6.6	3.8	6.0	19.5	4.2	4.33	4.47

Evaluation of the efficiency of herbicide on different establishment methods of Aus rice (Binadhan-19)

A field experiment was conducted at the Agronomy field Laboratory of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh under wet land condition during April to July in Aus season 2018. The treatments of four establishment methods were broadcasting, line sowing, dibbling and transplanting and two selected commercial grade herbicides i,e; H_0 =Control, H_1 = Super mix and H_2 = Granite. The aim was to observe the effects of herbicides on weed control, crop growth and yield in boro rice. In all cases herbicides were applied in 4-5 cm standing water in the plots. The size of the individual plot was 4m x 3m. Treatments were assigned in unit plots at random. Data on crop yield were collected at proper maturity stages of the crop. All the recorded data were compiled and analyzed using M-STAT programme and the means were judged by LSD.

The application of two selected commercial grade herbicides increased rice yield significantly. In control, grain yield was significantly decreased due to weed infestation. The treatments among four establishment methods transplanting gives the maximum yield (4.60 t ha^{-1}). The treatments among two selected commercial grade herbicides the super mix gives the highest yield (4.05 t ha^{-1}). The observation of weed competition in serious and super mix treated plot was lower than other plots. The number of effective tillers, field grains panicle^{-1} and grain yield was higher in compare with other treatment. The interaction effect of establishment methods and herbicide showed that the combination of transplanting method with super mix application gives the maximum yield 4.58 t ha^{-1} (Table 7).

Table 7. Evaluation of the efficiency of herbicide on different establishment methods of aus rice (Binadhan-19) yield and yield contributing characters

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Populations m^{-2} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Methods :										
Broadcastins (M_1)	96.0	10.6	9.0	48.8	21.4	67.3	15.1	23.7	3.99	7.12
Line sowing (M_2)	90.8	9.8	8.7	42.9	21.0	57.2	20.1	24.4	3.85	6.54
Dibbling (M_3)	92.7	10.1	8.5	41.9	20.3	59.2	12.4	24.2	4.18	6.36
Transplanting(M_4)	91.0	9.1	7.8	40.9	22.0	80.2	21.4	24.1	4.60	6.12
$LSD_{.05}$	NS	NS	NS	5.5	0.9	22.5	NS	0.5	0.83	NS
Herbicide										
Control (H_0)	92.7	9.4	8.1	44.8	21.6	76.3	15.6	24.0	3.95	6.48
Super mix(H_1)	93.4	10.2	8.7	44.8	21.2	63.7	17.5	24.2	4.05	6.59
Granite (H_2)	91.7	10.2	8.7	41.3	20.7	58.0	18.6	24.0	3.80	6.54
$LSD_{.05}$	NS	NS	NS	NS	0.8	11.8	NS	NS	0.31	NS
Methods × Herbicide :										
M_1 H_0	97.5	9.2	8.5	47.0	21.9	65.7	18.7	23.9	3.92	5.75
M_1 H_1	96.9	11.1	9.4	54.0	20.2	62.9	13.9	24.9	4.23	7.67
M_1 H_2	93.6	11.4	9.0	45.3	22.1	73.3	12.7	22.3	3.82	7.93
M_2 H_0	90.7	9.9	8.7	45.7	21.3	73.5	16.2	24.0	3.89	6.59
M_2 H_1	91.7	10.9	9.4	39.7	21.1	49.6	16.9	24.6	3.96	6.34
M_2 H_2	90.1	8.7	8.1	43.3	20.5	48.5	27.1	24.5	3.71	6.69
M_3 H_0	92.5	10.5	8.6	42.0	20.2	64.7	8.5	23.8	3.12	7.22
M_3 H_1	94.6	9.9	8.6	44.0	21.5	61.7	16.0	23.4	3.42	6.42
M_3 H_2	91.2	10.0	8.3	39.7	19.1	51.3	12.7	25.5	4.01	5.44
M_4 H_0	90.2	8.0	6.7	44.3	22.8	101.1	19.0	24.4	3.88	6.36
M_4 H_1	90.6	8.8	7.4	41.7	22.1	80.5	23.3	23.9	4.58	5.92
M_4 H_2	92.1	10.5	9.3	36.7	21.2	59.1	22.0	23.9	3.95	6.09
$LSD_{.05}$	NS	2.1	2.1	8.3	1.6	23.6	10.4	1.1	0.62	1.85
CV%	7.50	12.40	13.90	10.90	4.20	15.60	14.80	2.60	12.14	16.37

Effect of different herbicides on weed infestation and yield in boro rice (Binadhan-14)

A field experiment was conducted at the Agronomy field Laboratory of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh under wet land condition during January to May 2018. Ten selected commercial grade herbicides were i,e; H_0 =Control, H_1 = Rifit, H_2 = Hammar, H_3 = Granite, H_4 = Panida, H_5 = Serious, H_6 = Logron, H_7 = Superpower, H_8 = Ornet, H_9 = Sunrise and H_{10} = Super mix. The aim was to observe the effects of herbicides on weed control, crop growth and yield in boro rice. In all cases herbicides were applied in 4-5 cm standing water in the plots. The size of the individual plot was 4m x 3m. Treatments were assigned in unit plots at random. Data on crop yield were collected at proper maturity stages of the crop. All the recorded data were compiled and analyzed using M-STAT programme of computer and the means were judged by LSD.

The application of ten selected commercial grade herbicides increased rice yield significantly.

In control treatment grain yield was significantly decreased due to weed infestation. Among ten selected commercial grade herbicides, the Serious showed the highest yield (5.49 t ha^{-1}) followed by Super mix (5.36 t ha^{-1}). The observation of weed competition in Serious and Super mix treated plot was lower than other plots. The number of effective tillers, field grains panicle^{-1} and grain yield was higher in compare with other treatment (Table 8).

Table 08. Effect of herbicide and weed management on the yield and yield contributing characters of Boro rice

Treatments	Plant height (cm)	Total tiller plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Control(H_0)	89.7	11.4	9.4	20.3	64.7	30.9	21.9	4.02	5.65
Rifit (H_1)	91.3	11.1	8.9	20.6	80.1	18.0	22.9	4.94	6.07
Hammar (H_2)	90.3	11.3	8.6	21.1	79.6	23.1	23.1	4.99	6.73
Granite (H_3)	89.3	10.9	8.8	22.0	90.9	17.1	22.6	4.73	6.60
Panida (H_4)	89.3	12.3	9.5	21.3	91.3	18.3	23.0	4.93	6.50
Serious (H_5)	90.3	11.5	10.2	21.0	107.5	12.5	22.8	5.49	6.54
Logron (H_6)	90.0	11.1	9.5	21.0	73.2	21.8	22.4	5.05	5.93
Superpower (H_7)	90.7	11.9	9.1	21.0	85.7	22.3	23.0	4.58	6.34
Ornet (H_8)	89.3	11.4	9.5	20.9	76.7	19.5	22.7	4.85	5.97
Sunrise (H_9)	89.7	11.9	9.1	21.4	77.0	21.7	23.0	4.59	6.33
Super mix (H_{10})	90.3	11.7	10.7	20.4	106.5	10.9	23.3	5.36	6.42
$LSD_{0.05}$	NS	NS	NS	1.2	15.7	10.2	1.1	1.02	1.19
CV(%)	2.0	12.5	15.8	3.4	11.2	9.8	2.8	12.22	11.14

Determination of optimum seed rate for growth and yield of lentil mutant line/variety

The experiment was conducted at BINA substation, Ishurdi and Chapainawabganj during 2018-19 to evaluate the effect of optimum seed rate (20 kg ha^{-1}, 25 kg ha^{-1}, 30 kg ha^{-1} and 35 kg ha^{-1}) on the growth and yield contributing characters of three advanced lentil lines/variety viz. LM-118-9, LM-138-3, LM-206-5 along with one check variety (Binamasur-8). The experiment was laid out in a split- plot design with three replications. The unit plot size was 4 m × 3 m. The recommended doses of fertilizers were applied. The pods were harvested on different dates according to the maturity of the mutant lines/variety. The data on yield and yield attributes were recorded from randomly selected ten plants while the yield data were recorded from the harvest of whole plot. All the recorded data were statistically analyzed using MSTAT programme according to the design used for the experiment. Least significant difference (LSD) was used to compare variations among the treatments.

Among different advance lines/variety, LM-118-9 produced the highest seed yield (1.76 t ha^{-1}) followed by Binamasur-8 (1.67 t ha^{-1}) (Table 9). The highest yield was contributed by highest pods plant^{-1} and 1000 seed weight. Mean effect of different seed rate showed significant results on seed yield. Among different seed rate, 30 kg ha^{-1} showed the highest seed yield (1.78 t ha^{-1}). The interaction results of mutant/variety and seed rate revealed that the yield of LM-183-1 was the highest (1.92 t ha^{-1}) at 30 kg ha^{-1}. The interaction effect of mutant/variety and location showed that LM-118-9 produced maximum seed yield (1.93 t ha^{-1}) in Ishurdi followed by Chapainawabgang (1.83 t ha^{-1}). The interaction effect of seed rate and location showed that seed rate at 30 kg ha^{-1} produced maximum seed yield (1.99 t ha^{-1}) at Ishurdi followed by 30 kg ha^{-1} (1.94 t ha^{-1}) at Chapainawabgang . The interaction effect of seed rate, variety and location showed that at 30 kg ha^{-1}, LM-118-9 produced the highest yield (1.96 t ha^{-1}) at Ishurdi followed by LM-118-9 (1.92 t ha^{-1}) at Chapainawabgonj. The data recorded on crop duration revealed that the advanced mutant line LM-118-9 required the least average (95 days) and Binamasur-5 required maximum average (100 days) (Table 9).

Table 9. Determination of optimum seed rate for growth and yield of lentil lines during 2018-2019 at BINA substations, Ishurdi and Chapainawabganj

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Populations m^{-2} (no.)	Seeds pod^{-1} (no.)	1000 seed wt.(g)	Pods plant^{-1} (no.)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
Location(s) :								
Ishurdi (L_1)	44.3	9.0	108.0	1.6	21.6	60.4	1.85	4.80
Chapainawabgang (L_2)	28.8	7.6	106.4	1.7	19.8	69.4	1.48	4.93
T value	*	*	NS	NS	NS	NS	*	NS
Mutants/Variety :								
LM-118-9 (V_1)	35.7	7.8	111.5	1.7	21.2	65.8	1.76	4.64
LM-138-3 (V_2)	37.1	8.1	102.5	1.7	20.1	63.8	1.66	4.97
LM-206-5 (V_3)	35.8	8.9	105.8	1.6	20.4	62.5	1.57	4.92
Binamasur-8 (V_4)	37.7	8.3	108.9	1.7	20.1	67.6	1.67	4.94
$LSD_{0.05}$	2.5	0.9	2.6	NS	0.5	NS	0.19	0.46
Seed rate :								
20 kg ha^{-1} (S_1)	35.8	8.2	107.6	1.7	20.8	53.9	1.46	4.71
25 kg ha^{-1} (S_2)	36.2	8.3	107.9	1.7	20.8	60.4	1.68	4.79
30 kg ha^{-1} (S_3)	36.2	8.3	106.1	1.7	20.7	69.2	1.78	4.87
35 kg ha^{-1} (S_4)	38.1	8.3	107.2	1.7	20.5	76.2	1.73	5.11
$LSD_{0.05}$	1.8	NS	2.1	NS	0.2	4.2	0.10	0.21
Mutants/Variety × Seed rates :								
V_1S_1	36.2	7.7	111.7	1.7	21.7	46.0	1.52	4.48
V_1S_2	34.5	8.1	112.1	1.8	21.4	59.7	1.81	4.46
V_1S_3	34.9	7.5	114.0	1.8	21.1	74.8	1.92	4.49

V_1S_4	37.2	7.8	108.4	1.7	20.5	82.7	1.80	5.12
V_2S_1	36.2	8.1	103.7	1.7	19.9	56.8	1.45	5.08
V_2S_2	37.5	8.0	104.1	1.7	20.0	56.3	1.61	4.86
V_2S_3	35.2	8.3	100.3	1.7	20.2	66.3	1.83	4.84
V_2S_4	39.6	8.1	101.8	1.8	20.3	75.8	1.73	5.13
V_3S_1	34.1	9.4	104.9	1.6	21.5	52.0	1.36	4.63
V_3S_2	35.1	8.4	104.3	1.7	21.5	58.3	1.61	4.79
V_3S_3	36.8	8.6	105.3	1.6	21.6	68.8	1.69	5.20
V_3S_4	37.0	9.1	108.8	1.7	21.2	70.7	1.63	5.06
V_4S_1	36.6	7.5	110.0	1.8	20.1	60.7	1.52	4.65
V_4S_2	37.5	8.6	111.0	1.6	20.3	67.2	1.70	5.03
V_4S_3	38.0	9.0	104.9	1.6	20.0	66.8	1.81	4.93
V_4S_4	38.5	8.3	109.7	1.7	20.1	75.7	1.63	5.14
$LSD_{0.05}$	3.5	1.8	4.2	0.2	0.5	8.4	0.19	0.42
Mutants/Variety × location :								
V_1L_1	42.3	8.2	112.7	1.7	22.1	57.6	1.93	4.50
V_1L_2	45.9	8.7	102.5	1.7	20.8	62.5	1.83	4.92
V_2L_1	43.2	10.2	106.3	1.6	22.1	58.3	1.73	4.92
V_2L_2	45.8	8.8	110.4	1.6	21.3	63.3	1.81	4.87
V_3L_1	29.1	7.4	110.4	1.7	20.3	74.0	1.50	4.78
V_3L_2	28.4	7.6	102.5	1.8	19.4	65.2	1.48	5.03
V_4L_1	28.3	7.6	105.3	1.7	20.8	66.6	1.42	4.92
V_4L_2	29.5	7.8	107.4	1.8	18.9	71.9	1.51	5.01
$LSD_{0.05}$	3.5	1.2	3.6	0.2	0.7	9.1	0.27	0.65
Seed rates × location :								
S_1L_1	43.1	8.8	108.4	1.6	21.7	50.3	1.62	4.60
S_1L_2	43.2	9.4	108.0	1.6	21.7	58.0	1.85	4.56
S_2L_1	43.9	8.9	107.7	1.7	21.6	63.8	1.99	4.88
S_2L_2	47.0	8.7	107.9	1.6	21.4	69.5	1.94	5.16
S_3L_1	28.5	7.5	106.8	1.8	19.9	57.4	1.30	4.81
S_3L_2	28.6	7.2	107.8	1.7	19.9	62.8	1.51	5.01
S_4L_1	29.1	7.8	104.5	1.7	19.9	74.6	1.57	4.86
S_4L_2	29.2	8.0	106.4	1.8	19.6	82.9	1.52	5.06
$LSD_{0.05}$	2.5	1.2	3.0	0.1	0.3	6.0	0.14	0.30
Location× Mutants/Variety × Seed rates :								
$L_1V_1S_1$	42.9	7.7	113.3	1.7	22.3	43.3	1.78	4.15
$L_2V_1S_1$	39.3	9.1	112.4	1.7	22.2	54.0	1.87	4.08
$L_1V_1S_2$	41.1	8.3	116.0	1.8	22.0	62.3	1.96	4.63
$L_2V_1S_2$	45.7	7.8	109.1	1.7	21.7	70.7	1.90	5.12
$L_1V_1S_3$	44.2	8.7	103.7	1.5	20.8	56.3	1.59	5.23
$L_2V_1S_3$	45.3	9.7	104.1	1.7	20.8	57.7	1.81	4.70
$L_1V_1S_4$	43.8	8.1	100.3	1.7	21.2	64.0	1.90	4.75
$L_2V_1S_4$	50.3	8.1	101.8	1.7	20.5	72.0	1.94	5.02
$L_1V_2S_1$	40.6	11.1	104.9	1.5	22.3	51.7	1.45	4.55
$L_2V_2S_1$	43.3	9.6	104.3	1.7	22.2	59.3	1.75	4.71
$L_1V_2S_2$	44.0	9.5	105.3	1.6	22.0	61.7	1.89	5.24
$L_2V_2S_2$	45.0	10.4	110.7	1.5	22.0	60.7	1.81	5.16
$L_1V_2S_3$	44.7	7.9	111.4	1.6	21.4	50.0	1.66	4.47
$L_2V_2S_3$	45.0	9.2	111.0	1.5	21.4	61.0	1.86	4.76
$L_1V_2S_4$	46.7	9.7	109.3	1.6	21.0	67.3	1.92	4.89
$L_2V_2S_4$	47.0	8.6	110.0	1.5	21.2	74.7	1.76	5.35
$L_1V_3S_1$	29.5	7.7	110.0	1.7	21.0	48.7	1.26	4.80
$L_2V_3S_1$	29.7	7.1	111.7	1.8	20.6	65.3	1.64	4.85
$L_1V_3S_2$	28.7	6.7	112.0	1.7	20.3	87.3	1.50	4.36
$L_2V_3S_2$	28.6	7.9	107.7	1.7	19.2	94.7	1.59	5.11
$L_1V_3S_3$	28.3	7.5	103.7	1.9	19.0	57.3	1.30	4.93
$L_2V_3S_3$	29.7	6.3	104.1	1.7	19.1	55.0	1.41	5.02
$L_1V_3S_4$	26.6	8.4	100.3	1.7	19.3	68.7	1.68	4.92
$L_2V_3S_4$	29.0	8.1	101.8	1.8	20.0	79.7	1.53	5.23
$L_1V_4S_1$	27.5	7.6	104.9	1.7	20.7	52.3	1.26	4.71

$L_2V_4S_1$	26.9	7.2	104.3	1.7	20.9	57.3	1.47	4.88
$L_1V_4S_2$	29.6	7.7	105.3	1.6	21.2	76.0	1.49	5.16
$L_2V_4S_2$	29.1	7.9	106.8	1.8	20.4	80.7	1.45	4.96
$L_1V_4S_3$	28.5	7.1	108.5	1.9	18.8	71.3	1.37	4.82
$L_2V_4S_3$	30.1	7.9	111.0	1.7	19.1	73.3	1.54	5.30
$L_1V_4S_4$	29.3	8.3	100.5	1.7	18.9	66.3	1.63	4.98
$L_2V_4S_4$	30.0	8.0	109.3	1.8	18.9	76.7	1.51	4.93
$LSD_{0.05}$	5.0	2.5	5.9	NS	0.7	11.9	0.27	0.60
CV%	8.3	18.2	8.4	11.1	4.0	11.2	10.04	7.45

Determination of optimum dates of sowing and spacing on yield and yield contributing characters of mungbean mutants/variety

The experiment was conducted at BINA substation, Ishurdi and Magura. Two advanced mutant lines were evaluated compared with two check varieties with three different levels of spacing. The objective was to evaluate the yield performances of mutant lines as affected by different dates of sowing and spacing's. Four different dates of sowing were; Feb. 15, Feb. 28, Mar. 15 and Mar. 30. Three levels of spacing were 20 cm, 25 cm and 30 cm. The advanced mutant lines were MBM-656-51-2, MBM-427-87-3, and two check varieties were BARI Mung-8 and Binamung-8. Data on yield and yield components were recorded at harvest and analyzed statistically following the design (split-split plot over location) used for the experiment and the means were compared with LSD. The results are discussed below separately.

The effect of sowing date on seed yield was the highest at Feb. 28 (752.8 kg ha^{-1}) while March 30 sowing produced the lowest seed yields (658.3 kg ha^{-1}) (Table 10). The seed yield of 25 cm row spacing was the highest (764.7 kg ha^{-1}) whereas 30 cm row spacing produced the lowest seed yield (705 kg ha^{-1}). Among the mutant lines/varieties, MBM-656-51-2 produced the highest seed yield (794.5 kg ha^{-1}) followed by MBM-427-87-3 and BARI Mung8. The interaction effect of sowing date and mutants/variety showed that MBM-656-51-2 produced the maximum seed yield (817.8 kg ha^{-1}) followed by BARI Mung8 (799.3 kg ha^{-1}) same sowing date at Feb 28. The interaction effect of sowing date and row spacing sowing at Feb. 28 and 25 cm row spacing produced the maximum seed yield (783.9 kg ha^{-1}) followed by sowing at Feb 15 (756.7 kg ha^{-1}) 25 cm row spacing. The interaction effect of variety and row spacing showed that Binamung-8 produced maximum seed yield (809 kg ha^{-1}) at 25cm row spacing followed by BARI Mung-8 (791.8 kg ha^{-1}) at 25cm row spacing. The interaction effect of sowing date, variety and row spacing showed that MBM-656-51-2 produced maximum seed yield (843.3 kg ha^{-1}) at 25cm row spacing followed by BARI Mung-8 (828.6 kg ha^{-1}) at 25 cm row spacing at Feb 18 sowing. The data recorded on crop duration from sowing to maturity revealed that the advanced mutant line MBM-656-51-2 required the least average (75 days) and BARI Mung-8 required maximum average (78 days) (Table 10).

Table 10. Effect of different dates of sowing and spacing on yield and yield contributing characters of mungbean mutants/variety in BINA Substations Ishurdi and Magura

Treatment	Populations m^{-2} (no.)	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000 seed wt.(g)	Seed yield ($t\ ha^{-1}$)
Location(s) :								
Ishurdi (L_1)	39.6	44.3	0.8	10.8	7.4	10.2	47.1	740.2
Magura (L_2)	40.6	51.4	0.8	10.5	7.4	10.3	41.4	739.7
T value	NS	*	NS	NS	NS	NS	*	NS
Sowing date :								
Feb. 15 (D_1)	38.9	26.8	0.8	8.6	7.4	9.7	45.1	679.6
Feb. 28 (D_2)	40.1	40.6	0.5	12.0	8.1	10.1	44.2	752.8
Mar. 15 (D_3)	41.7	54.3	1.1	9.7	7.0	10.2	43.7	709.2
Mar. 30 (D_4)	39.7	69.6	0.7	12.2	7.3	10.9	42.4	658.3
$LSD_{0.05}$	NS	21.9	NS	NS	NS	NS	1.3	42.5
Mutant/varieties :								
MBM-656-51-2 (V_1)	39.5	46.1	0.7	10.2	7.4	10.3	43.2	794.5
MBM-427-87-3(V_2)	40.7	48.6	0.8	10.7	7.3	10.3	48.1	763.8
BARI Mung-8(V_3)	40.5	48.4	0.8	11.0	7.4	10.2	43.2	705.6
Binamung-8(V_4)	39.6	48.3	0.8	10.6	7.5	10.3	43.6	696.0
$LSD_{0.05}$	NS	3.1	NS	NS	NS	NS	0.6	20.6
Row spacing :								
20 cm (S_1)	41.1	47.4	0.7	10.0	7.4	10.2	43.7	729.3
25 cm (S_2)	40.0	49.1	0.8	10.7	7.4	10.3	44.2	764.7
30 cm (S_3)	39.2	47.0	0.8	11.1	7.5	10.2	43.4	705.8
$LSD_{0.05}$	1.1	1.7	NS	0.9	NS	NS	NS	15.6
Sowing date × Mutant/varieties :								
D_1V_1	39.2	26.3	0.7	8.3	7.2	9.5	46.4	784.4
D_1V_2	39.9	25.6	0.8	8.5	7.3	9.9	47.5	755.0
D_1V_3	38.1	26.5	0.8	9.4	7.5	9.6	44.3	711.1
D_1V_4	38.3	28.9	0.9	8.4	7.7	10.0	46.5	700.0
D_2V_1	37.8	37.4	0.4	12.1	8.3	10.0	43.4	817.8
D_2V_2	40.7	41.5	0.4	11.3	8.1	10.2	46.1	763.0
D_2V_3	41.5	41.8	0.6	11.8	7.9	10.2	45.3	799.7
D_2V_4	40.4	41.9	0.6	12.8	8.0	10.1	45.5	699.4
D_3V_1	40.1	50.4	0.9	8.7	6.9	10.6	42.1	764.1
D_3V_2	42.6	56.7	1.2	10.7	6.9	10.2	50.1	775.6
D_3V_3	42.6	55.7	1.2	9.5	6.9	9.9	43.4	708.9
D_3V_4	41.6	54.5	1.0	9.8	7.2	10.0	43.2	694.4
D_4V_1	40.9	70.4	0.7	11.6	7.3	11.0	40.2	776.1
D_4V_2	39.8	70.5	0.6	12.2	7.1	10.7	48.7	761.7
D_4V_3	40.0	69.5	0.6	13.4	7.4	11.0	40.1	693.3
D_4V_4	38.2	67.9	0.8	11.5	7.3	11.0	40.1	690.0
$LSD_{0.05}$	3.5	2.8	0.3	1.9	NS	NS	2.1	41.2
Sowing date × Row spacing :								
D_1S_1	39.5	25.6	0.8	8.4	7.0	9.9	46.3	750.4
D_1S_2	38.1	29.0	0.9	8.3	7.7	10.0	46.1	756.7
D_1S_3	38.9	25.9	0.8	9.3	7.6	9.3	45.9	705.8
D_2S_1	41.5	41.7	0.5	11.1	8.6	10.0	45.2	753.1
D_2S_2	40.5	40.6	0.5	12.7	7.7	10.2	44.7	783.9
D_2S_3	38.4	39.6	0.5	12.2	7.9	10.2	45.5	711.3
D_3S_1	43.0	53.1	1.0	9.4	7.0	10.0	45.5	755.8

D_3S_2	41.6	56.9	1.0	9.3	6.8	10.2	44.4	742.5
D_3S_3	40.6	53.1	1.2	10.2	7.1	10.4	44.3	719.2
D_4S_1	40.4	69.3	0.7	11.2	7.2	11.0	42.5	739.6
D_4S_2	39.9	70.1	0.6	12.6	7.3	10.9	41.4	734.2
D_4S_3	38.8	69.3	0.7	12.7	7.2	10.9	42.1	687.1
$LSD_{0.05}$	2.3	1.7	NS	NS	0.6	0.5	1.6	31.3
Mutant/variety × Row spacing :								
V_1S_1	39.8	46.6	0.7	9.9	7.5	10.2	42.7	775.7
V_1S_2	39.2	46.4	0.6	10.0	7.2	10.3	43.2	809.4
V_1S_3	39.6	45.5	0.7	10.6	7.6	10.3	43.5	760.8
V_2S_1	42.0	47.8	0.8	10.4	7.2	10.3	49.1	770.8
V_2S_2	40.8	49.0	0.8	10.3	7.4	10.3	47.5	777.7
V_2S_3	39.5	49.0	0.7	11.3	7.4	10.2	48.2	712.9
V_3S_1	42.0	48.7	0.8	10.4	7.5	10.2	43.4	735.8
V_3S_2	40.4	49.1	0.8	11.3	7.5	10.5	43.7	791.8
V_3S_3	39.2	47.3	0.8	11.3	7.2	9.8	42.9	660.0
V_4S_1	40.7	46.7	0.7	9.4	7.5	10.3	43.9	719.6
V_4S_2	39.7	52.1	0.8	11.3	7.5	10.1	43.7	703.8
V_4S_3	38.5	46.1	0.9	11.2	7.6	10.5	43.2	664.6
$LSD_{0.05}$	2.3	3.4	NS	1.8	0.6	0.5	1.3	31.3
Sowing date× Mutant/variety × Row spacing :								
$D_1V_1S_1$	38.7	25.8	0.7	7.8	6.3	9.7	45.1	776.7
$D_1V_1 S_2$	36.7	25.9	0.7	8.2	7.5	9.8	47.6	783.3
$D_1V_1 S_3$	42.1	27.2	0.8	9.0	7.7	9.1	46.2	773.3
$D_1V_2 S_1$	41.4	25.9	0.9	9.3	6.6	10.1	47.3	781.7
$D_1V_2 S_2$	39.3	26.5	0.9	8.5	7.8	10.0	46.6	773.3
$D_1V_2 S_3$	38.9	24.5	0.6	7.7	7.5	9.5	48.5	710.0
$D_1V_3 S_1$	38.8	26.1	0.7	9.0	7.7	10.0	45.2	726.7
$D_1V_3 S_2$	38.5	25.6	0.8	7.8	7.7	9.8	44.8	730.0
$D_1V_3 S_3$	36.9	27.8	0.9	11.4	7.2	8.9	43.3	676.7
$D_1V_4 S_1$	39.2	24.6	0.9	7.6	7.3	9.9	46.4	716.7
$D_1V_4 S_2$	38.0	37.8	1.0	8.6	7.8	10.5	47.5	720.0
$D_1V_4 S_3$	37.8	24.3	0.8	9.0	7.8	9.7	45.2	663.3
$D_2V_1S_1$	38.9	38.1	0.3	11.1	9.6	9.7	43.6	805.8
$D_2V_1 S_2$	39.7	36.3	0.4	12.6	7.5	10.1	43.1	843.3
$D_2V_1 S_3$	34.9	37.7	0.6	12.4	7.8	10.2	45.3	790.0
$D_2V_2 S_1$	41.5	43.4	0.6	11.0	8.1	10.4	46.6	783.3
$D_2V_2 S_2$	42.0	40.8	0.5	11.7	8.0	10.2	46.1	790.7
$D_2V_2 S_3$	38.7	40.4	0.2	11.2	8.2	10.0	47.1	715.0
$D_2V_3 S_1$	43.2	43.1	0.5	11.1	8.3	10.0	45.9	726.7
$D_2V_3 S_2$	40.4	40.8	0.6	12.2	7.8	10.7	44.3	828.6
$D_2V_3 S_3$	41.0	41.3	0.6	12.3	7.7	10.0	44.8	660.0
$D_2V_4 S_1$	42.3	42.2	0.4	11.2	8.4	10.1	46.1	696.7
$D_2V_4 S_2$	40.0	44.4	0.6	14.3	7.7	9.7	45.1	721.7
$D_2V_4 S_3$	39.0	38.9	0.6	13.0	8.0	10.6	45.3	680.0
$D_3V_1S_1$	41.0	52.4	0.8	9.2	6.9	10.2	42.2	806.7
$D_3V_1 S_2$	40.0	54.0	0.7	7.9	6.6	10.7	42.2	821.3
$D_3V_1 S_3$	39.4	44.9	1.0	9.0	7.3	11.0	42.1	817.3
$D_3V_2 S_1$	42.3	54.9	1.0	9.6	6.9	10.0	51.8	803.3
$D_3V_2 S_2$	43.2	58.4	1.3	9.3	6.5	10.1	50.0	773.3
$D_3V_2 S_3$	42.4	56.8	1.4	13.1	7.2	10.6	48.5	730.0
$D_3V_3 S_1$	44.8	53.0	1.3	9.6	6.8	9.6	43.6	760.0
$D_3V_3 S_2$	42.2	59.2	1.3	10.2	7.1	10.3	44.4	706.7
$D_3V_3 S_3$	40.8	54.9	1.2	8.8	6.7	9.7	42.8	660.0
$D_3V_4 S_1$	44.0	52.0	1.0	9.3	7.3	10.2	42.6	733.3
$D_3V_4 S_2$	41.0	55.9	0.8	10.0	7.0	9.6	43.1	686.7
$D_3V_4 S_3$	39.7	55.7	1.2	10.0	7.3	10.2	44.0	663.3
$D_4V_1S_1$	40.4	69.8	0.9	11.3	7.1	11.1	39.8	801.7
$D_4V_1 S_2$	40.5	69.2	0.6	11.5	7.2	10.7	39.3	770.0
$D_4V_1 S_3$	41.8	72.2	0.5	12.0	7.4	11.2	41.3	756.7

$D_4V_2S_1$	42.6	66.9	0.6	11.7	7.1	10.7	50.4	815.0
$D_4V_2S_2$	38.7	70.3	0.5	11.7	7.4	11.0	47.2	773.3
$D_4V_2S_3$	37.9	74.3	0.6	13.2	6.9	10.6	48.5	696.7
$D_4V_3S_1$	41.4	72.7	0.5	12.0	7.3	11.0	40.4	730.0
$D_4V_3S_2$	40.6	70.6	0.5	15.2	7.5	11.3	41.4	706.7
$D_4V_3S_3$	38.0	65.2	0.7	12.9	7.3	10.6	40.0	643.3
$D_4V_4S_1$	37.3	67.8	0.6	9.7	7.2	11.0	40.4	731.7
$D_4V_4S_2$	39.9	70.4	0.8	12.1	7.3	10.6	39.7	686.7
$D_4V_4S_3$	37.5	65.4	0.9	12.7	7.4	11.4	40.4	651.7
$LSD_{0.05}$	4.5	6.9	0.5	3.6	1.3	1.1	3.2	62.5
CV (%)	10.1	12.3	17.4	10.0	14.4	11.2	8.1	7.2

Determination of optimum row spacing on yield and yield contributing characters of sesame mutants/variety

The experiment was conducted at BINA substation, Ishurdi and Chapainawabganj during 2018-19 to evaluate the effect of line spacing on the growth and yield contributing characters of three advanced sesame lines/variety viz. SM-001, SM-002, SM-003 along with one check variety (Binatil-2). The experiment was laid out in a split-split design with three replications. The unit plot size was 4 m × 3 m. The recommended doses of fertilizers were applied. The capsules were harvested on different dates according to the maturity of the mutant lines/variety. The data on yield and yield attributes were recorded from randomly selected ten plants while the yield data were recorded from the harvest of whole plot. All the recorded data were analyzed statistically using MSTAT computer program according to the design used for the experiment. Least significant difference (LSD) was used to compare variations among the treatments.

Among different advance lines/variety, SM-002 produced the highest seed yield (1.07 t ha^{-1}) followed by Binatil-2 (1.05 t ha^{-1}). The highest yield was contributed by higher pods $plant^{-1}$ and 1000 seed weight. Mean effect of different line spacing showed significant results on seed yield. Among different line spacing and 25cm showed the highest seed yield (1.11 t ha^{-1}). The interaction results of mutant/variety and location revealed that the yield of SM-003 was the highest (1.15 t ha^{-1}) at Chapainawabganj. The interaction effect of line spacing and location, SM-002 produced the maximum seed yield (1.14 t ha^{-1}) in Chapainawabganj. The interaction effect of mutant/variety, line spacings and locations showed that mutant line SM-003 produced maximum seed yield (1.19 t ha^{-1}) at 30 cm line spacing in Chapainawabganj. The data recorded on crop duration revealed that the advanced mutant line SM-003 required the least average (82 days) and mutant line SM-001 required maximum average (85 days) (Table 11).

Table 11. Effect of different row spacing on the yield and yield contributing characters of sesame mutant/variety in BINA Substations Ishurdi and Chapainawabganj

Treatment	Plant height (cm)	Populations m^{-2} (no.)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Seed $capsul^{-1}$ (no.)	Pod length (cm)	1000 seed wt. (g.)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Location(s) :									
Ishurdi (L_1)	98.0	46.3	1.7	60.8	59.5	2.5	2.8	1.00	2.29
Chapai(L_2)	86.6	53.0	0.9	53.4	60.6	2.5	2.8	1.05	2.37
T value	*	*	*	*	NS	NS	NS	NS	NS
Mutant/Variety :									
SM-001 (V_1)	99.1	52.1	0.7	45.4	63.4	2.5	2.8	1.02	2.37
SM-002 (V_2)	95.0	45.1	0.6	49.5	58.8	2.5	2.8	1.07	2.25
SM-003 (V_3)	86.1	45.9	0.6	47.9	59.3	2.5	2.8	0.96	2.28
Binatil-2(V_4)	89.1	55.4	3.3	45.5	58.5	2.5	2.8	1.05	2.41
$LSD_{0.05}$	5.4	5.8	0.2	7.8	7.8	0.1	0.0	0.07	0.17
Line spacing :									
20 cm (S_1)	94.6	59.6	1.2	41.6	58.0	2.4	2.8	1.00	2.36
25 cm (S_2)	97.2	51.9	1.1	45.2	58.6	2.5	2.8	1.11	2.40
30 cm (S_3)	90.1	45.2	1.3	48.5	60.3	2.6	2.8	1.02	2.28
35 cm (S_4)	87.3	41.7	1.5	53.0	63.1	2.5	2.8	0.99	2.27
$LSD_{0.05}$	5.4	2.5	0.3	4.7	2.6	0.1	0.0	0.04	0.11
Mutants/Variety × Location :									
V_1L_1	102.0	45.2	1.3	55.7	62.9	2.5	2.8	0.98	2.30
V_1L_2	96.0	43.0	1.3	61.5	58.8	2.5	2.8	0.99	2.18
V_2L_1	98.8	51.5	1.1	64.1	57.2	2.5	2.8	0.95	2.24
V_2L_2	95.0	45.3	3.0	62.0	58.9	2.5	2.8	1.08	2.43
V_3L_1	96.1	59.0	0.0	35.2	64.0	2.5	2.8	1.07	2.43
V_3L_2	94.0	47.1	0.0	37.5	58.8	2.5	2.8	1.15	2.33
V_4L_1	73.3	40.3	0.0	31.8	61.4	2.5	2.8	0.97	2.32
V_4L_2	83.1	65.5	3.6	29.0	58.1	2.5	2.8	1.03	2.38
$LSD_{0.05}$	7.6	8.2	0.3	11.0	11.0	0.2	0.0	0.10	0.24
Line spacing × Location :									
S_1L_1	103.0	55.9	1.6	57.3	57.6	2.4	2.8	0.97	2.29
S_1L_2	107.0	48.8	1.4	59.3	58.2	2.5	2.8	1.08	2.41
S_2L_1	93.7	42.4	1.7	61.5	59.5	2.5	2.8	1.02	2.25
S_2L_2	88.3	37.9	1.9	65.2	62.6	2.5	2.8	1.14	2.21
S_3L_1	86.3	63.3	0.9	26.0	58.5	2.4	2.8	1.02	2.43
S_3L_2	87.4	55.0	0.8	31.2	59.0	2.5	2.8	0.94	2.40
S_4L_1	86.4	48.0	0.9	35.6	61.1	2.6	2.8	1.02	2.32
S_4L_2	86.3	45.6	1.0	40.7	63.7	2.5	2.8	1.03	2.32
$LSD_{0.05}$	7.7	3.5	0.4	6.7	3.6	0.2	0.1	0.05	0.16
Mutants /variety × Line spacing :									
V_1S_1	103.4	63.0	0.7	39.1	57.5	2.3	2.8	0.99	2.24
V_1S_2	100.7	55.4	0.3	42.4	63.3	2.6	2.8	1.13	2.61
V_1S_3	93.7	46.7	0.8	49.7	64.8	2.6	2.9	1.00	2.37
V_1S_4	98.5	43.3	0.8	50.5	68.0	2.4	2.8	0.97	2.25
V_2S_1	97.3	52.8	0.6	45.9	57.7	2.4	2.8	1.02	2.25
V_2S_2	106.1	46.6	0.5	49.4	56.7	2.3	2.8	1.13	2.17
V_2S_3	95.9	40.8	0.7	48.6	59.4	2.5	2.8	1.08	2.29
V_2S_4	80.7	40.2	0.8	54.1	61.3	2.6	2.8	1.06	2.31
V_3S_1	89.5	56.4	0.7	41.2	57.1	2.4	2.8	0.96	2.28
V_3S_2	88.8	48.5	0.8	45.0	57.5	2.5	2.9	1.02	2.31
V_3S_3	81.0	41.6	0.4	50.9	58.2	2.5	2.8	0.93	2.28
V_3S_4	85.1	36.9	0.4	54.6	64.3	2.5	2.8	0.94	2.25
V_4S_1	88.4	66.2	3.0	40.3	59.8	2.5	2.8	1.01	2.66
V_4S_2	93.3	57.3	2.9	44.1	56.8	2.5	2.9	1.16	2.51

V_4S_3	89.7	51.6	3.2	44.9	58.7	2.6	2.7	1.06	2.19
V_4S_4	84.9	46.4	3.9	52.7	58.7	2.5	2.8	0.98	2.26
$LSD_{0.05}$	10.8	4.9	0.6	9.5	5.1	0.3	0.1	0.07	0.23
Location ×Mutant/variety × Line spacing :									
$L_1V_1S_1$	107.8	54.1	1.3	51.5	57.5	2.4	2.8	0.92	2.15
$L_2V_1S_1$	102.1	47.1	0.7	52.1	63.3	2.6	2.7	1.10	2.53
$L_1V_1S_2$	99.7	41.8	1.6	61.8	64.8	2.6	2.8	0.98	2.35
$L_2V_1S_2$	98.5	37.8	1.7	57.3	65.9	2.4	2.8	0.92	2.17
$L_1V_1S_3$	103.2	53.3	1.2	62.7	57.7	2.4	2.8	0.95	2.14
$L_2V_1S_3$	111.3	46.1	0.9	64.1	56.7	2.3	2.7	1.06	2.14
$L_1V_1S_4$	98.5	38.4	1.4	56.1	59.4	2.5	2.8	1.03	2.22
$L_2V_1S_4$	71.1	34.3	1.6	63.2	61.3	2.6	2.8	0.92	2.20
$L_1V_2S_1$	103.5	60.1	1.3	57.2	55.5	2.4	2.7	0.96	2.21
$L_2V_2S_1$	106.0	55.1	1.5	61.2	55.9	2.4	2.8	0.97	2.24
$L_1V_2S_2$	84.3	49.2	0.9	67.9	54.9	2.5	2.9	0.94	2.22
$L_2V_2S_2$	101.5	41.5	0.7	69.9	62.7	2.5	2.7	0.93	2.27
$L_1V_2S_3$	97.3	56.0	2.6	57.7	59.8	2.6	2.8	1.03	2.65
$L_2V_2S_3$	108.5	47.1	2.6	59.8	56.8	2.5	2.9	1.17	2.70
$L_1V_2S_4$	92.3	40.1	2.9	60.2	58.7	2.6	2.7	1.10	2.19
$L_2V_2S_4$	82.0	38.0	3.7	70.3	60.4	2.5	2.8	0.99	2.19
$L_1V_3S_1$	99.1	71.9	0.0	26.8	57.5	2.2	2.8	1.05	2.33
$L_2V_3S_1$	99.2	63.6	0.0	32.6	63.3	2.6	2.8	1.16	2.68
$L_1V_3S_2$	87.7	51.6	0.0	37.7	64.8	2.7	2.9	1.02	2.39
$L_2V_3S_2$	98.6	48.8	0.0	43.7	70.2	2.3	2.8	1.02	2.33
$L_1V_3S_3$	91.5	52.2	0.0	29.1	57.7	2.4	2.7	1.09	2.36
$L_2V_3S_3$	100.9	47.1	0.0	34.7	56.7	2.3	2.8	1.19	2.20
$L_1V_3S_4$	93.3	43.1	0.0	41.1	59.4	2.5	2.8	1.11	2.36
$L_2V_3S_4$	90.3	46.1	0.0	45.0	61.3	2.6	2.8	1.18	2.42
$L_1V_4S_1$	75.4	52.8	0.0	25.2	58.8	2.4	2.8	0.95	2.35
$L_2V_4S_1$	71.5	41.9	0.0	28.9	59.2	2.5	2.9	1.06	2.38
$L_1V_4S_2$	77.7	34.0	0.0	33.9	61.5	2.5	2.7	0.91	2.33
$L_2V_4S_2$	68.7	32.4	0.0	39.2	66.0	2.5	2.8	0.93	2.22
$L_1V_4S_3$	79.4	76.4	3.4	22.9	59.8	2.4	2.8	0.99	2.67
$L_2V_4S_3$	78.1	67.4	3.2	28.5	56.8	2.5	2.8	1.14	2.32
$L_1V_4S_4$	87.1	63.2	3.5	29.6	58.7	2.6	2.8	1.01	2.19
$L_2V_4S_4$	87.7	54.9	4.1	35.0	57.1	2.4	2.8	0.95	2.33
$LSD_{0.05}$	15.3	6.9	0.8	13.4	7.2	0.4	0.1	0.10	0.32
CV%	10.1	8.5	9.7	17.3	7.4	8.9	2.6	6.00	8.40

Determination of optimum row spacing on yield and yield contributing characters of mustard mutants/variety

The experiment was conducted at BINA substations, Rangpur and Magura during 2018-19 to evaluate the effect of optimum line spacing on the growth and yield contributing characteristics of advance mustard lines/variety viz. RM-03, RM-07, RM-10 along with one check variety BARI sarisha-15. The experiment was laid out in split- split plot design with three replications. The unit plot size was 4 m × 3 m. The recommended doses of fertilizers were applied. The crops were harvested on different dates according to the maturity of the mutant lines/variety. The data on yield and yield attributes were recorded from randomly selected ten plants while the yield data were recorded from the harvest of whole plot. All the recorded data were analyzed using MSTAT computer programme according to the design used for the experiment. Least significant difference (LSD) was used to compare variations among the treatments.

Among different advance lines/variety, RM-03 produced the highest seed yield (1.60 t ha^{-1}) followed by RM-10 (1.50 t ha^{-1}). Among different line spacing, 20 cm showed highest seed yield (1.66 t ha^{-1}). The interaction of mutant/variety and location revealed that the yield of RM-10 was the highest (1.54 t ha^{-1}) at Rangpur. The interaction effect of line spacing and location showed that 25 cm line spacing produced the maximum seed yield (1.68 t ha^{-1}) in Magura followed by 20 cm (1.64 t ha^{-1}) in Rangpur. The interaction effect of mutant and line spacing showed that mutant line, RM-03 at 20 cm produced maximum seed yield (1.68 t ha^{-1}) line spacing in Rangpur. The interaction effect of mutant/variety, line spacing and location showed that RM-10 produced highest seed yield (1.73 t ha^{-1}) at 20 cm line spacing in Rangpur followed by RM-07 produced the highest seed yield (1.66 t ha^{-1}) at same spacing and same location. The data recorded on crop duration revealed that the advanced mutant line RM-03, RM-07, RM-10 required the least average 86 days and BARIsarisha-15 required maximum average 88 days (Table 12).

Table 12. Effect of different levels of line spacing on the yield and yield contributing characters of mustard mutant/variety in BINA Substations Rangpur and Magura

Treatment	Plant height (cm)	Populations m^{-2} (no.)	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Siliqua length (cm)	Seeds siliqua (cm)	1000 seed wt.(g.)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Location(s) :									
Rangpur (L_1)	79.2	55.5	4.1	71.1	3.5	17.7	3.2	1.47	3.09
Magura (L_2)	83.8	53.0	4.7	67.6	4.4	19.9	3.2	1.50	3.08
T value	NS	NS	*	*	*	NS	NS	NS	NS
Mutant/Variety :									
RM-03 (V_1)	77.4	53.6	4.6	68.0	4.1	20.4	3.5	1.60	3.00
RM-07 (V_2)	77.5	55.5	4.3	73.1	4.1	17.5	3.3	1.46	3.18
RM-10 (V_3)	73.4	54.7	4.7	70.1	3.9	18.9	3.3	1.50	3.15
BARI sarisha-15 (V_4)	97.7	53.1	4.0	66.2	3.7	18.2	2.7	1.47	3.00
$LSD_{0.05}$	4.3	NS	0.3	NS	0.2	1.0	0.1	NS	NS
Line spacing :									
20 cm (S_1)	79.3	63.0	4.3	66.3	4.1	18.9	3.2	1.66	3.32
25 cm (S_2)	81.7	57.1	4.3	68.3	3.9	18.8	3.2	1.56	3.19
30 cm (S_3)	81.9	52.4	4.3	68.8	3.9	19.0	3.2	1.40	2.88
35 cm (S_4)	83.3	44.3	4.7	74.0	4.0	18.4	3.2	1.31	2.95
$LSD_{0.05}$	2.2	1.7	NS	3.2	NS	1.0	0.1	0.03	0.15
Mutants/Variety × Location :									
V_1L_1	74.0	54.2	5.0	72.6	3.7	20.7	3.5	1.46	3.03
V_1L_2	76.2	54.8	3.9	74.0	3.7	15.2	3.3	1.48	3.17
V_2L_1	71.8	58.8	4.5	74.2	3.4	18.7	3.3	1.49	3.17
V_2L_2	95.0	54.1	3.0	63.7	3.4	16.1	2.8	1.43	2.99
V_3L_1	80.9	53.0	4.1	63.4	4.6	20.1	3.4	1.54	2.98

V_3L_2	78.8	56.3	4.7	72.2	4.5	19.9	3.3	1.45	3.20
V_4L_1	75.1	50.7	4.9	66.1	4.5	19.1	3.3	1.50	3.12
V_4L_2	100.5	52.1	5.1	68.6	4.0	20.4	2.7	1.52	3.02
$LSD_{0.05}$	6.1	NS	0.4	NS	0.3	1.4	0.1	NS	NS
Line spacing × Location :									
S_1L_1	77.4	64.2	4.0	68.6	3.8	17.8	3.3	1.64	3.26
S_1L_2	80.4	58.8	4.0	71.7	3.4	18.0	3.2	1.54	3.23
S_2L_1	78.4	54.0	3.9	69.8	3.4	17.9	3.2	1.68	2.84
S_2L_2	80.7	44.9	4.4	74.4	3.5	17.0	3.2	1.49	3.02
S_3L_1	81.2	61.9	4.6	64.1	4.3	20.0	3.1	1.39	3.37
S_3L_2	83.0	55.5	4.5	64.8	4.4	19.7	3.1	1.58	3.16
S_4L_1	85.3	50.8	4.7	67.8	4.4	20.0	3.2	1.42	2.92
S_4L_2	85.8	43.8	4.9	73.6	4.5	19.8	3.2	1.33	2.87
$LSD_{0.05}$	3.1	2.4	NS	4.5	0.3	1.4	0.1	0.05	0.21
Mutants/Variety × Line spacing :									
V_1S_1	74.9	61.0	4.6	66.4	4.3	20.8	3.5	1.68	3.33
V_1S_2	79.8	56.7	4.2	63.5	3.9	20.7	3.5	1.51	3.07
V_1S_3	77.6	51.5	4.6	68.7	4.2	21.0	3.4	1.44	2.87
V_1S_4	77.5	45.2	4.8	73.4	4.2	19.2	3.5	1.37	2.74
V_2S_1	76.4	66.7	4.1	69.5	4.0	17.4	3.3	1.61	3.50
V_2S_2	76.9	57.8	4.1	72.8	4.0	18.1	3.2	1.61	3.38
V_2S_3	77.7	53.0	4.4	71.9	4.0	17.6	3.3	1.36	2.86
V_2S_4	78.9	44.7	4.5	78.2	4.3	17.0	3.3	1.26	2.99
V_3S_1	69.8	64.7	4.6	68.5	4.1	18.5	3.2	1.66	3.14
V_3S_2	71.0	57.0	4.8	71.5	3.9	19.0	3.3	1.59	3.29
V_3S_3	75.5	52.7	4.3	68.7	3.8	18.7	3.3	1.41	2.93
V_3S_4	77.5	44.5	5.0	71.8	4.0	19.4	3.3	1.33	3.22
V_4S_1	96.1	59.8	4.0	60.8	3.9	18.8	2.8	1.68	3.29
V_4S_2	99.0	57.0	3.9	65.3	3.8	17.5	2.7	1.54	3.04
V_4S_3	96.7	52.5	3.9	66.0	3.7	18.6	2.8	1.39	2.85
V_4S_4	99.2	43.0	4.3	72.5	3.5	18.0	2.8	1.29	2.83
$LSD_{0.05}$	4.3	3.3	0.8	6.3	0.4	2.0	0.1	0.07	0.30
Location × Mutant/Variety × Line spacing :									
$L_1V_1S_1$	72.9	62.0	5.2	73.2	4.1	20.5	3.5	1.62	3.29
$L_2V_1S_1$	75.1	56.7	4.4	68.2	3.3	21.7	3.6	1.48	3.15
$L_1V_1S_2$	75.1	52.7	4.9	75.3	3.6	21.9	3.5	1.40	2.91
$L_2V_1S_2$	72.8	45.3	5.5	73.6	3.5	18.8	3.6	1.33	2.76
$L_1V_1S_3$	74.3	67.0	3.5	68.9	3.8	15.0	3.4	1.63	3.52
$L_2V_1S_3$	75.5	57.3	3.9	77.8	3.4	15.5	3.3	1.62	3.41
$L_1V_1S_4$	75.3	51.3	4.0	71.7	3.4	15.0	3.3	1.39	2.71
$L_2V_1S_4$	79.5	43.7	4.1	77.5	4.1	15.2	3.2	1.27	3.04
$L_1V_2S_1$	67.1	68.7	4.3	74.7	3.5	17.7	3.3	1.66	3.08
$L_2V_2S_1$	72.8	62.3	4.9	77.7	3.4	19.1	3.3	1.58	3.32
$L_1V_2S_2$	70.8	57.7	3.9	68.4	3.3	18.5	3.3	1.41	2.96
$L_2V_2S_2$	76.5	46.3	5.0	75.8	3.3	19.6	3.3	1.32	3.31
$L_1V_2S_3$	95.4	59.0	2.9	57.4	3.7	17.9	2.8	1.63	3.16
$L_2V_2S_3$	98.1	58.7	2.8	62.9	3.5	15.6	2.7	1.49	3.04
$L_1V_2S_4$	92.3	54.3	2.9	63.7	3.3	16.3	2.8	1.34	2.79
$L_2V_2S_4$	94.1	44.3	3.2	70.6	3.1	14.5	2.8	1.25	2.96
$L_1V_3S_1$	76.9	60.0	4.0	59.7	4.4	21.1	3.4	1.74	3.38
$L_2V_3S_1$	84.5	56.7	4.0	58.7	4.5	19.7	3.4	1.55	3.00
$L_1V_3S_2$	80.0	50.3	4.4	62.0	4.8	20.1	3.4	1.48	2.82
$L_2V_3S_2$	82.3	45.0	4.1	73.3	4.8	19.7	3.5	1.41	2.72
$L_1V_3S_3$	78.5	66.3	4.6	70.1	4.2	19.9	3.3	1.60	3.48
$L_2V_3S_3$	78.4	58.3	4.3	67.7	4.5	20.7	3.2	1.60	3.35
$L_1V_3S_4$	80.1	54.7	4.8	72.1	4.6	20.1	3.3	1.34	3.01
$L_2V_3S_4$	78.2	45.7	4.9	78.9	4.5	18.8	3.3	1.25	2.95
$L_1V_4S_1$	72.5	60.7	4.8	62.3	4.6	19.4	3.2	1.62	3.21
$L_2V_4S_1$	69.2	51.7	4.7	65.3	4.4	18.9	3.3	1.60	3.25
$L_1V_4S_2$	80.1	47.7	4.8	68.9	4.3	18.9	3.3	1.41	2.91

$L_2V_4S_2$	78.5	42.7	5.1	67.9	4.6	19.2	3.3	1.34	3.13
$L_1V_4S_3$	96.8	60.7	5.1	64.3	4.1	19.7	2.7	1.63	3.43
$L_2V_4S_3$	99.8	55.3	5.1	67.6	4.1	19.3	2.7	1.58	3.03
$L_1V_4S_4$	101.1	50.7	4.9	68.3	4.1	21.0	2.7	1.43	2.92
$L_2V_4S_4$	104.3	41.7	5.3	74.4	4.0	21.5	2.7	1.33	2.70
$LSD_{0.05}$	6.1	4.7	1.1	9.0	0.5	2.9	0.2	0.09	0.43
CV%	8.5	5.3	10.4	7.9	8.3	9.3	5.4	10.78	8.43

Evaluation of yield and yield contributing characters of wheat mutant/varieties during 2018-19

The experiment was conducted in BINA Substation Rangpur, Ishurdi and Chapainawabganj during Rabi season 2018-19. One mutant line was evaluated compared with two check variety with three locations. The objective was to evaluate the yield performances of mutant line as affected by agro-climatic condition in Bangladesh. The mutant line was Morocco Gom-1, the check varieties were, BARI Gom 28, BARI Gom 29. The experiment was carried out with randomized complete block designed with three replications. The unit plot size was 3 m×4 m. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were compared with LSD. The results are discussed below separately.

Among different mutant line/variety, mutant line Morocco Gom produced highest seed yield (4.42 t ha^{-1}) followed by BARI Gom 28 (4.18 t ha^{-1}). Among different location, the highest grain yield (4.20 t ha^{-1}) was found in Rangpur. The interaction results of variety and locations, revealed that the yield of Morocco Gom was the highest (4.46 t ha^{-1}) at Rangpur (Table 13). The Morocco Gom-1 took the highest duration 133 days to maturity BARI Gom 28 took the lowest duration 122 days to maturity.

Table 13. Performances of different wheat mutant line/variety on yield and yield contributing character in BINA Substation Rangpur, Ishurdi and Chapainawabganj

Treatments	Plant height (cm)	Total tillers $hill^{-1}$ (no.)	Effective tillers hill (no.)	Spike length (cm)	Spikelet's $spike^{-1}$ (no.)	1000 seed wt. (g)	Grain yield. t. ha^{-1}	Straw yield t. ha^{-1}
Location(s)								
Rangpur (L_1)	94.6	7.9	7.1	11.5	44.8	48.1	4.20	10.71
Ishurdi (L_2)	98.5	7.9	7.1	13.0	49.3	43.6	4.18	9.45
Chapainawabgonj (L_3)	95.6	8.0	7.2	13.1	50.3	46.0	4.02	9.66
$LSD_{0.05}$	NS	NS	NS	0.6	1.0	3.6	NS	1.05
Varieties:								
Morocco Gom-1 (V_1)	90.0	10.1	8.7	10.4	48.7	42.5	4.42	11.20
BARI Gom 28 (V_2)	100.1	6.7	6.0	10.2	45.5	45.8	4.18	9.31
BARI Gom 29 (V_3)	98.6	6.9	6.5	17.0	50.2	49.5	3.79	9.31
$LSD_{0.05}$	4.6	1.5	1.3	0.6	1.0	3.6	0.61	1.05
Variety × Location:								

$V_1 L_1$	87.0	9.1	7.8	8.2	43.0	43.3	4.46	11.17
$V_1 L_2$	93.0	10.6	9.3	11.2	50.3	40.3	4.39	11.17
$V_1 L_3$	90.1	10.7	9.2	11.9	52.7	44.0	4.36	11.26
$V_2 L_1$	100.0	6.6	5.8	8.8	46.5	45.3	4.01	10.47
$V_2 L_2$	100.0	6.7	5.9	10.9	45.2	46.0	4.25	8.59
$V_2 L_3$	100.3	6.9	6.3	11.0	44.8	46.0	4.27	8.86
$V_3 L_1$	96.9	8.0	7.5	17.6	45.0	55.6	4.11	10.47
$V_3 L_2$	102.5	6.3	6.0	16.9	52.3	44.7	3.83	8.59
$V_3 L_3$	96.5	6.3	6.0	16.5	53.3	48.1	3.42	8.86
$LSD_{0.05}$	7.9	2.6	2.3	1.0	1.7	6.2	1.05	1.81
CV(%)	4.7	18.7	18.8	4.5	2.0	7.8	14.67	10.53

Adaptive Research & Extension Division

Research Highlights

- During 2018-19 a total of 676 adaptive trials/block farming with BINA developed different crop varieties were conducted at the farmers' field in collaboration with the Department of Agricultural Extension (DAE) and in-charge of different BINA sub-stations.
- In block farming, early T. aman rice varietiy Binadhan-7 produced average grain yield of 4.51 t ha^{-1}, which was 2.61 percent higher compared to check varieties (BRRI dhan57). Maturity period of Binadhan-7 and BRRI dhan57 were 110 and 116 days respectively. Binadhan-7 showed higher yield performance. It is indicating that there were slight difference among the varieties in respect of yield and duration. Block farming with Binadhan-16 were conducted at farmers' plots in Mymensingh district in collaboration with DAE produced average grain yield of 4.67 t ha^{-1}, which was 7.15 percent higher compared to check varieties (BRRI dhan71). Average duration and yield of Binadhan-16 and check BRRI dhan71 were 111 and 130 days. It is indicating that there were little difference among the varieties in respect of yield and duration. Average duration and yield of Binadhan-17 and check BRRI dhan72 were 112 and 124 days and 5.34 and 5.36 t ha$^{-1,}$ respectively. It is indicating that there were almost no difference among the varieties in respect of yield and duration Binadhan-11 produced average grain yield of 4.60 t ha^{-1}, which was 9.55 percent higher compared to check varieties (BRRI dhan52). Maturity period of Binadhan-11 and BRRI dhan52 were 120 and 137 days respectively. Binadhan-11 showed higher yield performance in both submerged and normal condition. That's why, farmers were found much keen to cultivate Binadhan-11 in the upcoming years.
- Block farming with salt tolerant Binadhan-10 produced average grain yield of 5.54 t ha^{-1} and matured in 129 days, Farmers were found very much interested to cultivate Binadhan-10 due to its better performance in both saline and non saline soils. They also made request to BINA authority to conduct more demonstrations for farmers' motivation and their better understanding about the variety. Block farming with Binadhan-14 produced average grain yield of 5.32 t ha^{-1} and matured in 110 days, which was almost 25 days shorter duration than the check variety, BRRI dhan28. Popularity of Binadhan-14 is increasing due to its better grain yield, shorter duration and late transplanting capabilities, which facilitates rabi crop cultivation between aman and boro rice. Adopting this variety an additional rabi crop can be easily cultivated.
- Block farming with aus rice Binadhan-19 and check variety (BRRI dhan48) were produced average grain yields of 4.49 and 4.25 t ha^{-1} respectively. Maturity period of Binadhan-19 and BRRI dhan48 were 100 and 113 days respectively, which was almost 3 days shorter duration than the check variety, BRRI dhan48.
- Block farming with Binasarisha-9 produced average seed yield of 1.61 t ha^{-1}. There were slight difference in respect of duration and yield of tested varieties. Block farming with Binchinabadam-4 produced average seed yield of 1.81t ha^{-1}, which were to popular check variety Dhaka-1 (1.36 t ha^{-1}). The duration of Binachinabadam-4 was almost similar to Dhaka-1 indicating that both were the popular in farmers' field. Block farming with Binachinabadam-5 produced average seed yield of 1.55 t ha^{-1}, which was slightly higher to popular check variety BARIchinabadam-5 (1.36t ha^{-1}). The duration of Binachinabadam-5 was also similar to BARIchinabadam-5 indicating that both were the popular in farmers' field. Almost no difference was observed in duration of Binachinabadam-9 and BARIchinabadam-7. The highest seed yield 2.14 t ha^{-1} of Binachinabadam-9 was recorded at sadar upazila of Mymensingh district. Block farming with Binatil-2 produced average seed yield of 1.33 t ha^{-1}. Farmers showed their interest to cultivate Binatil-2 for its higher seed yield, oil content, attractive seed and oil colour. Observation trials with Binatil-2 and Binatil-3 produced average seed yield of 1.11 and 1.16 t ha^{-1} respectively which was higher than the check variety Atshira (0.94 t ha^{-1}). Binatil-3 showed better performances in respect of duration and seed yield. Further trials would be needed to identify the suitable area for large-scale extension of this variety.

- Binamasur-8 and Binamasur-10 produced average seed yield of 1.43 and 1.49 t ha^{-1} , and matured in 109 days indicating that an additional rabi crop lentil like BINA released varieties could easily be cultivated by introducing late boro rice variety, Binadhan-14.
- In order to promotion of BINA generated crop varieties, a total of four farmers training courses were organized during this period, and 240 male and female farmers were trained on cultivation of BINA developed improved crop varieties across the country. A total of 10 field days were also organized in different areas of the country to motivate farmers and popularize the BINA developed crop varieties/technologies to the end users. Besides these, Two TV programme were telecasted to popularize some BINA crop varieties.

ON FARM RESEARCH AND TECHNOLOGY TRANSFER

Adaptive trial/Block farming with rice varieties developed by BINA

Block farming with early T. aman rice variety Binadhan-7 compared to check variety

During aman season of 2018-19, 23 demonstrations with Binadhan-7 were conducted at farmers' plots in Mymensingh districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binadhan-7 for its dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next seasons. Unit plot size of individual plot was 1 bigha at all the locations. Seed beds were prepared during end of June to mid of July and transplanting was completed with mid-July to mid-August 2018. Fertilizers were applied as per recommendation. Data were recorded on crop duration and grain yield. The results are presented in Table 1.

Table 1: Performance of early T. aman rice varietiy Binadhan-7 during 2018-19

District	Upazilla	No. of Expt.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-7	BRRI dhan57	Binadhan-7	BRRI dhan57	
Mymensingh	Sadar	19	110	115	4.58	4.30	6.51
	Gouripur	4	111	116	4.44	4.50	-1.33
	Total	**23**					
	Mean		**110**	**116**	**4.51**	**4.40**	**2.61**

The results presented in Table1 shows that average duration and yield of Binadhan-7 and check BRRI dhan57 were 110 and 116 days and 4.51 and 4.40 t ha^{-1}, respectively. It is indicating that there were almost no difference among the varieties in respect of yield and duration.

Block farming with early T. aman rice variety Binadhan-16 compared to check variety

During aman season of 2018-19, 22 demonstrations with Binadhan-16 were conducted at farmers' plots in Mymensingh district in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binadhan-16 for its dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next seasons. Unit plot size of individual adaptive trial was 1 bigha at all the locations. Seed beds were prepared during end of June to mid of July and transplanting was completed with mid-July to mid-August 2018. Fertilizers were applied as per recommendation. Data were recorded on crop duration and grain yield. The results are presented in Table 2.

Table 2.Performance of early T. aman rice variety Binadhan-16 during 2018-19

District	Upazilla	No. of Expt.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-16	BRRIdhan-71	Binadhan-16	BRRI dhan71	
Mymensingh	Sadar	2	112	120	4.58	4.30	6.51
	Gouripur	5	110	121	4.44	4.50	-1.33
	Bhaluka	15	111	118	5.00	4.30	16.28
	Total	**22**					
	Mean		**111**	**119**	**4.67**	**4.36**	**7.15**

The results presented in Table 2 shows that average duration and yield of Binadhan-16 and check BRRIdhan-71 were 111 and 130 days and 4.67 and 4.36 t ha^{-1}, respectively. It is indicating that there were almost no difference among the varieties in respect of yield and duration.

Block farming with early T. aman rice variety Binadhan-17 compared to check variety

During aman season of 2018-19, 60 demonstrations with Binadhan-17 were conducted at farmers' plots in Mymensingh districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binadhan-17 for its dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next seasons. Unit plot size of individual adaptive trial was 1 bigha at all the locations. Seed beds were prepared during end of June to mid of July and transplanting was completed with mid July to mid August 2018. Fertilizers were applied as per recommendation. Data were recorded on crop duration and grain yield. The results are presented in Table 3.

Table3.Performance of early T. aman rice variety Binadhan-17 during 2018-19

District	Upazilla	No. of Expt.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-17	BRRIdhan-72	Binadhan-17	BRRIdhan-72	
Mymensingh	Sadar	38	112	120	5.58	5.30	5.28
	Gouripur	7	113	124	5.44	5.50	-1.09
	Bhaluka	15	114	128	5.00	5.30	-5.66
	Total	**60**					
	Mean		**112**	**124**	**5.34**	**5.36**	**-0.49**

The results presented in Table 3 shows that average duration and yield of Binadhan-17 and check BRRIdhan-72 were 112 and 124 days and 5.34 and 5.36 t ha^{-1}, respectively. It is indicating that there were almost no difference among the varieties in respect of yield and duration.

Block Farming with submergence tolerant aman rice variety, Binadhan-11 compared to popular cultivar in different locations

During aman season of 2018-19, 94 block farming with submergence tolerant aman rice Binadhan-11 were conducted at the farmer's fields in different locations in collaboration with the DAE. The main objectives were to evaluate the performance of this variety at different flood prone areas and widening its adoption by the farmers. Area of each plot was one acre. Spacing between line-to-line and plant-to-plant was 20 cm × 15 cm. All fertilizers were applied by farmers as per recommendation. Transplanting dates ranged from 15 July to 15 August, 2018 and age of seedlings were 20 to 25 days. Based on the available reports of block farming plots are presented in Table 4.

Table 4. Performance of submergence tolerant aman rice (Binadhan-11) compared to popular cultivar in different locations during 2018-19

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-11	BRRI dhan52	Binadhan-11	BRRI dhan52	
Mymensingh	Sadar	19	122	134	4.34	4.25	2.11
	Haluaghat	9	125	144	4.60	3.43	34.11
	Dhobaura	10	122	140	4.80	4.43	8.35
	Gouripur	16	115	131	4.40	4.02	9.45
Kishoreganj	Kuliarchar	10	121	141	4.15	3.98	4.27
	Pakundia	5	119	140	5.00	5.30	-5.66
	Kotiadi	5	125	136	4.30	4.40	-2.27
	Tarail	5	114	124	5.20	3.50	48.57
	Bajitpur	5	119	143	4.50	4.20	7.14
	Karimganj	5	123	141	5.00	4.80	4.16
	Hossainpur	5	116	141	4.75	4.50	5.56
	Total	**94**					
	Mean		**120**	**137**	**4.60**	**4.25**	**9.55**

The data of Table 1 revealed that Binadhan-11 produced average grain yield of 4.60 t ha^{-1}, which was 9.55 percent higher compared to check varieties (BRRI dhan52). Maturity period of Binadhan-11 and BRRI dhan52 were 120 and 137 days, respectively. Binadhan-11 showed higher yield performance in both submerged and normal condition. That's why farmers were found much keen to cultivate Binadhan-11 in the upcoming years.

Block farming with salt tolerant boro rice variety (Binadhan-10) compared to popular cultivar in different locations

During boro season of 2018-19, 100 block farming with Binadhan-10 were conducted at the farmer's fields in different locations in collaboration with the DAE. Area of each demonstration plot was one acre. Spacing between line to line and plant to plant was 20cm x

15cm. All fertilizers were applied by farmers as per recommendation. Transplanting dates ranged from 10 to 31 January 2019 and age of seedlings were 40 to 50 days. Based on the available reports, data of block farming plots are presented in Table 3.

Table 5. Performance of salt tolerant boro rice (Binadhan-10) compared to popular cultivar in different locations during 2018-19

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-10	BRRI dhan47	Binadhan-10	BRRI dhan47	
Bhola	Daulatkhan	20	128	141	6.33	5.77	9.71
Patuakhali	Kalapara	10	126	135	6.30	4.80	31.25
	Rangabali	10	117	133	6.20	5.00	24.00
Khulna	Paikgacha	10	131	144	5.10	4.47	14.09
Jhalokathi	Sadar	10	133	138	4.10	4.20	-2.33
Pirojpur	Indurkani	10	128	141	6.12	5.17	18.38
Feni	Sonagazi/ Sadar	10	132	131	5.21	4.90	6.33
Chattogram	Bashkhali	10	135	150	5.47	5.84	-6.34
Cox's bazar	Tecknaf	10	126	141	4.26	4.74	-10.13
	Total	**100**					
	Mean		**129**	**140**	**5.54**	**4.98**	**9.44**

Data in the Table 5 revealed that Binadhan-10 and check variety (BRRI dhan47) were Produced average grain yields of 5.54 and 4.98 t ha^{-1} respectively. Maturity period of Binadhan-10 and BRRI dhan47 were 129 and 140 days, respectively. Farmers were found very much interested to cultivate Binadhan-10 due to its better performance in both saline and non saline soils. They also made request to BINA authority to conduct more demonstrations for farmers' motivation and their better understanding about the variety. Farmers of above all districts were found keen to cultivate Binadhan-10. It needs more trials in different locations for identifying other suitable areas of Binadhan-10 cultivation and thereby massive extension.

Block farming with late boro rice variety (Binadhan-14) compared to popular cultivar in different locations

During boro season of 2018-19, 35 block farming with late boro rice Binadhan-14 were conducted at the farmer's fields in different locations in collaboration with the DAE. Area of each demonstration plot was one acre. Spacing between line-to-line 20 cm and plant-to-plant was 15 cm. All fertilizers were applied by farmers as per recommendation. Transplanting dates ranged from 15 February to 15 March 2018 and age of seedlings were 20 to 25 days. Based on the available reports, data of demonstration plots are presented in Table 6.

Table 6. Performance of late boro rice (Binadhan-14) compared to popular cultivar in different locations during 2018-19

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-14	BRRI dhan28	Binadhan-14	BRRI dhan28	
Manikgonj	Shibaloy	5	110	134	5.17	4.85	6.60
	Daulotpur	5	109	132	5.43	4.63	17.27
Sherpur	Nakla	7	112	135	4.96	4.79	3.55
Mymensingh	Sadar	5	112	133	5.53	5.11	8.22
	Tarakanda	13	109	136	5.52	4.79	15.24
	Total	**35**					
	Mean		110	135	5.32	4.83	10.18

Data in the Table 6 revealed that Binadhan-14 and check variety (BRRI dhan28) were Produced average grain yields of 5.32 and 4.83 t ha^{-1}, respectively. Maturity period of Binadhan-14 and BRRI dhan28 were 110 and 135 days, respectively. It was a late sowing boro variety which promoted an extra HYV oilseed, pulse and potato varieties easily before boro cultivation, facilitating to attain self-sufficiency in oilseed, pulse and vegetable production.

Performance of Aus rice (Binadhan-19) compared to popular cultivar in different locations during 2018-19

During aus season of 2018-19, 50 block farming with Aus rice Binadhan-19 were conducted at the farmer’s fields in different locations in collaboration with the DAE. Area of each demonstration plot was one acre. Spacing between line-to-line 20 cm and plant-to-plant was 15 cm. All fertilizers were applied by farmers as per recommendation. Transplanting dates ranged from 15 April to 15 May 2018 and age of seedlings were 20 to 25 days. Based on the available reports, data of block farming plots are presented in Table 6. Data of demonstration plots are presented in Table 6.

Table 7. Performance of Aus rice rice (Binadhan-19) compared to popular cultivar in different locations during 2018-19

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-19	BRRI dhan48	Binadhan-19	BRRI dhan48	
Manikganj	Shibaloy	5	102	114	4.47	4.23	5.67
	Daulotpur	5	100	116	4.61	4.28	7.71
	Ghior	5	103	114	4.63	4.41	4.99
Mymensingh	Sadar	15	98	113	4.52	4.11	9.98
	Tarakanda	10	100	116	4.43	4.15	6.75
	Fulpur	5	99	112	4.47	4.35	2.76
	Gouripur	5	102	111	4.34	4.23	2.60
	Total	50					

Mean	100	113	4.49	4.25	5.78

Data in the Table 7 revealed that Binadhan-19 and check variety (BRRI dhan48) were Produced average grain yields of 4.49 and 4.25 t ha^{-1} respectively. Maturity period of Binadhan-19 and BRRI dhan48 were 100 and 113 days, respectively.

Block farming with mustard variety, Binasarisha-9 compared to BARIsarisha-14 variety

During the rabi season of 2018-19, 194 Block farming were conducted with Binasarisha-9 and BARIsarisha-14 in 2 different districts in collaboration with the DAE. The main objectives were to demonstrate the performance of Binasarisha-9 to evaluate their location specific suitability and widen adoption by the farmers. Unit plot size of Block farming was one bigha at all the locations. Seeds were sown during October to November 2018 at the rate of 7.5 kg ha^{-1}. The check variety was BARI sarisha-14. All fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Data were recorded on crop duration and seed yield. The results are presented in Table 8.

Table 8. Performance of Binasharisa-9 compared to BARI sharisa-14 in different locations during 2018-19

District	Upazilla	No. of Expt.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Bina sarisha-9	BARI Sarisha-14	Bina sarisha-9	BARI Sarisha-14	
Mymensingh	Sadar	24	82	81	1.56	1.45	7.59
	Gouripur	20	83	82	1.49	1.47	1.36
Manikganj	Ghior	50	82	81	1.64	1.62	1.23
	Daulatpur	50	82	81	1.65	1.61	2.48
	Shivalaya	50	83	82	1.69	1.60	5.62
	Total	**194**					
	Mean		**82**	**81**	**1.61**	**1.55**	**3.66**

The data presented in Table 8 indicated that Binasarisha-9 and BARI sharisha-14 produced average seed yield of 1.61 and 1.55 t ha^{-1} with duration of 82 and 81, respectively. The results indicated that there was almost no difference in respect of duration and yield of tested varieties. However, considering the duration of tested varieties indicated that farmers of all the locations easily include those varieties as an extra crop between T. aman and boro rice for increasing cropping intensity from 200% to 300%.

Block farming with groundnut variety Binachinabadam-4 compared to popular cultivar in different locations

During Kharif-1 season of 2018-19, 15 block farming with variety Binachinabadam-4 were conducted at farmers' plots in 2 districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binachinabadam-4 for their dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next season. Unit plot size of individual block farming was one bigha at all the locations. Seeds were sown during February to March 2018. The local check variety was Dhaka-1. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 9.

Table 9. Performance of Binachinabadam-4 in different locations during 2018-19

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binchinabadam-4	Dhaka-1	Binchinabadam-4	Dhaka-1	
Mymensingh	Sadar	5	112	113	1.4	1.22	14.75
Kishoreganj	Bhairab	10	111	114	2.22	1.51	47.02
	Total	**15**					
	Mean		**111**	**113**	**1.81**	**1.36**	**30.89**

The data of Table 9 revealed that Binchinabadam-4 produced average seed yield of 1.81 t ha^{-1}, which was almost similar to popular check variety Dhaka-1 (1.36 tha^{-1}). The duration of Binchinabadam-4 was almost similar to Dhaka-1 indicating that both were the popular in farmers' field.

Block farming with groundnut variety Binachinabadam-5 compared to popular cultivar in different locations

During Kharif-1 season of 2018-19, 6 block farming with variety Binachinabadam-5 were conducted at farmers' plots in 1 district in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binachinabadam-5 for their dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next season. Unit plot size of individual block farming was one bigha at all the locations. Seeds were sown during February to March 2018. The local check variety was BARIchinaadam-5. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 10

Table 10. Performance of Binachinabadam-5 in different locations during 2018-19

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binachina badam-5	BARIchina badam-5	Binachinabadam-5	BARIchina badam-5	
Mymensingh	Sadar	1	112	113	1.5	1.22	22.95
Kishoreganj	Bhairab	5	112	114	1.6	1.51	5.96
	Total	**6**					
	Mean		**112**	**113**	**1.55**	**1.36**	**14.46**

The data of Table 10 revealed that Binchinabadam-5 produced average seed yield of 1.55 t ha^{-1}, which was slightly higher to popular check variety BARIchinabadam-5 (1.36t ha^{-1}). The duration of Binchinabadam-5 was also similar to BARIchinabadam-5 indicating that both were the popular in farmers' field.

Adaptive trail of groundnut variety Binachinabadam-9 and BARI Chinabadam-7 variety in different locations in collaboration with DAE

During Kharif-2 season of 2018-19, Five block farming with variety Binachinabadam-9 and BARIchinabadam-7 were conducted at farmers' plots in Mymensingh district in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binachinabadam-9 and BARIchinabadam-7 for their dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next season. Unit plot size of individual block farming was one bigha. Seeds were sown during February to March 2018. The local check variety was BARIchinabadam-7. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 11.

Table 11. Performance of Binachinabadam-9 compared to BARIchinabadam-7 during 2018-19

District	Upazilla	No. of Expt.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binachina badam-9	BARI China badam-7	Binachina badam-9	BARI China badam-7	
Mymensingh	Sadar	5	117	118	2.14	2.0	7.00

The data in Table 11 indicated that almost no difference was observed in duration of Binachinabadam-9 and BARIchinabadam-7. The highest seed yield 2.14 t ha^{-1} of Binachinabadam-9 was recorded at sadar upazila of Mymensingh district.

Block farming with Binatil-2 compared to local check variety

During Kharif-1 season of 2018-19, 20 block farming with variety Binatil-2 were conducted at farmers' plots in 3 districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binatil-2 for their dissemination and encourage the farmers for adopting these varieties. Unit plot size of individual block farming was one bigha at all the locations. Seeds were sown during February to March 2019. The local check variety was Atshira. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 12.

Table 12. Performance of Binatil-2 compared to popular cultivar in different locations during 2018-19

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binatil-2	Atshira	Binatil-2	Atshira	
Rajbari	Sadar	5	89	91	1.21	1.13	7.08
Manikganj	Doulatpur	5	92	94	1.44	1.19	21.01
	Ghior	5	87	88	1.24	1.12	10.71
Mymensingh	Sadar	5	86	91	1.43	1.17	22.22
	Total	**20**					
	Mean		**88**	**91**	**1.33**	**1.15**	**15.26**

The data of Table 12 revealed that Binatil-2 produced average seed yield of 1.33 t ha^{-1}, which was almost similar to popular check variety Atshira (1.15 t ha^{-1}). The duration of Binatil-2 was also similar to Atshira indicating that both were the popular in farmers' field.

Farmers' Observation Trials of sesame varieties in different locations

During kharif-1 season of 2018-19, 12 adaptive trials with 2 sesame varieties i.e., Binatil-2 and Binatil-3 were arranged at farmers' plots in 3 districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of with Binatil-2 and Binatil-3 for its dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next seasons. Unit plot size of individual plot was one bigha at all the locations. Seeds were sown during mid-February to March, 2019 in kharif-1 season. The local check variety was Atshira in all the locations. Fertilizers were applied as per recommendation. Data were recorded on crop duration and grain yield. The results are presented in Table 13.

Table 13. Performance of Binatil-2 and Binatil-3 compared to Atshira in different locations during 2018-19

District	Upazilla	No. of Expt.	Duration (days)			Yield (t ha^{-1})			Yield increased over control (%)	
			Binatil-2	Binatil-3	Atshira	Binatil-2	Binatil-3	Atshira	Binatil-2	Binatil-3
Mymensingh	Sadar	3	87	86	92	1.11	1.16	0.96	15.63	20.83
Rajbari	Sadar	3	90	88	96	1.06	1.09	0.92	15.22	18.48
Manikganj	Doulatpur	3	93	90	97	1.09	1.17	0.89	22.47	31.46
	Ghior	3	90	90	92	1.18	1.23	0.97	21.65	26.80
	Total	**12**								
	Mean		**90**	**88**	**94**	**1.11**	**1.16**	**0.94**	**18.74**	**24.39**

The results presented in Table 13 showed that average duration and yield of Binatil-2, Binatil-3 and Atshira were 90, 88 and 94 days and 1.11, 1.16 and 0.94 t ha^{-1}, respectively. It is indicating that Binatil-3 showed better performances both in respect of duration and seed yield. That's why, farmers' of all locations preferred Binatil-3. However, for identification of best variety its need further trials to conclude.

Block farming of lentil variety Binamasur-8 in different locations in collaboration with DAE

During kharif-1 season of 2018-19, a total of 20 block farming with Binamasur-8 were set up at the farmer's fields in 4 upazila under 4 districts. The main objectives were to demonstrate and evaluate the performance of Binamasur-8 compared to check variety across the locations and encourage the farmers to continue the variety in their fields. The area for each of the demonstration plots was one acre. Data on crop duration, insect and disease infestation and seed yield were recorded. The results are presented in Table 14.

Table 14. Performance of Binamasur-8 compared to BARI Mashur 8 in different locations during 2018-19

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binamasur-8	BARImashur 8	Binamasur-8	BARImashur 8	
Jashore	Sadar	5	104	111	1.42	1.30	8.45
Rajbari	Sadar	5	103	112	1.49	1.25	16.11
Faridpur	Sadar	5	105	108	1.69	1.50	11.24
Mymensingh	Sadar	5	104	105	1.22	1.40	-14.75
	Total	**20**					
	Mean		**104**	**109**	**1.43**	**1.366**	**5.26**

The data in Table 14 indicated that almost no difference was observed in duration of Binamasur-8 and the check variety BARImashur 8. The highest seed yield (1.69 t ha^{-1}) was recorded at Faridpur sadar upazila.

Block farming of lentil variety in different locations in collaboration with DAE

During kharif-1 season of 2018-19, a total of 20 block farming with Binamasur-10 were set up at the farmers' fields in 4 upazila under 4 districts. The main objectives were to demonstrate and evaluate the performance of Binamasur-10 compared to check variety across the locations and encourage the farmers to continue the variety in their fields. The area for each of the demonstration plots was one acre. Data on crop duration, insect and disease infestation and seed yield were recorded. The results are presented in Table 15.

Table 15. Performance of Binamasur-10 compared to BARI Masur-8 in different locations during 2018-19

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binamasur-10	BARImashur 8	Binamasur-10	BARImashur 8	
Jashore	Sadar	5	101	111	1.72	1.40	18.60
Rajbari	Sadar	5	105	112	1.51	1.30	13.91
Faridpur	Sadar	5	102	108	1.57	1.22	22.30
Mymensingh	Sadar	5	108	105	1.29	1.40	-8.52
	Total	**20**					
	Mean		**104**	**109**	**1.49**	**1.33**	**11.57**

The data in Table 15 indicated that almost no difference was observed in duration of Binamasur-10 and the check variety BARI masur-8. The highest seed yield (1.72 t ha^{-1}) was recorded at Sadar upazila of Jashore.

Training on the use of BINA developed technologies

In order to technology promotion, 4 training courses were organized during the period of 2018-19. A total of 240 female and male farmers were trained on establishment of demonstration & seed preservation method of BINA developed rice varieties. Details of the training are presented in Table 16.

Table 16. Farmers and SAAO Training on the use of BINA developed technologies during 2017-2018

Sl No	Topic	Place of Training	No. of participants	Source of fund
1.	Farmers training on "Cultivation technique of Binadhan-19''	Tarakanda, Mymensingh	60	Rev.

2.	Farmers training on "Production procedure and seed preservation of Binadhan-19''	Bhaluka, Mymensingh	60	Rev.
3.	Farmers training on "Production technology of aus rice Binadhan-19''	Trishal, Mymensingh	60	Rev.
4.	Farmers training on "Cultivation technique of BINA develped popular aus rice variety''	Sadar, Mymensingh	60	Rev.

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 10 field days/on-farm farmers' training on different crop varieties was organized across the country. Details of the field day activities are presented in Table 17.

Table 17. Field days organized at the farmer's fields on different crop varieties during 2018-2019

Sl. No.	Crops	Varieties	Date	Locations	Participants
1	Mustard	Binasarisha-9	31.01.2019	Poranganj, Mymensingh	150
		Binasarisha-9	06.02.2019	Char ghagra, Mymensingh	200
2.	Rice	Binadhan-19	14.08.2018	Trishal, Mymensingh	200
		Binadhan-19	16.08.2018	Bhaluka, Mymensingh	200
		Binadhan-11	07.11.2018	Haluaghat,Mymensingh	200
		Binadhan-14	20.052019	Tarakanda,Mymensingh	200
3.	Pulse	Binamosur-8	03.03.2019	Sadar, Rajbari	200
		Binamosur-8	07.03.2019	Sadar, Mymensingh	200
		Binamosur-10	04.03.2019	Sadar, Faridpur	200
4.	Oilseed	Binachinabadam-4	29.08.2018	Char kashia, Mymensingh	200

Publications and photographic enrichment

For technology transfer through print and electronic media, three programme were telecast to popularize some BINA crop varieties. Details of the publication activities and electronics media exposure are presented in Table 18.

Table 18. Electronic media exposure on different crop varieties during 2018-19

Sl. No.	Name of crops/ varieties	Name of the channel	Location	Remarks
1.	Binasarisha-9 & Binasarisha 10	Masranga & MY TV	Charghagra, Mymensingh	It was very effective for awareness creation
2.	Binasarisha-9	MY TV	Poranganj, Mymensingh	
3.	Binadhan-19	MY TV	Tarakanda, Mymensingh	

Agricultural Economics Division

Research Highlights

- Yield gap of Binasarisha-4 was investigated in five locations of major mustard growing areas of Bangladesh. The average yield of Binasarisha-4 was 1.34 t ha^{-1}.The results showed that the farmers level highest yield was observed from Magura (1.46 t ha^{-1}) followed by Jashore (1.38 t ha^{-1}), Sirajganj (1.26 t ha^{-1}), Rangpur (1.20 t ha^{-1}), and Tangail (1.17 t ha^{-1}) district.
- The estimated average yield gap-I was 0.08 t ha^{-1} (4.72 %.) and average yield gap -II was 0.20 t ha^{-1} (13.35 %.).
- Considering all, the average total yield gap was 0.28 t ha^{-1} (17.46%). The lowest gap was 0.19 t ha^{-1} (11.52%) observed in Magura district and it was the highest 0.40 t ha^{-1} (25.00 %) in case of Rangpur district. and much scope for yield enhancement in the variety.
- The average seed rate was 7.06Kg ha^{-1}, Urea 209.56 Kg ha^{-1}, MoP 78.77 Kg ha^{-1}, TSP 164.03 Kg h^{-1} and seedling age 4.35 days respectively, indicating that they are either below or range the recommendation.
- In average 67 % used power tiller more than two times, 69% irrigated their lands 1-2 times and 64 % weeded their lands 1 times and 58 % spray pesticide and insecticide to control disease and insect.
- The contribution of specified factors affecting production of Binasharisha-4 could be seen from the estimation of regression equation. Very few farmers used Sulphur and manure, so this was not including in the equation.
- The result showed that few coefficients do not have the expected sign. However, the coefficients for power tiller, seed, Urea, TSP, MoP, Gypsum, soil fertility and experience were found to be positively significant at 1%, 5% and 10% level.
- The positive sign indicated that using more of these inputs in Binasharisha-4 production could increase the yield to some extent. The negative sign of Zn and farm size indicate that yield was not achieved according to the Zn and the farm size.
- Major constraints that mentioned by the farmers and limit the yields of Binasharisha-4 were adulterated inputs (seed, fertilizer, pesticides), rainfall during harvesting time, lack of credit facilities, inadequate labour during harvesting time, lack of training on oilseed cultivation, infestation of insects, imbalanced use fertilizer, natural calamities, etc.

- Profitability of Binamasur-8 was investigated in four lentil growing areas of Bangladesh. In this study was found that the average age of Binamasur-8 cultivated farmers was 46.5 years with minimum age of 17 years and the maximum of 79 years. About 87 percent of farmer's occupation was agriculture.

- Majority of the Binamasur-8 cultivated farmers (72% of the total farmers) had primary and secondary levels of education. Only 4 percent Binamasur-8 cultivated farmers' were found to have completed their higher level of education.
- Eighteen percent of the farmers had basically no education. The average farm size per household was estimated at 1.51 ha. The highest farm size was found in Faridpur (1.76 ha.) followed by Pabna (1.65 ha.), Magura (1.41 ha.) and Chapai Nawabganj (1.21 ha.), respectively.
- The average yearly household income was Tk. 239050. The highest household income was found in Pabna (Tk. 274356) followed by Magura (Tk. 251217), Faridpur (Tk. 236270) and Chapai Nawabganj (Tk. 194356), respectively.
- The average costs of Binamasur-8 cultivation were Tk. 58299 and Tk. 40272 per hectare on full cost and cash cost basis, respectively. The highest production cost was for human labour (36.8%), followed by land use (17.1%), power tiller (15.4%), seed and irrigation (6.8%). The cost of Binamasur-8 cultivation was found highest in Magura (Tk. 61266 ha^{-1}) followed by that in Chapai Nawabganj (Tk. 59171 ha^{-1}), Pabna (Tk. 57697 ha^{-1}) and Faridpur (Tk. 55063 ha^{-1}), respectively.
- The average yield of Binamasur-8 was observed 1691 kg ha^{-1}. The yield was highest at Pabna (1803 kg ha^{-1}) followed by Magura (1797 kg ha^{-1}), Chapai Nawabganj (1684 kg ha^{-1}) and Faridpur (1479 kg ha^{-1}).
- The price of Binamasur-8 was found the highest in Magura (Tk. 57.00 kg^{-1}) and the lowest in Chapai Nawabganj (Tk. 54.00 kg^{-1}).
- The average net return per hectare was Tk. 38536. The net return was highest in Pabna (Tk. 45835ha^{-1}) followed by Magura (Tk. 43936 ha^{-1}), Chapai Nawabganj (Tk. 34965 ha^{-1}) and Faridpur (Tk. 29382 ha^{-1}), respectively.
- BCR was estimated at 1.66 and 2.40 on full cost and variable cost basis implying that the Binamasur-8 cultivation at farm level was highly profitable.
- The first ranked constraint was unavailability of Binamasur-8 varieties' seeds in all areas. Other constraints were lack of training (63%), lack of technical know-how (31%), insect infestation high (28%), attack of diseases (22%), crop loss due to diseases (11%) and high price of pesticides (9%).
- Potentiality and performance of Binasarisha-9 study was conducted done in three Binasarisha-9 growing areas of Bangladesh namely Sherpur, Mymensingh and Rangpur. In this study, it was found that the average cost of production of Binasarisha-9 was Tk. 44126.98 per hectare with an average yield was 1.4 t ha^{-1}which indicate to a production cost of Tk.32.16 kg^{-1}.
- Binasarisha-9 production the variable cost and fixed cost covered 62.91% and 37.09% of total cost, respectively.
- The major production cost was for human labour (35.80%), followed by land use (22.13%), fertilizer cost (22.06%), power tiller (12.73%), and irrigation (4.24%).

- The cost of Binasarisha-9 cultivation was found highest in Rangpur (Tk. 47971.59 ha^{-1}) followed by Mymensingh (Tk. 42692.19 ha^{-1}), Sherpur (Tk. 41717.16 ha^{-1}) respectively.
- The highest yield was found at Rangpur (1497.24 kg ha^{-1}) followed by Sherpur (1328.11 kg ha^{-1}) and Mymensingh (1291.25 kg ha^{-1}).
- The average selling price of Binasarisha-9 was Tk.45.15 kg^{-1}. The highest price of Binasarisha-9 was found in Rangpur (Tk. 49.16 kg $^{-1}$) and the lowest found in Mymensingh district (Tk. 42.10 kg^{-1}).
- The average net return per hectare was Tk. 22278.34. The net return was highest in Rangpur (Tk. 30334.53 ha^{-1}) followed by Sherpur (Tk. 20771.68 ha^{-1}), and Mymensingh (Tk. 16519.40 ha^{-1}) respectively.
- Thirteen explanatory variables were performed in logit regression analysis in this study. The result showed that experience of household head, farm size, annual income, yield, training, and extension contact were found as positively significant and earning person, duration and weather were found as negatively significant variables in explaining the variation in Binasarisha-9 adoption of farm households.
- About 20% mentioned about lack of training facilities and was top ranked followed by quality seed in timely (13.33%), Infestation of disease (11.11%), and other (9.99%) were found among the mustard growers.

- Area coverage position of BINA developed rice, pulse and oilseed varieties was investigated in collaboration with DAE and Sub-stations of BINA in 34 districts of Bangladesh. In this study, the results were found that the overall area coverage of BINA developed rice varieties were 2.34%. Among the three seasons; Aus, Aman and Boro the highest area coverage was found in aman season i. e. 4.27% followed by boro 0.26% and aus 0.01% respectively.
- The overall area coverage of BINA developed pulse and oilseed varieties were 2.53% and 2.26%., respectively.

Expt 1: Yield gap of potential oilseed variety Binasarisha-4 in some selected areas of Bangladesh

The study was conducted in five major Binasharisha-4 growing areas of Bangladesh namely Rangpur, Sirajganj, Jashore, Tangail and Magura. The objectives of the study were i) to estimate the yield gap of Binasarisha-4 among the study areas; ii) to identify the factor affecting the yield of the variety; and iii) to suggest some policy guidelines to minimize the yield gap. A total of 200 farmers were randomly selected (40 from each location) to collect the data with a pre-designed questionnaire. Tabular and statistical analyses were used to analyze the data.

In this study, the concept of yield gap as suggested by Zandstra *et al.* (1981) was followed. Total yield gap can be decomposed into two parts i.e. Yield gap I and Yield gap II. Yield Gap I refer to the difference between research station's yield and potential farm yield obtained at demonstration plots, while Yield Gap II, reflecting the effects of biophysical and socio-economic constraints, is the difference between yield obtained at the nearest demonstration plot and actual yield obtained on farmers' fields. The yield gaps were estimated as follows:

$$\text{Yield Gap I} = [(Y_R - Y_D)/Y_R] \times 100$$
$$\text{Yield Gap II} = [(Y_D - Y_F)/Y_D] \times 100$$

Where,
Y_R is the yield of research stations,
Y_D is the yield of demonstration plots, and
Y_F is the yield of actual farmers field.

The production of Binasarisha-4 is likely to be influenced by different factors, such as, seed, fertilizer, etc. The following Cobb-Douglas type production function was used to estimate the parameters. The functional form of the Cobb- Douglas multiple regression equation was as follows:

$$Y = AX_1^{b1} X_2^{b2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots X_n^{bn} e^{ui}$$

The production function was converted to logarithmic form so that it could be solved by least square method i.e.

$$\text{Log } Y = \text{Log } a + b_1 \log X_1 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + b_n \text{Log } X_n + e^{ui}$$

The empirical production function was the following:

$$\text{LogY} = \text{Loga} + b_1 \text{LogX}_1 + b_2 \text{LogX}_2 + b_3 \text{LogX}_3 + b_4 \text{LogX}_4 + b_5 \text{LogX}_5 + b_6 \text{LogX}_6 + b_7 \text{LogX}_7 + b_8 \text{LogX}_8 + b_9 \text{LogX}_9 + b_{10} \text{LogX}_{10} + \text{Ui}$$

Where,

Y= Yield (kg/ha)
X_1 = No. of power tiller
X_2 = Amount of Seed (kg/ha)
X_3= Amount of Urea (kg/ha)
X_4= Amount of TSP (kg/ha)
X_5= Amount of MoP (kg/ha)
X_6= Amount of Gypsum (kg/ha)
X_7= Amount of Zn (kg/ha)
X_8= Soil fertility
X_9= Farm size
X_{10}= Experience

a= constant value
b_1 b_2 .... b_6 = Co-efficient of the respective variables and
U_i = Error term.

Results and Discussion

The results showed that the farmers level highest yield was obtained from Magura (1.46 t ha^{-1}) followed by Jashore (1.38 t ha^{-1}), Sirajganj (1.26 t ha^{-1}), Rangpur (1.20 t ha^{-1}), and Tangail (1.17 t ha^{-1}) district. The average yield of Binasarisha-4 was 1.34 t ha^{-1} (Table 1). As seen from Table 1, the estimated average yield gap-I was 0.08 t ha^{-1} (4.72 %.) and average yield gap-II was 0.20 t ha^{-1} (13.35 %.). The lowest gap was 0.19 t ha^{-1} (11.52%) observed in Magura district and it was the highest 0.40 t ha^{-1} (25.00 %) in case of Rangpur district. Considering all, the average total yield gap was 0.28 t ha^{-1} (17.46%) and much scope for yield enhancement in the variety.

Table 1. Estimated yield gap of Binasarisha-4 in different locations

Particular	Rangpur	Jashore	Tangail	Sirajganj	Magura	Average
Average yield of research station (Y_R), t ha^{-1}	1.60	1.65*	1.55*	1.60*	1.65	1.62
Average yield of demonstration plots (Y_D), t ha^{-1}	1.50	1.54*	1.49*	1.50	1.59	1.54
Average yield of actual farm (Y_F), t ha^{-1}	1.20	1.38	1.18	1.26	1.46	1.34
Yield gap-I (%)	0.10 (6.25)	0.11 (6.67)	0.07 (3.87)	0.10 (6.25)	0.06 (3.64)	0.08 (4.72)
Yield gap-II (%)	0.30 (20.00)	0.16 (10.39)	0.32 (21.48)	0.24 (16.00)	0.13 (8.18)	0.20 (13.35)

Total yield gap (%)	0.40 (25.00)	0.27 (16.36)	0.38 (24.52)	0.34 (21.25)	0.19 (11.52)	0.28 (17.46)

*Indicates the value of nearest sub-stations

Major factors that influencing the yield of Binasarisha-4

In Table 2, the district wise farmers have to maintain according to recommended dose in some extant but in average, the farmers among the study areas did not consider the recommended doses of seed rate, fertilizer and seedling age. The average seed rate was 7.06 Kg ha^{-1}, Urea 209.56 Kg ha^{-1}, MoP 78.77 Kg ha^{-1}, TSP 164.03 Kg h^{-1} and $ZnSO_4$ 4.35 Kg ha^{-1}, respectively, indicating that they are either below or range the recommendation.

Table 2. Input–use pattern of Binasarisha-4 growing farmers

Factors	Seed Kg ha^{-1}	Urea Kg ha^{-1}	MoP Kg ha^{-1}	TSP Kg ha^{-1}	Zypsum Kg ha^{-1}	ZnSO4 Kg ha^{-1}
Recommendation	7.41	197-247	74-86	148-173	123-148	5
Rangpur	7.11	223.91	82.40	165.32	139.46	4.72
Sirajgonj	6.96	199.96	73.51	160.62	127.35	4.10
Jashore	7.30	209.25	75.26	170.36	141.56	4.07
Tangail	6.22	198.26	77.37	151.46	130.22	3.85
Magura	7.38	216.46	85.33	172.41	137.18	4.36
Average	7.06	209.56	78.77	164.03	135.15	4.35

Other factors which were also responsible in the yield of Binasarisha-4 are described in Table 2. In average 67 % used power tiller more than two times, 69% irrigated their lands 1-2 times and 64 % weeded their lands 1 times and 58 % spray pesticide and insecticide to control disease and insect.

Table 3. Input–use pattern of Binasarisha-4 growing area (cont.)

Factors	Rangpur	Sirajganj	Jashore	Tangail	Magura	Average
Power Tiller (%)						
One times	5	-	10	15	5	8
Two times	20	20	20	25	28	25
More than 2	75	80	70	60	67	67
Irrigation (%)						
No irrigation	35	26	32	44	17	31
Irrigation (1-2)	65	74	68	56	83	69
Weeding (%)						
No Weeding	41	37	49	34	19	36
Weeding (1)	59	63	51	66	81	64
Pesticide and insecticide (%)	62	47	65	41	76	58

Table 4. Factor affecting the production for Binasarisha-4 cultivation in the study areas

Item	Co-efficient	t-value	P>t-value
Intercept	3.703***	8.96	0.000
Power tiller (X_1)	0.028***	6.14	0.000
Seed (X_2)	0.363***	4.02	0.000
Urea (X_3)	0.129***	2.91	0.000
TSP (X_4)	0.145***	0.027	0.000
MoP (X_5)	0.098**	0.81	0.415
Gypsum (X_6)	0.001*	1.80	0.072
Zn (X_7)	-0.032	2.15	0.032
Soil fertility (X_8)	0.074*	1.00	0.319
Farm size (X_9)	-0.220 **	2.81	0.006
Experience (X_{10})	0.138 **	1.38	0.028

Note: '*' '**' and '***' indicate significant at 10%, 5% and 1% level.

In Table 4, the contribution of specified factors affecting production of Binasarisha-4 could be seen from the estimation of regression equation. Very few farmers used sulphur and manure, so this was not including in the equation. The result showed that few coefficients do not have the expected sign. However, the coefficients for power tiller, seed, Urea, TSP, MoP, Gypsum, soil fertility and experience were found to be positively significant at 1%, 5% and 10% level. The positive sign indicated that using more of these inputs in Binasarisha-4 production could increase the yield to some extent. The negative sign of Zn and farm size indicate that yield was not achieved according to the Zn and the farm size.

Constraints of Binasarisha-4 cultivation

Farmers of Binasarisha-4 growing areas were facing some problem in cultivating this variety by which yield. Major constraints that mentioned by the farmers and limit the yields of Binasarisha-4 below the potential yield are described in Table 5.

Table 5. Major Constraints of Binasharisha-4 cultivation

Sl. No	Particulars	Rangpur	Sirajganj	Jashore	Tangail	Magura	Average
1.	Adulterated inputs (seed, fertilizer, pesticides)	36.5	41.2	54.4	46.1	45.5	44.7
2.	Rainfall during harvesting time	35.3	61.1	27.7	25.5	36.2	37.2
3.	Lack of credit facilities	29.9	24.2	53.6	25.8	32.3	33.2
4.	Inadequate labour during harvesting time	47.3	28.8	38.5	66.5	42.5	42.9
5.	Lack of training on oilseed cultivation	10.0	17.1	26.3	20.0	13.0	17.3

6.	Others*	9.0	13.1	8.3	5.5	9.0	8.9

* Infestation of insects, imbalanced use fertilizer, natural calamities, etc.

Some policy guidelines to reduce the Yield Gap

The majority of the respondent farmers wanted to provide Binasarisha-4 varieties for the next year due to higher yield, low cultivation cost and higher profit. In order to decrease the yield gap of Binasarisha-4 at farm level, the Government should ensure the adequate supply of adulteration free or quality inputs (seed, fertilizer, pesticides, etc.). Drainage system should be developed to reduce loss during harvesting time. It was suggested that the farmers were supported by adequate credit facilities in time for using inputs timely with favourable terms & conditions. Ensuring labour facilities during harvesting time influence mustard farmers to a greater extent to reduce yield gap. Frequent interaction was needed among farmers, extension personnel and Binasarisha-4 growers. Training on improved mustard cultivation and crop management practices for the mustard growing farmers is also an important and government should take care of it. Results of the farmers level at different locations revealed that infestation of insects, imbalanced use fertilizer, natural calamities, etc. Therefore, Government should take appropriate steps on these aspects so that farmers become enthusiastic toward improved mustard cultivation.

Conclusion

Binasarisha-4 production in the study areas was profitable. Binasarisha-4 farmers received high return on its investment and cultivation of this variety increasing in the study areas day by day due to its higher yield potential.

Expt:2 Profitability of Binamasur-8 cultivation in some selected areas of Bangladesh

The study was conducted in four major Binamasur-8 growing areas of Bangladesh, namely Magura, Faridpur, Pabna and Chapai Nawabganj district. The objectives were (i) to identify the socio-economic profile of Binamasur-8 growers; (ii) to estimate the profitability of Binamasur-8; and (iii) to identify the major constraints to Binamasur-8 production. Srtatified random sampling technique was followed for this study. A total of 200 farmers were randomly selected as sample size in the study areas, 50 from each district. Data were collected from Binamasur-8 growers through interview schedule. Collected data were edited, summarized, tabulated and analyzed to fulfill the objectives. Some descriptive statistics were used for analyzing the collected data. In the study, costs and return analysis were done on both cash cost and full cost basis.

Results and Discussion

Socio-economic profile of the Binamasur-8 producing farmers

Age is an important factor that influences farmer's decision to adopt improved technologies. The average age of the farmers was 46.5 years with minimum age of 17 years and the maximum of 79 years. About 87 percent of farmer's occupation was agriculture. The sample farmers were grouped into five categories based on their level of education. Majority of the farmers (72% of the total farmers) had primary and secondary levels of education. Only 4 percent farmers' were found to have completed their higher level of education. Eighteen percent of the farmers had basically no education. Length of experience in crop farming is also an important factor that influences farmers' level of adoption for new technologies. The average length of experience of Binamasur-8 cultivated farmers was 21 years. Farmers of Faridpur communicated with different extension personnel like Sub-Assistant Agriculture Officer (SAAO), Upazilla Agriculture Officer, and BINA scientists more frequently than the farmers of other study areas for getting improved Binamasur-8 technology. The average farm size per household was estimated at 1.51 ha. The highest farm size was found in Faridpur (1.76 ha.) followed by Pabna (1.65 ha.), Magura (1.41 ha.) and Chapai Nawabganj (1.21 ha.), respectively. The average yearly household income was Tk. 239050. The highest household income was found in Pabna (Tk. 274356) followed by Magura (Tk. 251217), Faridpur (Tk. 236270) and Chapai Nawabganj (Tk. 194356), respectively (Table 6).

Table 6. Socio-economic profile of Binamasur-8 producers in the study areas

Items	Magura	Faridpur	Pabna	Chapai Nawabganj	All area
Sample size	50	50	50	50	200
1. Farmer's age (year)	47.5	46.2	45.4	46.8	46.5
2. Occupation (%)					
Agriculture	91	86	89	81	87
Business	4	5	8	6	6
Service	3	2	4	3	3
*Others	2	4	5	5	4
3. Level of education (%)					
Illiterate	14	15	21	23	18
Primary	48	44	46	41	45
Secondary	24	25	29	28	27
Higher Secondary	7	8	6	5	7

Degree & above	5	5	3	2	4
4. Farming experience (year)	21	23	20	18	21
. Communication with extension agents (Score)	15.4	16.2	14.7	9.4	13.9
6. Farm size (ha)	1.41	1.76	1.65	1.21	1.51
7. Household income (Tk/yr)	251217	236270	274356	194356	239050

*Others: Rickshaw and van puller, day laborer, student etc.

Profitability level of Binamasur-8 production

Profitability is one of the major criteria for determination of acceptance of a crop. The cost of Binamasur-8 production, gross return, gross margin, net return and the benefit cost ratio (BCR) for Binamasur-8 cultivation are being discussed in the following sections.

Cost of Binamasur-8 cultivation

The cost of human labour, land preparation, seed, fertilizers, pesticides and irrigation were taken into consideration, while calculating cost of Binamasur-8 production. Beside this, interest on operating capital was also considered as the cost of Binamasur-8 production. Total cost consists of variable cost and fixed cost that covered 69.1% and 30.9% of total cost for Binamasur-8 production.

The average costs of Binamasur-8 cultivation were Tk. 58299 and Tk. 40272 per hectare on full cost and cash cost basis, respectively (Table-7). The highest production cost was for human labour (36.8%), followed by land use (17.1%), power tiller (15.4%), seed and irrigation (6.8%). The cost of Binamasur-8 cultivation was found highest in Magura (Tk. 61266 ha^{-1}) followed by that in Chapai Nawabganj (Tk. 59171 ha^{-1}), Pabna (Tk. 57697 ha^{-1}) and Faridpur (Tk. 55063 ha^{-1}), respectively.

Table 7. Per hectare cost of Binamasur-8 production in different locations

Cost Component	Cost of production (Tk/hectare)				All area	% of total cost
	Magura	Faridpur	Pabna	Chapai Nawabganj		
(A)Variable Cost	42489	37968	39111	41520	40272	69.1
Hired labour (Man days)	14634	11660	13569	13766	13407	23.0
Power tiller	9879	8735	7876	9365	8964	15.4
Seed	4180	3980	3783	3965	3977	6.8
Fertilizers:						
Urea	1460	1350	1168	1534	1378	2.4
TSP	3963	3751	3823	3880	3854	6.6
MoP	1042	1124	1462	1260	1222	2.1

Gypsum	560	480	690	580	578	1.0
Cow dung	1734	1860	1682	1780	1764	3.0
Pesticides	854	768	698	832	788	1.4
Irrigation	3782	3861	4014	4182	3960	6.8
Int. on operating capital	401	399	346	376	381	0.7
(B) Fixed Cost	18777	17095	18586	17651	18027	30.9
Family labour	7423	8642	8245	7986	8074	13.8
Land use cost	11354	8453	10341	9665	9953	17.1
Total Cost (A+B)	61266	55063	57697	59171	58299	100

Return from Binamasur-8 production

The average return from Binamasur-8 production in different locations is shown in Table 8. The average yield of Binamasur-8 was 1691 kg/ha. The yield was highest at Pabna (1803 kg/ha) followed by Magura (1797 kg ha^{-1}), Chapai Nawabganj (1684 kg ha^{-1}) and Faridpur (1479 kg ha^{-1}). Most of the farmers in the study areas sold their product just after harvest. The price of Binamasur-8 was found the highest in Magura (Tk. 57.00 kg^{-1}) and the lowest in Chapai Nawabganj (Tk. 54.00 kg^{-1}). The total return from Binamasur-8 production consists of the values of Binamasur-8 and straw.

The average gross margin was found Tk. 56564 ha^{-1}on variable cost basis. Gross margin was highest in Pabna (Tk. 64421 ha^{-1}) followed by Magura (Tk. 62740 ha^{-1}), Chapai Nawabganj (Tk. 52616 ha^{-1}) and Faridpur (Tk. 46477 ha^{-1}), respectively. The average net return per hectare was Tk. 38536. The net return was highest in Pabna (Tk. 45835 ha^{-1}) followed by Magura (Tk. 43936 ha^{-1}), Chapai Nawabganj (Tk. 34965 ha^{-1}) and Faridpur (Tk. 29382 ha^{-1}), respectively. Benefit cost ratio was estimated at 1.66 and 2.40 on full cost and variable cost basis implying that the Binamasur-8 cultivation at farm level was highly profitable.

Table 8: Profitability of Binamasur-8 cultivation in different location

Type	Study areas				All areas
	Magura	Faridpur	Pabna	Chapai Nawabganj	
Yield from mustard (Kg ha^{-1}.)	1797	1479	1803	1684	1691
Return from mustard (Tk. ha^{-1})	102429	81345	100968	90936	93920
Return from straw (Tk. ha^{-1})	2800	3100	2564	3200	2916
Total return (Tk. ha^{-1})	105229	84445	103532	94136	96836

Total variable cost (Tk. ha^{-1})	42489	37968	39111	41520	40272
Total Cost (Tk. ha^{-1})	61266	55063	57697	59171	58299
Gross margin (Tk. ha^{-1})	62740	46477	64421	52616	56564
Net return (Tk. ha^{-1})	43963	29382	45835	34965	38536
Rate of return (BCR)					
BCR on full cost	1.72	1.53	1.79	1.59	1.66
BCR on variable cost	2.48	2.22	2.65	2.27	2.40

Major constraints to Binamasur-8 cultivation

The farmers in the study areas encountered some constraints to Binamasur-8 production. The first ranked constraint was unavailability of Binamasur-8 varieties' seeds in all areas. Other constraints were lack of training (63%), lack of technical know-how (31%), insect infestation high (28%), attack of diseases (22%), crop loss due to diseases (11%) and high price of pesticides (9%).

Table 9. Major constraints to Binamasur-8 cultivation in the study areas

Sl. No	Constraints	% of farmers responded					Rank
		Magura	Faridpur	Pabna	Chapai Nawabganj	All area	
1.	Unavailability of Binamasur-8 seed	95	98	91	78	91	1
2.	Lack of training	65	55	59	71	63	2
3.	Lack technical know-how	32	56	9	28	31	3
4.	High insect infestation	30	25	41	15	28	4
5.	Attack of diseases	17	27	12	31	22	5
6.	Crop loss due to diseases	10	15	8	12	11	6
7.	High price of pesticides	8	13	8	7	9	7

Conclusion

Binamasur-8 production in the study areas is profitable. The yield performance and economic return of Binamasur-8 production were encouraging to the farmer’s and cultivation of this variety increasing day by day in the study areas. Farmers need more training about production management practices along with seed preservation knowledge.

Expt. 3: Exploring the potential and performance of the oilseed variety Binasarisha-9 in some selected areas of Bangladesh

The study was conducted in three Binasarisha-9 growing areas of Bangladesh, namely Mymensingh, Sherpur and Ranpur district. The objectives were (i) to estimate the profitability of Binasarisha-9; (ii) to determine factors affecting the adoption of the variety, and (iii) to identify constrains and problem of the variety cultivation. In total, data were collected from randomly selected 180 farmers, 60 farmers from each area. Survey was conducted in Sadar and Gouripur upazila of Mymensingh and Nalitabari upazila of Sherpur district, respectively. From each areas 30 farmers was adopters and 30 was non-adopters. In the sampled areas data were collected through pre-designed interview schedule. Tabular, descriptive statistics and logit model wer used to fulfill objectives.

Methodology

Financial profitability of Binasarisha-9 Cultivation

Financial profitability is a major criterion to make decision for producing any crop at farm level. It has been measured based on net return, gross margin and ratio of return to total cost. Financial profitability has been calculated using the farm survey data of Binasarisha-9.

Estimation of financial profitability

Profitability analysis of Binasarisha-9 has been determined on the basis of net return analysis. To determine the net returns from Binasarisha-9 production, gross costs (variable and fixed cost) were deducted from gross returns. For this purpose, the following equation was used (Dillon and Hardaker, 1993).

The equation has been applied for each of the selected farmers:

π = Pm* Ym+Pb* Yb-Σ(Pxi * Xi)-TFC

Where, π = Net return

Pm = Price of main product per units

Ym = Total quantity of main product

P_b = Price of by-product per unit

Y_b = Quantity of by-product

Px_i = Price of ith input per unit used for mustard production

X_i = Quantity of the ith input used for mustard production

TFC = Total fixed cost

i = 1, 2, 3...........................n (number of input)

The estimation of Interest on operating capital (IOC) was as follows:

Interest on OC = AI × i × t

Where, AI = (Total investment)/2; I = Rate of interest per annum (%); and t = Period of mustard production (in month).

To measure the financial profitability two types of cost were estimated, cost items identified for the study were as follows:

Variable costs: Cost of human labour is one of the major cost components in the production process. Generally cost of hired labour required for different operations such as land preparation, sowing, weeding, fertilizer and pesticide application, irrigation, harvesting etc. are included as variable cost. Besides, for land preparation power tiller cost was estimated, which was used by farmer on contract basis and in cash. Cost of material inputs in the production process, farmers use different types of material inputs such as seeds, fertilizers, pesticides, irrigation, cow dung etc. The inputs can be supplied from home/own sources and purchased from the markets. Both own and purchased was considered in the study. Interest on operating capital was determined for three months production period; hence, at the rate of 11 percent per annum was used for calculating interest on operating capital was computed.

Fixed cost: Family labour cost was estimated. Cash rental value of land has been used for cost of land use.

Gross return: Per hectare gross return was calculated by multiplying the total amount of product and byproduct by their respective per unit prices.

Net return: Net return was calculated by deducting the total production cost from the total return or gross return. That is, Net return = Total return – Total production cost

Gross margin: Gross margin is defined as the difference between gross return and variable costs. Generally, farmers want maximum return over variable cost of production. The argument for using the gross margin analysis is that the farmers are interested to get returns over variable cost. Gross margin was calculated on TVC basis. Per hectare gross margin was obtained by subtracting variable costs from gross return. That is, Gross margin = Gross return – Variable cost. (Barnard, 1999, Uddin, M.L. *et al*, 2016)

Measure of Production Performance by Efficiency: As a measure of performance, efficiency ratio, profitability ratio is specified as follows (Folorunso. T. *et al*, 2013):

i. Efficiency ratio (ER) = TR/TC

ii. Profitability ratio (PR) = π /TC

Determination of factor affecting to adoption of the variety

The logit regression model was used to determine the factors affecting the adoption of the variety. The logit regression model is one of the binary choice regression model in which a dichotomous regression variable is considered as the dependent variable. When the dependent variable is binary, the linear probability model (LPM), logit and probit can be used (Ramnathan 1998; Greene 2000). logit model have been widely used in order to explore the factors affecting farmers' decision in adoption studies (Jarvis 1981; Feder and O'Mara 1982; Adesina et al. 2000; and Vandeveer 2001).The general logistic model expresses a qualitative dependent variable as a function of several independent variables, both qualitative and quantitative. The implicit form of the model was as follows:

$$Zi = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + U_i$$

In order to obtain the Zi there need a dichotomous response variable, if the dependent variable is 1 then the farmer is adopter of the variety otherwise zero.

The independent variables were captured as:

X_1 =Age of the respondent (Year)
X_2 =Gender
X_3 = Education (Year of schooling)
X_4 = Farmers experience in farming (years)
X_5 = Earning person (no. /household)
X_6 =Annual income
X_7 = Farm size (hectare)
X_8 = Availability of seed
X_9 =Yield (Kg)
X_{10} =Duration (Days)
X_{11} = Training
X_{12} =Extension contact
X_{13}= Weather

Measurement of dependent and explanatory variables were given in Table 10

Table10. Measurement of dependent and explanatory variables

Variable	Type	Measurement
Dependent variable	Dummy	1 if farmer has adopted, otherwise 0
Explanatory Variable		
X_1 =Age	Continuous	Age of the household head (years)
X_2 =Gender	Dummy	1 if household respondent was male, otherwise 0
X_3 = Education	Continuous	Formal education of the respondent (years of schooling)
X_4 = Experience in farming	Continuous	Farming experiences of the respondents (years)
X_5 = Earning person	Continuous	Number of active (aged 15–60 yrs) members in the family (persons)

X_6 =Annual income	Continuous	Amount of money earned by the family members in a year ('000 BDT)
X_7 = Farm size	Continuous	Amount of land under mustard cultivation (ha)
X_8 = Availability of Seed	Continuous	Seed used by farmers
X_9 =Yield	Continuous	Yield obtained by farmers in kg
X_{10} =Duration (Days)	Continuous	No of days required for harvest
X_{11} = Training	Dummy	if received=1; otherwise=0
X_{12}=Extension Contact	Dummy	1 indicates having extension contact and 0 otherwise
X_{13}=Weather or climate	Dummy	if favorable=1; otherwise=0

Results and Discussion

Cost of Production of Binasarisha-9

The average cost of production of Binasarisha-9 was Tk. 44126.98 per hectare with an average yield was1.4 t ha^{-1}which indicate to a production cost of Tk.32.16/kg. For Binasarisha-9 production the variable cost and fixed cost covered 62.91% and 37.09% of total cost, respectively. The major production cost was for human labour (35.80%), followed by land use (22.13%), fertilizer cost (22.06%), power tiller (12.73%), and irrigation (4.24%). The cost of Binasarisha-9 cultivation was found highest in Rangpur (Tk. 47971.59/ha) followed by that in Mymensingh (Tk. 42692.19/ha), Sherpur (Tk. 41717.16/ha) respectively (Table-11).

Table 11. Per hectare cost of Binasarisha-9 production in different locations

Cost Component	Cost of production (Tk/hectare)			
	Mymensingh	Sherpur	Rangpur	All areas
Variable Cost	25024.2	26332.67	31919.77	27758.88(62.91)
Hired labour (Man days)	7762.5	9033.61	10129	8975.034(20.33)
Power tiller	4656.25	5907.56	6289.32	5617.71(12.73)
Seed	735	508.4	856.58	699.99 (1.58)
Fertilizers:	8928	9287.599	10991.66	9735.754(22.06)
Urea	1688.25	1893.95	2486.96	2023.053
TSP	2217.5	2951.26	3873.09	3013.95
MoP	1044.75	1314.28	1677.94	1345.66
Gypsum	490.00	355.00	484.88	443.29
Cowdung	3487.50	2773.11	2468.79	2909.80
Pesticides	118.75	58.82	1052.84	410.136(0.92)
Irrigation	2417.5	1109.24	2082.25	1869.66(4.24)
Int. on operating capital	406.20	427.44	518.13	450.59(1.38)
Fixed Cost	17668	15384.5	16051.82	16368.11(14.95)
Family labour	7788.00	6739.50	5269.70	6599.07

Land use cost	9880.00	8645.00	10782.12	9769.04(22.13)
Total Cost	42692.2	41717.16	47971.59	44126.98

Note: Bracketed figures indicate the percentage of total cost

Return from Binasarisha-9 production

The average return from Binasarisha-9 production in different locations is shown in Table 12.The highest yield was found at Rangpur (1497.24 kg ha^{-1}) followed by Sherpur (1328.11 kg ha^{-1}) and Mymensingh (1291.25kg ha^{-1}), respectively. The average selling price of Binasarisha-9 was Tk.45.15Kg^{-1}. The highest price of Binasarisha-9 was found in Rangpur (Tk. 49.16kg^{-1}) and the lowest found in Mymensingh district (Tk. 42.10kg^{-1}). The average gross margin was found Tk. 38646.44 on variable cost basis. Gross margin was highest in Rangpur (Tk. 46386.35 ha^{-1}) followed by Sherpur (Tk. 36156.171/ ha^{-1}), and Mymensingh (Tk. 34187.43 ha^{-1}) respectively. The average net return per hectare was Tk. 22278.34. The net return was highest in Ranpur (Tk. 30334.53 ha^{-1}) followed by Sherpur (Tk. 20771.68 ha^{-1}) and Mymensingh (Tk. 16519.40 ha^{-1}), respectively.

Table 12. Profitability of Binasarisha-9 cultivation in different locations

Type	Study areas			
	Mymensingh	Sherpur	Rangpur	All areas
Yield from Binasarisha-9 (Kg/ha.)	1291.25	1328.11	1497.24	1372.2
Price Tk/ kg	42.10	44.19	49.16	45.15
Return from Binasarisha-9 (Tk./ha)	54361.63	58689.19	73604.32	61954.83
Return from straw (Tk./ha)	4850.00	3799.66	4701.80	4450.49
Total return (Tk./ha)	59211.63	62488.84	78306.12	66405.32
Total variable cost (Tk./ha)	25024.2	26332.67	31919.77	27758.88
Total cost (Tk./ha)	42692.2	41717.16	47971.59	44126.98
Gross margin (Tk./ha)	34187.43	36156.171	46386.35	38646.44
Net return (Tk./ha)	16519.40	20771.68	30334.53	22278.34
Profitability ratio	0.39	0.50	0.63	0.50
Efficiency ratio	1.40	1.49	1.63	1.50

Measure of production performance (profitability and efficiencies)

Profitability ratio: The computed production profitability ratio as presented in Table 3 for Mymensing, Sherpur and Ranpur farmers were 0.39, 0.50 and 0.63 respectively. This means that for every Tk. invested by Binasarisha-9 farmers, each gained Tk. 0.39, 0.50 and 0.63

respectively in the study area .Thus, Binasarisha-9 were confirm to be profitable in conformity with the earlier findings under cost and return analysis.

Efficiency ratio: The estimated efficiency ratios for Mymensing, Sherpur and Ranpur farmers were 1.40, 1.49 and 1.63, respectively which are greater than unity and is an indication that their operations were efficient. However, the efficiency of Rangpur farmers was higher than those of Mymensing, Sherpur farmers, indicating that Binasarisha -9 had a positive impact on the farmers in the study area (Table 12).

Logit analysis for factor affecting the adoption of the variety

An important purpose of this study was to explore the important factors that influence farmers' decisions to adopt Binasarisha-9. Thirteen explanatory variables were performed in logit regression analysis in this study (Table 13). In this study, the result of test of multi-colinearity assures that such problem does not exist. The outcomes of the model were as follows.

Age of household: The expected effect of this variable (Age of household) on Binasarisha-9 has a positive coefficient but it was insignificant. So, it has a minor impact on adopting the variety.

Gender: The expected effect of this variable has a negative coefficient but it was insignificant. So, it has a minor impact on adopting the variety.

Experience: Experience of farming has a positive coefficient which was 0.038 and it was significant. One unit increase in the farming will increase the log odds ratio of adopting the variety by 1.038.

Education level: The expected effect of this variable on Binasarisha-9 has a negative coefficient but it was insignificant. So, it has a minor impact on adopting the variety.

Earning person: Earning person of sample family has a negative coefficient which was 0.599 and it was significant. One unit increase the no. of earning person will decrease the log odds ratio of adopting the variety by 0.550.

Annual income: This result implies that the higher the household farm income, greater the probability of adopting the variety. One-unit increase in the level of farm income will increase the log odds ratio of adopting the variety by 1.0. (MT Uddin *et al*, 2016; Batz *et al*., 1999;).

Farm size: It has a positive coefficient which was 0.013 and it was significant. One unit increase in the size will increase the log odds ratio of adopting the variety by 1.014.

Availability of seed: The expected effect of this variable on Binasarisha-9 has a positive coefficient but it was insignificant. So, it has a minor impact on adopting the variety.

Yield: The coefficient of yield of farmer was 0.04 and it was significant at 5% probability level. The estimated value means that if one unit increase of the variable will increase the log odds ratio of adopting the variety by 1.004.

Duration: Table 4 indicates that the coefficient of duration of the variety was -0.113 and it was significant at 1% probability level. One unit increase of duration of the variety will decrease the log odds ratio of adopting the variety by 0.893 while holding all other variables in the model constant.

Training: The coefficient of training of farmer was 1.235 and it was significant at 5% probability level. The estimated value means that if one unit increase of the variable will increase the log odds ratio of adopting the variety by 3.439.

Extension contact: Table 4 depicts that the coefficient of extension contact was 1.006. The estimated value means that farmers' adoption is 2.733 units higher in case of having extension contact compared to other condition while holding all other variables in the model constant.

Weather: Weather of the study areas had a negative coefficient which was 1.404 and it was significant at 5 % level of probability. One unit increase in the vector will decrease the log odds ratio of adopting the variety by 0.246.

Table 13. Estimates of the logistic regression of determinants of adopt Binasarisha-9 of farm households

Variable	Co-efficient (β)	Standard error (S.E.)	Level of significance (Sig.)	Exponential of coefficient or odds ratio Exp(β)
Age (X_1)	0.024	0.016	0.125	1.024
Gender(X_2)	-0.543	1.322	0.681	0.581
Exp(X_3)	0.038**	0.018	0.041	1.038
Education(X_4)	-0.057	0.122	0.643	0.945
Earning Persons(X_5)	-0.599**	0.238	0.012	0.550
Income(X_6)	0.000**	0.000	0.029	1.000
Farm size(X_7)	0.013*	0.008	0.088	1.014
Availability of seed(X_8)	0.171	0.371	0.645	1.187
Yield(X_9)	0.004**	0.002	0.050	1.004
Duration(X_{10})	-0.113***	0.030	0.000	0.893
Training(X_{11})	1.235**	0.540	0.022	3.439
Ext cont($X1_2$)	1.006*	0.626	0.100	2.733
Weather(X_{13})	-1.404**	0.624	0.025	0.246

*, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively

Problems and constraints to Binasarisha-9 cultivation in the study areas

The data presented in Table 14 indicated the major problems face by Binasarisha-9 growing farmers in the study areas. About 20% mentioned about lack of training facilities and was top ranked followed by quality seed in timely (13.33%), Infestation of disease (11.11%), and other (9.99%) were found among the mustard growers.

Table 14: Major problems to Binasarisha-9 cultivation in the study areas

Type of problem	% of farmers respondent				
	Mymensingh	Sherpur	Rangpur	All areas	Rank
Availability of quality seed	10	16.66	13.33	13.33	2
Lack of training	20	16.66	23.33	19.99	1
Infestation of disease	16.66	10	6.66	11.11	3
Others*	6.66	10	13.33	9.99	4

*Scarcity of labour, adulteration of fertilizer, high price of fertilizer, soil fertility degradation, higher price of ploughing, storage facility.

Some of the respondent farmers mentioned few constraints that were: farmer need cash money for increase the number of crops in a year including Binasarisha-9. Availability of cultivable land and more extension contact were also demanded by the farmers for the dissemination of the variety.

Conclusion

Binasarisha-9 production in the study areas is profitable. Farmer gets good yield and also large amount of substitute. The result of logit regression model shows that experience of household head, farm size, annual income, yield, training, and extension contact were found as positively significant and earning person, duration and weather were found as negatively significant variables in explaining the variation in Binasarisha-9 adoption of farm households. By include this moderately short duration variety (85 days) in cropping pattern farmer of our country also become benefited.

Expt. No. 4 Area coverage of BINA developed rice, pulse and oilseed varieties in collaboration with DAE and Sub-stations of BINA.

The study was conducted in 34 districts of Bangladesh to determine the area coverage of BINA developed rice, pulse and oilseed varieties at 2018-19 & suggest some policy guidelines. Secondary data were used for this study. Secondary data were collected from 34 districts through DAE office and Substations of BINA. Both tabular and descriptive statistical analysis were used to fulfill the objectives. Finally, data were classified into 14 regions to identify the major area coverage of BINA developed varieties and partially results were obtained in the study. However, the study will be continued to the next year with 64 districts,.

Results and Discussion

From table 15 it was seen that the overall area coverage of BINA developed rice varieties were 2.34%. Among the three season; Aus, Aman and Boro the highest area coverage was found in aman season i. e. 4.27% followed by Boro 0.26% and Aus 0.01% respectively.

Table 15: Area coverage of BINA developed rice varieties 2018-19

Total Area (ha) (%)	Variety Name	B. C. Area (ha)
	Rice	132713.84 (2.34%)
Aus (565802) (0.01%)	Binashail	833.00
	Binadhan-4	15.00
	Binadhan-5	33.00
	Binadhan-6	1520.00
	Binadhan-7	108973.00
Aman (2464070) (4.72%)	Binadhan-8	798.00
	Binadhan-9	21.00
	Binadhan-10	1276.00
	Binadhan-11	4692.00
	Binadhan-12	110.00
	Binadhan-14	3240.00
Boro (2635798) (0.26 %)	Binadhan-16	188.00
	Binadhan-17	1362.55
	Binadhan-18	4.13
	Binadhan-19	62.13
	Binadhan-20	22.00

Here, B.C means BINA variety Cultivated areas & % indicates BINA developed variety cultivated areas among the study areas.

The results presented in Table 15 showed that the highest area coverage for boro season was in Barishal region (9.06%) and it lowest in Cumilla (0.01%), respectively..

For Aman season it was the highest in Bogra (0.10%) and the lowest in Cumilla (0.80%.) respectively..

For Aus season it was the highest in Mymensingh (0.26%) and the lowest in Sylhel (0.00%), respectively.

Table:16 Region wise area coverage of BINA developed rice variety

Region	Rice (ha)						B. C. Area (%)		
	T. C. Area (HYV)			B.C. Area					
	Aus	Aman	Boro	Aus	Aman	Boro	Aus (%)	Aman (%)	Boro (%)
Cumilla	70725	98835	134849	0	461	0	0	0.47	0
Chandpur	9590	21195	60918	0	505	15	0	2.38	0.02
Cumilla region	80315	120030	195767	0	966	15	0	0.80	0.01
Mymensingh	16591	214185	585760	12	4396	97	0.07	2.05	0.02
Sherpur	2150	58850	66116	20	4833	0	0.93	8.21	0
Netrokona	430	86510	160357	0	7741	0	0	8.95	0
Jamalpur	1137	66840	106517	20	2847	398	1.759 015	4.26	0.38
Mymensingh rigion	20308	426385	570034	52	19817	495	0.26	4.65	0.09
Sylhet	58015	87390	66896	0	5095	109	0	5.83	0.16
Moulovi Bazar	45574	94232	50705	0	1005	20	0	1.07	0.03
Hobiganj	44820	71800	66896	0	2595	1618	0	3.61	2.42
Sunamganj	11581	56195	172060	0	3846	158	0	6.84	0.09
Sylhet region	159990	309617	356557	0	12541	1905	0	4.05	0.53
Khagrachari	1950	26023	6956	0	52	10	0	0.20	0.14
Rangamati	470	8906	3800	0	12	40	0	0.13	1.05
Rangamati (Hilly) region	2420	34929	10756	0	64	50	0	0.18	0.47
Sathkhira	6350	83075	55633	0	7907	1969	0	9.52	3.54
Khulna region	6350	83075	55633	0	7907	1969	0	9.52	3.54
Pirojpur	11550	9507	11483	0	182.45	1040	0	1.92	9.06
Barishal region	11550	9507	11483	0	182.45	1040	0	1.92	9.06
Rajsahi	46529	69218	64615	0	8360	143	0	12.08	0.22
Naogaon	59190	138077	189312	0.13	240	240.26	0.00	0.17	0.13
Sirajganj	1825	57515	127520	0	2508	106	0	4.36	0.08
Natore	6345	55773	58349	0	14262	0	0	25.57	0
Chapainwabganj	44630	45028	46389	0	117	3	0	0.26	0.006
Rajsahi region	158519	365611	486185	0.13	25487	492.26	0.000	6.97	0.10
Gaibandha	1608	107230	94406	0	1105	420	0	1.03	0.44
Rangpur	16075	162043	91143	0	4625	1585	0	2.85	1.74
Kurigram	970	97063	82190	0	3725	35	0	3.84	0.04
Ranpur Region	18653	366336	267739	0	9455	2040	0	2.58	0.77
Nilphamary	406	111298	68185	0	756	0	0	0.88	0
Dinajpur Region	406	111298	68185	0	756	0	0	0.88	0
Bogura	19075	156880	170607	0	15954	201	0	10.17	0.12

Joypurhat	251	69820	49735	0	6934	65	0	9.93	0.13
Bogura region	19326	226700	220342	0	22888	266	0	10.10	0.12
Dhaka	746	8117	46511	0	505	0	0	6.22	0
Munsiganj	89	510	26339	0	0	0	0	0	0
Dhaka region	835	8627	72850	0	505	0	0	5.85	0
Noakhali	31471	93375	19885	0	6	479	0	0.006	2.41
Chattagram region	31471	93375	19885	0	6	479	0	0.006	2.41
Jashore	20435	124790	135077	0	10631	0	0	8.52	0
Narail	1909	28205	42904	0	0	0	0	0	0
Magura	3050	56430	36935	10	12606	89	0.33	22.34	0.24
Jhenaidah	30265	99155	85466	0	0	0	0	0	0
Jashore region	55659	308580	300382	10	23237	89	0.02	7.53	0.03
Faridpur	1300	62017	25660	6184	6389	4	475.69	10.30	0.02
Madaripur	275	5832	31424	1875	1891	10	681.81	32.42	0.03
Gopalganj	540	7255	31503	73	1003	584	13.52	13.82	1.85
Razbari	147	42886	12364	9882	9815	64		22.89	.52
Shariatpur	1800	1937	18829	2	593	303	.11	30.61	1.61
Faridpur region	4062	1119927	119780	18016	19691	965	7893.27	110.04	4.03

*Here T. C Area means total cultivated areas

From Table 17, the overall area coverage of BINA developed pulse varieties were 2.53%. The highest area was found for Binamoog-8 and the lowest was seen in Binachola-4.

Table 17: Area coverage of BINA developed Pulse varieties 2018-19

Total Area (ha.)	Pulse	3419 (2.53%)
134717	Binamasur-5	323.00
	Binamasur-6	73.00
	Binamasur-7	4.00
	Binamasur-8	50.00
	Binamug-1	1.00
	Binamug-2	2.00
	Binamug-5	218.00
	Binamug-6	80.00
	Binamug-7	585.00
	Binamug-8	2065.00
	Binamug-9	0.00
	Binachola-2	2.00
	Binachola-4	0.00
	Binachola-6	2.00
	Binakhesari-1	201.00
	Binakhesari-3	38.00
	Binamas	10.00

The overall area coverage of BINA developed oilseed varieties were 2.26%. The highest area was found for Binasarisha-4 and lowest was seen in Binasoybean-5 (Table 18).

Table 18 : Area coverage of BINA developed oilseed varieties 2018-19

Total Area (ha.)	Oil seed	5292 (2.26%)
233710	Binasoybean-1	7.00
	Binasoybean-2	18.00
	Binasoybean-3	19.00
	Binasoybean-4	2.00
	Binasoybean-5	1.00
	Binachinabadam-4	544.00
	Binachinabadam-5	2.00
	Binachinabadam-6	10.00
	Binachinabadam-7	5.00
	Binachinabadam-8	107.00
	Binachinabadam-10	23.00
	Binatil-1	411.00
	Binatil-2	115.00
	Binatil-3	5.00
	Binasrisha-4	3676.00
	Binasrisha-5	35.00
	Binasrisha-7	12.00
	Binasrisha-8	05.00
	Binasrisha-9	251.00
	Binasrisha-10	17.00

It can be seen from Table 19 that the highest area coverage for pulse varieties was found in Rangamati region (22.02%) and the lowest in Dhaka region (0.07%), respectively.

In case of oilseed it was the highest in Dinajpur region (8.71%) and the lowest in Sylhet region (0.00%), respectively (Table 19).

Table: 19 Region wise area coverage of BINA developed pulse & oilseed varieties 2018-19.

Region	Pulse		Oilseed		B. C. Area in %	
	T. C. Area	B. C. Area	T. C. Area	B. C. Area	Pulse (%)	Oilseed (%)
Cumilla	822	0	3938	1063	0	26.99
Chandpur	414	30	3277	63	7.25	1.922
Brahmon Baria	1392	0	8547	32	0	0.37
Cumilla region	2628	30	15762	1158	1.14	7.35
Mymensingh	545	7	2737	69	1.28	2.52
Sherpur	97	0	2175	12	0	0.55
Netrokona	88	0	1052	0	0	0
Jamalpur	700	2	10047	150	0.29	1.49
Mymensingh rigion	1430	9	16011	231	0.63	1.44
Sylhet	2.43	0	1023	0	0	0
Maulovi Bazar	51	0	330	0	0	0
Habiganj	115	0	869	0	0	0
Sunamganj	0	0	1553	0	0	0

Sylhet region	168.43	0	3775	0	0	0
Khagrachari	31	13	242	114	41.93	47.11
Rangamati	28	0	1622	1.75	0	0.11
Rangamati (Hilly) region	59	13	1864	115.75	22.03	6.21
Sathkhira	1668	13	5521	27	0.78	0.49
Khulna region	1668	13	5521	27	0.78	0.49
Pirojpur	2818	10	58	0	0.35	0
Barishal region	2818	10	58	0	0.35	0
Rajsahi	24969	200	16262	67	0.80	0.41
Naogaon	466	120	22085	1	25.75	0.004
Sirajganj	3100	3	51040	345	0.10	0.68
Natore	23683	2090	4366	255	8.82	5.84
Chapainwabganj	4864	4	7775	83	0.08	1.07
Rajsahi region	57082	2417	101528	751	4.23	0.74
Gaibandha	690	85	2996	35	12.37	1.168
Rangpur	150	0	4081	533	0	13.06
Kurigram	1403	0	5479	0	0	0
Ranpur Region	2243	85	12556	568	3.79	4.52
Nilphamary	85	0	999	87	0	8.71
Dinajpur Region	85	0	999	87	0	8.71
Bogura	517	1	16880	57	0.19	0.34
Joypurhat	173	80	2359	11	46.24	0.47
Bogura region	690	81	19239	68	11.74	0.35
Dhaka	1349	0	10346	0	0	0
Munsiganj	148	1	2487	0	0.68	0
Dhaka region	1497	1	12833	0	0.07	0
Noakhali	6235	0	16674	54	0	0.32
Chattagram region	6235	0	16674	54	0	0.32
Jashore	11715	0	11906	88	0	0.74
Narail	15842	0	4520	0	0	0
Magura	18045	760	5014	2145	4.21	42.78
Jhenaidah	12512	0	5450	0	0	0
Jashore region	58114	760	26890	2233	1.30	8.30
Total	134717.43	3419	233710	5292.75	2.54	2.26

In conclusion, the study identifies some solution to increase area coverage of BINA developed varieties such as i) increasing number of demonstrations in the union level ; ii) more training facilities and iii) develop collaboration with DAE personnel.

BINA Sub-station, Ishurdi

Research Highlights

- Binadhan-17 matured one week earlier than Binadhan-5 and BRRIdhan 29. Binadhan-17 produced more gains in each panicle compare to other varieties which lid to produce higher yield (8.47 t ha^{-1}).
- Irrespective to varieties more tillers were produced when younger seedlings were transplanted compare to more aged seedling of rice. When transplanted younger seedling of short duration boro rice variety Binadhan-14 produce significantly more grain and it was decreased with increase of seedling age but in-case of long duration rice it did not varied significantly. Highest grain yield (8.75 t ha^{-1}) was found in BRRIdhan 29 when used 45 days old seedling which was statistically similar to other aged seedling of same variety as well as Binadhan-5 of all seedling age and lowest yield (3.59 t ha^{-1}) was observed when transplanted of most aged seedling of Binadhan-14.
- Total number of demonstration during 2018-2019 were 608 nos. among them Binadhan-7 (5 no.) produced average yield 4.41 t ha^{-1}, Binadhan-11(20 no.) produced average yield 4.45 t ha^{-1}, Binadhan-12 (10 no.) produced average yield 4.17 t ha^{-1}, Binadhan-17 (157 no.) produced average yield 5.80 t ha^{-1}, number of demonstration of lentil was 81, mustard was 45, mungbean was 110, sesame was 99 and grass pea was 15.

Yield performance of Binadhan-17 at Boro season

The field experiment was conducted at the farms of BINA sub-stations at Ishurdi, during Rabi, 2018 to observed the yield performance of Binadhan-17. Four rice varieties (Binadhan-14, Binadhan-17, Binadhan-5 and BRRI dhan29) were used as experimental materials. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was $20m^2$ (5m × 4m) keeping 20 cm spacing between two rows and 15 cm among the hills in rows. Recommended production packages like application of recommended doses of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Days to 50 % flowering , days to maturity, Number of tiller at booting to heading, duration of flag leaf greenness were taken for grain yield one m^2 were harvested from each plot and converted into t ha^{-1} and yield attributes like plant height (cm), no of effective tiller, panicle length, no of filled grain and unfilled grain, 1000-grain weight (g) were collected from 10 randomly selected plants from each plot. Data were then analyzed by analysis of variance (ANOVA) using MSTAT package and the means were compared according to Least Significant Different Test at 5% significance.

Table. 1. Grain yield and yield attributes of four Boro rice varieties

Variety	Plant height (cm)	Effective Tiller $plant^{-1}$	Panicle length (cm)	Filled grain	unfilled grain $panicle^{-1}$	Seed size (gm)	Growth duration	Yield (t/ha)
Binadhan-14	83.22	14.78	20.56	80.22	15.11	2.42	128	6.44
Binadhan-17	94.00	13.11	22.11	127.33	24.78	2.17	149	8.47
Binadhan-5	112.22	11.89	25.00	100.33	24.00	2.46	156	8.14
BRRIdhan 29	107.33	11.22	26.56	103.67	18.56	2.08	157	8.27
$LSD_{(0.05)}$	**2.61**	**1.12**	**2.22**	**4.321**	**NS**	**NS**	**4.21**	**0.78**

The results showed significant variations for plant height, effective tillers $plant^{-1}$, panicle length, filled grain, growth duration and yield among the varieties (Table-1). Among the four varieties Binadhan-5 produced the tallest plant (112.22 cm) compare to other three varieties but more tillering capacity (14.78) were observed in Binadhan-14 where longest panicle were observed in BRRIdhan 29(26.56) which was statistically similar to Binadhan-5. Binadhan-14 was the short duration variety compare to others. Binadhan-17 matured one week earlier than Binadhan-5 and BRRIdhan 29. Binadhan-17 produced more gains in each panicle compare to other varieties which lid to produce higher yield (8.47 t ha^{-1}).

Influence of Seedling age on Growth and Yield of Boro Rice

The field experiment was conducted in the farms of BINA sub-stations at Ishurdi, during Rabi, 2018 to investigate the influences of seedling age on tiller dynamics and yield boro rice. Where three rice varieties (Binadhan-5, Binadhan-14 and BRRI dhan29) were used as Factor A and four seedling ages (30days, 45days, 60days and 75 days) were factor B. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was $20m^2$ (5m × 4m) keeping 20 cm spacing between two rows and 15 cm among the hills in rows. Recommended production packages like application of recommended doses of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Days to 50 % flowering, days to maturity, Number of tiller at booting to heading, duration of flag leaf greenness were taken, for grain yield one m^2 were harvested from each plot and converted into t ha^{-1} and yield attributes like plant height (cm), panicle length, no of filled grain and unfilled grain, 1000-grain weight (g) were collected from 10 randomly selected plants from each plot. For tiller dynamics, tillers per hill of 10 hills were recorded from each plot every fifteen days interval from transplanting to harvest. Data were then analyzed by analysis of variance (ANOVA) using MSTAT package and the means were compared according to Least Significant Different Test at 5% significance.

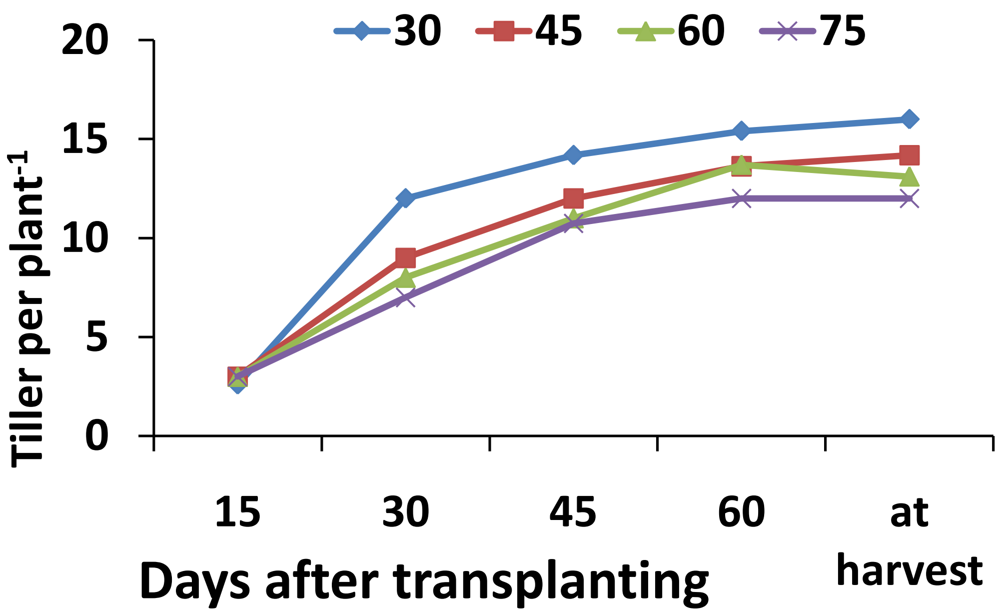


Fig. 1. Tillerring pattern of rice affected by seedling age.

Irrespective to varieties more tillers were produced when younger seedlings were transplanted compare to more aged seedling of rice (Fig. 1.) and tiller was decreased with increase of seedling age but effective tiller per plant did not follow this trend.

Plant height, effective tiller per plant, panicle length, filled grain and yield were significantly influenced with seedling and variety (Table-2). Results indicated that total and effective tillers hill^{-1} decreased with increasing seedling age. Long durated rice varieties (Binadhan-5 and BRRI dhan29) showed the highest grain yield when 45 days old seedlings were transplanted and short duration rice variety Binadhan-14 produced the highest grain yield when 30 days old seedlings were transplanted

Table. 2. Growth and yield attributes of Boro rice influenced by seedling age

Variety	**Seedling age (days)**	**Plant height (cm)**	**Total tiller plant^{-1}**	**Effective tiller plant^{-1}**	**Panicle length (cm)**	**Filled grain panicle^{-1}**	**Grain size (gm)**	**Yield (t ha^{-1})**
Binadhan-5	30	107.89	16.67	13.00	24.33	101.89	2.82	8.67
	45	109.44	13.00	11.56	26.00	130.22	3.31	8.33
	60	105.11	10.44	10.00	25.56	134.44	2.94	8.21
	75	109.22	10.11	10.11	26.44	141.89	3.08	8.19
Binadhan-14	30	86.11	16.67	13.22	20.78	109.67	2.33	6.14
	45	83.56	17.33	14.22	20.67	92.22	2.23	5.34
	60	77.22	14.67	13.67	18.89	77.11	2.04	4.76
	75	77.00	13.00	12.22	20.22	74.44	2.27	3.59
BRRIdhan 29	30	103.56	16.78	12.44	25.22	106.33	2.79	8.58
	45	102.44	15.22	10.78	26.00	142.00	2.67	8.75
	60	103.11	11.67	11.56	26.00	122.00	2.39	8.42
	75	99.89	11.89	11.11	27.11	134.44	2.59	7.67
CV%		**3.53**	**11.36**	**12.27**	**1.14**	**15.67**	**1.04**	**12.85**
LSD(0.05)		**4.71**	**1.21**	**1.03**	**1.13**	**9.38**	**NS**	**0.943**

BINA Sub-station, Rangpur

Research Highlights

- A total of 18 demonstrations with Binadhan-20 showed that Binadhan-20 produced better yield (7.4 % yield increased) with less maturity period than check varieties of BRRI dhan72.

- A total of 32 demonstrations with Binadhan-19 revealed that Binadhan-19 produced lower yield (2.6 % yield decreased) with less maturity period & fine grain than check varieties of BRRI dhan48.

- Cropping patterns: T.Aman (Binadhan-7/11/17) — Mustard (Binasarisha-9) — Mungbean (Binamoog-8)- T.Aus (Binadhan-19) was found more profitable as compared to T.Aman (Gooti Swarna) – Potato (BARI released) - Boro (BRRIdhan-28) .

Observation trails with BINA developed Binadhan-20 in Rangpur region

During Kharif-2 of 2018-19, eighteen (18) demonstrations were conducted with Binadhan-20 in Rangpur region. The check variety was BRRI dhan72. The main objectives were to demonstrate the performance of Binadhan-20 and widening their adoption by the farmers. Area of demonstration plots was 66 decimals. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 1.

Table 1: Mean performance of Binadhan-20 in Rangpur region during 2018-19

Locations (Upazilas)	No. of demo.	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-20	BRRI dhan72 (check)	Binadhan-20	BRRI dhan72 (check)	
Rangpur Sadar	04	127	135	5.8	4.8	20.48
Pirgacha, Rangpur	05	130	132	5.0	4.6	12.0
Pirganj, Rangpur	04	129	129	5.5	5.6	--
Mithapukur, Rangpur	05	130	132	5.3	5.0	5.6
Total	18					
Mean		129	132	5.4	5.0	7.4

Results indicated that Binadhan-20 produced average seed yields of 5.4 t ha^{-1} which higher 7.4 percent higher compared to check variety BRRI dhan72. Average maturity period of Binadhan-20 was 129 days. The check variety BRRI dhan72 produced average gain yield of 5.0 t ha^{-1} with maturity period of 132 days. Therefore, the variety of Binadhan-20 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-20 in Rangpur region.

Observation trails with BINA developed Binadhan-19 in Rangpur region

During the kharif-1 season of 2018-19, 3 demonstrations were conducted with Binadhan-19 in Rangpur region. The check variety was BRRI dhan48.The main objectives were to demonstrate the performance of Binadhan-19 and widening their adoption by the farmers. Area of each demonstration plot was 50 decimals. Seedlings were transplanted during April to May 2019 at the age of 15-20 days seedling. All fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and seed yield. The results are presented in Table 2.

Table 2: Performance of Binadhan-19 Rangpur region during 2018-19

Upazila	No. of demo.	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-19	BRRI dhan48	Binadhan-19	BRRI dhan48	
Mithapukur, Rangpur	10	100	112	5.4	5.6	(-) 3.7
Sundarganj, Gaibandha	05	105	110	5.2	5.4	(-) 3.8
Lalmonirhat sadar,Lalmonirhat	05	100	112	5.6	5.6	(-) 0.0
Dimla, Nilphamari	05	98	114	5.5	5.5	(-) 0.0
Fulbari, Kurigram	07	102	112	5.2	5.5	(-) 5.7
Total	32	-	-	-	-	-
Mean		101	112	5.38	5.52	(-) 2.6

Data in Table 2 reveal that Binadhan-19 produced average seed yields of 5.38 tha^{-1} respectively, which lower 2.6 percent lower compared to check variety BRRI dhan48. Average maturity period of Binadhan-19 was 101 days. The check variety BRRI dhan48 produced average gain yield of 5.52 t ha^{-1} with average maturity period of 112 days. Binadhan-19 matured earlier with attractive grain size that farmers were found interested to cultivate these variety in Rangpur region during Aus growing season.

Development of Cropping Pattern Using BINA released Varieties in Rangpur Region

Existing Pattern: T.Aman(Gooti Swarna) **–** Potato(BARI released)- Boro (BRRIdhan-28)

Improved Cropping pattern: T.Aman (Binadhan-7/11/17) — Mustard (Binasarisha-9) — Mung (Binamoog-8) - T.Aus (Binadhan-19)

Time period: Kharif-2, 2018 - Kharif,2019

Methodology:

Experiments were conducted in the different location of **Sadar & Mithapukur upazila, Rangpur**. Land size of the proposed patterns on which experiment was done was 1 *bigha* (33 decimal) for each pattern. For land preparation, planting method, time, weeding, pest control, rouguing, harvest, etc. farmers local practice was used.

Results:

Please see table 1a—1g

Conclusion:

From the above studied cropping patterns T.Aman(Binadhan-7/11/17)—Mustard(Binasarisha-9)—Mung (Binamoog-8)- T.Aus (Binadhan-19) was found more profitable compared to T.Aman(Gooti Swarna) – Potato(BARI released)- Boro(BRRIdhan-28) . Hence further research work is needed to justify this for greater area/region.

Table 1a: Yield attributes and profitability of Binadhan-17 in improved Cropping Pattern

Locations	Bd-17	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grain/ panicle	No. of Unfilled grain/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Sadar ,	**Mean**	109.3	13.4	23.89	65.69	21.44	24.03	111	688	5.15	1.28
Mithapukur,	**Max.**	112	16	24.55	72	23					
Rangpur	**Min.**	107	10	22.45	61	15					

Note: Bd= Binadhan

Table 1b: Yield attributes and profitability of Binasarisha-9 in improved Cropping pattern

Locations	BS-9	Plant height (cm)	No. of Branch/ plant	No. of siliqua/ plant	siliqua length (cm)	No. of seeds/ siliqua	1000 seed wt. (g.)	Crop duration (days)	Yield /*bigha* (Kg)	Yield (t/ha)	BCR
Sadar ,	**Mean**	95.4	4.2	83.4	3.4	18.2	3.22	97	214	1.6	**1.56**
Mithapukur,	**Max.**	98	4	90	4	20					
Rangpur	**Min.**	94	2	76	3	17					

Note: BS= Binasarisha.

Table 1c: Yield attributes and profitability of Binamoog-8 in improved Cropping pattern

Locations	Bm-8	Plant height (cm)	No. of pod/ plant	Pod length (cm)	No. of seeds/ pod	100 seed wt. (g.)	Crop duration (days)	Yield /*bigha* (Kg)	Yield (t/ha)	BCR
Sadar ,	**Mean**	35	83.4	9	4	3.22	68	214	1.6	**1.56**
Mithapukur,	**Max.**	42	90	12	6					
Rangpur	**Min.**	32	76	7	4					

Note: Bm= Binamoog.

Table 1d: Yield attributes and profitability of Binadhan-19 in improved cropping pattern

Locations	Bd-14	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grain/ panicle	No. of Unfilled grain/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Sadar ,	**Mean**	99.4	10.8	21.6	119.6	16.8	24.33	102	754	5.5	1.19
Mithapukur,	**Max.**	102	13	24	130	22					
Rangpur	**Min.**	96	10	21	110	13					

Note: Bd= Binadhan

Table 1e Yield attributes and profitability of Gooti Swarna in existing cropping pattern

Locations	Gs	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grain/ panicle	No. of Unfilled grain/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Sadar ,	**Mean**	110	7	24.4	124.6	19.8	24.7	150	550	3.9	0.80
Mithapukur,	**Max.**	117	10	25	138	26					
Rangpur	**Min.**	105	5	24	112	13					

Note: Gs= Gooti swarna

Table 1f: Yield attributes and profitability of Potato (Diamant) in existing cropping pattern

Locations	Diam.	Plant height (cm)	No. of tubers/ hill	Wt. of tubers/ hill (g.)	Crop duration (days)	Yield /*bigha* (ton)	Yield (t/ha)	BCR
Sadar ,	**Mean**	44	5	99	85	1.5	11.1	**1.43**
Mithapukur,	**Max.**	53	7					
Rangpur	**Min.**	40	3					

Note: Diam. = Diamant

Table 1g: Yield attributes and profitability of BRRI dhan-28 in in existing cropping pattern

Locations	BRD-28	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grain/ panicle	No. of Unfilled grain/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Sadar ,	**Mean**	99.4	10.8	21.6	119.6	16.8	24.33	152	612	4.5	1.10
Mithapukur,	**Max.**	102	13	24	130	22					
Rangpur	**Min.**	96	10	21	110	13					

Note: BRD= BRRIdhan-28

Establishment of BINA Technology village, in surrounding area of BINA Sub-station, Rangpur

In order to establish BINA-Technology village demonstrations and other extension work were done in surrounding area of BINA-substation, Rangpur at the farmer's fields. Results of overall promotional activities related to BINA-Technology village establishment at Chandanpat Union are presented below.

Table 3: Performance of BINA developed varieties at Chandanpat Union during 2018-19

Sl. No	Crops	Varity Name	No of Demonstration	Average Duration	Average Yield (t/ha)

1	Rice	Binadhan-19	5	102	5.1
		Binadhan-10	5	142	6.5
		Binadhan-20	2	128	5.0
		Binadhan-14	5	105	5.0
		Binadhan-17	5	118	6.0
2	Mustard	Binasarisha-4	3	87	1.6
		Binasarisha-9	4	80	1.5
		Binasarisha-10	2	78	1.3

Results indicated that Binadhan-14 produced higher grain yield with moderate crop duration (Table 3). Transplanted Aman, Boro & Aus varieties Binadhan-10, Binadhan-17, Binadhan-20, Binadhan-16 & Binadhan-19 produced desirable yield. Farmers had been interested to cultivate BINA developed Aman rice varieties in Aman season for their high yield, short crop duration and getting varietals diversification. Mustard variety, Binasarisha-4, Binasarisha-9 & Binasarisha-10 showed immense potentials in terms of yield and duration for cultivation in between Aman and Boro rice. BINA technology village Establishment in Chandanpat Union is in progress.

BINA Sub-station, Magura

Research Highlights

- On-station trail of Binadhan-17 along with different planting time at Magura showed that Binadhan-17, Binadhan-18 and BRRI dhan29 had the maximum grain yield transplanted at January 24; which was 7.29 t/ha, 7.14 t/ha and 7.42 t/ha respectively. Whereas, the lowest yield and days to maturity was found with Binadhan-18 transplanted at February 13 (4.72 t/ha and 132.22 days).
- On farm trial it was found that, Binadhan-17 transplanted at February 03 (8.60 t/ha) gave the maximum grain yield and the lowest was obtained with Binadhan-18 transplanted at February 13 (6.33 t/ha). Days to maturity was also found to be minimum (133.00 days) with this treatment. BRRI dhan29 transplanted at January 24 had the maximum days to maturity. (151.33 days).
- So it was revealed that, optimum time of planting for Binadhan-17 in magura region could be between January 24 to February 03
- In the development a profitable cropping pattern experiment, it was evident that ‘Binadhan-17—Binamasur-8—Binatil-3’ was the most profitable (MBCR 2,20) compared to the other patterns. Hence further research work is needed to justify this for greater area/region.

Performance of Binadhan-17 along with different planting time in Magura

Three varieties were evaluated under three dates of transplanting during Boro season at BINA farm and farmer's field of Magura. The objective was to know the optimum transplanting time of Binadhan-17, Binadhan-18 and BRRI dhan-29 for achieving maximum grain yield. Three dates of transplanting were January 24; February 03 and February 13. Forty days old seedlings were transplanted in a RCBD with three replications. The unit plot size was 3m × 2m. Data on yield and yield components were collected at harvest and analyzed statistically.

Table 1. On-station performance of *Boro* rice varieties in relation to planting times

Treatments	**Plant Height (cm)**	**No. of total tillers/hill**	**Panicle length (cm)**	**No. of filled spikelets/ panicle**	**Sterility (%)**	**1000-seed weight (g)**	**Days to maturity**	**Grain yield (t/ha)**
Variety								
Binadhan-17 (V_1)	88.47 b	8.79 a	22.54 b	117.00 a	28.56 a	22.84 b	144.00 a	5.61 b
Binadhan-18 (V_2)	101.22 a	8.96 a	25.22 a	78.89 b	47.38 a	25.82 a	137.44 b	6.07 a
BRRI dhan 29 (V_3)	97.63 a	10.58 a	24.95 a	118.69 a	37.70 a	21.94 b	145.00 a	6.21 a
Level of significance	*	NS	*	*	*	*	NS	*
Planting Time								
Jan 24 (T_1)	97.54 a	9.98 a	24.42 a	115.51 a	38.86 a	23.62 a	147.33 a	7.28 a
Feb 03 (T_2)	96.27 a	9.29 a	24.06 a	90.98 a	34.68 a	23.58 a	142.78 a	6.07 b
Feb 13 (T_3)	93.51 a	9.06 a	24.23 a	108.09 a	40.10 a	23.40 a	136.33 b	4.54 c
Level of significance	NS	NS	NS	NS	NS	NS	*	*
Variety ×Dates								
V_1T_1	90.27 cd	8.53 b	22.07 c	139.73 a	32.69 abc	23.23 b	148.33 ab	7.29 a
V_1T_2	87.80 d	9.20 b	23.13 bc	99.53 de	27.46bc	22.90 bc	145.00 ab	5.91 c
V_1T_3	87.33 d	8.63 b	22.42 bc	111.73 bcd	25.54 c	22.38 bc	138.67 c	3.63 f
V_2T_1	104.20 a	9.73 ab	25.60 a	76.40 ef	47.68 ab	25.52 a	144.00 b	7.14 a
V_2T_2	101.40 a	8.67 b	25.06 a	73.33 f	44.94 abc	26.26 a	136.00 cd	6.36 b
V_2T_3	98.87 a	8.47 b	24.99 a	86.93 def	49.52 a	25.68 a	132.33 d	4.72 e
V_3T_1	99.95 a	11.67 a	25.60 a	130.40 ab	36.21 abc	22.12 bc	149.67 a	7.42 a
V_3T_2	98.60 ab	10.00 ab	23.98 ab	100.07 cde	31.64 abc	21.58 c	147.33 ab	5.93 c
V_3T_3	94.33 bc	10.07 ab	25.27 a	125.60 abc	45.24 abc	22.13 bc	138.00 c	5.27 d
CV%	**2.65%**	**13.18%**	**4.04%**	**14.35%**	**32.91%**	**3.93%**	**1.92%**	**3.82%**

Figures bearing same letter (s) in a column do not differ significantly at 5% level of probability by LSD. NS- Non-Significant.

The highest grain yield was recorded in BRRI dhan29 under farm condition whereas at farmer's field Binadhan-17 showed the highest grain yield (Tables 1 and 2). Binadhan-18 took the lowest days to mature (137.44). Binadhan-17 (144.00) and BRRI dhan29 took longer days to maturity. The January 24 transplanting time was found suitable for getting higher grain yield. The lowest grain yield was recorded when transplanting on February 13.

Table 2. On-farm performance of *Boro*rice varieties with relation to planting times

Treatments	Plant Height (cm)	No. of total tiller/hill	Panicle length (cm)	No. of filled spikelets/ panicle	Sterility (%)	1000 seed weight (g)	Days to maturity	Grain yield (t/ha)
Variety								
Binadhan-17 (V_1)	95.62c	11.514a	23.311c	138.53a	35.909b	23.758b	142.89b	7.80 a
Binadhan-18 (V_2)	116.82a	10.978a	25.918a	76.93c	52.329a	27.024a	138.11c	7.46 a
BRRI dhan 29 (V_3)	104.51b	11.689a	24.695b	97.16b	48.236ab	22.112c	144.89a	6.86b
Level of significance	*	NS	*	*	*	*	*	*
Planting Time								
Jan 24 (T_1)	104.78b	11.67a	25.72a	113.91a	42.19a	24.33 ab	147.44a	7.59a
Feb 03 (T_2)	107.22a	11.47a	24.80a	110.76a	46.22 a	24.49 a	142.00b	7.63 a
Feb 13 (T_3)	104.95b	11.04a	23.40b	87.96b	48.07 a	24.08b	136.44c	6.90 b
Level of significance	*	NS	*	*	NS	*	*	*
Variety × Dates								
V_1T_1	97.53 ef	13.47 a	24.08cd	142.67a	29.52 c	24.007b	147.00 b	7.44cd
V_1T_2	93.87 g	9.68 a	23.85de	143.27a	43.66 abc	24.057b	144.33 c	8.60 a
V_1T_3	95.47 fg	11.40 a	22.00e	129.67a	34.55bc	23.210c	137.33 d	7.35cd
V_2T_1	116.40 b	9.87 a	27.27a	68.73cd	60.90a	26.927a	144.00 c	8.14ab
V_2T_2	121.53 a	11.73 a	26.07ab	90.40bc	42.05abc	27.110a	137.33 d	7.90bc
V_2T_3	112.52 c	11.33 a	24.42bcd	71.67bcd	54.03abc	27.037a	133.00 e	6.33 f
V_3T_1	100.40 e	11.67 a	25.82 abc	130.33a	36.16 bc	22.043d	151.33 a	7.20d
V_3T_2	106.27 d	13.00 a	24.49 bcd	98.60b	52.94abc	22.290d	144.33 c	6.38ef
V_3T_3	106.87 d	10.40 a	23.78de	62.53d	55.61ab	22.003d	139.00 d	7.00de
Level of significance	*	NS	*	*	*	*	*	*
CV%	2.65%	13.18%	4.04%	14.35%	32.91%	3.93%	1.92%	3.82%

Figures bearing same letter (s) in a column do not differ significantly at 5% level of probability by LSD. NS- Non-Significant.

Study on the development a profitable cropping pattern with 3 crops

Four cropping patterns were studied for one year (12 months) over the existing two patterns at the different farmers' field at Magura. The existing cropping patterns were—

(I) Aman – Boro – fallow .

(II) Aman – Mustard – Jute

Studied cropping patterns were—

(I) Binadhan-7—Binasarisha-9—Binadhan-14

(II) Binadhan-16—Binasarisha-10—Binadhan-14

(III) Binadhan-17---Binasarisha-10--Binadhan-14

(IV) Binadhan-17---Binamasur-8--Binatil-3

The above patterns were implemented and studied during period of July 2018 to June 2019. Land size of the proposed patterns on which experiment were done was 1 bigha (33 decimal) for each pattern. For land preparation, planting method, time, weeding, pest control, rouguing, harvest, etc. farmers local practice was used. At harvest of each experiment data were collected on yield, yield contributing character and BCR of individual trial was calculated. Results obtained from the study are presented in Tables 3-16.

Table 3. Yield attributes and profitability of Binadhan-7 in Pattern-I (Bd-7—Bs-9—Bd-14).

Location	Bd-7	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grains / panicle	No. of Unfilled grains/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Moghi, Magura, Sadar	Mean	96.4	10.4	24.4	124.6	19.8	24.7	120	708	5.3	1.24
	Max.	99	12	25	138	26					
	Min.	93	9	24	112	13					

NOTE: Bd= Binadhan, Bs= Binasarisha.

Table 4. Yield attributes and profitability of Binasarisha-9 in Pattern-I (Bd-7--Bs-9--Bd-14).

Location	BS-9	Plant height (cm)	No. of Branch / plant	No. of siliqua / plant	siliqua length (cm)	No. of seeds/ siliqua	1000 seed wt. (g.)	Crop duration (days)	Yield /*bigha* (Kg)	Yield (t/ha)	BCR
Moghi, Magura, Sadar	Mean	95.4	4.2	83.4	3.4	18.2	3.22	97	214	1.6	1.56
	Max.	98	4	90	4	20					
	Min.	94	2	76	3	17					

NOTE: Bd= Binadhan, Bs= Binasarisha.

Table 5. Yield attributes and profitability of Binadhan-14 in Pattern-I (Bd-7--Bs-9--Bd-14).

Location	Bd-14	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grains/ panicle	No. of Unfilled grains/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Moghi, Magura, Sadar	Mean	99.4	10.8	21.6	119.6	16.8	24.33	122	868	6.5	1.19
	Max.	102	13	24	130	22					
	Min.	96	10	21	110	13					

NOTE: Bd= Binadhan, Bs= Binasarisha.

Table 6. Yield attributes and profitability of Binadhan-16 in Pattern-II (Bd-16—Bs-10—Bd-14).

Location	Bd-16	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grains/ panicle	No. of Unfilled grains/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
*Batikadanga*Magura, Sadar	Mean	119.1	17.4	24.97	107.2	22.4	24.7	104	616	4.61	1.20
	Max.	120.9	19	25.32	120	27					
	Min.	116.2	16	23.23	98	18					

NOTE: Bd= Binadhan, Bs= Binasarisha.

Table 7. Yield attributes and profitability of Binasarisha-10 in Pattern-II (Bd-16—Bs-10—Bd-14).

Location	BS-10	Plant height (cm)	No. of Branch/ plant	No. of siliqua/ plant	siliqua length (cm)	No. of seeds/ siliqua	1000 seed wt. (g.)	Crop duration (days)	Yield /*bigha* (Kg)	Yield (t/ha)	BCR
*Batikadanga*Magura, Sadar	Mean	92.6	3.3	73.2	3.4	14.4	2.85	85	174	1.3	1.27
	Max.	95	5	95	4	16					
	Min.	90	3	52	3	12					

NOTE: Bd= Binadhan, BS= Binasarisha.

Table 8. Yield attributes and profitability of Binadhan-14 in Pattern-II (Bd-16—Bs-10—Bd-14).

Location	Bd-14	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grains/ panicle	No. of Unfilled grains/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
*Batikadanga*Magura, Sadar	Mean	103.4	11.2	23.80	112.6	19.78	24.03	119	843	6.31	1.15
	Max.	112	13	24.33	129	26					
	Min.	100	8	22.33	108	16					

NOTE: Bd= Binadhan, BS= Binasarisha.

Table 9. Yield attributes and profitability of Binadhan-17 in Pattern-III (Bd-17—Bs-10—Bd-14).

Location	Bd-17	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grains/ panicle	No. of Unfilled grains/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Ramnagar,Magura, Sadar	Mean	109.3	13.4	23.89	65.69	21.44	24.03	111	688	5.15	1.28
	Max.	112	16	24.55	72	23					
	Min.	107	10	22.45	61	15					

NOTE: Bd= Binadhan, BS= Binasarisha.

Table 10. Yield attributes and profitability of Binasarisha-10 in Pattern-III (Bd-17—Bs-10—Bd-14).

Location	BS-10	Plant height (cm)	No. of Branch/ plant	No. of siliqua/ plant	siliqua length (cm)	No. of seeds/ siliqua	1000 seed wt. (g.)	Crop duration (days)	Yield /*bigha* (Kg)	Yield (t/ha)	BCR
Ramnagar,Magura, Sadar	Mean	99.5	2.8	61.8	2.89	17.4	2.72	88	190	1.44	1.32
	Max.	106	4	85	3.8	20					
	Min.	92	2	45	2.4	14					

NOTE: Bd= Binadhan, BS= Binasarisha.

Table 11. Yield attributes and profitability of Binadhan-14 in Pattern-III (Bd-17—Bs-10—Bd-14).

Location	Bd-14	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grains/ panicle	No. of Unfilled grains/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Ramnagar,Magura, Sadar	Mean	98.6	11.4	22.2	111	10.8	24.18	120	775	5.80	1.16
	Max.	105	12	25	122	20					
	Min.	98	7	19	104	9					

NOTE: Bd= Binadhan, BS= Binasarisha.

Table 12. Yield attributes and profitability of Binadhan-17 in Pattern-IV (Bd-17—Bm-8—Bt-2).

Location	Bd-17	Plant height (cm)	No. of Effective tiller	Panicle length (cm)	No. of Filled grains/ panicle	No. of Unfilled grains/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Shachani,Magura, Sadar	Mean	101.1	14	24.20	71.64	22.60	24.75	105	653	4.88	1.27
	Max.	103	16	26	78	24					
	Min.	91	10	22	66	17					

NOTE: Bd= Binadhan, Bm= Binamasur, Bt= Binatil.

Table 13. Yield attributes and profitability of Binamashur-8 in Pattern-IV (Bd-17—Bm-8—Bt-2).

Location	BM-8	Plant height (cm)	Primary branch plant (no.)	Pods/ plant	1000 seed weight (g)	Crop duration (days)	Yield /*bigha* (Kg)	Yield (t/ha)	BCR
Shachani,Magura, Sadar	Mean	43.2	2.6	46.8	23.77	94	250	1.87	2.20
	Max.	45	4	72					
	Min.	40	2	28					

NOTE: Bd= Binadhan, Bm= Binamasur, Bt= Binatil.

Table 14. Yield attributes and profitability of Binatil-2 in Pattern-IV (Bd-17—Bm-8—Bt-2).

Location	Bt-2	Plant height (cm)	No. of Branch/ plant	No. of Capsule/plant	Capsule length (cm)	No. of Seeds/ capsule	Crop duration (days)	Yield /*bigha* (Kg)	Yield (t/ha)	BCR
Shachani,Magura, Sadar	Mean	132.5	3.8	131.5	2.64	68	105	187	1.40	1.81
	Max.	155	6	150	3.1	72				
	Min.	120	2	109	2.3	64				

NOTE: Bd= Binadhan, Bm= Binamasur, Bt= Binatil.

From the above studied cropping patterns pattern-IV (Binadhan-17---Binamasur-8--Binatil-3) was found to more profitable followed by pattern-II (Binadhan-7—Binasarisha-9—Binadhan-14) compared to the other patterns. Hence further research work is needed to justify this for greater area/region.

Establishment of BINA Technology village through block demonstration in surrounding area of BINA Sub-station, Magura

In order to establish BINA-Technology village, demonstrations were done in surrounding area of BINA-substation, Magura as well as at the farmer's field of greater Jashore region. Results of overall promotional activities related to BINA-Technology village establishment are presented below—

Table 15. Performance of BINA developed varieties during 2018-19

SL.	Crops	Variety Name	No. of demo.	Avg. Duration (days)	Av.Yield (t ha^{-1})
1.	Rice	Binadhan-7	20	122	4.91
		Binadhan-14	50	119	6.40
		Binadhan-16	10	103	4.58
		Binadhan-17	30	116	5.15
		Binadhan-19	10	104	4.16
		Binadhan-20	10	127	4.25
2.	Mustard	Binasarisha-4	10	95	1.11
		Binasarisha-9	35	90	1.33
		Binasarisha-10	40	84	1.15
3.	Lentil	Binamasur-5	30	104	1.91
		Binamasur-8	90	99	2.12
4.	Chickpea	Binasola-4	10	128	1.09
5.	Grasspea	Binakhesari-1	05	127	1.54
6.	Groundnut(Rabi)	Binachinabadam-4	20	131.28	1.79
7.	Mungbean	Binamoog-8	10	70.60	1.21
8.	Sesame	Binatil-1	10	90	1.11
		Binatil-3	15	85	1.34

Results (Table 15) indicated that in Aus season, Binadhan-19 had higher grain yield with short duration. Farmers preferred this variety due its slender and long fine grain. In Aman season rice growers of greater Jashore region widely cultivates Binadhan-7; but Binadhan-17 have more yield with short duration. As a result, growers are continuously extending the cultivation of Binadhan-17. Binasarisha-4, Binasarisha-9 and Binasarisha-10 showed immense potentials in terms of yield and duration. Most of these are suitable for cultivation in between Aman and Boro rice. BARI Sarisha-14 is a extensively cultivated mustard variety in this area. Farmers prefer this variety more than the BINA developed varieties due to its short duration and high seed yield. Though BINA developed mustard varieties are facing high competition with BARI released varieties average performance of BINAsarisha-4, 9 and 10 were satisfactory and farmers were more interested to cultivate Binasarisha-9 than Binasarisha-4 and Binasarisha-10 due to higher yield and quality. Among the lentil verities Binamasur-8 was the most preferred due to higher yield and tolerant to root rot and

Stemphylium blight over the local and BARI varieties. There is no established variety of chickpea and grasspea in magura; with the limited number of demonstrations farmers were keen to grow Binasola-4 and Binakhesari-1. Binacheenabadam-4 is established and renowned variety in greater Jashore region. Farmers prefer this groundnut due to high market price, seed size and yield. Farmers of Magura were not so interested to grow Mungbean as it required 2-3 times picking which is labor intensive work; thus they suggested to develop a variety which requires single plucking at final harvest.

BINA Sub-station, Cumilla

Research Highlights

- Five advanced lines from T.Aman were selected from Preliminary Yield Trial (PYT) for uniformity in desirable characters and high yield potential with diverse genetic background having earliness, good grain type, compact panicle, lodging resistance selected from BC_2F_7 during T.Aman. Another four advanced lines from T.Aman were selected from Advanced Yield Trial (AYT) for Fe and Zn rich rice with high yield potential.
- During T. Aman in PYT considering the yield performance (5-5.5t/ha) and premium quality and earliness five lines were selected for further evaluation in AYT during next T. Aman season. For, biofortified rice i.e. Fe and Zn rich four rice lines were selected from for giving satisfactory yield (5-5.5 ton/ha) and growth duration (110-120) as compared with all the standard checks for further evaluation.
- Three advanced lines for short duration fine rice during Boro 2018-19 were selected from Advanced Yield Trial (AYT). Those lines showed (5.5-6) t/ha average yield with (130-135) days growth duration were selected for further evaluation during next Boro season.
- Thirteen advanced lines having earliness, fine grain quality, high yield potential were evaluated as Observational Trial (OT) with standard checks. Among them, 7 were selected for further evaluation.
- An experiment was conducted to evaluate the performance of Binadhan-17 compare with some promising BRRI varieties in Boro season in respect of yield and diseases susceptibility especially blast.

VARIETAL DEVELOPMENT

Observational trials (OT)

Thirteen advanced breeding materials were grown in OT with standards checks to select agronomically desirable and high yield potential materials in Aus 2019. Furthermore 7 advanced breeding lines were selected depending on the duration and comparable yield with checks.

Preliminary Yield Trial (PYT):

One Preliminary Yield Trial (PYT) containing 8 lines were grown along with standard checks viz BRRI dhan62 for selection of genetically fixed lines with uniform plant height, short duration, heading, plant type and grain type along with high yield potential. Each genotype was grown in a 2.55m x 1m plot with a spacing of 20 x 15 cm using single seedling per hill for transplanting. Twenty five day old seedlings were used for transplanting. Fertilizer doses were applied at the time of final land preparation. N was applied in three splits at 15, 30 and 45 days after transplanting. Gypsum and Zinc Sulphate @ 100 and 10 kg/ha were applied during land preparation. Other cultural operations were done as and when necessary. Five lines were selected from PYT#1considering field duration ranged from 100-115 and good phenotyping acceptability. (Table.1).

Table 1. Yield and Yield attributes of some early fine rice lines

SL No	Genotype	Plant height (cm)	Effective Tiller/plant (no.)	Panicle length (cm)	Days to maturity	Yield (t/ha)
1	EF32	89.7	12.4	22.98	104.5	5.37
2	EF21	82.1	13	21.22	100.5	5.13
3	EF66	86.8	15.9	22.46	107.5	5.00
4	EF58	86.0	11.7	22.47	102.5	4.83
5	EF38	85.4	15.5	25.86	111.0	5.26
6	EF59	97.5	13.8	26.30	102.0	5.30
7	EF35	86.25	10.2	23.75	109.5	5.23
8	EF23	85.65	12.7	23.05	115.0	5.01
9	BRRIdhan62 (check)	98.8	16.5	22.66	101	4.34
	$LSD_{(0.05)}$	3.14	3.17	1.68	6.9	1.05

Advanced Yield trial (AYT)

Advanced Yield Trial (AYT) containing 6 lines were grown along with standard checks viz BRRI dhan62 during T. Aman for selection of agrnomically desirable and high yield potential along with Fe and Zn rich rice. Each line was grown in a 5m x 4m plot with a spacing of 20 x 15 cm using single seedling per hill for transplanting. Twenty five day old seedlings were used for transplanting. Fertilizer doses were applied at the time of final land preparation. N was applied in three splits at 15, 30 and 45 days after transplanting. Gypsum and Zinc Sulphate @ 100 and 10 kg/ha were applied during land preparation. Other cultural operations were done as and when necessary. Four lines were selected from AYT # 1considering field duration ranged from 103-110 and good phenotyping acceptability. Three lines were selected from AYT#2 for short duration fine rice during Boro 2018-19 (Table.2).

Table 2. Yield and Yield attributes of some iron and zinc rich rice lines

Genotype	Plant height (cm)	Effective Tiller/plant (no.)	Panicle length (cm)	Days to maturity	Yield (t/ha)
SL44	88.8	14.60	21.29	106.50	5.15
SL10	90.4	14.00	24.97	110.00	5.30
SL 26	89.4	13.30	22.91	107.50	4.57
SL57	98.5	14.50	23.83	103.50	5.12
SL45	98.6	14.40	24.98	108.00	5.19
SL42	93.2	14.50	21.88	106.50	4.37
BRRIdhan62 (check)	98.3	19.00	22.66	103.00	4.27
$LSD_{(0.05)}$	5.53	5.61	2.05	4.89	0.47

Growing of M_1 generation of sweet gourd in summer season

With a view to improve yield potential and resistant to disease particularly fruit flies, dry seed of BARI Misti kumra-1 irradiated with 70, 100 and 150Gy doses of gamma rays from the ^{60}Co source of BINA. For each dose 100 g seeds of BARI Misti kumra-1 were used. Immediately after irradiation, the seeds were sown in pit dose wise, separately, on first week of March at BINA sub-station, comilla following non replicated design at 2.5 m distance. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc sulphate. Cultural and intercultural practices were followed as and when necessitated. Data recorded on survivalist and plant length seeds were collected and stored to screen and evaluate in the next generation.

Development of three crops based cropping pattern (Rabi-Boro-T.aman) against with two crops based cropping pattern (Fallow+Boro+T.Aman)

The experiment was conducted at Rampur, Dayarampur and Ebdarpur village under Brurichongupazilla of Cumilla district and at Alampur, Mondabag and Shahpur village under Kasbaupazilla of Brahmanbaria district during Rabi, Boro and Aman season of 2018-2019 with a view to evaluate the performance of Rabi (Mustard)-Boro-T.Aman cropping pattern in rice based dominant cropping pattern instead of Fallow-Boro-T.aman rice cropping pattern. Data were recorded on crop duration and yield. Recorded data presented in Table 3.

Table. 3. Crop duration and yield of existing and proposed cropping pattern at six different location of cumilla and Brahminbaria district during Rabi, Boro and Aman season of 2017-2018.

Locations	**Duration and yield (t ha^{-1}) of Existing cropping pattern**					**Proposed cropping pattern**					
	Fallow	**Boro (BRRI dhan-28)**		**T.aman (Binadhan-7)**		**Rabi (Binasarisha-4)**		**Boro (Binadhan-14)**		**T.aman (Binadhan-17)**	
		Duration	**Yield (t ha^{-1})**	**Duration**	**Yield (t ha^{-1})**	**Duration**	**Yield (t ha^{-1})**	**Duration**	**Yield (t ha^{-1})**	**Duration**	**Yield (t ha^{-1})**
Rampur	-	140	6.10	112	4.20	85	1.80	132	4.65	119	5.70
Dayarampur	-	141	5.54	104	3.90	87	1.84	127	4.70	116	4.87
Abdarpur	-	140	6.50	118	3.89	75	1.45	124	4.16	117	4.56
Alampur	-	144	6.98	121	4.87	79	1.37	130	4.98	112	5.87
Mondabag	-	145	5.48	109	4.12	82	1.98	128	4.10	127	5.98
Shahpur	-	147	5.87	113	4.50	87	2.00	125	4.74	124	5.89
Mean		**142.83**	**6.07**	**112.8**	**4.24**	**82.5**	**1.74**	**127.6**	**4.55**	**119**	**5.47**

From the result of cropping pattern research it may be concluded that three crops based cropping pattern such as Rabi (mustard) – Boro - T.aman is agronomically feasible and economically profitable compared to existing farmers cropping pattern Fallow-Boro-T.aman. Due to growing of three crops in a year in the same piece of land cropping intensity and productivity are increased, more employment opportunity for male and female labors is generated and at the same time due to the increased population of rice and mustard the food and nutritional security are increased for the farmers and the nation as a whole.

Performance of Binachenabadam-4 in Cumilla region:

In season of Kharif-1, 2019 some demonstrations were conducted in Cumilla region to find out the result of Binachenabadam-4 and to know the farmer reaction to it. Dhaka-1 used as check variety. The size of per demonstration plot was 33 decimal. Recommendated fertilizer and cultural practices were followed. Data were recorded on crop duration and yield. Recorded data presented in Table 4.

Table. 4. Duration and Yield of Binachinabadam-4 in Cumilla region during 2017-18

Locations	No. of demonstration	Average Duration (days)		Average Yield (t ha^{-1})		Yield increased over check (%)
		Binachina badam-4	Dhaka-1 (check)	Binachina badam-4	Dhaka-1 (check)	
Sadar, Brahminbaria	3	103	124	1.98	1.18	40.40
Ashuganj, Brahminbaria	2	109	128	2.00	1.29	35.50
Muradnagar, cumilla	3	105	126	2.10	1.30	38.09
Titas, cumilla	3	115	129	2.04	1.26	38.23
Homna, cumilla	3	113	125	2.07	1.31	36.71
Meghna, cumilla	2	110	124	2.10	1.32	37.14
Sadardakshin, cumilla	2	115	125	2.12	1.20	43.39
Total	18	-	-	-	-	-
Mean	-	110	125	2.11	1.26	38.49

Results indicated that Binachenabadam-4 produced 2.11 t/ha pod yield within 110 days maturity where Dhaka-1 took 125 days to produce 1.26 t/ha pod yield. It means Binachenabadam-4, 15 days earlier and 38.49% higher yield producer than Dhaka-1. As a result farmers are highly interested to cultivate Binachenabadam-4 instead of Dhaka-1.

Performance of Binadhan-11 in Cumilla region.

In Aman, season, 2018, 10 demonstrations were conducted in Cumilla and Brahminbaria zilla to find out the recovery potentially after submerged and farmers response to Binadhan-11. Seeds were sown in different time in different location. 25 days aged Seedling was transplanted in 20 cm row to row and 15 cm plant to plant distance. The area of each demonstration was 33 decimal. 24 kg urea, 16 TSP, 9 kg MOP, 7 kg Gypsum and 0.5 kg Zinc sulphate was applied per each demonstration plot. Weeding and irrigation were done when necessary. Data was collected on crop duration, days under submerged and yield (t/ha). Recorded data presented in Table 5.

Table. 5. Days under submerged, Duration and Yield of Binadhan-11 in some upazilla of Cumilla and Bijoynagar upazilla of Brahmanbaria during 2017-18.

Locations	No. of the demonstration	Days under submerge	Duration (days)	Yield (t/ha)
Bijoynagar, Brahmanbaria	2	15	128	3.98
Chauddagram, cumilla	2	14	132	4.00
Sadardakshin, cumilla	2	-	114	4.87
Burichong, cumilla	2	12	124	4.10
Brahmanpara, cumilla	2	17	135	3.89
Total	**10**			
Mean		15	126.6	4.16

Under submergible condition, Binadhan-11 performed moderate grain yield ranged 3.89-4.87 t/ha that is highly demandable for this region. This variety can tolerate up to 17 days under submerged and gave average yield 4.16 t/ha. Famers of this region are interested to cultivate this variety due to submergence tolerance.

Performance of Binadhan-17 in Cumilla region

Twenty demonstrations were conducted during Aman season 2018 in Cumilla region to find out the yield potential compare with check variety BRRI Dhan-49. Size of the each demonstration was 33 decimal. Seeds were sown during mid June to 1st week of July. 25 days aged seedling was transplanted maintaining optimum spacing (20 cm × 15 cm). 20 kg urea, 13 kg TSP, 6 kg MP, 6 Gypsum and 0.5 kg zinc sulphate was applied each demonstration plot for Binadhan-17. On the other hand 20 kg urea, 13 kg TSP, 9 kg MP, 8 kg Gypsum and 1 kg zinc sulphate for BRRI Dhan-49. Intercultural operation was done when necessary. Data on crop duration and yield were which are presented in following Table 6.

Table. 6. Duration and Yield of Binachenabadam-17 in Cumilla region during 2017-18.

Upazila	**No. of demonstration**	**Duration (days)**		**Yield (t ha^{-1})**		**Yield increased over check (%)**
		Binadhan -17	**BRRI dhan49 (check)**	**Binadhan-17**	**BRRI dhan49 (check)**	
Kasba, Brahmanbaria	2	120	138	5.80	4.40	24.13
Chandina, Cumilla	10	117	140	5.88	4.78	18.70
Sadardakshin, Cumilla	5	125	137	5.74	4.81	16.20
Burichong, Cumilla	1	124	134	6.01	4.96	17.47
Debidwar, Cumilla	1	119	133	5.94	5.00	15.82
Sadar, Cumilla	1	114	138	6.00	4.90	18.33
Total	20					
Mean		119.83	136.66	5.89	4.80	18.44

Results showed that Binadhan-17 is earlier and higher yield producer than BRRI dhan49 (Table 6). Farmers are highly interested to cultivate Binadhan-17 due to its high yield, short duration.

Establishment of BINA Technology village, in Burichong, Sadardakshin and Brahmanpara upazilla of Cumilla and Kasba Upazilla of Brahminbaria.

Table 7 shows that Binadhan-10 produced the highest grain yield (6 t/ha) amongst 8 varieties. Between 2 varieties of mustard, Binasarisha-4 performed better than Binasarisha-9. Binachinabadam-4, Binamoog-7 and Binatil-2 performed moderate seed yield.

Table. 7. Performance of BINA developed rice, mustard, mungbean and sesame in Burichong, Sadardakshin and Brahmanpara upazilla of Cumilla and Kasba Upazilla of Brahminbaria.

Crops	Variety Name	Demonstration No.	Av. Duration in days	Av.Yield (t ha^{-1})
	Binadhan-10	15	138	6.00
Rice	Binadhan-14	25	131	4.70
	Binadhan-11	20	118	4.21
	Binadhan-12	5	130	3.98
	Binadhan-13	5	138	2.19
	Binadhan-16	5	98	4.14
	Binadhan-17	20	112	5.98
	Binadhan-18	5	142	5.31
Mustard	Binasarisha-4	8	85	1.87
	Binasarisha-9	7	72	1.51
Groundnut	Binachinabadam-4	10	113	1.89
Mungbean	Binamoog-7	9	60	1.86
Till	Binatill-2	15	100	1.13

BINA Sub-station, Satkhira

Research Highlights

- A total of 134 demonstrations with short durated T. aman rice, BINAdhan-7, Binadhan-16, Binadhan-17 and Binadhan-20 produced average grain yields of 5.28, 5.2, 6.41 and 4.99 t ha^{-1}, respectively. Average maturity period of Binadahn-7, Binadhan-16, Binadhan-17 and BINAdhan-20 was 117,104,117 and 126 days, respectively. Farmers were found interested to cultivate Binadhan-7, Binadhan-16, Binadhan-17 & binadhan-20.
- A total of 95 demonstrations with short durative high yielding Binasarisha-4, Binasarisha-9 and Binasarisha-10 which produced better yield than check variety of BARI sarisha-14.
- A total of 250 demonstrations with salt tolerant Boro rice Binadhan-10 which produced better yield with short maturity period than check varieties of BRRI dhan67.

- A total of 20 demonstrations with high yielding late Boro rice Binadhan-14 which produced better yield with short maturity period than check varieties of BRRI dhan28.
- A total of 25 demonstrations with high yielding moog variety Binamoog-8 which produced better yield than check varieties of BARI mung-6.
- A total of 20 demonstrations with high yielding sesame variety Binatil-3 which produced better yield than check varieties of BARI til-3.

Up-scaling BINA developed high yielding and short durative T.Aman rice variety in Satkhira and Khulna region

During Aman season of 2018-19, 163 demonstrations with Binadhan-7, Binadhan-16, Binadhan-17 and Binadhan-20 were conducted at the farmer's fields in Satkhira and Khulna region. The main objectives were to demonstrate the yield performance of these varieties and widening their adoption by the farmers. Area of demonstration plot was 33 decimals. Spacing between line-to-line and plant-to-plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 31 July to 8 August 2018, and age of seedlings was 20 to 25 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 1-4.

Table 1: Performance of Binadhan-7 in Satkhira and Khulna region during 2018-19

Upazila	No.of demonstration	Date of transplanting	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
			Binadhan-7	BRRI dhan49 (check)	Binadhan-7	BRRI dhan49 (check)	
Sadar	5	31/07/18	116	132	5.1	5.0	2.0
Tala	6	31/07/18	118	136	5.3	5.18	2.32
Kolaroya	5	30/07/18	117	132	5.4	5.2	3.85
Koyra	5	03/08/18	117	134	5.3	5.15	2.91
Total	21						
Mean			117	134	5.28	5.13	2.77

Data in Table 1 reveal that Binadhan-7 produced average grain yield of 5.28 t ha^{-1}, which was 2.77 percent higher compared to check variety. Average maturity period of Binadhan-7 was only 117 days on the other hand BRRI dhan49 was 134 days. The mean yield of Binadhan-7 was 5.28 tha^{-1} which differs statistically from BRRI dhan49 (5.13 tha^{-1}). Therefore Binadhan-7 increased crop production, cropping intensity as well as farmer's income. Farmers were found interested to cultivate Binadhan-7 as a Aman variety in Satkhira and Khulna region.

Table 2: Performance of Binadhan-16 in Satkhira and Khulna region during 2018-19

Upazila	No. of demonstration	Date of transplanting	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
			Binadhan-16	BRRI dhan66 (check)	Binadhan-16	BRRI dhan66 (check)	
Sakhira Sadar	06	08/08/18	103	118	5.10	4.65	9.68

Tala	03	05/08/18	105	119	5.23	4.70	11.28
Koyra	04	08/08/18	104	117	5.27	4.58	15.06
Total	13	-	-	-	-	-	-
Mean			104	118	5.20	4.64	12.00

Data in Table 2 reveal that Binadhan-16 produced average grain yield of 5.2 t ha^{-1}, which was 12.00 percent higher compared to check variety, BRRI dhan66. Average maturity period of Binadhan-16 was 104 days and BRRI dhan66 was 118 days. The mean yield of Binadhan-16 was 5.2 tha^{-1} which significantly higher than BRRI dhan66 (4.64 tha^{-1}). Therefore Binadhan-16 increased crop production, cropping intensity as well as farmer's income. Farmers were found interested to cultivate Binadhan-16 as a Aman variety in Satkhira and Khulna region.

Table 3: Performance of Binadhan-17 in Satkhira and Khulna region during 2018-19

Upazila	No. of demonstration	Date of transplanting	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
			Binadhan-17	BRRI dhan75 (check)	Binadhan-17	BRRI dhan75 (check)	
Satkhira sadar	20	31/07/18	118	120	6.50	5.6	16.07
Tala	20	05/08/18	117	118	6.35	5.45	16.51
Shyamnogor	10	03/08/18	117	118	6.30	5.6	12.5
Kolaroya	15	01/08/18	117	119	6.58	5.8	13.49
Dumuria	10	03/08/18	117	119	6.30	5.5	14.55
Koyra	10	05/08/18	116	120	6.40	5.58	14.70
Total	85						
Mean			117	119	6.41	5.58	14.67

Data in Table 3 reveal that Binadhan-17 produced average grain yield of 6.41 t ha^{-1}, which was 14.67 percent higher compared to check variety, BRRI dhan75. Average maturity period of Binadhan-17 and BRRI dhan75 was almost similar. The mean yield of Binadhan-17 was 6.41 t ha^{-1} which was significantly higher than BRRI dhan75 (5.58 tha^{-1}). Therefore Binadhan-17 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-17 as a Aman variety in Satkhira and Khulna region.

Table 4: Performance of Binadhan-20 in Satkhira and Khulna region during 2018-19

Upazila	No. of demonstration	Date of transplanting	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
			Binadhan-20	BRRI dhan49 (check)	Binadhan-20	BRRI dhan66 (check)	
Satkhira sadar	05	31/07/18	125	120	4.90	4.6	6.52

Tala	03	05/08/18	127	118	4.85	4.55	6.59
Shyamnogor	02	03/08/18	127	118	5.00	4.54	10.13
Koyra	05	05/08/18	126	120	5.20	4.58	13.54
Total	15	05/08/18	125				
Mean			126	119	4.99	4.57	9.19

Data in Table 4 reveal that Binadhan-20 produced average grain yield of 4.99 t ha^{-1}, which was 9.19 percent higher compared to check variety. Average maturity period of Binadhan-20 was 126 days and BRRI dhan66 was 119 days. The mean yield of Binadhan-20 was 4.99 tha^{-1} which differs statistically from BRRI dhan66 (4.57 tha^{-1}). Therefore Binadhan-20 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-20 as a Aman variety in Satkhira and Khulna region.

Up-scaling BINA developed high yielding and short durative mustard variety in Satkhira region

During the Rabi season of 2018-19, total 103 demonstrations were conducted with Binasarisha-4, Binasarisha-9 and Binasarisha-10 in Satkhira region. The main objectives were to demonstrate the performance of Binasarisha-4, Binasarisha-9 and Binasarisha-10 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown during October to November 2018 at the rate of 7.5 kg ha^{-1}. The check variety was BARI sarisha-14. All fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Tables 5-7.

Table 5: Performance of Binasarisha-4 compared to popular cultivar in Satkhira region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		BINAsarisha-4	BARI sarisha-14 (Check)	BINAsarisha-4	BARI sarisha-14 (Check)	
Satkhira Sadar	15	86	78	2.0	1.68	19.05
Tala	10	85	78	1.8	1.55	16.13
Kolaroya	08	86	79	1.9	1.60	18.75
Shyamnogor	02	84	77	1.7	1.55	9.68
Total	35	-	-	-	-	-
Mean	-	85	78	1.85	1.6	15.90

Data in Table 5 reveal that Binasarisha-4 produced average seed yield of 1.85 t ha^{-1}, which was 15.90 percent higher than the cheek variety BARI sarisha-14. Average maturity period of Binasarisha-4 was 85 days. BARI sarisha-14 produced average gain yield of 1.6 t ha^{-1} with average maturity period of 78 days. Therefor, Binasarisa-4 increase crop production as well as income of farmer's. Farmers were found interested to cultivate Binasarisha-4.

Table 6: Performance of Binasarisha-9 compared to popular cultivar in Satkhira region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisha-9	BARI sarisha-14 (Check)	Binasarisha-9	BARI sarisha-14 (Check)	
Satkhira sodor	18	80	78	1.9	1.65	15.15
Tala	15	79	78	1.65	1.5	10.00
Kolaroya	17	81	78	1.70	1.56	8.97
Total	**50**					
Mean		**80**	**78**	**1.75**	**1.57**	**11.37**

Data in Table 6 reveal that Binasarisha-9 produced average seed yield of 1.75 t ha^{-1} which was 11.37 percent higher than the check variety BARI sarisha-14. Average maturity period of Binasarisha-9 was 80 days. BARI sarisha-14 produced average gain yield of 1.57 t ha^{-1} with average maturity period of 78 days. There for its increase crop production as well as income of farmer's. Farmers were found interested to cultivate Binasarisha-9.

Table 7: Performance of Binasarisha-10 compared to popular cultivar in Satkhira region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisha-10	BARI sarisha-14 (Check)	Binasarisha-10	BARI sarisha-14 (Check)	
Satkhira sodor	03	75	78	1.56	1.54	1.3
Tala	04	75	77	1.54	1.52	1.3
Kolaroya	03	75	79	1.6	1.57	1.92
Total	10	-	-	-	-	-
Mean	-	75	78	1.57	1.54	1.51

Data in Table 7 reveal that Binasarisha-10 produced average seed yield of 1.57 t ha^{-1} which was 1.51 percent higher than the check variety BARI sarisha-14. Average maturity period of Binasarisha-10 was 75 days. BARI sarisha-14 produced average gain yield of 1.54 t ha^{-1} with average maturity period of 78 days. Therefore its increase crop production as well as income of farmer’s. Farmers were found interested to cultivate Binasarisha-10.

Up-scaling BINA developed salt tolerant variety Binadhan-10 in Satkhira and Khulna region

During Boro season of 2018-19, 120 demonstration with Binadhan-10 were conducted at the farmer’s fields in Satkhira and Khulna region. The main objectives were to demonstrate the yield performance of the variety and widening it’s adoption by the farmers. Area of demonstration plots was 33 decimals. Spacing between line-to-line and plant-to-plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 19 January to 29 January 2018, and age of seedlings was 35 to 40 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 7.

Table 8: Performance of Binadhan-10 in Satkhira and Khulna region during 2018-19

Upazila	No. of demonstration	Duration (days) Binadhan-10	BRRI dhan-67 (check)	Yield (t ha^{-1}) Binadhan-10	BRRI dhan- 67 (check)	Yield increased over check (%)
Satkhira Sadar	50	128	141	5.6	5.2	7.69
Shyamnogor	50	127	141	5.57	5.3	5.09
Koyra	60	127	140	5.58	5.5	1.45
Asasuni	10	128	143	5.8	5.45	6.42
Tala	15	130	145	5.6	5.48	2.19
Dumuria	10	132	141	5.8	5.58	3.49
Debhata	05	131	143	5.6	5.49	2.0
Kaliganj	15	130	140	5.69	5.5	3.45
Mollahat	35	131	142	5.65	5.4	4.63
Total	250	-	-	-	-	-
Mean		130	142	5.63	5.45	4.05

Data in Table 8 reveal that BINAdhan-10 produced average yields of 5.63 t ha^{-1} which was 4.05 percent higher compared to check variety BRRI dhan-67. Average maturity period of BINAdhan-10 was 130 days. The check variety BRRI dhan-67 produced average grain yield of 5.45 t ha^{-1} with average maturity period of 142 days. Therefore the variety of BINA, BINAdhan-10 increased crop production as well as farmer’s income. Farmers were found interested to cultivate BINAdhan-10 in Satkhira and Khulna region.

Up-scaling BINA developed high yielding late Boro variety Binadhan-14 in Satkhira region

During Boro season of 2018-19, 08 demonstration with Binadhan-14 were conducted at the farmer's fields in Satkhira region. The main objectives were to demonstrate the yield performance of the variety and widening it's adoption by the farmers. Area of demonstration plots was 33 decimals. Spacing between line-to-line and plant-to-plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 19 February to 29 February 2018, and age of seedlings was 35 to 40 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 8

Table 9: Performance of Binadhan-14 in Satkhira region during 2018-19

Upazila	No. of demonstration	Date of transplant ting	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
			Binadhan-14	BRRI dhan-28 (check)	Binadhan-14	BRRI dhan-28 (check)	
Kolaroa	10	19/02/18	128	136	6.60	6.0	10
Sadar	10	29/02/18	130	138	6.40	5.9	8.47
Total	20	-	-	-	-	-	-
Mean			129	137	6.50	6.15	9.24

Data in Table 9 reveal that Binadhan-14 produced average grain yield of 6.50 t ha^{-1}, which was 9.24 percent higher compared to check variety, BRRI dhan28. Average maturity period of Binadhan-14 was 129 days. Therefore Binadhan-14 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-14 as a late Boro variety in Satkhira region.

Up-scaling BINA developed high yielding and short durative moog variety in Satkhira region

During the Rabi season of 2018-19, total 10 demonstrations were conducted with Binamug-8 in Satkhira region. The main objectives were to demonstrate the performance of Binamug-8 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown during mid February to mid March 2018 at the rate of 30 kg ha^{-1}. The check variety was BARI mug-6. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 9.

Table 10: Performance of Binamoog-8 compared to popular cultivar in Satkhira region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		BINAmoog-8	BARI mung-6	BINAmoog-8	BARI mug-6	
Satkhira sodor	10	67	60	1.6	1.5	6.67
Tala	05	68	62	1.59	1.55	2.58
Kolaroya	10	66	61	1.55	1.45	3.45
Total	25					
Mean		67	61	1.58	1.5	4.23

Data in Table 10 revealed that BINAmoog-8 produced average grain yield of 1.58 t ha^{-1}, which was 4.23 percent higher compared to check variety, BARI mung-6. Average maturity period of BINAmoog-8 was 67 days. Therefore, BINAmoog-8 increased crop production as well as farmer's income. Farmers were found interested to cultivate BINAmoog-8 as a summer moog variety in Satkhira region.

Up-scaling BINA developed high yielding Sesame variety in Satkhira region

During the Rabi season of 2018-19, total 20 demonstrations were conducted with Binatil-3 in satkhira region. The main objectives were to demonstrate the performance of Binatil-3 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown during mid February to mid March 2018 at the rate of 7-8 kg ha^{-1}. The check variety was BARI til-3. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 10.

Table 11: Performance of Binamoog-8 compared to popular cultivar in Satkhira region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binatil-3	BARI til-3	Binatil-3	BARI til-3	
Satkhira sodor	05	87	95	1.45	1.38	5.07
Tala	10	85	94	1.5	1.4	7.14
Kaliganj	05	86	98	1.45	1.35	7.14
Total	20					

Mean	86	96	1.47	1.38	6.45

Data in Table 11 reveal that Binatil-3 produced average grain yield of 1.47 t ha^{-1}, which was 6.45 percent higher compared to check variety, BARI til-3. Average maturity period of Binatil-3 was 86 days. Therefore Binatil-3 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binatil-3 in Satkhira region.

Establishment of BINA Technology village, in surrounding area of BINA Sub-station, Satkhira

In order to establish BINA-Technology village demonstrations and other extension work were done in surrounding area of BINA-substation, Sunamganj at the farmer's fields. Results of overall promotional activities related to BINA-Technology village establishment at Surma Union are presented below.

Table 12: Performance of BINA developed varieties at Nogorghata union during 2018-19

Sl. No	Crops	Variety Name	Demonstration No.	Av. Duration in days	Av.Yield (t ha^{-1})
1.	Rice	Binadhan-10	5	131	5.50
		Binadhan-14	3	125	6.50
		Binadhan-7	3	115	4.60
		Binadhan-16	3	100	4.79
		Binadhan-17	5	113	6.20
2.	Mustard	Binasarisha-4	3	83	1.65
		Binasarisha-9	5	79	1.62
		Binasarisha-10	4	76	1.5
3.	Mungbean	Binamoog-8	3	66	1.53

Nogorghata Union in Satkhira district is very suitable area for growing rice, oilseeds, pulse and vegetables. Results indicated that Binadhan-14 produced higher grain yield with moderate crop duration (Table 10).Transplanted aman varieties Binadhan-17, Binadhan-11, Binadhan-7 & Binadhan-16 produced higher grain yield than check. Farmers had been interested to cultivate BINA developed aman rice varieties in aman season for their high yield, short crop duration and getting varietals diversification. Mustard variety, Binasarisha-4 ,Binasarisha-9 and Binasarisha-10showed immense potentials in terms of yield and duration for cultivation in between aman and boro rice. Binamoog-8 also produced higher grain yield than check. BINA technology village Establishment in Nogorghata union is in progress.

BINA Sub-station, Jamalpur

Research Highlights

- A field experiment was carried out to reveal the effects of different soil amendments, nitrogen level and irrigation on the growth, N uptake and yield of Wheat.It was found that grain yield of wheat was increased with increasing application of N, irrigation water and soil amendments. The combined application of irrigation 3 times at 21, 55 and 80 days and soil amendments potassium@90kg/ha + Gypsum@ 100 kg/ha + FYM@ 5 t/ha may be considered as the best among the treatments to grow wheat.
- An experiment was conducted at Jamalpur during 2018-19 to determine a profitable cropping pattern for Jamalpur with BINA developed varieties. Three cropping patterns were taken to consider as treatments. Among them Mustard–Mungbean–Aus–T. Aman cropping sequences produced the highest yield.
- An experiment was conducted at BINA substation farm to evaluate long-term evaluation of eco-compost organic fentilizerthnoughvegefableproducton.The highest fresh lady's finger yield (12.11 t ha^{-1}) was obtained from treatment T_2 (100% chemical fertilizer). However, the treatments received only eco-compost produce low yield compared to the chemical fertilizer treated plot.
- A total of 512 demonstrations (33 decimal/demonstration) were conducted in Jamalpur during the year 2018-19.
- A total number of 6,630 kg seed including breeder and truthfully labeled seed (TLS)was produced during 2018-19.
- During the year 2018-19,three training two workshop and Five field day programs were organized whereas 203 farmers and 57 Sub Assistant Agriculture Officers (SAAO) were trained.

Effects of different Soil amendments, Nitrogen level and Irrigation on the growth, N uptake and yield of Wheat

A field experiment was conducted from November, 2018 to April, 2019 following a split-split plot design of randomized complete block with I_1= Irrigation at 55 days and I_2= Irrigation at 21, 55 and 80 days practices as main plot; T_1= Control (No amendment added), T_2= Application of potassium @90kg/ha + Gypsum@ 100 kg/ha, T_3= Application of potassium @90kg/ha + FYM@ 5 t/ha and T_4= Application of potassium @90kg/ha + Gypsum@ 100 kg/ha + FYM@ 5 t/ha as a sub plot and N_1=Application of N @100kg/ha & N_2=Application of N @120kg/ha as a sub-sub plot with three replications. The experiment comprises 16 treatments ($I_1T_1N_1$, $I_1T_1N_2$, $I_1T_2N_1$, $I_1T_2N_2$, $I_1T_3N_1$, $I_1T_3N_2$, $I_1T_4N_1$, $I_1T_4N_2$, $I_2T_1N_1$, $I_2T_1N_2$, $I_2T_2N_1$, $I_2T_2N_2$, $I_2T_3N_1$, $I_2T_3N_2$, $I_2T_4N_1$, $I_2T_4N_2$).

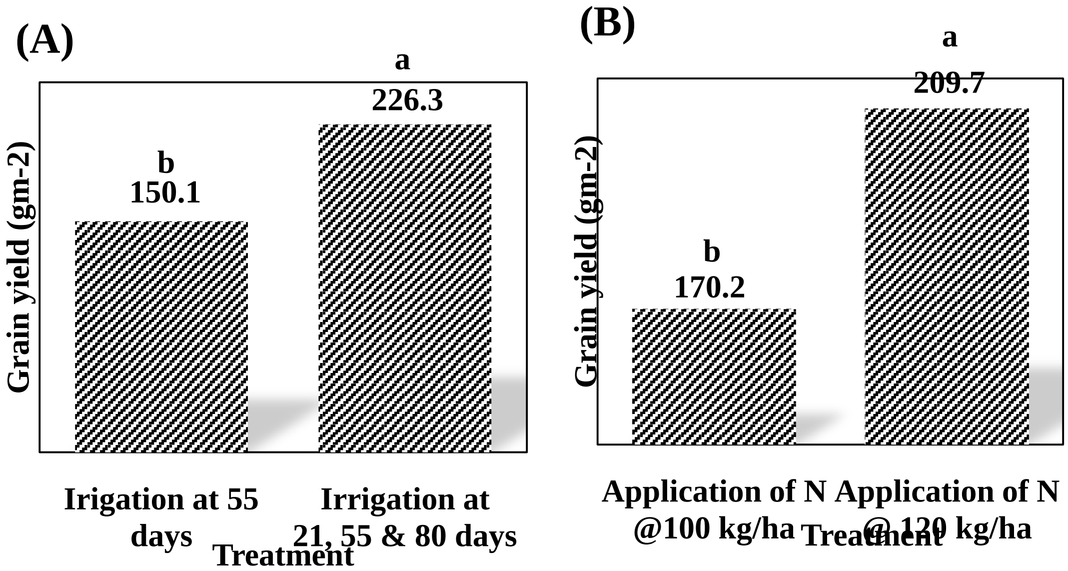


Figure 1: Effects of (A) irrigation and (B) nitrogen level on grain yield of wheat

(C)

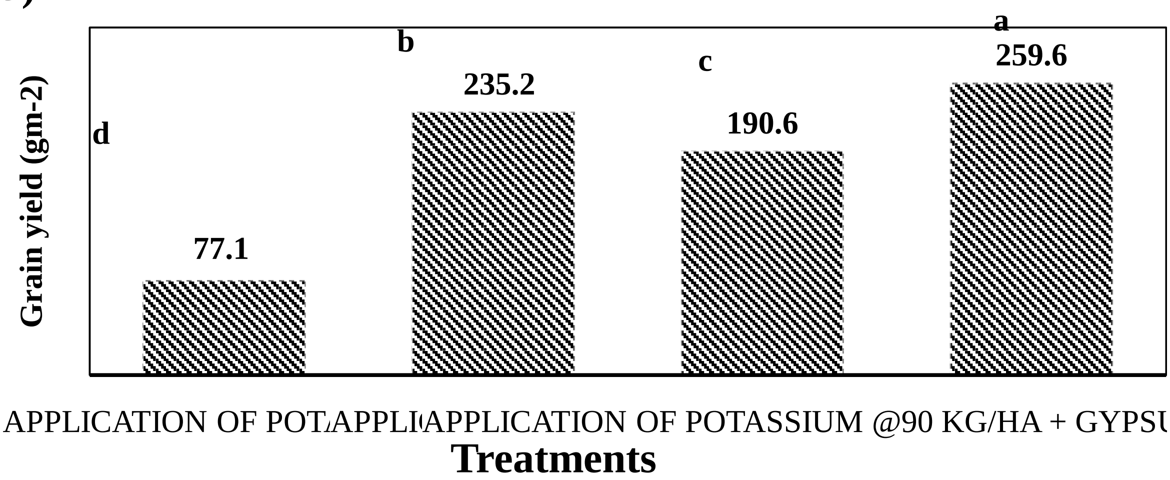


Figure 2: Effects of (A) irrigation, (B) nitrogen level and (C) soil amendments on grain yield of wheat

Wheat was directly seeded in December and grains were harvested in end of March the following year. All data were analyzed with Statistix10 program.

The treatments of irrigation, N level and soil amendments significantly differed for grain yield per plot (Figure 2). Between the treatments of irrigation higher grain yield was observed in I_2= Irrigation at 21, 55 and 80 days (226.3 gm^{-2}) than I_1= Irrigation at 55 days treatment (150.1 gm^{-2}).On the other hand, N_2=Application of N @120kg/ha showed higher grain yield of 209.7gm^{-2}compared to grain yield of 170.2gm^{-2}of N_1=Application of N @100kg/ha treatment . Grain yield was also significantly differed in different level of soil amendment treatments. Among the treatmentsT_4= Application of potassium @90kg/ha + Gypsum@ 100 kg/ha + FYM@ 5 t/ha produced the highest grain yield of 259.6 gm-^{2} and the lowest yield of 77.1 gm^{-2} was obtained from treatment T_1= Control (No amendment added).

It could be concluded that grain yield of wheat was increased with increasing application N, irrigation water and soil amendments. The combined application of irrigation 3 times at 21, 55 and 80 days and soil amendments potassium @90kg/ha + Gypsum@ 100 kg/ha + FYM@ 5 t/ha may be considered as the best among the treatments to grow wheat.

Determination of profitable cropping pattern with BINA developed crop varieties for Jamalpur

The experiment was conducted at three location of Sadar, Jamalpur during 2018-19. Three treatments of cropping sequence were taken to conduct the study which is as follows:

T_1: Mustard - Mungbean – Aus – T. Aman
T_2: Mustard – Jute – T. Aman
T_3: Boro – Fallow – T. Aman

Varieties developed by BINA were chosen to cultivate in cropping sequences except Jute and Boro rice. The details of crop management of different crops under two proposed and one existing cropping pattern are shown in the Table 2. Recommended fertilizer dose was applied in each crop. Intercultural operations were done as necessary. In the 4 crops cropping pattern short duration rice variety Binadhan-7 and mustard variety Binasarisha-10 were introduced. Total field duration of four crops pattern Mustard - Mungbean – Aus – T. Aman will needed 323 days (excluding seedling age of rice) to complete the cycle. The experiment was started from the Robi season (mustard) and ended at Kharif-II season (T. Aman). Data were recorded on per hectare yield.

Tabel. 1: Spacing, sowing & harvesting time and crop duration of the varieties of crops in the cropping pattern

Crops	Variety	Spacing	Sowing/transplanting time	Harvesting time	Crop duration (days)
Boro	BRRIdhan 28	20cm x 15cm	24/12/18 (sowing) 30/01/18 (transplanting)	12/05/2018	138
Mustard	Binasarisha-10	30cm x 5cm	06/11/2018	25/01/2019	79
Mungbean	Binamoog-8	30cm x 5cm	25/02/2019	01/05/2019	64
Aus	Binadhan-19	20cm x 15cm	05/05/2019	10/08/2019	95
Jute	CVL-1	30cm x 5cm	01/04/2019	20/07/2019	109
T. Aman	Binadhan-7	20cm x 15cm	20/07/19 (sowing) 15/08/19 (transplanting)	10/11/2019	110

Yield

Mustard (Binasarisha-10) was grown both in 4 crops and 3 crops cropping pattern and found same yield (1.5 t/ha) in both cases (Table 3). The yield of mungbean (Binamoog-8) and Aus(Binadhan-19) was recorded 0.85 t/ha and 3.1 t/ha, respectively. Mungbean and Aus produced comparatively lower yield than average yield of these variety due to heavy and continuous rainfall at the harvesting time of the crops. CVL-1 variety of jute was used in the cropping pattern. The yield of jute was found 2.5 t/ha. T. Aman (Binadhan-7) was also grown both in 4 crops and 3 crops cropping pattern and found average same yield (4.5 t/ha) in 4 crops and exiting cropping pattern and 4.6 t/ha in 3 crops cropping pattern.

Table .2: Yield crops grown in different cropping pattern

Cropping pattern	Yield (t/ha)					
	Boro (local)	Mustard (Binasarisha-10)	Mungbean (Binamoog-8)	Aus	Jute (CVL-1)	T. Aman (Binadhan-7
Mustard - Mungbean – Aus – T. Aman	-	1.5	0.85	3.1	-	4.6
Mustard – Jute – T. Aman	-	1.6	-	-	2.5	4.6
Boro – Fallow – T. Aman	5.6	-	-	-	-	4.5

Long-term Evaluation of eco-comport organic fertilizer through vegetable production

An experiment was conducted to evaluate the eco-compost using lady's finger as a test crop during February 2019 at Bina Substation farm Jamalpur. The experiment comprise five treatments, viz: T_1:control, T_2:100% chemical fertilizer, T_3: 3 t/ha eco-compost, T_4 : 4 t/ha eco-compost, T_5 : 5 t/ha eco-compost. The experiment was conducted following RCBD design with three replications. Recommended dose of TSP, MOP Gypsum was applied as basal dose. Urea was applied in three splits. First one-third as basal dose, second one-third on 12 march, 2019 and the lost one-third on 27 march, 2019.

Table 3 : Effect of Treatments (chemical fertilizer and different doses of eco-compost) on yield of Lady's finger.

Treatments	Yield (tha^{-1})
T_1 :control	2.25
T_2 :100% chemical fertilizer	11.15
T_3 : 3 t/ha eco-compost	6.0
T_4 : 4 t/ha eco-compost	6.5
T_5 : 5 t/ha eco-compost	6.9

Fertilizer dose:N-$_{120}$ P-$_{40}$ K-$_{80}$ S-$_{20}$kg ha^{-1}

The yield of lady's finger for different treatments is presented in Table 4. The yield was increased markedly due to the treatments. The highest fresh fruit yield of lady's finger (11.15 t ha^{-1}) was obtained in T2 treatment (100% chemical fertilizer). However, the treatments received only eco-compost produce low yield compared to the chemical fertilizer treated plot. The control treatment produced lowest yield.

Demonstration with different Aman rice (Kharif II), mustard (Robi) and groundnut varieties developed by BINA

The different varieties of rice, mustard and developed by BINA were demonstrated at different location of Jamalpur to show the performance of the varieties and to extend the varieties among the farmers. The demonstration program was conducted at different upazila of Jamalpur and Tangail districts. Five varieties of rice (Binadhan-11, Binadhan-17, Binadhan-14, Binadhan-18 and Binadhan-19), 2 varieties of mustard (Binasarisha-4, Binasarisha-9), Binamoog-8 and Binatil-1were considered to disseminate. For the demonstration program 100 decimal and 33 decimal areas were taken for each demonstration of rice, and mustard varieties, respectively. The lands were fertilized with recommended dose of fertilizers and other intercultural operations were done as necessary. Fertilizer cost per demonstration was given to the farmers as partial cost of production of the crops.

Table.4. Demonstration of different varieties and crops (rice, mustard, Moog and Til)at different upazila of Jamalpur and Tangail district.

Sl. No.	Crops	Variety	Locations	No. of farmers	Area (decimal)	Yield (t/ha)
1	Rice	Binadhan-11	Sadar	90	33	4.6
			Melandah	25	33	4.3
			Madargonj	25	33	4.2
			Sarishabari	25	33	4.0
			Bakshgong	25	33	4.1
			Dewangong	10	33	4.2
		Binadhan-17	Sadar	20	33	6.1
			Melandah	11	33	5.5
2	Mustard	Binasarisha-4	Sadar	2	33	1.6
			Sadar	20	33	1.7
			Melandah	1	33	1.5
			Melandah	10	33	1.6
		Binasarisha-9	Sadar	40	33	1.6
			Melandah	20	33	1.7
		Binasarisha-10	Sadar	17	33	1.3
			Melandah	10	33	1.4
3	Rice	Binadhan-14	Sadar	28	33	6.2
			Melandah	17	33	5.9
			Islampur	3	33	5.8
			Sarishabai	3	33	6.0
			Dewangong	3	33	5.9
			Dhanbari	6	33	5.7
		Binadhan-18	Melandah	5	33	1.9
4	Moog	Binamoog-8	Sadar	5	33	1.6
5	Til	Binatil-1	Sadar	8	33	1.1
6	Rice	Binadhan-19	Sadar	40	33	3.9
			Melandah	11	33	3.5
			Bakshgong	5	33	3.3

Dhanbari	22	33	4.2
Roumari, Kurigram	5	33	4.3`

The Demonstration of rice, mustard and were presented in Table 4.

BINA Sub-station, Gopalganj

Effect of different spacing on yield and yield contributing characters of Binadhan-19

Field experiment was conducted at BINA Sub-station, Gopalganj to evaluate the effect of different spacing on yield and yield attributing characters of rice. Treatment combinations were S_1=15cm×15cm, S_2=20cm×15cm, S_3=20cm×20cm and S_4=25cm×20cm. Experiment was laid out in a randomized in randomized completely block design with three replications. Results revealed that different spacing performed significantly differed yield contributing characters (plant height, panicle length, no. total, effective and non-effective tiller, no. of filled and unfilled grain, 100 seed weight, grain and straw yield of rice. Treatment S_1, S_2, S_3 and S_4 were adopted 49, 42, 36 & 30 hills per square meter plot. Effects of different spacing on plant height results are presented (Table 1). Plant height ranged from 74.67 to 83.40 cm among the different treatments with being the highest in . S_4 treatment and the shortest plant height was obtained from S_1 treatment. Significantly higher panicle length was recorded in S_4 treatment. The closer spacing is an inefficient regarding tillering capacity and significantly lower number of tillers. S_1 treatment produced lower number of tiller than other treatments except S_3 treatment. S_4 treatment yielded higher tiller number than other treatments. On the other hand, S_1 produced the highest number of non-effective tillers.

Table 1. Effect of different spacing on yield and yield attributing characters of rice

Treatment	Plant height (cm)	Panicle length (cm)	Total tiller/hill(no.)	Effective tiller/hill(no.)	Non-effective tiller/hill(no.)	Root length (cm)	Root weight(g/5plant)	Total grain (no.)	Filled grain (no.)	Unfilled grain(no.)
S_1	74.67	19.60	9.73	7.87	1.60	16.07	18.83	81.00	63.27	17.73
S_2	79.53	19.53	9.73	8.87	0.80	14.67	19.83	82.20	64.27	16.20
S_3	77.20	17.87	9.27	8.40	0.87	15.27	24.00	77.67	61.33	16.33
S_4	83.40	19.73	12.33	11.00	1.00	16.07	38.00	87.73	70.53	16.40
SD Value	3.71	0.88	1.40	1.37	0.37	0.68	8.84	4.19	3.98	0.72

Maximum root length was found in S_1 and S_4 treatments and the lowest root length was obtained from S_2 treatment. Root weight of rice plant ranged from 18.83 to 38.00 g/5 plants. Highest root weight was found in S_4 treatment and the lowest root was observed in S_1 treatment. Maximum number of grain was found in S_4 treatment.

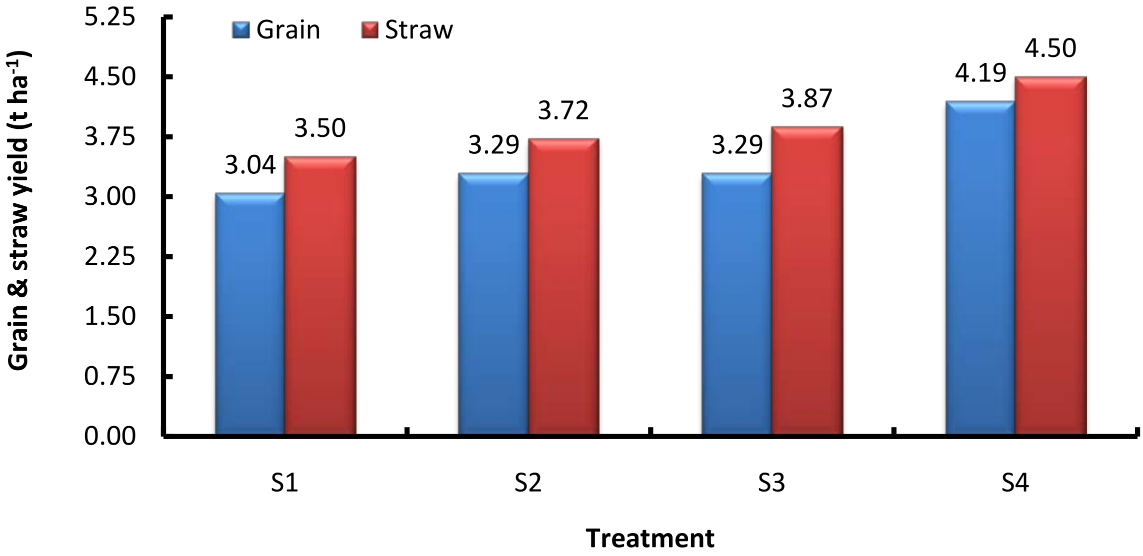


Fig. 1 Effect of different spacing on grain and straw yield of rice

Results on grain and straw yield are presented in Figure 1. Maximum grain yield was found in S_4 treatment and the minimum grain yield was observed in S_1 treatment. S_4 treatment produced the highest grain yield of rice due to good performance of yield attributing characters of rice. Similar trend of straw yield was found in this study. From these results, it may be concluded that wider spacing (25cm×20cm) performed better results on rice.

Demonstration on different BINA released crop varieties at greater district of Faridpur

BINA released crop varieties were used as demonstration to popularize among the farmers of greater district of Faridpur during 2018 -19. Crop duration was 115, 129, 123, 115, 103, 113, 104, 128 days of Binadhan 7, 10, 11, 15, 16, 17, 19 & 20 rice varieties, respectively. Most of the BINA released rice varieties can help to increase cropping intensity with optimum yield in greater Faridpur district. Oil and pulse seed crops also effective for greater Faridpur district in respect of yield and duration.

Table 1. Field demonstration of BINA released varieties

Crops	Duration (days)	No. of demonstration	Yield (t ha^{-1})
Binadhan-7	115	10	5.34
Binadhan-10	129	20	8.89
Binadhan-11	123	2	4.72
Binadhan-15	115	2	4.97
Binadhan-16	103	20	6.29
Binadhan-17	113	20	6.58
Binadhan-19	104	10	4.90
Binadhan-20	128	20	5.13
Binasarisha-9	82	5	1.65
Binamasur-8	98	10	2.05
Binakhesari-1	114	30	1.48
Binachinabadam-4	146	30	2.55
Binatil-2	94	30	1.71
Binamoog-8	65	10	1.35
Binasola-4	121	2	1.10

BINA Sub-station, Nalitabari

Research Highlights

Rice

- M_4 mutants were selected on the basis of compact panicle, green colour, lodging, grain size and shape, plant colour, during harvest time and yield. Evaluation of 12 local cultivated indigenous Aman rice varieties in Nalitabari, Sherpur for yield and yield contributing characters .

Ber

- Thirteen indigenous Ber germplasm were collected for screening, evaluation and improvement of indigenous Ber (*Zyzyphusmauritiana*) germplasm

Technology Transfer

In adaptive trials with Aman rice variety Binadhan-17 was produced highest yield (6.16 t ha^{-1}) and Binadhan-16 was the lowest duration (105 days). In Mustard varieties Binasarisha-9 was produced highest seed yield and short duration (1.6 t ha^{-1} and 83 days) compared to BARI sarisha-14 (1.4 t ha^{-1} and 80 days)

A total no of 201 demonstrations were conducted of Binadhan-11, Binadhan-16, Binadhan-17 and check with BRRI dhan 49 in T. Amon season. Result showed than higher yield (6.00t ha^{-1}) of Binadhan-17 and short duration (110 days) of Binadhan-16 than the check variety BRRI dhan 49 (5.05 t ha^{-1} with 132.32 days) respectively. A total of98 demonstration were conducted of Binasarisha-4, Binasarisha-9 and Binasarisha-10 and check with BARI sarisha-14 in winter season and result showed that produced higher yield (1.4 t ha^{-1}) of Binasarisha-4 and short duration (80 days) of Binasarisha-10 than the check BARI sarisha-14 (1.55 tha^{-1} with 85 days) respectively. A total of74 demonstration were conducted of Binadhan-10, Binadhan-14 and Binadhan-18 with check variety BRRI dhan-28 and result showed that highest yield and short duration (6.5 tha^{-1} and 110 days) of Binadhan-14 than the check BRRI dhan -28 (5.5 $tha^{-1}$and 140 days) respectively. A total of142 demonstrations were conducted of Binadhan-19 with check variety BRRI dhan 48 in Aus season and result showed that highest yield and short duration (4.0 t ha^{-1} and 102days) compared to BRRI dhan-48 (3.6 t ha^{-1} and 112 days) A profitable three crop based cropping pattern (Aman-Sarisha-Boro) where developed by BINA released varieties in Nalitabari, Sherpur.

In order to technology promotion, 4 training programme ware organized during the period of 2018-19. A total of 120 DAE personnel (Sub-assistant Agriculture Officer, SAAO) and 229 female and male farmers were trained on cultivation of BINA developed improved crop varieties.

To motivate the farmers to adopt BINA developed varieties/technologies, ten field days on different crop varieties ware organized in Sherpur district.

Screening of M_3 population of local rice Tulsimala

A large number of M_4 mutants were developed from M_3 bulk population of recurrent irradiated (150 +150, 200 +200, 250+ 205, 300 +300 and 350 +350 Gy) indigenous local aromatic rice Tulsimala. The M_3 bulk populations were grown in plant-progeny-rows for selecting desirable mutants at BINA substation, Nalitabari farm on 27 July, 2018. Recommended doses of fertilizer, cultural and intercultural operations were followed. M_4 mutants were selected on the basis of compact panicle, green colour, lodging, grain sizeand shape, plant colour during harvesting time and yield.

Evaluation of 12 local cultivated indigenous Aman rice varieties in Nalitabari, Sherpur for yield and yield contributing characters

A field experiment was carried out during June to November 2018 at the Field Laboratory of the BINA Sub-Station, Nalitabari, Sherpur to study the performance in relation to duration, yield, tolerant to lodging, pest and diseases, quality. The experiment consisted of 12 varieties, namely Tulshimala (aromatic local), Chinishail (aromatic local), Baishmuthi (local), Paijam, Binni, and Biroi (local), withBinadhan-13 and Binashail as a check variety. The experiment was laid out in randomized complete block design (RCDB) with three replications. Preliminary results revealed that there existed significant variation among the collected varieties for all the parameters studied. The highest grain yield was recorded in Baishmuthi (3.88 t ha^{-1}) followed by Habu (3.81 t ha^{-1}), whereas the lowest grain yield was observed in Tulsimala (2.91 t ha^{-1}) followed by Sarnalota-1 (2.94 t ha$^{-1)}$ (Table 1). The highly lodging tolerant variety was observed in Baishmuthi followed by Noasha, Paijam, and Binni. Visual observation suggested that the variety Biori, Sharnalata and Chinishailwas highly susceptible to BLB.

Table 1. Variation in yield and yield contributing characters of 12 local cultivated indigenous Aman rice varieties in Nalitabari, Sherpur.

Variety/ genotypes	Plant height (cm)	Panicle length (cm)	No. of tiller plant^{-1}	No. of panicle plant^{-1}	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	Wt. of 1000 seeds (gm)	Yield (t ha^{-1})
Tulsimala	157.30 a	22.39 cd	12.90 bcd	11.60 cde	105.80 f	15.90 f	12.50 f	2.91 e
Chinishail	137.00 c	24.80 ab	13.00 bc	9.90 fg	114.60de	11.90 g	14.00 e	3.35 c

Baishmuthi	145.60 abc	22.40 cd	11.70 ef	11.70 cde	109.60 ef	20.30 e	17.75 b	3.88a
Binni	151.70 abc	22.20 cd	12.90 bcd	12.00 cd	131.80 c	34.00 d	17.25 b	3.04 de
Paijam	153.90 ab	25.20 a	13.70 b	13.00 bc	104.10 f	72.00 a	14.25 de	2.96 e
Biroi	150.30 abc	22.60 cd	16.60 a	16.70 a	93.00 g	19.60 e	17.00 bc	3.25 cd
Noasha	101.20 e	21.70 cd	13.10 bc	12.40 cd	135.00 c	31.40d	19.50 a	3.15 cde
Shornalata-1	110.90 de	21.00de	11.00 f	10.30 efg	137.90 c	32.20 d	18.50 ab	2.94 e
Habu	108.70de	19.60 e	11.00 ef	11.00 defg	152.70 b	18.70 e	15.25 de	3.81ab
Hutra	102.10 e	22.90 cd	10.60 f	10.10 fg	172.20a	42.20 c	15.25 de	3.09 de
Santu-2	141.00 bc	21.70 cd	10.60 f	9.70g	134.20 c	14.00 fg	14.50 de	3.64ab
Santu- 3	121.30 d	23.20bc	12.20 cde	11.60 cde	107.80 ef	19.60 e	15.75 cd	3.08 de
Binadhan-13	147.90 abc	22.80 cd	11.70def	11.20 def	75.50 h	8.30 h	12.50 f	3.25 cd
Binashail	150.70 abc	25.60 a	16.30a	14.00 b	117.90d	45.40 b	17.50 b	3.62 b
Mean	134.25	22.72	12.66	11.80	120.86	27.54	15.82	3.28
$LSD_{0.05}$	13.54	1.68	1.09	1.29	6.76	2.71	1.42	0.231
CV (%)	6.01	4.40	5.12	6.52	3.33	5.87	5.33	4.24
Level of sig.	**	**	**	**	**	**	**	**

** =Significant at 1% level of probability (In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT))

Collection, screening, evaluation and improvement of indigenous Ber (*Zyzyphusmauritiana*) germplasm

A field experiment was started June 2018 at the Field Laboratory of the BINA Sub-Station, Nalitabari, Sherpur to study Collection, screening, evaluation and improvement of indigenous Ber (*Zyzyphusmauritiana*) germplasm. Thirteen gerplasms were collected from Kushtia, Pabna, Mymensingh and Sherpur districts in Bangladesh. The experiment was laid out in randomized complete block design (RCDB) with three replications. After one year plant height and number branches plant^{-1} was recorded.

Table 2: Average plant height (cm) and No. of branch/plant of 13 of indigenous Ber (*Zyzyphusmauritiana*) germplasm

SL. No.	Name of the germplasm	Plant height (cm)	Branches/plant (no.)
1.	Mymensingh-1	168.00	10.00
2.	Ishwardi-1	160.33	10.67
3.	Mymensingh-T	252.33	16.67
4.	Kushtia-D	235.33	12.67
5.	Mymensingh-T-2	66.00	4.00
6.	Kushtia-1	193.00	11.00
7.	Mymensingh-HC	156.67	9.67
8.	BAU-germ-1	176.00	11.00
9.	Shrpur- J	149.00	9.00
10.	BAU-germ-2	262.00	13.33
11.	Ishwardi-2	160.33	10.67
12.	Kushtia-2	276.67	12.67
13.	Mymensingh-HC-2	227.00	12.67

The highest plant height was recorded in Kushtia-2 (276.67 cm) followed by BAU-germ-2 (262.00 cm) and the shortest was recorded in Mymensingh-T-2 (66.00 cm). On the other hand, maximum branches/plant was found BAU-germ-2 (13.33) and minimum branch/plant ware found Mymensingh-T2 (4.0)

Technology Transfer

Adaptive trial of BINA developed Aman rice varieties Binadhan-11, Binadhan-16 and Binadhan-17 in Sherpur District.

During Aman season of 2018-19, a 5 adaptive trials with Binadhan-11, Binadhan-16 and Binadhan-17 were conducted at farmers' plot in Sherpur districts. The objectives were to demonstrate and evaluate the performance of Binadhan-11, Binadhan-16 and Binadhan-17 for its dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for next season. Unit plot size of individual adaptive trial was 100 decimal at all locations. The check variety was BRRI dhan 56 in all locations. Fertilizers were applied as per recommendation. Data were recorded on crop duration and grain yield. The results are presented in Table-3.

Table 3: Yield performance of Binadhan-11, Binadhan-16, and Binadhan-17 at four locations during 2018-19.

Name of the location	No. of demn.	Name of The variety	Duration (days)		Yield (t/ha)	
			Bina varieties	Check varieties	Bina varieties	Check varieties
Nalitabari, Sherpur	1	Binadahn-11	120	122	5.2	4.9
		Binadahn-16	105	122	5.3	4.9
		Binadahn-17	115	122	6.3	4.9
Nokla, Sherpur	1	Binadahn-11	121	123	5.0	5.0
		Binadahn-16	100	123	5.5	5.0
		Binadahn-17	117	123	5.9	5.0
Sadar, Sherpur	1	Binadahn-11	119	120	5.5	5.1
		Binadahn-16	102	120	5.3	5.1
		Binadahn-17	120	120	6.2	5.1
Jhenaigati, Sherpur	1	Binadahn-11	120	121	5.5	5.0
		Binadahn-16	103	121	5.4	5.0
		Binadahn-17	120	121	6.4	5.0
Shreebordi, Sherpur	1	Binadahn-11	120	124	5.4	5.1
		Binadahn-16	105	124	5.2	5.1
		Binadahn-17	118	124	6.0	5.1

Table 3 showed that average duration and yield of Binadhan-11, Binadhan-16 and Binadhan-17 and BRRI dhan-56 were 103, 120, and 122 days and 5.32, 6.16 and 5.02 t ha $^{-1}$ respectively. Farmers are interested to cultivate Binadhan-17 for its higher yield potential.

Adaptive trial of Mustard variety Binasarisha-9 in Sherpur district.

Five adaptive trials with Binasarisha-9 were conducted at farmer’s plot in Sherpur districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binasarisha-9 for its dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for next season. Unit plot size of individual adaptive trial was 100 decimal at all the locations. Seed ware sown during October to November 2018 at the rate of 7.5 kg ha^{-1}. The check varieties were BARI Sarisha-14 in all locations. Fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticide were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 4

Table 4 : Performance ofBinasarisha-9compared to BARI Sarisha-14 in different locations during 2018-19.

Name of the location	No. of demn.	Name of The variety	Duration (days)		Yield (t/ha)	
			Bina varieties	Check varieties (BARI Sarisha-14)	Bina varieties	Check varieties (BARI Sarisha-14)
Nalitabari, Sherpur	1	Binasarisha-9	84	85	1.8	1.4
Nokla, Sherpur	1	Binasarisha-9	84	82	1.6	1.6
Sadar, Sherpur	1	Binasarisha-9	81	84	1.7	1.3
Jhenaigati, Sherpur	1	Binasarisha-9	83	81	1.4	1.2
Shreebordi, Sherpur	1	Binasarisha-9	83	80	1.5	1.5

The average duration and yield of Binasarisha-9 and BARI Sarisha-14 were 83 and 80 days and 1.6 and 1.4 tha $^{-1}$, respectively. It is indicating that there were little difference among the varieties in respect of duration and yield.However, considering the duration of tested varieties indicated that farmers of all the locations easily include those varieties as an extra crop between T.aman and boro rice for increasing cropping intensity from 200% o 300%.

Block demonstration with different BINA released crop varieties in Sherpur Districts

During 2018-19 a total of 515 block demonstration of Aman, Mustard, Boro and Aus were set up at the farmer's field in Sherpur and Netrokona districts in collaboration with DAE. The main objectives were to demonstrate and evaluate the performance of Bina released variety in the location and encourage the farmers to continue the variety in their fields.

Rice

Aman

During Aman season of 2018-19, 201 demonstrations with Binadhan- 11, 16 17 and 20 were conducted at the farmer's fields inSherpur and Netrokona districts. The main objectives were to demonstrate the yield performance of these varieties and widening their adoption by the farmers. The plots size was 33 decimals and 100 decimals. Spacing between line to line and plant-to-plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 31 July to 8 August 2018 and age of seedlings was 20 to 24 days. The farmers managed all the production practices as per recommendation. Based on the available information, data of demonstration plots are presented in Table 5.

Table 5: Performance of Binadhan-11, Binadhan-16 and Binadhan-17 in Sherpur region during 2018-19

Name of the Districts	Name of the Variety	No. of Demons tration	Duration (days)		Yield (t ha^{-1})	
			Bina varieties	BRRI dhan49 (check)	Bina varieties	BRRI dhan49 (check)
Sherpur	Binadhan-11	60	118	133	5.10	5.05
	Binadhan-16	06	110	133	4.25	5.10
	Binadhan-17	60	125	134	6.00	5.11
	Binadhan-20	05	130	132	5.30	5.08
Netrokona	Binadhan-11	35	120	130	5.00	4.90
	Binadhan-17	35	125	133	5.75	5.11
Total		85				

Data in Table 5revealed that the total of201 demonstrations with short duration T. aman rice Binadhan-11, Binadhan-16, Binadhan-17 and Binadhan-20 produced average grain yields of 5.10 t ha^{-1}, 4.25t ha^{-1}, 6.00t ha^{-1} and 5.30 t ha^{-1} respectively. Average maturity period of Binadahn-11 was 118 days, Binadhan-16 was 110 days , Binadhan-17 was 125 days and Binadhan-20 was 132 days. One of the mostly popular cultivars was used as a check, BRRI dhan49. BRRI dhan49 was produced average gain yield of 5.05 t ha^{-1} with maturity period of 132.67 days. Result showed that BINA released variety increasedcrop productions and income of farmer's. Therefore,farmers are interested to cultivate BINA released varieties.

Mustard

During the Rabi season of 2018-19 a total of 98 demonstrations were conducted with Binasarisha-4, Binasarisha-9 and Binasarisha-10 in Sherpur and Netrokona districts. The main objectives were to demonstrate the performance of Binasarisha-4, Binasarisha-9 and Binasarisha-10 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during 20 October to 15 November 2018 at the rate of 7.5 kg ha^{-1}. The check variety was BARI sarisha-14. Fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticides were sprayed when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 6.

Table 6: Performance of Binasarisha-4, Binasarisha-9 and Binasarisha-10 compared to popular cultivar in Sherpur regionduring 2018-19

Name of the Districts	Name of the Variety	No. of Demons tration	Duration (days)		Yield (t ha^{-1})	
			Bina variety	BARI Sarisha-14 (Check)	Bina variety	BARI Sarisha-14 (Check)
Sherpur	Binasarisha-4	05	90	85	1.7	1.6
	Binasarisha-9	48	83	85	1.6	1.5
	Binasarisha-10	30	80	85	1.5	1.5
Netrokona	Binasarisha-9	05	85	84	1.6	1.5
	Binasarisha-10	10	80	86	1.5	1.5
Total		98				

Data in Table 6reveal that a total 98 demonstrations with short duration high yielding Binasarisha-4, Binasarisha-9 and Binasarisha-10 which produced average yields 1.7 tha^{-1}, 1.6 t $ha^{-1}$and 1.5 t ha^{-1} respectively whereas the check variety of BARI Sarisha-14 given 1.55 tha^{-1} . Average maturity period of Binasarisha-4was 90 days, Binasarisha-9 was 84 days,Binasarisha-10was 80 days and BARI Sarisha -14 was 85 days respectively.Therefore,farmers were interested to cultivate Binasarisha-9.

Boro

During Boro season of 2018-19, a total of 74 demonstrations with Binadhan-10, 14 and 18 were conducted at the farmer's fields inSherpur and Netrokona district. The main objectives were to demonstrate the yield performance of the variety and widening its adoption by the farmers. Area of demonstration plots was 33 and 100 decimals. Spacing between line to line and plant to plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 22 January (except Binadhan14) 2018, and age of seedlings was 30 to 35 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 7.

Table 7: Performance of Binadhan-10 in Sherpur region during 2017-18

Name of the Districts	Name of the Variety	No. of Demons tration	Duration (days)		Yield (t ha^{-1})	
			Bina Varieties	BRRI dhan -28	Bina Varieties	BRRI dhan -28
Sherpur	Binadhan-10	32	132	140	6.0	5.5
	Binadhan-14	16	110	110	6.5	5.6
	Binadhan-18	18	150	141	6.3	5.4

Netrokona	Binadhan-10	4	132	140	6.0	5.5
	Binadhan-14	4	110	112	6.5	5.6
	Binadhan-18	4	150	141	6.5	5.4
Total		74				

Data revealed that, a total of74 demonstrations with salt tolerant Boro rice Binadhan-14 which produced higher yield 6.5 tha^{-1} with less maturity 110 days than check varieties of BRRI dhan 28 with yield 5.5tha^{-1} and maturity period 140 days respectively.Therefore, the variety of Binadhan-10 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-10 in Sherpur and Netrokona district.

Aus

During Aus season of 2018-19 a total of 142 demonstrations with Binadhan-19 were conducted at the farmer's fields inSherpur and Netrokona districts. The main objectives were to demonstrate the yield performance of the variety and widening its adoption by the farmers. Area of demonstration plots was 33 and 100 decimals. Spacing between line to line and plant to plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 15 March-30 April 2018, and age of seedlings was 25-30 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 8.

Table 8: Performance of Binadhan-19, in Sherpur regionduring 2018-19

Name of the Districts	**Name of the Variety**	**No. of Demons tration**	**Duration (days)**		**Yield (t ha^{-1})**	
			Binadhan-19	**BRRI dhan 48**	**Binadha n-19**	**BRRI dhan 48**
Sherpur	Binadhan-19	122	100	110	4.0	3.7
Netrokona	Binadhan-19	20	104	114	4.0	3.5
	Total	142				

Data in Table 8showed that a total of142 demonstrations with Binadhan-19 produced average grain yields of 4.0 t ha^{-1} and average maturity period of Binadahn-19 was 102 days. Check variety BRRI dhan 48 produced average gain yield of 3.6 t ha^{-1} with average maturity period of 112 days.Farmers` easily can grow four crops in their field. Therefore the variety of BINA, Binadhan-19 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-19 in Sherpur and Netrokona districts.

Profitable cropping pattern by BINA released varieties in Sherpur district.

75%of land covered by two crops (mainly rice) based cropping pattern at Nalitabari in Sherpur district. Most of the farmers are followed two crop based cropping pattern such as Indigenous rice (75% local rice like as Tulsimala, Chinishail and Paijam)-Fallow- Boro rice (mainly Hybrid rice). The research works ware taken for the increase the cropping intensity and improve the existing cropping pattern and also improvement the socio-economic condition of the farmers.The improved cropping pattern was T aman (Binadhan-11) --Rabi (Bina sarisha 9) –Boro (BRRI Dhan28) during 2018-19 at, Noyabil Union,and Roshitola, in Naliatabari, Sherpur. This experiment was carried out since 2016-17. It has been observed that this cropping pattern is being rapidly disseminated among the local growers.

BINA Sub-station, Barishal

Research Highlights

- Two rice genotypes were evaluated for premium quality grain rice in Boro season to observe the performance of yield and yield contributing characters. Results revealed that the premium quality grain mutant line RM (2)-40C-4-2-8 showed better performance in panicle length, higher number of filled grains and unfilled grains except number of effective tillers compared to check variety, BRRI dhan28. The mutant line also produced the higher grain yield.

- A total of 123 demonstrations using Binadhan-11 and Binadhan-17 were conducted in Barishal region during aman season. Binadhan-11 and Binadhan-17 produced the average yield 4.60 and 5.25 t ha^{-1} with average maturity period 117 and 116 days, respectively. Besides, check variety BRRI dhan76 showed average grain yield 4.25 t ha^{-1} with average maturity period 154 days. Therefore, yield increased over check was observed 8.42% and 24.17% in Binadhan-11 and Binadhan-17, respectively.

- During the Rabi season, 120 demonstrations were conducted with Binasarisha-4, Binasarisha-9 and Binasarisha-10 in Barishal, Bhola and Jhalokathi district. Binasarisha-4, Binasarisha-9 and Binasarisha-10 produced the grain yield of 1.70, 1.60 and 1.35 t ha^{-1}, respectively. All the mustard varieties showed an increased yield over check variety BARI sarisha-14.

- In Boro season, a total of 90 demonstrations were conducted using Binadhan-8, Binadhan-10 and Binadhan-18 in Barishal region. Binadhan-8 and Binadhan-10 showed the average yield 5.55 and 6.20 t ha^{-1} with an average maturity period 136 and 127 days, respectively. In addition, Binadhan-18 produced lower yield compared to check variety BRRI dhan67 due to blast infestation.

- A total of 100 demonstrations were employed in the farmer's field of Barishal region using BINA developed mungbean varieties. Where, Binamoog-7 and Binamoog-8 produced 1.48 and 1.62 t ha^{-1} grain yield which showed 10-12% higher yield than the check variety, BARI moog-6.

Field evaluation of short duration high yielding M_{10} rice mutant with premium quality grains

The trials were carried out for evaluating a premium quality grain mutant line RM (2)-40C-4-2-8 along with a check variety, BRRI dhan28 at BINA sub-station farm, Barishal and farmers fields at Gojalia, Babugonj, Barishal. The experiments were laid out in RCBD with three replications. Unit plot size 5 m × 6 m and spacing between hills and rows were 15 and 20 cm, respectively. The seedlings of rice plants were 30 days during transplanting. Intercultural operations were done when needed. Phenotypic data was collected from five randomly selected plants from each plot. Yield of ten meter square's was converted to t ha^{-1}.

Table 1. Yield and yield contributing characters of premium quality grain rice

Location	Variety/ mutant name	Days to maturity (days)	Plant height (cm)	Panicle length (cm)	Effective tillers plant^{-1} (no)	Filled Grains panicle^{-1} (no)	Unfilled grains panicle^{-1} (no)	Yield (t ha^{-1})
Sub-station farm Barishal	RM(2)-40 (C)-4-2-8	142 a	115.0 b	27.55 a	11.6 b	142.9 b	51.13 a	6.53 a
	BRRI dhan28	135 b	92.6 d	22.36 b	13.73 a	87.6 d	24.4 c	5.48 c
Gojalia Barishal	RM(2)-40 (C)-4-2-8	135 b	122.7 a	27.94 a	10.4 bc	160.8 a	49.8 a	6.25 ab
	BRRI dhan28	129 c	101.4 c	23.14 b	9.93 c	120.7 c	29.4 b	6.16 b

The mutant showed an increased plant height, panicle length, number of filled grains and unfilled grains per panicle except number of effective tillers compared to check variety, BRRI dhan28 at both locations(Table 1). The mutant line also produced the higher grain yield in both locations. Therefore, the mutant RM (2)-40C-4-2-8 may be recommended for releasing as a variety to fulfill the demand of premium quality grain rice in Bangladesh after few more trials.

Up-scaling BINA developed T. aman rice in Barishal region

A total of 123 demonstrations during Aman season of 2018 with Binadhan-11 and Binadhan-17 were conducted at the farmer's fields in Barishal region. The main objectives were to demonstrate the yield performance of the BINA developed rice variety and widening its adoption by the farmers. Area of demonstration plots was 33 decimals. Spacing between line-to-line and plant-to-plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 25 July to 15 August 2018 and age of seedlings was 25 to 30 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 2.

Table 2: Performance of Binadhan-11 and Binadhan-17 compared to popular cultivar in Barishal region during 2018-19

Districts	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-11	BRRI dhan76	Binadhan-11	BRRI dhan76		Binadhan-17	BRRI dhan76	Binadhan-17	BRRI dhan76	
Barishal	23	114	151	4.60	4.10	12.19	113	151	5.50	4.10	34.14
Pirojpur	15	116	153	4.50	4.30	4.65	115	153	5.30	4.30	23.25
Jhalokathi	20	118	155	4.70	4.00	17.53	116	155	5.40	4.00	35.00
Patuakhali	22	115	154	4.50	4.20	7.14	114	154	4.90	4.20	16.66
Barguna	20	119	153	4.60	4.50	2.21	118	153	5.20	4.50	15.55
Bhola	23	120	155	4.70	4.40	6.81	117	155	5.30	4.40	20.45
Total	**123**										
Mean		**117**	**154**	**4.60**	**4.25**	**8.42**	**116**	**154**	**5.26**	**4.25**	**24.17**

Bd-11= Binadhan-11, Bd-17= Binadhan-17 Chek= BRRI dhan76

Data revealed that Binadhan-11 produced average grain yields of 4.60 t ha^{-1}, which was 8.42 percent higher compared to check varieties. Binadhan-17 produced average grain yields of 5.26 t ha^{-1}, which was 24.17 percent higher compared to check variety. Average maturity period of Binadhan-11 was 117 days and average maturity period of Binadhan-17 was 116 days. Binadhan-11 and Binadhan-17 demonstrated better yield performance without submergence condition. Check variety was BRRI dhan76 which produced average gain yield of 4.25 with average maturity period of 154 days. Therefore, yield increased over check was observed 8.42% and 24.17% in Binadhan-11 and Binadhan-17 that will increase farmer's income.

Up-scaling BINA developed mustard variety in Barishal region

During the Rabi season of 2018-19, a total 120 demonstrations were conducted with Binasarisha-4, Binasarisha-9 and Binasarisha-10 in Barishal region. The main objectives were to demonstrate the performance of Binasarisha-4, Binasarisha-9 and Binasarisha-10 and widening their adoption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown during October to November 2018 at the rate of 7.0 kg ha^{-1}. The check variety was BARI sarisha-14. Intercultural operations were done as recommended Data were recorded on crop duration and seed yield. The results are presented in Table 3.

Table 3: Performance of Binasarisha-4 compared to popular cultivar in Barishal region during 2018-19

District name	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisa-4	BARI sarisha-14	Binasarisa-4	BARI sarisha-14	
Barishal	30	87	77	1.7	1.4	21.42
Bhola	20	85	76	1.8	1.6	12.50
Jhalokathi	10	84	79	1.6	1.3	23.07
Total	**60**					
Mean		**85**	**77**	**1.70**	**1.43**	**18.99**

Data showed that Binasarisha-4 produced average seed yield of 1.70 t ha^{-1}, which was 18.99 percent higher than the cheek variety BARI sarisha-14. Average maturity period of Binasarisha-4 was 85 days. BARI sarisha-14 produced average gain yield of 1.43 t ha^{-1} with average maturity period of 77 days. Thus Binasarisha-4 increase crop production as well as farmer's income.

Table 4: Performance of Binasarisha-9 compared to popular cultivar in Barishal region during 2018-19

District name	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisa-9	BARI sarisha-14	Binasarisa-9	BARI sarisha-14	
Barishal	20	79	77	1.7	1.5	13.33
Bhola	20	81	76	1.6	1.4	14.28
Jhalokathi	10	83	75	1.5	1.3	15.38
Total	**50**					
Mean		**81**	**76**	**1.60**	**1.40**	**14.33**

Binasarisha-9 produced average seed yield of 1.60 t ha^{-1}, which was 14.33 percent higher than the check variety BARI sarisha-14 (Table 4). Average maturity period of Binasarisha-9 was 81 days. BARI sarisha-14 produced average gain yield of 1.40 t ha^{-1} with average maturity period of 76 days. Therefore, Binasarisha-9 is getting popular to the farmers due to higher yield.

Table 5: Performance of Binasarisha-10 in Barishal region during 2018-19

District name	No. of	Duration (days)	Yield (t ha^{-1})	Yield increased

	demo	Binasarisa-10	BARI sarisha-14	Binasarisa-10	BARI sarisha-14	over check (%)
Barishal	05	77	81	1.4	1.3	7.69
Bhola	05	76	78	1.3	1.2	8.33
Total	**10**					
Mean		**76**	**79**	**1.35**	**1.25**	**8.01**

Data presented in Table 5 showed that Binasarisha-10 produced average seed yield of 1.35 t ha^{-1} that was 8.01 percent higher than the check variety BARI sarisha-14. Average maturity period of Binasarisha-10 was 76 days. BARI sarisha-14 produced average gain yield of 1.25 t ha^{-1} with average maturity period of 79 days. Therefore, Binasarisha-10 is recommend for the farmers considering the duration and yield.

Up-scaling BINA developed salt tolerant Boro rice in Barishal region

During Boro season of 2018-19, 90 demonstrations with Binadhan-8, Binadhan-10 and Binadhan-18 were conducted at the farmer's fields in Barishal region. The main objectives were to demonstrate the yield performance and spreading in the farmer's field. The area of demonstration plots was 1 acre and 33 decimals. Spacing between line-to-line and plant-to-plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 1 december/2018 to January 2019, and age of seedlings was 30 to 35 days. The farmers managed all the production practices as suggested.

Table 6: Performance of Binadhan-8 compared to popular cultivar in Barishal region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-8	BRRI dhan74	Binadhan-8	BRRI dhan74	
Babugonj	05	136	138	5.5	5.3	3.77
Uzirpur	05	137	136	5.6	5.4	3.70
Total	**10**					
Mean		**136**	**137**	**5.55**	**5.35**	**3.73**

Data in Table 6 revealed that Binadhan-8 and BRRI dhan74 showed almost similar performance regarding grain yield and days required to maturity. Binadhan-10 produced average seed yield of 5.95 t ha^{-1}, which was 14.91 percent higher than the cheek variety BRRI dhan67 (Table 7). Average maturity period of Binadhan-10 was 128 days. BRRI dhan67 produced the average gain yield 5.20 t ha^{-1} with average maturity period of 143 days. Therefore, farmers are interested in Binadhan-10 cultivation due to higher grain yield and salt tolerance behavior.

Table 7: Performance of Binadhan-10 in Barishal region during 2018-19

Upazila/Zila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-10	BRRI dhan67	Binadhan-10	BRRI dhan67	
Babugonj	10	129	142	5.70	5.30	7.54
Uzirpur	10	126	144	6.10	5.40	12.96
Sadar,Barishal	05	128	139	5.90	5.20	13.33
Bakergonj	10	125	146	5.70	5.10	13.46
Banaripara	05	127	145	6.20	4.90	26.53
Jhalokathi	20	129	141	6.30	5.20	21.15
Pirojpur	10	130	145	5.80	5.30	9.43
Total	**70**					
Mean		**128**	**143**	**5.95**	**5.20**	**14.91**

Bd-10= Binadhan-10, check= BRRI dhan67

Data in Table 8 revealed that Binadhan-18 produced the average seed yield 4.15 tha^{-1}, which was 20.95 percent lower than the cheek variety BRRI dhan67. Binadhan-18 displayed the lower yield due to blast infestation in Barishal region. Average maturity period of Binadhan-18 was 148 days. BRRI dhan67 produced average gain yield of 5.25 t ha^{-1} with average maturity period of 144 days. Therefore, Binadhan-18 may not use by the farmers due to lower yield production.

Table 8: Performance of Binadhan-18 compared to popular cultivar in Barishal region during 2018-19

Zila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield decreased over check (%)
		Binadhan-18	BRRI dhan67	Binadhan-18	BRRI dhan67	
Babugonj	05	147	144	4.20	5.30	20.75
Uzirpur	05	150	145	4.10	5.20	21.15
Total	**10**					
Mean		**148**	**144**	**4.15**	**5.25**	**20.95**

Up-scaling BINA developed high yielding Binamoog-7 and Binamoog-8 in Barishal region

During Kharif-I season, 2019, a total of 100 demonstrations with Binamoog-7 and Binamoog-8 were conducted at the farmer's fields in Barishal region. The main objectives were to demonstrate the yield performance of the variety and widening its adoption by the farmers. The plot size of demonstration field was 1 acre. All fertilizers were applied as per recommendation. Seed sowing dates ranged from 01 February to 25 February 2019. The farmers managed all the production practices as per recommendation. Based on the farmer's reports, data of demonstration plots are presented in Table 9.

Data in Table 9 showed that Binamoog-7 produced average grain yields of 1.85 t ha^{-1}, which was 10.50 percent higher compared to check varieties BARI moog-6. Binamoog-8 produced average grain yields of 1.62 t ha^{-1}, which was 12.04 percent higher compared to check varieties BARI mung-6. Average maturity period of Binamoog-7 and Binamoog-8 was 76 and 68 days, respectively where BARI mung-6 took 70 days to maturity. But Binamoog-7 was found yellow mosaic virus susceptible. Therefore, Binamoog-8 will be recommended in the coming year in Barishal region.

Table 9: Performance of Binamoog-7 and Binamoog-8 compared to popular cultivar in Barishal region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Bm-7	**check**	**Bm-7**	**check**		**Bm-8**	**check**	**Bm-8**	**check**	
Barishal Sadar	20	73	77	1.90	1.80	5.55	65	77	1.7	1.60	6.25
Babugonj	20	76	75	2.10	1.70	23.35	67	75	1.9	1.80	5.55
Uzirpur	15	77	73	2.00	1.90	5.26	64	78	1.8	1.60	12.50
Bakergonj	10	79	75	1.70	1.70	0	86	75	2.1	1.70	23.52
Pirojpur Sadar	15	78	74	1.80	1.60	12.50	67	74	1.90	1.50	13.33
Rajapur,Pirojpur	10	76	77	1.80	1.70	5.88	65	77	2.00	1.70	17.64
Betagi,Barguna	10	79	78	1.70	1.70	0	68	76	1.70	1.80	5.55
Total	**100**										
Mean		**76**	**75**	**1.85**	**1.48**	**10.50**	**68**	**76**	**1.62**	**1.67**	**12.04**

Bm-7= Binamoog-7, Bd-8= Binamoog-8 Check= BARI mung-6

BINA Sub-station, Chapainawabganj

Research Highlights

- A total of 58 demonstrations with two short duration T. Aman rice varieties Binadhan-16 and Binadhan-17 were conducted and produced average grain yields of 4.79 t ha^{-1} and 6.17 t ha^{-1} respectively. Average maturity period of Binadhan-16 was 104 days and Binadhan-17 was 125 days. Check variety BRRI dhan49 produced average gain yield of 5.23 t ha^{-1} with average maturity period of 135 days. Farmers were found interested to cultivate Binadhan-16 and Binadhan-17.
- A total of 93 demonstrations were conducted with short duration high yielding Binasarisha-4 and Binasarisha-9 which produced better yield than check variety of BARI sarisha-14.
- A total of 50 demonstrations were conducted with short duration high yielding Binamasur-5 and Binamasur-8 which produced better yield with less maturity period in most of the time than check variety of local cultivar.
- A total of 15 demonstrations were carried out with high yielding Binachola-4 which produced better yield with less maturity period than check variety of local cultivar.
- A total of 10 demonstrations were carried with high yielding Binakhesari-1 which produced better yield with less maturity period than check variety of local cultivar.
- A total of 85 demonstrations were carried with high yielding moog variety Binamoog-8 which produced better yield than check varieties of BARI Mung-6.
- A total of 35 demonstrations were carried with high yielding sesame variety Binatil-2 and Binatil-3 which produced better yield than check varieties of local cultivars.
- A total of 60 demonstrations were carried with short duration high yielding Binadhan-19 which produced better yield with less maturity period than check variety of BRRI Dhan-48.
- A total of 10 demonstrations were carried with short duration high yielding Binadhan-14 which produced better yield with less maturity period than check variety of local cultivars.

Block demonstrations with BINA developed high yielding and short duration T. Aman rice variety in Chapainawabganj region

During Aman season of 2018-19, 58 demonstrations with Binadhan-16 and Binadhan-17 were conducted at the farmer's fields in Chapainawabganj region. The main objectives were to demonstrate the yield performance of these varieties and widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Spacing between line-to-line and plant-to-plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from mid July to 1st week of August 2018, and age of seedlings was 20 to 25 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Tables 1-2.

Table 1: Performance of Binadhan-16 in Chapainawabganj region during 2018-19

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-16	BRRI dhan49 (check)	Binadhan-16	BRRI dhan49 (check)	
Gomostapur	2	101	133	4.71	5.21	-9.60
Nachol	6	107	138	4.86	5.25	-7.43
Total	8					
Mean		104	135.5	4.79	5.23	-8.41

Results reveal that Binadhan-16 produced average grain yield of 4.79 t ha^{-1}, which was 8.41 percent lower compared to check variety, BRRI dhan49 (Table-1). Average maturity period of Binadhan-16 was 104 days which was 31 days shorter than BRRI dhan49. Therefore farmers were found interested to cultivate Binadhan-16 as an Aman variety in Chapainawabganj region.

Table 2: Performance of Binadhan-17 in Chapainawabganj region during 2018-19

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-17	BRRI dhan49 (check)	Binadhan-17	BRRI dhan49 (check)	
Sadar	8	126		6.23		
Nachol	10	120		6.15		
Tanore	10	131		6.28		
Gomostapur	10	122	135	6.01	5.23	17.97
Volahat	10	124		6.15		
Shibganj	2	127		6.19		
Total	50					

Mean	125	6.17	

Results reveal that Binadhan-17 produced average grain yield of 6.17 t ha^{-1}, which was 17.97 percent higher compared to check variety, BRRI dhan49 (Table-2). Average maturity period of Binadhan-17 was 125 days. The mean yield of Binadhan-17 was 6.17 t ha^{-1} which differs statistically from BRRI dhan-49 (5.23 t ha^{-1}). Therefore Binadhan-17 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-17 as an Aman variety in Chapainawabganj region.

Block demonstrations with BINA developed high yielding and short duration mustard variety in Chapainawabganj region

During the Rabi season of 2018-19, total 93 demonstrations were conducted with Binasarisha-4 and Binasarisha-9 in Chapainawabganj region. The main objectives were to demonstrate the performance as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during October to November 2018 at the rate of 7.5 kg ha^{-1}. The check variety was BARI sarisha-14. All fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 3: Performance of Binasarisha-4 compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisha-4	BARI sarisha-14 (Check)	Binasarisha-4	BARI sarisha-14 (Check)	
Sadar	5	88	81	1.80	1.41	20.81
Nachol	5	81	81	1.79	1.57	
Gomostapur	5	83	81	1.77	1.55	
Shibganj	2	89	80	1.81	1.61	
Volahat	1	85	82	1.82	1.32	
Tanore	5	88	81	1.83	1.52	
Godagari	3	86	80	1.81	1.47	
Total	26					
Mean		86	81	1.80	1.49	

Results reveal that Binasarisha-4 produced average seed yield of 1.80 t ha^{-1}, which was 20.81 percent higher than the cheek variety BARI sarisha-14 (Table-3). Average maturity period of

Binasarisha-4 was 86 days. BARI sarisha-14 produced average gain yield of 1.49 t ha^{-1} with average maturity period of 81 days. Farmers were found interested to cultivate Binasarisha-4.

Table 4: Performance of Binasarisha-9 compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisha-9	BARI sarisha-14 (Check)	Binasarisha-9	BARI sarisha-14 (Check)	
Sadar	15	80	81	1.71	1.41	13.42
Nachol	15	77	81	1.62	1.57	
Gomostapur	15	79	81	1.63	1.55	
Shibganj	3	82	80	1.69	1.61	
Volahat	4	81	82	1.73	1.32	
Tanore	10	83	81	1.75	1.52	
Godagari	5	83	80	1.72	1.47	
Total	67					
Mean		81	81	1.69	1.49	

Results reveal that Binasarisha-9 produced average seed yield of 1.69 t ha^{-1} which was 13.42 percent higher than the check variety BARI sarisha-14 (Table-4). Average maturity period of Binasarisha-9 was 84 days. BARI sarisha-14 produced average gain yield of 1.49 t ha^{-1} with average maturity period of 81 days. Farmers were found interested to cultivate Binasarisha-9.

Block demonstrations with BINA developed high yielding and short duration lentil variety in Chapainawabganj region

During the Rabi season of 2018-19, total 50 demonstrations were conducted with Binamasur-5 and Binamasur-8 in Chapainawabganj region. The main objectives were to demonstrate the performance as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during October to November 2018 at the rate of 30 kg ha^{-1}. The check variety was local cultivar. All fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 5: Performance of Binamasur-5 compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check
		Binamasur-5	Local cultivar (Check)	Binamasur-5	Local cultivar	

					(Check)	(%)
Sadar	5	102	119	1.81	1.41	30.50
Nachol	5	105	115	1.88	1.37	
Gomostapur	5	101	113	1.83	1.39	
Volahat	5	104	114	1.91	1.51	
Godagari	5	107	117	1.79	1.39	
Total	25					
Mean		104	116	1.84	1.41	

Results reveal that Binamasur-5 produced average seed yield of 1.84 t ha^{-1}, which was 30.50 percent higher than the local check variety (Table-5). Average maturity period of Binamasur-5 was 104 days. Local variety produced average gain yield of 1.41 t ha^{-1} with average maturity period of 116 days. Farmers were found interested to cultivate Binamasur-5.

Table 6: Performance of Binamasur-8 compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamasur-8	Local cultivar (Check)	Binamasur-8	Local cultivar (Check)	
Sadar	5	101	119	1.91	1.41	31.91
Nachol	5	99	115	1.88	1.37	
Gomostapur	5	97	113	1.83	1.39	
Volahat	5	100	114	1.89	1.51	
Godagari	5	96	117	1.81	1.39	
Total	25					
Mean		99	116	1.86	1.41	

Binamasur-8 produced average seed yield of 1.86 t ha^{-1}, which was 31.91 percent higher than the check variety (Table-6). Average maturity period of Binamasur-8 was 99 days. Local variety produced average gain yield of 1.41 t ha^{-1} with average maturity period of 116 days. Farmers were found interested to cultivate Binamasur-8.

Block demonstrations with BINA developed high yielding and short duration Chickpea variety in Chapainawabganj region

During the Rabi season of 2018-19, total 15 demonstrations were conducted with Binachola-4 in Chapainawabganj region. The main objectives were to demonstrate the performance of Binachola-4 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during October to November 2018 at the rate of 30 kg ha^{-}

[1]. The check variety was local cultivar. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 7: Performance of Binachola-4 compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binachola-4	Local cultivar (Check)	Binachola-4	Local cultivar (Check)	
Sadar	15	127	143	1.19	0.93	27.96
Total	15					
Mean		127	143	1.19	0.93	27.96

Results indicated that Binachola-4 produced average grain yield of 1.19 t ha^{-1}, which was 27.96 percent higher compared to check variety (Table-7). Average maturity period of Binachola-4 was 127 days. Farmers were found interested to cultivate Binachola-4 in Chapainawabganj region.

Block demonstrations with BINA developed high yielding and short duration Grasspea variety in Chapainawabganj region

During the Rabi season of 2018-19, total 10 demonstrations were conducted with Binakhesari-1 in Chapainawabganj region. The main objectives were to demonstrate the performance of Binakhesari-1 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during October to November 2018 at the rate of 40 kg ha^{-1}. The check variety was local cultivar. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 8: Performance of Binakhesari-1compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binakhesari-1	Local cultivar (Check)	Binakhesari-1	Local cultivar (Check)	
Sadar	10	121	138	1.75	1.48	18.24
Total	10					
Mean		121	138	1.75	1.48	18.24

Results reveal that Binakhesari-1 produced average grain yield of 1.75 t ha^{-1}, which was 18.24 percent higher compared to check variety (Table-8). Average maturity period of

Binakhesari-1 was 121 days. Farmers were found interested to cultivate Binakhesari-1 in Chapainawabganj region.

Block demonstrations with BINA developed high yielding and short duration Mungbean variety in Chapainawabganj region

During the Kharif-1 season of 2018-19, total 85 demonstrations were conducted with Binamoog-8 in Chapainawabganj region. The main objectives were to demonstrate the performance of Binamoog-8 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during mid February to mid March 2018 at the rate of 30 kg ha^{-1}. The check variety was BARI mug-6. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 9: Performance of Binamug-8 compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamuoog-8	BARI mung-6	Binamoog-8	BARI mug-6	
Sadar	30	65	62	1.23	1.11	6.15
Shibganj	25	69	68	1.41	1.26	
Gomostapur	20	71	68	1.37	1.42	
Nachol	10	68	66	1.50	1.42	
Total	85					
Mean		68	66	1.38	1.30	

Results reveal that Binamug-8 produced average grain yield of 1.38 t ha^{-1}, which was 6.15 percent higher compared to check variety (Table-9). Average maturity period of Binamug-8 was 68 days. Farmers were found interested to cultivate Binamug-8 as a summer mug variety in Chapainawabganj region.

Block demonstrations with BINA developed high yielding and short duration Sesame variety in Chapainawabganj region

During the Kharif-1 season of 2018-19, total 35 demonstrations were conducted with Binatil-3 in Chapainawabganj region. The main objectives were to demonstrate the performance of Binatil-3 as well as widening their adoption by the farmers. Area of demonstration plots was

33 decimals. Seeds were sown during mid February to mid March 2018 at the rate of 7.5 kg ha^{-1}. The check variety was local cultivar. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 10: Performance of Binatil-3 compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binatil-3	Local cultivar	Binatil-3	Local cultivar	
Shibganj	35	92	103	1.2	1.15	4.35
Total	35					
Mean		92	103	1.2	1.15	4.35

Results reveal that Binatil-3 produced average grain yield of 1.2 t ha^{-1}, which was 4.35 percent higher compared to check variety (Table-10). Average maturity period of Binatil-3 was 92 days. Farmers were found interested to cultivate Binatil-3 as a summer mug variety in Chapainawabganj region.

Block demonstrations with BINA developed high yielding and short duration Late Boro Rice variety in Chapainawabganj region

During the Kharif-1 season of 2018-19, total 85 demonstrations were conducted with Binadhan-14 in Chapainawabganj region. The main objectives were to demonstrate the performance of Binadhan-14 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during January and transplanted during February 2018 at the rate of 30 kg ha^{-1}. The check variety was a local cultivar. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 11: Performance of Binadhan-14 compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-14	Local Cultivar	Binadhan-14	Local Cultivar	
Godagari	5	123	149	6.19	5.88	3.39

Nachol	5	124	155	6.02	5.94	
Total	10					
Mean		124	152	6.11	5.91	

Results reveal that Binadhan-14 produced average grain yield of 6.11 t ha^{-1}, which was 3.39 percent higher compared to check variety (Table-11). Average maturity period of Binadhan-14 was 124 days. Farmers were found interested to cultivate Binadhan-14 as a late Boro rice variety in Chapainawabganj region.

Block demonstrations with BINA developed high yielding and short duration Aus Rice variety in Chapainawabganj region

During the Kharif-1 season of 2018-19, total 60 demonstrations were conducted with Binadhan-19 in Chapainawabganj region. The main objectives were to demonstrate the performance of Binadhan-19 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during mid February to mid March 2018 at the rate of 30 kg ha^{-1}. The check variety was BRRI Dhan-48. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 11: Performance of Binadhan-19 compared to popular cultivar in Chapainawabganj region during 2018-19

Upazila	**No. of demo**	**Duration (days)**		**Yield (t ha^{-1})**		**Yield increased over check (%)**
		Binadhan-19	**BRRI Dhan-48**	**Binadhan-19**	**BRRI Dhan-48**	
Chapai	15	105	131	5.05	4.85	
Rajshahi	10	109	133	4.99	4.91	
Naogaon	10	111	130	4.91	4.93	
Mohonpur	5	103	127	5.07	4.98	2.03
Godagari	10	107	128	5.01	4.87	
Nachol	10	104	133	5.03	4.91	
Total	60					
Mean		107	130	5.01	4.91	

Results reveal that Binadhan-19 produced average grain yield of 5.01 t ha^{-1}, which was 2.03 percent higher compared to check variety, BRRI dhan48 (Table-11). Average maturity period of Binadhan-19 was 107 days that was 23 days earlier than BRRI dhan48. Farmers were found interested to cultivate Binadhan-19 as an Aus variety in Chapainawabganj region.

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Research Highlights

- A total of 06 validation trials during the Aus season with Binadhan-14, Binadhan-19 and NERICA (M) showed that Binadhan-14 produced less yield than NERICA (M) and Binadhan-19 . Duration of Binadhan-14 (103 days) and Binadhan-19 (100 days) was less compared to NERICA (M) (114 days). Though NERICA gave higher yield than Binadhan-14 and Binadhan-19, Binadhan-19 was found to be promising variety; it gave 4.90 t ha^{-1} yield within 100 days maturity. Farmers found interest to cultivate Binadhan-19 for its high yielding potential, slender fine grain and short duration.

- Among the 08 validation trials during the Aman season with Binadhan-17, Binadhan-20, BRRI dhan70 and local variety (Sylheti Paijam) showed that Binadhan-17 produced 21.81% and 19.86% higher yield than BRRI dhan70 and Sylheti Paijam, respectively. Duration of Binadhan-17 (116 days) and Binadhan-20 (127 days) was less compared to BRRI dhan70 (130 days) and Sylheti Paijam (136 days). Farmers found interest in Binadhan-17 for high yielding, slender medium fine grain and short duration and Binadhan-20 for zinc rich and long slender grain.
- Among the 10 observation trials with four HYV (Binasarisha-4, Binasarisha-9, Binasarisha-10, BARI sarisha-16) and one local mustard cultivar (*Doli*) revealed that Binasarisha-9 and Binasarisha-4 were superior in terms of seed yield. Average seed yield of Binasarisha-9 and Binasarisha-10 was 1.58 t ha^{-1} and 1.52 t ha^{-1}. The check varieties BARI sarisha-16 and *Doli* produced a yield of 1.49 t ha^{-1} and 1.30 t ha^{-1} respectively. Growth duration was lowest in Binasarisha-4 (82 days) followed by Binasarisha-10 (83 days), *Doli* (83 days) and BARI sarisha-16 (108 days).

- The validation trial on Binadhan-18, BRRI dhan28 and BRRI dhan29 revealed that BRRI dhan29 gave higher yield (6.60 t ha^{-1}) than Binadhan-18 (5.64 t ha^{-1}) and BRRI dhan28 (5.28 t ha^{-1}). In case of duration BRRI dhan29 took long days to maturity 166.5 days than Binadhan-18 (160 days) and BRRI dhan28 (151 days).

Validation of Binadhan-19, Binadhan-14 and NERICA (M)

During Aus season of 2018-19, total 06 validation trials were conducted with Binadhan-14, Binadhan-19 and NERICA (M) in Khagrachari. Check variety was NERICA (M). The main objective was to demonstrate the relative performance Binadhan-14, Binadhan-19 and NERICA (M) and find out the advantages and disadvantages of these varieties. So that farmers may choose the right variety suitable for them. Area of the trial plots were 33 decimals or one bigha for each variety and there were 2 (two) locations. Seeds were sown during mid-May at the rate of 10 kg ha^{-1} and 25 days old seedlings were transplanted in the main field. All fertilizers were applied as per recommendation in the trial plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 1.

Table 1: Performance of Binadhan-14 with NERICA (M) and Binadhan-19 with NERICA (M) in Khagrachari Sadar Upazila during 2018-19

$Locat^n$	No. s	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Bd-14	check-1	Bd-14	check-1		Bd-19	check-1	Bd-19	check-1	
L_1	3	104	110	3.95	5.78	- 46.33	99	110	4.45	5.78	-29.88
L_2	3	102	118	4.14	5.34	-28.98	101	118	5.35	5.34	0.00
Total/Mean	**06**	**103**	**114**	**4.05**	**5.56**	**-37.66**	**100**	**114**	**4.90**	**5.56**	**-29.88**

NOTE: $Locat^n$ = Location, L_1 = Charpara, Khagrachari L_2 = Satvaiyapara, Khagrachari. No.s = Number of validation trials. Bd = Binadhan. Check-1= NERICA.

Data in Table 1 shows that Binadhan-14 produced average seed yield of 4.05 t ha^{-1} with took days to maturity only 103 days and Binadhan-19 gave an average seed yield of 4.90 t ha^{-1} with life duration 100 days. One check variety NERICA (M) gave higher yield (5.56 t ha^{-1}) than both of the BINA varieties and it took 11 to 14.5 days more to mature. Though NERICA (M) gave higher yield, the farmers not interest to grow NERICA (M) because of un-uniform flowering and bold grain. Farmers were very interested for cultivation of Binadhan-19 due its slender fine grain, short duration and dwarf height. Overall, the farmers of Khagrachari were motivated to cultivate Binadhan-19 in next season.

Validation of Binadhan-17, Binadhan-20, BRRI dhan70 and Local variety

During Aman season of 2018-19, total 08 validation trials were conducted with Binadhan-17, Binadhan-20, BRRI dhan70 and local variety (Sylheti Paijam) in Khagrachari district. Check variety was BRRI dhan70 and Sylheti Paijam. The main objective was to demonstrate the performance Binadhan-17 and Binadhan-20 over BRRI dhan70 and Sylheti Paijam and find out the advantages and disadvantages of these varieties. So that farmers may choose the right variety suitable for them in Aman season. Area of the trial plots were 33 decimals or one bigha for each variety and there were 2 (two) locations. Seeds were sown during mid-July at the rate of 25 kg ha^{-1} and 27 days old seedlings were transplanted in the main field. All fertilizers were applied as per recommendation in the trial plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 2.

Table 2: Performance of Binadhan-17 with BRRI dhan70 and local variety in Khagrachari Sadar Upazila during 2018-19

Locat^n	No.s	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Bd-17	check-1	Bd-17	check-1		Bd-17	check-2	Bd-17	check-2	
L_1	4	115	131	6.12	4.82	+ 21.24	115	132	6.12	5.08	+ 16.99
L_2	4	117	129	5.85	4.54	+ 22.39	117	140	5.85	4.52	+ 22.73
Total/Mean	**06**	**116**	**130**	**5.98**	**4.68**	**+ 21.81**	**116**	**136**	**5.98**	**4.80**	**+ 19.86**

NOTE: Locat^n = Location, L_1 = Anandanagar, Khagrachari L_2 = Thakurchara, Khagrachari. No.s = Number of validation trials. Bd = Binadhan. Check-1= BRRI dhan70, Check-2=Sylheti Paijam.

Data in Table 2 shows that Binadhan-17 produced average seed yield of 5.98 t ha^{-1} with took 116 DAS for maturity and BRRI dhan70 gave 4.68 t ha^{-1} with 130 DAS and Sylheti Paijam gave 4.80 t ha^{-1} with 136 DAS. The check variety BRRI dhan70 showed lower yields (4.74 t ha^{-1}) than Binadhan-17 and it took 14 days more to mature. On the other hand widely cultivated variety local variety Sylheti Paijam (check-2) yielded 1.18 t ha^{-1} lower and took longer duration (20 days more) for maturity than Binadhan-17.

Table 3: Performance of Binadhan-20 with BRRI dhan70 and local variety in Khagrachari Sadar Upazila during 2018-19

Locat^n	No.s	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Bd-20	check-1	Bd-20	check-1		Bd-20	check-2	Bd-20	check-2	
L_1	4	128	131	5.36	4.82	+ 10.07	128	132	5.36	5.08	+ 0.05
L_2	4	126	129	4.94	4.54	+ 8.10	126	140	4.94	4.52	+ 0.08
Total/Mean	**06**	**127**	**130**	**5.15**	**4.68**	**+ 9.08**	**127**	**136**	**5.15**	**4.80**	**+ 0.06**

NOTE: Locat^n = Location, L_1 = Anandanagar, Khagrachari L_2 = Thakurchara, Khagrachari. No.s = Number of validation trials. Bd = Binadhan. Check-1= BRRI dhan70, Check-2=Sylheti Paijam.

Table 3 shows that Binadhan-20 produced average seed yield of 5.15 t ha^{-1} with took 127 days for maturity and BRRI dhan70 gave 4.68 t ha^{-1} with took 130 days for maturity. Sylheti Paijam gave 4.80 t ha^{-1} with took 136 days for maturity. The check variety BRRI dhan70 gave lower yields (0.47 t ha^{-1}) than Binadhan-20 and it took 3 days more to mature. On the other hand widely cultivated local variety Sylheti Paijam (check-2) yielded 0.35 t ha^{-1} lower and took long duration (9 days) for maturity than Binadhan-20.

Farmers were very interested for cultivation of Binadhan-17 due its slender fine grain and higher yield. The farmer also showed interest to grow Binadhan-20 because it's zinc enrichment and longer slender grain. Overall, the farmers of Khagrachari were motivated to cultivate Binadhan-17 and Binadhan-20 in next season.

Up-scaling of Binasarisha-4, 9, 10, Bari sarisha-16 and Doli (local cultivar)

During Rabi season of 2018-19, 10 observation trials of Binasarisha-4, Binasarisha-9, Binasarisha-10, BARI sarisha-16 and one local cultivar named *Doli* were conducted. Two variety/cultivar namely- BARI sarisha-1 and *Doli* was used as check. Objective was to field demonstrate the relative performances of different mustard variety and cultivar so that farmers can choose their desired variety in terms of yield and quality. Area of the trial plots were 33 decimals or one bigha for each variety and there were 2 (two) locations. Due to late arrival of winter season in Khagrachari seeds were sown in the 2nd week of November. Farmer's practices were followed for sowing mustard seeds which was broadcasting method @ 7.4 kg ha^{-1}. All types of fertilizers were applied as per recommendation in the trial plots. Pesticides were applied as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Tables 4-6.

Table 4: Performance of Binasarisha-4 with BARI sarisha-16 and *Doli* (local cultivar) during 2018-19

Loc^n	No. s	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Bs-4	check-1	Bs-4	check-1		Bs-4	check-2	Bs-4	check-2	
L_1	5	83	110	1.61	1.57	+2.48	83	85	1.61	1.38	+ 14.28
L_2	5	81	106	1.43	1.41	+1.40	81	81	1.43	1.22	+ 14.68
Total/ Mean	**10**	**82**	**108**	**1.52**	**1.49**	**+1.94**	**82**	**83**	**1.52**	**1.30**	**+ 14.48**

NOTE: Loc^n = Location, L_1 = Munigram, Khagrachari; L_2 = Jamtoli, Khagrachari; No.s = Number of validation trials.
Bs = Binasarisha. Check-1= BARI sarisha-16, Check-2= *Doli* (LC).

Data in Table 4 exhibits that Binasarisha-4 produced seed yield of 1.52 t ha^{-1} with 82 days life span; whereas BARI sarisha-16 produced 1.49 t ha^{-1} with 83 days life span. But the 2nd check variety Doli gave lower seed yield (1.30 t ha^{-1}) than Binasarisha-4 (1.52 t ha^{-1}).

Table 5: Performance of Binasarisha-9 with BARI sarisha-16 and *Doli* (local cultivar) during 2018-19

Loc^n	No.s	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Bs-9	check-1	Bs-9	check-1		Bs-9	check-2	Bs-9	check-2	

L_1	5	88	110	1.74	1.57	+2.48	88	85	1.74	1.38	+ 14.28
L_2	5	84	106	1.42	1.41	+1.40	84	81	1.42	1.22	+ 14.68
Total/ Mean	**10**	**86**	**108**	**1.58**	**1.49**	**+1.94**	**86**	**83**	**1.58**	**1.30**	**+ 14.48**

NOTE: Loc^n = Location, L_1 = Munigram, Khagrachari; L_2 = Jamtoli, Khagrachari; No.s = Number of validation trials.

Bs = Binasarisha. Check-1= BARI sarisha-16, Check-2= *Doli* (LC).

Table 5 shows that Binasarisha-9 produced seed yield of 1.58 t ha^{-1} with 86 days life span; whereas BARI sarisha-16 showed 1.49 t ha^{-1} yield with took 108 days for maturity. The 2nd check variety Doli gave lower grain yield (1.30 t ha^{-1}) with 83 days life span compared to Binasarisha-9 (1.58 t ha^{-1}) at 86 DAS.

Table 6: Performance of Binasarisha-10 with BARI sarisha-16 and *Doli* (local cultivar) during 2018-19

Loc^n	No.s	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Bs-10	check-1	Bs-10	check-1		Bs-10	check-2	Bs-10	check-2	
L_1	5	85	110	1.45	1.57	-8.27	85	85	1.45	1.38	+ 4.83
L_2	5	81	106	1.21	1.41	-16.53	81	81	1.21	1.22	-0.01
Total/ Mean	**10**	**83**	**108**	**1.33**	**1.49**	**-12.4**	**83**	**83**	**1.33**	**1.30**	**+ 2.41**

NOTE: Loc^n = Location, L_1 = Munigram, Khagrachari; L_2 = Jamtoli, Khagrachari; No.s = Number of validation trials.

Bs = Binasarisha. Check-1= BARI sarisha-16, Check-2= *Doli* (LC).

Table 6 shows that Binasarisha-10 yielded 1.33 t ha^{-1} at 83 DAS; whereas BARI sarisha-16 gave 1.49 t ha^{-1} yield at 108 DAS. Average decrease in yield of Binasarisha-9 is 12.4% over check-1 variety (BARI sarisha-16). The 2nd check variety Doli gave lower grain yield (1.30 t ha^{-1}) at 83 DAS compared to Binasarisha-10 (1.33 t ha^{-1}) at 83 DAS. Average yield increase was 2.41% in Binasarisha-10.

Farmers of Khagrachari were interested to cultivate the BINA developed HYV mustard varieties because of high yield potential and low pest incidence. Therefore seed is available in BINA sub-station and research extension support is good. But, BARI developed mustard varieties seeds are not available in the area; thus fewer farmers could cultivate those. Most of the farmers grow mustard for oil for good market price. They reported that the local cultivar *Doli* gives more oil content (%) than the the BINA mustard varieties. But they preserved seeds of Binasarisha-4, Binasarisha-9 and Binasarisha-10 for gaining high yield sustaining mustard production in every Rabi season.

Validation of Binadhan-18, BRRI dhan28 and BRRI dhan29

During Boro season of 2018-19, total 06 validation trials were conducted with Binadhan-18, BRRI dhan28 and BRRI dhan29 in Khagrachari district. Check variety was BRRI dhan28 and BRRI dhan29. The main objective was to demonstrate the performance Binadhan-18, BRRI dhan28 and BRRI dhan29 and find out the advantages and disadvantages of these varieties. So that farmers may choose the right variety suitable for them in boro season. Area of the trial plots were 33 decimals or one bigha for each variety and there were 2 (two) locations. Seeds were sown during mid-November at the rate of 25 kg ha^{-1} and 31 days old seedlings were transplanted in the main field. All fertilizers were applied as per recommendation in the trial plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 7.

Table 7: Performance of Binadhan-18 with BRRI dhan28 and BRRI dhan29 in Khagrachari Sadar Upazila during 2018-19

Locat^n	No.s	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Bd-18	check-1	Bd-18	check-1		Bd-18	check-2	Bd-18	check-2	
L_1	3	159	150	4.91	4.82	+ 1.83	159	165	4.91	6.28	- 27.90
L_2	3	161	152	6.37	5.73	+ 10.04	161	168	6.37	6.92	-08.63
Total/Mean	**06**	**160**	**151**	**5.64**	**5.28**	**+ 5.93**	**160**	**166.5**	**5.64**	**6.60**	**-18.26**

NOTE: Locat^n = Location, L_1 = Anandanagar, Khagrachari L_2 = Shalban, Khagrachari. No.s = Number of validation trials. Bd = Binadhan. Check-1= BRRI dhan28, Check-2= BRRI dhan29.

Data in Table 7 shows that Binadhan-18 produced average seed yield of 5.64 t ha^{-1} with 160 days maturity and BRRI dhan28 gave an average seed yield of 5.28 t ha^{-1} with 151 days maturity. One check variety BRRI dhan29 gave higher yield (6.60 t ha^{-1}) than Binadhan-18 and it took 6.5 days more to mature. On the other hand widely cultivated variety BRRI dhan28 (check-1) yielded 5.28 t ha^{-1} and took less duration (151 days) for maturity than Binadhan-18. Farmers were very interested for cultivation of BRRI dhan-29 due its slender fine grain and higher yield.

Establishment of BINA Technology village, in surrounding area of BINA Sub-station, Khagrachari

In order to establish BINA-Technology village demonstrations were done in surrounding area of BINA-substation, Khagrachari at the farmer's fields and other extension work were done in the three hill district (Bandarban, Rangamati and Khagrachari) . Results of overall promotional activities related to BINA-Technology village establishment and in the three hill districts are presented below.

Table 8: Performance of BINA developed varieties at Bandarban, Rangamati and Khagrachari district during 2018-19

Sl. No	Crops	Variety Name	Demonstration No.	Av. Duration in days	Av.Yield (t ha^{-1})
1.	Rice	Binadhan-19 (Aus)	31	102	4.85
		Binadhan-7 (Aman)	14	118	5.38
		Binadhan-11 (Aman)	10	114	4.38
		Binadhan-17 (Aman)	13	110	5.12
		Binadhan-20 (Aman)	23	122	5.27
		Binadhan-10 (Boro)	05	145	4.70
		Binadhan-14 (Boro)	70	106	4.95
		Total	166		
2.	Mustard	Binasarisha-4	15	82	1.52
		Binasarisha-9	135	86	1.58
		Binasarisha-10	10	83	1.30
		Total	160		
3.	Mungbean	Binamoog-8	20	72	1.23
4.	Sesame	Binatil-2	05	96	1.20

Agricultural lands of the three hill districts are mostly valleys and only 14% land which are suitable area for growing rice, oilseeds and vegetables. Results indicate that in Aus season, Binadhan-19 have higher grain yield with less duration (Table 8). In Aman season Binadhan-7 have higher grain yield with less duration (Table 8). But farmers are not interested to grow Binadhan-7 because the Atab cooked rice were sticky and less market demand. Transplanted Aman varieties Binadhan-20, Binadhan-17 and Binadhan-11 have higher grain yield than the other local cultivars. Farmers were interested to cultivate BINA developed Aman rice varieties in aman season for their high yield and short duration and for cooked rice quality. Mustard variety, Binasarisha-4, Binasarisha-9 and Binasarisha-10 showed immense potentials in terms of yield and duration. Most of these are suitable for cultivation in between Aman and Boro rice. In this area there is no established mustard variety. So, BINA developed mustard varieties extended to the mustard growing farmers. Binasarisha-9 had the maximum yield followed by Binasarisha-4 and Binasarisha-10. The yield of Binasarisha-9 is higher and farmers reported that it also produced more oil content (%) than rest of the two. Farmers are interested to Binamoog-8 because of its less duration to harvest and they can go for growing Aus rice or Aman rice. BINA technology village establishment beside BINA sub-station is in progress.

BINA Sub-station, Khagrachari

Research Highlights

- A total of 20 demonstrations with Binadhan-20 showed that Binadhan-20 produced better yield (11.08% yield increased) with less maturity period than check varieties of BRRI dhan49.

- A total of 10 demonstrations with biofertilizer on Binamug-8 that application biofertilizer was more effective in plant growth and yield attributes than application of urea.

- A total of 20 demonstrations with Binadhan-19 showed that Binadhan-19 produced better yield (3.96% yield increased) with less maturity period than check varieties of BRRI dhan48.

Observation trails with BINA developed Binadhan-20 in Sunamganj region

During Kharif-2 of 2018-19, 20 demonstrations were conducted with Binadhan-20 in Sunamganj region. The check variety was BRRI dhan49.The main objectives were to demonstrate the performance of Binadhan-20 and widening their adoption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown during mid July to August 2018 at the rate of 30 kg ha^{-1}. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 1

Table 1: Performance of Binachinabadam-4 in Sunamganj region during 2018-19

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-20	BRRI dhan49	Binadhan-20	BRRI dhan49	
Sunamganj Sadar	10	125	129	5.55	5.00	11.00
Bishsambarpur	5	123	129	5.50	4.90	12.24
Tahirpur	5	124	130	5.60	5.10	10.00
Total	10					
Mean		124	129	5.55	5.14	11.08

Data in Table 1 reveal that Binadhan-20 produced average seed yields of 5.55 t ha^{-1} which was 11.08 percent higher compared to check variety BRRI dhan49. Average maturity period of Binadhan-20 was 124 days. The check variety BRRI dhan49 produced average gain yield of 5.14 t ha^{-1} with average maturity period of 129 days. On the other hands rice of Binadhan-20 is long, tasty and zinc & iron enriched. Farmers were found interested to cultivate Binadhan-20 in Sunamganj region.

Demonstration of usefulness of biofertilizer on growth and yield of mungbean

During Kharif-1 of 2018-19, 10 demonstrations were conducted with Binamug-8 in Sunamganj region. 05 demonstrations were conducted with urea and 05 demonstrations were conducted with biofertilizer. The main objectives were to demonstrate the effect of biofertilizer on growth and yield of mugbean and widening their adoption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown in furrows during mid February to March 2019 at the rate of 30 kg ha^{-1}. All fertilizers accept urea were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 2.

Table 2. Effect of biofertilizer ongrowth and yield attributes mungbean

Treatment	Plant height (cm)	Branches / plant (no.)	Nodule s/plant (no.)	Pods/ plant (no.)	Pod length (cm)	Seeds /pod (no.)	1000-seed wt (g)	Seed wt./ plant (g)	Seed yield t/ha
Urea with no biofertilizer	47.35	1.35	17.15	16.05	8.36	10.05	47.70	7.50	1.40
Biofertilizer with no urea	47.75	1.45	14.95	16.75	8.40	10.12	47.75	7.85	1.45

Results showed that application biofertilizer was more effective in plant growth and yield attributes than application of urea. Therefore, biofertilizer may be recommended for increased seed yield of mungbean. On the other hands it is harvested about 80% pods at a time. So, the variety of BINA, Binamug-8 increased crop production as well as farmer's income. Farmers were found interested tocultivate Binamug-8 in Sunamganj.

Observation trails with BINA developed Binadhan-19 in Sunamganj region

During Kharif-1 of 2018-19, 20 demonstrations were conducted with Binadhan-19 in Sunamganj region. The check variety was BRRI dhan48.The main objectives were to demonstrate the performance of Binadhan-19 and widening their adoption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown during mid March to April 2019 at the rate of 30 kg ha^{-1}. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 3

Table 1: Performance of Binachinabadam-4 in Sunamganj region during 2018-19

Upazila	No. of demon stratio n	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-19	BRRI dhan48	Binadhan-19	BRRI dhan48	
Sunamganj Sadar	10	99	113	4.85	4.65	4.30
Bishsambarpur	5	98	112	4.75	4.60	3.26
Tahirpur	5	97	112	4.80	4.60	4.35
Total	10					
Mean		98	112	4.80	4.62	3.96

Data in Table 3 reveal that Binadhan-19 produced average seed yields of 4.80 t ha^{-1} which higher 3.96 percent compared to check variety BRRI dhan48. Average maturity period of Binadhan-19 was 98 days. The check variety BRRI dhan48 produced average gain yield of 4.61 t ha^{-1} with average maturity period of 112 days. On the other hands rice of Binadhan-19 is fine and tasty. Therefore the variety of BINA, Binadhan-19 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-19 in Sunamganj.

Establishment of BINA Technology village, in surrounding area of BINA Sub-station, Sunamganj

In order to establish BINA-Technology village demonstrations and other extension work were done in surrounding area of BINA-substation, Sunamganj at the farmer's fields. Results of overall promotional activities related to BINA-Technology village establishment at Surma Union are presented below.

Table 3: Performance of BINA developed varieties at Surma Union during 2018-19

Sl. No	Crops	Variety Name	Demonstration No.	Av. Duration in days	Av.Yield (t ha^{-1})
1.	Rice	Binadhan-5	10	162	7.60
		Binadhan-10	5	141	6.30
		Binadhan-14	5	125	5.50
		Binadhan-11	20	116	4.90
		Binadhan-13	3	139	2.90
		Binadhan-16	10	100	4.70
		Binadhan-17	20	113	6.15
		Binadhan-19	20	99	4.55
		Binadhan-20	10	125	5.65
2.	Mustard	Binasarisha-4	5	85	1.60
		Binasarisha-9	10	79	1.50
		Binasarisha-10	5	77	1.45
3.	Groundnut	Binachinabadam-4	5	118	2.12
4.	Mungbean	Binamoog-8	5	65	1.70
5.	Sesame	Binatil-2	5	95	1.30

Surma Union in Sunamganj district is very suitable area for growing rice, oilseeds, pulse and vegetables. Results indicated that Binadhan-5 produced higher grain yield with moderate crop duration (Table 3).Transplanted aman varieties Binadhan-17, Binadhan-20, Binadhan-11, Binadhan-7 & Binadhan-16 produced higher grain yield than check. Farmers had been interested to cultivate BINA developed aman rice varieties in aman season for their high yield, short crop duration and getting varietals diversification. Mustard variety, Binasarisha-4 & Binasarisha-9 showed immense potentials in terms of yield and duration for cultivation in between aman and boro rice. Binachinabadam-4, Binatil-2 and Binamoog-8 also produced higher grain yield than check. BINA technology village Establishment in Surma Union is in progress.

BINA Sub-station, Noakhali

Research Highlights

- A total of four experiments from BINA Head quarter were carried out at the farmer's field of Noakhali. Monitoring, data collection, data analysis and reporting were done by respective PI with the help of BINA substation, Noakhali.
- A total of 20 demonstrations with salt tolerant Boro rice Binadhan-10 produced better yield of 6.0 ha^{-1}. A total of 10 demonstrations with short durative T. Aman rice Binadhan-17 produced better yield of 6.3 ha^{-1}. Farmers demand is very high with better yield as well as salt tolerant and short duration.
- A total of 20 demonstrations with Binasoybean-3 and Binasoybean-5 produced higher yield with less maturity period than check variety of Shohag.
- A total of 4 demonstrations with Binachinabadam-6 and Binachinabadam-8 showed that Binachinabadam-6 and Binachinabadam-8 produced higher yield (40% and 33% yield increased, respectively) with less maturity period than check variety of Dacca-1.

Table 1: Total number of field experiment conducted at the farmer's field, Noakhali, 2018-2019

SL. No.	Division	Crops	Name of the Location	No. of Experiment
01.	Plant Breeding Division	Soybean	BADC Farm	1
			Londoni Courasta Char Jabbar	1
02.	Soil Science Division	Felon	Londoni Courasta	1
03.	Engineering Division	Soybean	Al-Amin Bazar Centre Bazar	1

Up-scaling BINA developed Binasoybean-5 in Noakhali and laxmipur region

During 2018-19, 10 demonstrations were conducted with Binasoybean-5 in Noakhali and Laxmipur region. The check variety was Shohag. The main objectives were to demonstrate the performance of Binasoybean-5 and widening their adaptability by the farmers. Area of demonstration plots was one acre. Seeds were sown during last January 2019. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 1

Table 2: Performance of Binasoybean-5 in Noakhali and Laxmipur region during 2018-19

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasoybean-5	Shohag (check)	Binasoybean-5	Shohag (check)	
Shubornochor	5	111	116	2.40	2.00	20.00
Hatia	1	110	115	2.20	1.90	15.79
Laxmipur	4	109	114	2.30	1.80	27.78
Total	10					
Mean		110	115	2.30	1.90	21.19

Table 2 reveals that Binasoybean-5 produced average seed yield of 2.30 t ha^{-1}, which is 22.00 percent higher than check variety Shohag. Average maturity period of Binasoybean-5 was 110 days. The check variety Shohag produced average seed yield of 1.90 t ha^{-1} with average maturity period of 115 days. Therefore the variety of BINA, Binasoybean-5 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binasoybean-5 in Noakhali and Laxmipur region.

Up-scaling BINA developed Binachinabadam-6 and Binachinabadam-8 in Noakhali region

During 2018-19, 4 demonstrations were conducted with Binachinabadam-6 and Binachinabadam-8 in Noakhali region. The check variety was Dhaka-1. The main objectives were to demonstrate the performance of Binachinabadam-6 and Binachinabadam-8 and widening their adaption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown during last January 2019 at the rate of 120 kg ha^{-1}. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 3.

Table 3: Performance of Binachinabadam-6 and Binachinabadam-8 in Noakhali region during 2018-19

Upazila	No. of demons tration	Duration (days)			Yield (t ha^{-1})			Yield increased over check (%)
		Binachina badam-6	Binachina badam-8	Dacca-1 (check)	Binachina badam-6	Binachinab adam-8	Dacca-1 (check)	
Shubornochor	3	145	-	150	2.10	-	1.50	40.00
Hatia	1	-	140	145	-	1.60	1.20	33.34
Total	4							
Mean		145	140	143	2.10		1.35	36.67

Data in Table 3 reveals that Binachinabadam-6 and Binachinabadam-8 produced average seed yields of 2.10 and 1.60 t ha^{-1}, respectively which is 40.00 and 33.34 percent higher than check variety Dhaka-1. Average maturity period of Binachinabadam-6 and Binachinabadam-8 was 145 and 140 days, respectively. The check variety Dhaka-1 produced average seed yield of 1.35 t ha^{-1} with average maturity period of 143 days. Therefore the variety of Binachinabadam-6 and Binachinabadam-8 increased crop production as well as farmer’s income. Farmers were found interested to cultivate Binachinabadam-6 in Noakhali region.

Establishment of BINA Technology village, in surrounding area of BINA Sub-station, Noakhali

In order to establish BINA-Technology village demonstrations and other extension work were done in surrounding area of BINA-substation, Noakhali at the farmer’s fields. Results of overall promotional activities related to BINA-Technology village establishment at Charbat Union in Shubornochor upazilla are presented in Table 4.

Table 4: Performance of BINA developed varieties at Charbata Union during 2018-19

Sl. No	Crops	Variety Name	Demonstration No.	Average duration (days)	Average yield (t ha^{-1})
1	Rice	Binadhan-10	10	140	5.60
		Binadhan-17	10	115	6.3
2.	Groundnut	Binachinabadam-6	3	140	2.10
		Binachinabadam-8	1	145	1.60
3.	Soybean	Binasoybean-3	10	110	2.10

Charbata Union in Shubornochor Upazilla at Noakhali district is very suitable area for growing rice, oilseeds and vegetables. Results indicated that Binadhan-10 and Binadhan-17 produced higher grain yield with moderate crop duration (Table 4). Farmers had been interested to cultivate BINA developed salt tolerant rice varieties for their high yield and short crop duration. Binasoybean-3 showed immense potentials in terms of yield and duration for cultivation and adaptation in salt affected areas. Binachinabadam-6 and Binachinabadam-8 also produced higher seed yield than check. BINA technology village establishment in Charbata union is in progress.