Annual Report

2019-20

Bangladesh Institute of Nuclear Agriculture (BINA)

BAU Campus, Mymensingh-2202

October, 2020

CONTENTS

Plant Breeding Division

Research Highlights 2019-20

Rice

One advanced dual tolerant (salinity-8dS^{-1}m and submergence-upto 15 days) rice line RC-251 has been released as Binadhan-23 by National Seed Board for growing in aman season for tidal flood prone areas. One rice line (SSB-3) was found promising for Bacterial leaf blight tolerance. It matured within 125-130 days and average grain yield was 5.7 ton/ha. Application will be made to NSB for variety release in T. Aman season. Popular T. Aman variety Binadhan-17 has already been evaluated by the Seed Certification Agency for release in Boro season. Three short duration (130-140 days) high yielding (6.0 to 6.5 ton/ha) rice lines were found promising for Haor areas in Boro season. Two promising salt tolerant medium slender rice mutants were selected for Boro season.

Two short duration and high yielding MAGIC rice lines have been selected for Boro season. The mutant RM-Kas-80(C)-1 derived from the phosphorus use efficient cultivar Kasalath produced average yield 5.37 t ha-1 which was more than BRRI dhan51 and mutant was one week earlier in maturity. Three M_8 mutants of deepwater rice which were developed by irradiating the seeds of the local cultivar Laksmidigha with 200 Gy dose of gamma rays produced higher yield of 3.03 to 3.25 t ha-1 yield and their plant height ranged from 161 to 176cm, duration between 132 days to 142 days. Three M_7 mutants of BR-11 have been selected which were almost free of bacterial leaf blight disease or with minimum symptoms in the last Aman season apart from these six M_4R_1 populations with minimum Blast, BLB or Sheath Blight were also selected. Moreover, two 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 was tall, lodging susceptible but high yielding with red pericarp color have been selected. Two mutants RM-16(N)-10-1 and RM-16(N)-8-1 with fine grains were developed by irradiating the seeds of NERICA-4 with N-ion beams produced average grain yield of 7.24 and 7.08 t ha-1 grains over 3 locations which was higher than the mega variety BRRI dha29 and took one week more time to mature than BRRI dhan28.

Wheat

F_1 seeds produced and each plant of each cross were collected them to grow BC_1F_1 population.

Rapeseed

Three rapeseed mutants named as RM-18, RM-20 (*B. rapa* var. yellow sarson) and RM-005 (*B. napus*) having higher seed yield and early maturity were selected, and at least two of them are expected to be registered as varieties. In addition, around 45 other mutants/lines at various generations were identified which will be evaluated in the next growing season.

Groundnut

Three mutants B6/282/80, B6/282/64 and B6/282/63 having the higher pod yield ha^{-1} along with higher shelling percentage and higher or equal kernel sizes have been selected for advance yield trial in the next Rabi season. Some F_2's have been evaluated and selected in F_3 generation based on large seed and higher shelling percentage in the next Rabi season.

Sesame

Three mutants (SM-11, SM-13 and SM-15) were selected based on their better agronomic performance in respect of seed yield and yield attributes. In addition, some mutant lines having higher seed yield potentials are under different trials for further evaluation.

Soybean

Five promising M_5 mutants (SMB-01, SMB-02, SMB-03, SMB-04 and SMB-05) were selected based on their better improved agronomic traits and higher seed yield potential, and at least two of them are expected to be registered as varieties after further evaluation both in research and farmers' fields. Furthermore, there are some other mutants at various generations, which will be evaluated in the next growing season.

Mungbean

One promising mungbean mutant (MBM-427-87-3) in respect of earliness, semi synchronous pod maturity, disease tolerant and high yielding has been registered as Binamoog-10 by the National Seed Board.

Chickpea

One promising mutant (CPM-8-300) with bolder seed size, higher seed yield and tolerant to diseases was selected from on-farm trial. Application will be made to NSB for variety release in the next Rabi season.

Jute

Two mutants JRO-524-1000-9 and JRO-524-1000-10 with taller plant height and higher fiber yield than the parent, JRO-524 have been selected for advance yield trial in the next season.

On farm and on station trial of three rice lines for fine grain and earliness

This experiment was carried out to assess yield performance of three NERICA rice lines along with one check variety BRRI dhan49 for fine grain and earliness tested in T. Aman season during 2019-20 at BINA HQ's farm, Mymensingh, BINA Sub-station Rangpur, Sunamgonj and Chapainawabganj. Seeds were sown on 8 July 2019 and transplanted to the field on 22 August 2019. The experiment followed RCB design with three replications. The size of unit plot was 4.0 m × 3.0 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 days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000 grain weight (g) and grain yield (t ha-1) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 1.

The results obtained from on farm and on station trials of individual locations and mean over locations for all characters are presented in Table 1. Most of the characters showed significant differences among the lines and check for four individual location and mean over locations. Among the lines and check variety, BRRI dhan49 performed better yield (5.11 t ha-1, 6.0 t ha-1, 5.12 t ha^{-1}, 5.18 t ha-1and 5.35 t ha^{-1}) statistically compared with SH1 found similar for all locations except Mymensingh (4.1 t ha^{-1}, 5.92 t ha^{-1}, 4.89 t ha^{-1}, 4.38 t ha^{-1}and 4.82 t ha^{-1}) among all locations (BINA HQ farm, Mymensingh BINA sub-stations Rangpur, Sunamgonj and Chapainawabganj) and mean over the locations. Statistically, there is no significance yield difference between BRRI dhan49 and SH1 in all locations and mean over the locations. But SH1 matured (120-125 days) 10-15 days earlier than BRRI dhan49 (130-135days) in all individual locations and mean over the locations. So, based on days to maturity and yield performance, SH1 would be recommended for evaluation for release as a variety in next T. Aman season.

Table 1: Agronomic performance of three NERICA rice lines along with check variety at BINA HQ's farm, Mymensingh, BINA Sub-station Rangpur, Sunamgonj and Chapainawabganj during Aman season 2019.

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha-1)
Mymensingh	SH1	95d	121 d	90.60 c	11 a	11a	24.20 ab	127 b	27 b	22.41 a	4.10 b
	N1/300/P-6-3-5(2)	100b	134 a	120.80 a	11 a	10a	26.00 a	140 a	44 a	21.03 b	4.40 b
	N10/300/P-2-3-5-2	104a	130 b	109.80 b	8 b	7b	23.20 bc	106 c	42 a	19.13 c	4.24 b
	BRRI dhan49	97c	135 a	108.73 b	10 a	10a	21.67 c	128 b	27 b	23.27 a	5.11 a
Rangpur	SH1	109c	119 b	101.67 b	8 ab	8 bc	24.30 ab	100 b	38 b	22.47 a	5.92 a
	N1/300/P-6-3-5(2)	100a	126 c	120.80 b	11 b	10 c	26.00 ab	107 ab	44 a	21.03 b	4.40 b
	N10/300/P-2-3-5-2	117b	132 a	127.50 a	10 a	10 a	27.37a	91b	62 a	19.80 c	5.09 b
	BRRI dhan49	99d	134 a	94.77 c	10 a	10 ab	22.50 b	130 a	41 b	23.20a	6.00 a
Sunamganj	SH1	97c	123 d	97.33 c	10^{NS}	9 b	24.00 bc	100 b	13 b	22.30 ^{NS}	4.89 ^{NS}
	N1/300/P-6-3-5(2)	102b	131 b	146.00 a	10	9 b	26.33a	176 a	30 ab	21.20	3.98
	N10/300/P-2-3-5-2	106a	141 a	119.67b	9	9 a	25.67 ab	201 a	38 a	23.74	5.32
	BRRI dhan49	99c	135 b	101.67 c	9	9b	22.67c	125 b	16 ab	23.33	5.12
Chapainababganj	SH1	103a	125 b	83.27 c	17 a	14 a	23.41 a	77 b	25a	24.33 a	4.38 ab
	N1/300/P-6-3-5(2)	10b	132 a	105.40 a	13b	12b	23.60a	101 ab	25a	21.57b	4.17 ab
	N10/300/P-2-3-5-2	103a	136 a	91.80 b	13b	12b	20.87b	103 ab	26a	20.27b	3.16 b
	BRRI dhan49	99c	136 a	85.00 c	13b	11b	21.60b	113a	25a	20.67b	5.18 a
Mean over location	SH1	101c	125 c	93.22 d	12 a	11 a	23.98 b	101 b	26 b	22.88 a	4.82 ^{NS}
	N1/300/P-6-3-5(2)	10b	129 b	123.25 a	11 b	10 c	25.48 a	139a	36a	21.21 a	4.24
	N10/300/P-2-3-5-2	108a	135a	112.19 b	10 b	10 c	24.28 ab	125a	44 a	18.23 b	4.45
	BRRI dhan49	99d	135a	97.54 c	11 ab	10 b	22.11 c	124a	26 b	22.62 a	5.35

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

On-farm and on station trial of some introgressed bacterial leaf blight resistant rice lines

This experiment was carried out with a BLB introgressed rice line, SSB-03 with BRRI dhan49 as a check to assess the yield potential over locations in aman season. Seeds were sown on 10-14 July 2019 and transplanted during 2- 5 August 2019 at different locations. This experiment was supposed to carry out at several on-station and on-farm locations, but due to lack of seed this experiment was set only at on-station viz., BINA HQ farm, Mymensingh and Ishurdi, Rangpur sub-station. The experiment followed RCB design with three replications. The size of the unit plot was 3.0m × 4.0m. 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 needed. Data on plant height, number of effective tillers, panicle length, filled and unfilled grains panicle^{-1} were recorded after harvest from 5 randomly selected competitive plants. Maturity was assessed plot basis. Grain yield was recorded from an area of 10 m^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 2.

From mean over locations, it appeared that the SSB line had significantly taller plant height, longer panicle length and shorter duration at all locations than the check variety, BRRI dhan49 (table 2). There was no significant difference between the test line and check for the number of effective tiller and number of filled grain. Grain yield of this line was considerably higher but not significantly different at mean over locations than the check variety BRRI dhan49. The SSB line was found resistant to BLB while check showed susceptible in visual observation at all locations. Considering earliness, BLB resistance and high yield the line SSB will be evaluated in next growing season.

Table 2: Agronomic performance of three NERICA rice lines along with check variety at BINA HQ's farm, Mymensingh, BINA Sub-station Ishurdi and Rangpur during Aman season 2019.

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha-1)
Mymensingh	SSB-03	86 b	120 b	115.60^{NS}	13^{NS}	12^{NS}	25.07 a	157^{NS}	61 a	23.03^{NS}	6.03^{NS}
	BRRI dhan49	94 a	128 a	110.33	11	10	21 b	140	25 b	23.23 a	5.35
Ishurdi	SSB-03	87 b	124 b	94.67^{NS}	9 b	8 b	24.99 a	126^{NS}	36^{NS}	22.47 b	6.02^{NS}
	BRRI dhan49	97 a	130 a	86.33	11 a	10 a	20.11 b	110	35 a	23.33 a	5.66 a
Rangpur	SSB-03	90 b	127 b	101.53^{NS}	11^{NS}	10^{NS}	23.83^{NS}	86 b	11^{NS}	22.17 b	6.31 a
	BRRI dhan49	99 a	130 a	95.60	12	11	22.07	124 a	13 a	23.37 a	4.54 b
Mean over location	SSB-03	87 b	124 b	103.93 a	11^{NS}	10^{NS}	24.63 a	123^{NS}	36 a	22.56^{NS}	6.12^{NS}
	BRRI dhan49	97 a	129 a	97.4 b	11	10	21.06 b	124 a	24 b	23.31 a	5.18 a

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

Regional yield trial of rice lines for better grain quality and higher grain yield

This experiment was carried out to assess overall performance for better grain quality and higher grain yield of six MAGIC rice lines along with one check variety BRRI dhan49 tested in T. Aman season during 2019-20 at BINA HQ's farm, Mymensingh, BINA Sub-station Magura and Rangpur. Seeds were sown on 12 July 2019 and transplanted to the field on8 August 2019. The experiment followed RCB design with three replications. The size of unit plot was 4.0 m × 3.0 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 days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000 grain weight (g) and grain yield (t ha^{-1}) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 3.

The results obtained from regional yield trials of individual location and mean over locations for all characters are presented in Table 3. Most of the characters showed significant differences among the lines and check for three individual locations and mean over locations. Among the lines and check variety, MAGIC-86 showed better performance in respect of effective tillers plant^{-1} (12, 14, 12 and 13), panicle length (27.47cm, 28.90cm, 24.83cm and 27.07cm), filled grain panicle^{-1} (143, 107, 133 and 115) and yield performance (4.01 t ha^{-1}, 5.07 t ha^{-1}, 4.95 t ha^{-1} and 4.49 t ha^{-1}) at BINA HQ's farm, Mymensingh**,** Magura, Rangpur and mean over the locations respectively followed by MAGIC-72. But MAGIC- 86 matured (122-128 days) 7 days earlier than BRRI dhan49 (130-135 days) in all individual locations and mean over the locations. In addition, statistically, there is no significance yield difference among BRRI dhan49, MAGIC-86 and MAGIC-72 in all locations and mean over the locations. So, considering days to maturity, effective tillers plant^{-1}, panicle length, filled grain panicle^{-1} and yield performance, MAGIC- 86 and MAGIC-72 are recommended for on-farm and on-station trial in next T. Aman season.

Table 3: Agronomic performance of rice lines along with check variety at BINA HQ's farm, Mymensingh, BINA Sub-station Magura and Chapainawabganj during Aman season 2019

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield ($t\ ha^{-1}$)
Mymensingh	MAGIC-69	82 cd	124 d	110.33 c	10 c	9 c	21.53 d	102 c	30 a	23.57 a	3.84 ^{NS}
	MAGIC-72	84 c	128 c	116.13 b	10 c	11 b	26.13 b	142 a	30 a	22.79 a	3.89
	MAGIC-75	80 e	120 e	117.33 b	11 b	9 c	24.83 c	143 a	61 a	20.68 b	3.72
	MAGIC-76	78 f	120 e	117.60 b	10 bc	10 bc	24.77 c	128 ab	23 a	21.57 b	3.95
	MAGIC-82	86 b	132 b	132.27 a	10 c	9 c	24.33 c	118 bc	32 a	20.77 b	3.62
	MAGIC-86	82 de	122 e	116.40 b	13 a	12 a	27.47 a	143 a	32 a	22.95 a	4.01
	BRRI dhan49	97 a	136 a	110.73 c	10 c	10 bc	21.47 d	135 ab	26 a	23.23 a	3.85
Magura	MAGIC-69	84 ab	130 b	90.73 d	13 ab	12 ab	22.07 d	80 b	36 a	22.93 a	4.50 bc
	MAGIC-72	84 ab	130 b	105.13 b	13 ab	13 ab	24.60 b	105 a	12 c	21.90 bc	4.90 ab
	MAGIC-75	76 b	126 c	95.13 cd	11 c	11 b	22.20 d	78 b	25 b	19.70 e	4.70 abc
	MAGIC-76	75 b	126 c	94.47 cd	15 a	14 a	22.47 cd	72 b	11 c	20.87d	4.90 ab
	MAGIC-82	74 b	130 b	119.50 a	15 a	14 a	23.87 bc	100 a	19 bc	21.07 cd	4.23 c
	MAGIC-86	76 b	128 c	101.70 bc	14 a	14 a	28.90 a	107 a	12 c	22.30 ab	5.07 a
	BRRI dhan49	95 a	134 a	98.00 bcd	12 bc	11 b	20.30 e	103 a	15 bc	23.10 a	4.33 c
Rangpur	MAGIC-69	88 d	135 ab	105.73 b	12 a	11 ^{NS}	21.57 bc	89 b	21 cd	22.30 a	4.47 ^{NS}
	M AGIC-72	95 b	128 c	106.93 b	12 a	12	24.47 a	96 b	31 ab	22.23 a	4.55
	MAGIC-75	88 d	124 d	102.93 b	12 a	12	21.77 bc	95 b	18 d	20.27 bc	4.54
	MAGIC-76	89 d	124 b	103.53 b	11 a	11	21.20 c	68 c	20 d	21.20 b	4.38
	MAGIC-82	92 c	133 b	126.27 a	13 a	11	22.77 b	99 b	38 a	20.03 c	4.07
	MAGIC-86	91 c	124 d	103.83 b	13 a	12	24.83 a	135 a	16 d	22.27 a	4.95
	BRRI dhan49	98 a	135 a	96.13 c	13 a	12	20.73 c	95 b	29 bc	23.03 a	4.41
Mean over location	MAGIC-69	85 bc	124 d	102.27 c	12 ab	11 c	21.72 d	93 d	29 ^{NS}	22.93 ab	4.23 ^{NS}
	MAGIC-72	88 b	128 c	109.40 b	12 ab	11 bc	25.07 b	114 ab	20	22.31 c	4.46
	MAGIC-75	81 cd	120 e	105.13 bc	11 b	11 bc	22.93 c	96 cd	30	20.22 e	4.32
	MAGIC-76	80 d	120 e	105.20 bc	12 b	12 b	22.81 c	112 ab	29	21.21 d	4.41
	MAGIC-82	84 bcd	129 b	126.01 a	13 ab	11 bc	23.66 c	104 bc	30	20.62 e	4.19
	MAGIC-86	83 cd	122 d	107.31 b	13 a	13 a	27.07 a	115 a	18	22.50 bc	4.49
	BRRI dhan49	97 a	134 a	101.62 c	11 b	11 bc	20.83 d	111 ab	24	23.12 a	4.20

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

Regional yield trial of three promising NERICA M_7 mutants for drought tolerance

This experiment was carried out to assess overall performance for better grain quality and higher grain yield of six MAGIC rice lines along with one check variety Binadhan 19 tested in Aus season during 2019-20 at BINA HQs farm, Mymensingh, BINA Sub-station Nalitabari and Chapainababganj. Seeds were sown on 14 April 2019 and transplanted to the field on 8 May 2019. The experiment followed RCB design with three replications. The size of unit plot was 4.0 m × 3.0 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 days to flowering, days to maturity, plant height, total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length, filled and unfilled grains panicle^{-1}, 1000 grain weight and grain yield were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 4.

It is observed that the results obtained from regional yield trials of individual location and mean over locations for all characters presented in Table 4, most of the characters showed significant differences among the lines and check for three individual locations and mean over locations. Among the lines and check variety, N4/250/P-2(6)26 showed better performance in respect of effective tillers plant^{-1} (11, 13, 13 and 11), panicle length (23.47cm, 27.37cm, 27.37cm and 26.07 cm), filled grain panicle^{-1} (103, 93, 101 and 96) and yield performance (4.85 t ha^{-1}, 4.61 t ha^{-1}, 4.69 t ha^{-1} and 4.69 t ha^{-1}) at BINA HQ's farm, Mymensingh**,** BINA Sub-station Nalitabari and Chapainababganj and mean over the locations respectively followed by N4/250/P-1(2). In addition, statistically, there is no significance yield difference among mutants lines and check variety in all individual locations and mean over the locations So, based on effective tillers plant^{-1}, panicle length, filled grain panicle^{-1} and yield performance, N4/250/P-2(6)26 and N4/250/P-1(2) might be recommended for on-farm and on-station trial in next Aus season.

Table 4: Agronomic performance of three NERICA rice lines along with check variety at BINA HQ's farm, Mymensingh, BINA Sub-station Nalitabari and Chapainababganj in Aus 2019.

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha^{-1})
Mymensingh	N4/250/P-2(6)26	73 c	101 c	98.73 b	12 a	11 a	23.47 a	103 ^{NS}	23 ^{NS}	22.70 a	4.85 a
	N4/250/P-1(2)	73 c	101 c	100.07 ab	12 a	10 a	21.13 b	99	21	20.67 c	4.59 ab
	SH-1	84 b	110 b	102.07 a	10 b	9 b	20.87 b	93	21	22.24 ab	4.41 ab
	Binadhan-19	85 a	111 a	89.60 c	10 b	9 b	20.87 b	90	22	21.62 bc	4.26 b
Nalitabari	N4/250/P-2(6)26	76 b	104 c	100.13 b	14 a	13 ^{NS}	27.37 a	93 ^{NS}	22 b	22.40 a	4.61 ^{NS}
	N4/250/P-1(2)	78 b	106 b	99.07 b	13 ab	12	24.03 b	88	35 ab	22.33 a	4.42
	SH-1	86 a	111 a	108.00 a	11 b	12	23.93 b	82	46 a	19.87 b	4.28
	Binadhan-19	85 a	111 a	89.60 c	12b	11	20.87 c	90	37 ab	21.62 a	4.26
Chapainababganj	N4/250/P-2(6)26	79 b	106 b	112.20 ab	15 ^{NS}	13 ^{NS}	27.37 a	101 ^{NS}	28 b	22.15 ab	4.69 ^{NS}
	N4/250/P-1(2)	80 b	108 c	114.67 a	14	13	25.13 b	98	30 ab	20.15 b	4.61
	SH-1	86 a	112 a	108.00 b	14	10	24.70 bc	93	46 a	23.38 a	4.31
	Binadhan-19	85 a	108 c	99.20 c	16	13	23.53 c	85	35 ab	21.57 ab	4.43
Mean over location	N4/250/P-2(6)26	76 c	103 b	103.69 a	13 a	11 ^{NS}	26.07 a	96 ^{NS}	27 b	22.65 a	4.69 a
	N4/250/P-1(2)	77 b	105 b	104.60 a	12 b	10	23.40 b	94	29 ab	22.42 ab	4.57 ab
	SH-1	85 a	111 a	106.02 a	13 a	12	23.20 b	89	38 a	20.23 c	4.33 ab
	Binadhan-19	85 a	110 a	92.80 b	13 ab	12	21.76 c	93	29 ab	21.60 b	4.32 b

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

Regional yield trial of promising rice lines in Boro season for Haor areas

This experiment was carried out to assess short duration and higher grain yield of six rice lines along with one check variety BRRI dhan28 tested in during Boro season 2019-20 at BINA Headquarter farm and BINA sub-station Sunamgonj and Sathkhira. Seeds were sown ranged from 5-11 December 2019 and transplanted to the field from 8-15 January 2020. The experiment followed RCB design with three replications. The size of a unit plot was 3m × 4m. 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 required. Data on plant height, number of effective tillers, panicle length, and filled and unfilled grains panicle^{-1} 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.

From the results, significant variations were observed for all the characters at mean over location. It was observed that SL-44 had the shortest plant height (74.35cm) among the lines and check. In case of panicle length and number of filled grain, SL-77 had the highest panicle length (25.44cm) and SL-44 had the highest number of filled grain (120) in mean over locations. Grain yield was highest for SL-44 because of it highest number of filled grain and medium grain size. SL-44 possessed shorter plant height, higher number of effective tillers, panicle length, number of filled grain, thousand grain weights and also grain yield at all three locations. Combining mean of three locations, it was observed that SL-44 produced the highest yield followed by SL-21. Both SL-44 and SL-21 had no lodging tendency with short duration compare to check variety BRRI dhan 28. In our country flash flood usually comes at haor areas from the 1st week of April to 2nd week. It causes huge loss of Boro crop at haor areas. To avoid early flash flood at haor areas we have to harvest Boro crop by the last week of March. Both of the line's duration are from 139-145 days. If we seeded those lines on 1-15 November on seedbed would be able to harvest by 25-30 March that could escape early flash flood at haor areas. Considering short duration and higher yield, these two lines (SL-44, SL-21) will be evaluated in the next season for on farm and on station trial at Haor areas.

Table 5: Agronomic performance of rice lines along with check variety at BINA HQ's farm, Mymensingh, BINA Sub-station Sunamgonj and Sathkhira during Boro season 2019-2020

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha^{-1})
Mymensingh	SL-10	106 a	140ab	80.89 c	10abc	10ab	24.03ab	116 b	33 a	22.49 b	5.85 b
	SL-21	105 a	142 a	75.38 e	9bc	9 b	22.63 c	93 e	14 d	22.73ab	5.57 b
	SL-28	102 b	141ab	78.89 d	9 c	9ab	23.54bc	116 b	30 b	22.64 b	5.64 b
	SL-44	104 a	139 b	74.35 e	11 a	10 a	23.94ab	119 a	33 a	23.62 a	6.22 a
	SL-56	106 a	141 a	84.62 b	9 c	9ab	22.89bc	115 b	11 e	22.64 b	5.50 b
	SL-77	104 a	141ab	79.39 cd	10abc	9ab	25.08 a	110 d	27 c	22.58 b	5.67 b
	BRRI dhan28	102 b	139 b	89.45 a	10ab	9ab	23.66bc	113 c	9 e	22.59 b	5.80 b
Sunamganj	SL-10	103 cde	138 d	80.54 c	10 ^{NS}	10 ab	23.51 cd	91 e	35 a	22.47 b	6.10 d
	SL-21	105 b	138 cd	76.16 e	9	9 b	22.83 d	95 d	15 d	23.29 ab	6.52 b
	SL-28	107 a	138 cd	79.00 d	10	9 ab	23.97 bc	118 ab	32 b	22.21 a	6.00 de
	SL-44	101 e	139 bc	76.11 e	11	10 a	24.33 b	120 a	35 a	23.96 b	6.98 a
	SL-56	103 bc	140 a	85.25 b	9	9 ab	23.39 cd	117 b	12 e	22.59 b	5.96 e
	SL-77	103 cd	139 ab	80.68 c	10	9 ab	25.70 a	113 c	29 c	22.73 b	6.12 d
	BRRI dhan28	102 de	138 cd	89.77 a	10	9 ab	23.34 cd	111 c	9 f	22.81 b	6.26 c
Satkhira	SL-10	104 ab	138 ^{NS}	81.30 c	11 ^{NS}	10 ^{NS}	23.92 b	91 c	33 a	21.77 b	5.50 bc
	SL-21	105 a	139	76.83 d	11	11	22.60 c	94 c	14 c	22.85 ab	5.75 bc
	SL-28	103 ab	139	79.77 c	10	9	23.70 b	115 b	30 ab	22.47 ab	5.44 d
	SL-44	105 a	139	75.42 d	11	10	23.98 b	119 a	32 ab	23.26 a	6.24 a
	SL-56	103 b	140	86.57 b	11	10	23.40 bc	114 b	12 cd	22.00 ab	5.73 bc
	SL-77	103 ab	139	80.49 c	11	11	25.55 a	112 b	28 b	22.40 ab	5.78 bc
	BRRI dhan28	102 b	139	89.23 a	11	10	23.28 bc	112 b	10 d	22.52 ab	5.87 b
Mean over Location	SL-10	104ab	139 c	80.91 c	10.33ab	9.70ab	23.82bc	91 e	34 a	22.24 b	5.82cde
	SL-21	105 a	140ab	76.13 e	9.78 b	9.33ab	22.68 d	94 d	14 d	22.96ab	5.95bc
	SL-28	104ab	140abc	79.22 d	9.67 b	9.19 b	23.73bc	116 b	31 b	22.44 b	5.69 e
	SL-44	103 b	139bc	75.29 e	10.89 a	10.11 a	24.09 b	119 a	33 a	23.61 a	6.48 a
	SL-56	104ab	141 a	85.48 b	9.89 b	9.52ab	23.23 cd	115 b	11 e	22.41 b	5.73 de
	SL-77	104 b	140ab	80.18 cd	10.56ab	9.85ab	25.44 a	112 c	28 c	22.57 b	5.86bcd
	BRRI dhan28	102 c	139 c	89.48 a	10.44ab	9.48ab	23.42bc	112 c	9 f	22.64 b	5.98 b

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

Regional yield trial of some promising rice lines for better grain quality, earliness and higher grain yield

Regional yield trial was carried out with four MAGIC rice lines along with a check variety BRRI dhan28 were tested in during Boro season 2019-20 at BINA HQs farm and BINA sub-station Rangpur, Magura, Sunamgonj. Seeds were sown on 7-11 December 2019 and transplanted to the field on 17-22 January 2020 at different locations. The experiment was laid out in RCBD with three replications. Unit plot size was 5m x 4m and spacing between hills and rows were 15 cm and 20 cm, 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 required. Data on plant height, number of effective tiller, panicle length, and filled and unfilled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Maturity was assessed plot basis. Plot yield was converted into t ha-1. Recorded data were finally subjected to proper statistical analyses and are presented in Table-6

From the results, significant variations were observed for all the characters at all the locations. Combining mean of four locations, it was observed that MAGIC-10 had the highest filled grain (131) and lower thousands grain weight (22.34g). In respect of yield, MAGIC-10 produced the highest yield (5.69 t ha^{-1}) followed by MAGIC-27 (5.68 t ha^{-1}). On an average, among the MAGIC lines and check variety MAGIC-10 and along with MAGIC-76 required the shortest maturity period of 141 days. Considering earliness, yield and yield contributing characters, the MAGIC-10 and MAGIC-27 lines will be evaluated in the next season for on farm and on station trial.

Table 6: Agronomic performance of rice lines along with check variety at BINA HQ's farm, Mymensingh, BINA Sub-station Rangpur, Magura, Sunamgonj during Boro season 2019-2020

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha^{-1})
Mymensingh	MAGIC-10	108 c	141 c	84.13 c	12bc	10 b	23.57abc	137 NS	22 NS	22.17 c	5.76 a
	MAGIC-12	109bc	146 a	104.23 a	11bc	10 b	25.43ab	126	19	23.89ab	5.27bc
	MAGIC-27	111ab	144 a	86.20 c	9 c	8 b	22.83bc	117	28	24.07 a	5.70ab
	MAGIC-76	112 a	142bc	87.67bc	14ab	13 a	21.97 c	116	20	21.63 d	5.22 c
	BRRI dhan28	110abc	142bc	93.50 b	16 a	14 a	26.03 a	123	18	23.62 b	5.26bc
Rangpur	MAGIC-10	110 c	141 c	81.27 d	10bc	10ab	22.53 b	139 NS	12 c	22.26 c	5.52 NS
	MAGIC-12	116 a	145 a	105.93 a	10bc	10ab	26.07 a	140	15bc	24.02 a	5.15
	MAGIC-27	113 b	143 b	89.07bc	8 c	8 b	22.47 b	129	30 a	24.10 a	5.70
	MAGIC-76	107 d	140 c	85.67 cd	14ab	13ab	23.13 b	125	24ab	21.84 d	5.10
	BRRI dhan28	111 c	140 c	93.60 b	17 a	15 a	24.60ab	125	18bc	23.50 b	5.36
Magura	MAGIC-10	108bc	141 c	83.87 b	8 b	8 b	23.07 c	142 a	29 a	22.40 d	5.64 NS
	MAGIC-12	108 a	144 a	109.87ab	10ab	9ab	25.00 a	110 b	22ab	24.10 b	5.02
	MAGIC-27	109ab	142 b	95.07ab	9ab	8ab	23.67bc	102 b	25ab	24.37 a	5.48
	MAGIC-76	109 c	141 b	95.47ab	10ab	9ab	21.53 d	91 b	17 b	21.82 e	5.05
	BRRI dhan28	107ab	143 b	99.87 a	11 a	10 a	24.67ab	87 b	22ab	23.65 c	5.53
Sunamganj	MAGIC-10	110 b	142 b	77.71 d	14 a	13 a	23.64 b	106 b	15 NS	22.52 b	5.83 a
	MAGIC-12	112 a	145 a	97.79 a	14 a	12 a	22.99 b	102 b	15	24.21 b	5.18 c
	MAGIC-27	106 d	142 b	81.01 c	11 b	10 b	21.97 c	116 a	13	24.18 c	5.85 a
	MAGIC-76	108 c	141 b	70.91 e	14 a	13 a	20.34 d	81 c	12	21.91 b	5.40bc
	BRRI dhan28	112 a	142 b	87.31 b	15 a	13 a	24.55 a	101 b	12	23.58 a	5.63ab
Mean over location	MAGIC-10	109 c	141 c	81.74 e	11bc	10bc	23.20 b	131 a	19 NS	22.34 c	5.69 a
	MAGIC-12	111 a	145 a	104.46 a	11bc	10 b	24.87 a	120 b	18	24.05 a	5.15 c
	MAGIC-27	110 b	143 b	87.84 c	9 c	9 c	22.73 b	116bc	24	24.18 a	5.68ab
	MAGIC-76	109 c	141 c	84.93ab	13ab	12 a	21.74 c	103 d	18	21.80 d	5.19 c
	BRRI dhan28	110 b	142bc	93.57 a	15 a	13 a	24.96 a	109 cd	18	23.59 b	5.44 b

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

Advanced Yield trial of some rice lines for better grain quality, earliness and higher grain yield

Six rice lines (RLM-7, RLM-35, RLM-37, RLM-49, RLM-53, RLM-58) along with one check variety BRRI dhan56 were tested in during T. Aman season 2019 at BINA HQs farm, Mymensingh and Rangpur substation. Seeds were sown at 15-17 July 2019 and transplanted to the field at 11-13 August 2019 at different locations. The experiment was laid out in RCBD with three replications. Unit plot size was 3m x 1.5m and spacing between hills and rows were 15 cm and 20 cm, 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 necessary. Data on days to maturity, plant height, total tillers plant^{-1}, effective tillers hill-^{1}(no.), panicle length (cm), filled grains panicle-^{1}(no.), unfilled grains panicle-^{1} and grain yield plot-^{1}(kg) were recorded from five randomly selected plants from each plot. Plot yield was converted into t ha-1.

Results obtained from the trial of individual location and combined over two locations for all the characters are presented in Table 7. Significant variations were observed among the lines and check varieties for most of the characters in both of individual location and combined over locations. From the result mean over locations, it is observed that the lowest days to maturity were observed in RLM-37 whereas the highest was in RLM-35. In case of number of filled grain plant-^{1,} the RLM-58 had the highest number of filled grain plant-^{1} and panicle length. RLM-58 produced the highest seed yield (6.2 t ha^{-1}) closely followed by RLM-49 with yield 5.7 t ha^{-1}. RLM-58 had highest thousand seed weight (24.03) which indicates having bold grain and RLM-37 had the lowest (20.70) which indicates slender grain. The RLM-37 line mature earlier (120 days) and also produced the higher yield (5.55) with slender grain. On the other hand, RLM-58 line produced the highest yield (6.20) but mature almost same days with bold grain. Considering earliness, grain quality and high yield the lines RLM-58, RLM-49 and RLM-37 were selected and will be recommended for RYT in next growing season.

Table 7: Agronomic performance of rice lines along with check variety at BINA HQ's farm, Mymensingh and BINA Sub-station Rangpur during Aman season 2019-2020

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha^{-1})
Mymensingh	RLM-7	89 b	125 c	92.067 b	12ab	11ab	23.93ab	105ab	23abc	23.18 a	5.59ab
	RLM-35	92 a	130 a	96.267 b	10 b	9 b	23.47 b	104ab	36 a	21.84 c	4.89 b
	RLM-37	89 b	122 d	79.133 c	13 a	12 a	20.07 c	110ab	25abc	20.25 d	5.41 b
	RLM-49	89 b	122 d	93.333 b	10 b	10 b	24.07ab	116 a	17bc	21.20 cd	5.70ab
	RLM-53	92 a	128 b	91.533 b	11ab	10 b	25.00 a	92 b	28ab	22.10bc	5.78ab
	RLM-58	86 c	125 c	112.933 a	10 b	10 b	25.27 a	112ab	20bc	24.27 e	6.44 a
	BRRI dhan56	84 d	120 e	95.667 b	10 b	10 b	23.87ab	105ab	11 c	23.00ab	5.10 b
Rangpur	RLM-7	88c	116 b	73.033 b	11 b	10bc	23.93 b	110 NS	20bc	23.00a	5.04 c
	RLM-35	88 c	123 a	95.067ab	10 b	9 d	23.90 b	108	37 a	22.57 b	4.89 c
	RLM-37	91ab	117 b	79.867 b	13 a	12 a	21.50 c	107	25bc	21.15 b	5.68ab
	RLM-49	89bc	124 a	91.933ab	11 b	10bc	24.17ab	109	18 c	21.63 b	5.69ab
	RLM-53	93 a	117 b	91.193ab	12 ab	11 b	24.57ab	101	30ab	21.27 b	5.14bc
	RLM-58	93 a	117 b	110.933 a	11 b	9 cd	25.17 a	114	25bc	24.80 c	5.95 a
	BRRI dhan56	90bc	118 b	94.800ab	11 b	10bc	24.10 b	113	22bc	23.08 a	5.12bc
Mean over location	RLM-7	88 c	121cde	82.55 cd	12ab	11 b	23.93bc	108ab	22bc	23.09 a	5.32bc
	RLM-35	90 b	126 a	95.67 b	10 b	9 c	23.68 c	106ab	36 a	22.21 b	4.89 c
	RLM-37	90 b	120 de	79.50 d	13 a	12 a	20.79 d	109ab	25abc	20.70 d	5.55abc
	RLM-49	89 c	123 b	92.63bc	11 b	10bc	24.12bc	113ab	17 c	21.42 c	5.70ab
	RLM-53	92 a	122bc	91.36bc	12ab	10bc	24.78ab	97 b	29ab	21.68bc	5.46bc
	RLM-58	90bc	121bcd	111.93 a	11 b	10bc	25.22 a	113 a	22bc	24.03 e	6.20 a
	BRRI dhan56	87 d	119 e	95.23 b	11 b	10bc	23.98bc	109ab	17 c	23.04 a	5.11bc

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

Advance Yield trial of four short duration high yielding rice lines

This experiment was carried out to assess earliness with high yield attributes of four SL rice lines (SL-28, SL-51SL-57, SL-58) along with one check variety BRRI dhan28 tested in during Boro season 2019-20 at BINA Headquarter farm, and BINA Sub-station, Sunamgonj and Sathkhira. Seeds were sown on 25-30 November 2019 and transplanted to the field on 5-8 January 2020 at different locations. The experiment was laid out in RCBD with three replications. Unit plot size was 3m x 4m and spacing between hills and rows were 15 cm and 20 cm, 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 required. 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 plot basis. Grain yield was recorded from an area of 10 m^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.

Results revealed that there was significant difference for most of the characters of mean over locations. The SL-58 was the shortest among the lines and check at all the locations. In case of effective tiller and panicle length, SL-51 had the highest number of effective tiller and SL-57 had the highest panicle. Grain yield was highest for SL-58 because of it highest number of filled grain and medium bold grain size. SL -57 and SL-58 possessed shorter plant height, higher number of effective tiller, panicle length, number of filled grain, thousand grain weight and also grain yield at all three locations. Combining mean of three locations, it was observed that SL-58 produced the highest yield followed by SL-57. Both the lines had no lodging tendency compare to check variety, BRRI dhan 28. From the above discussions, considering lodging resistant, short duration and yield performance, SL-57and SL-58 were evaluated in the next season for RYT.

Table 9: Agronomic performance of rice lines along with check variety at BINA HQ's farm, Mymensingh and BINA Sub-station Sunamganj, Satkhira during Boro season 2019-2020

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha^{-1})
Mymensingh	SL-28	105 a	141ab	78.41 d	9 c	9 c	24.15 a	115 b	33 a	22.19 ^{NS}	5.53 c
	SL-51	102 b	142 a	85.77 b	13 a	13 a	24.19 a	82 e	29 b	22.43	5.54 c
	SL-57	104 a	139 c	82.95 c	11 b	11 b	24.70 a	115 b	23 c	23.11	6.01 b
	SL-58	106 a	140bc	75.70 e	10bc	10 b	22.96 b	119 a	16 d	23.28	6.51 a
	BRRI dhan28	104 a	139 c	93.81 a	13 a	12 a	23.95 a	108 d	15 d	22.74	5.89 b
Sunamganj	SL-28	105ab	139 b	78.05 d	10 b	9 c	23.41bc	109 a	34 a	22.66ab	5.45 c
	SL-51	107 a	142 a	84.63 b	13 a	13 a	23.80ab	82 c	29 b	22.23 b	5.32 c
	SL-57	101 c	139 b	82.74 c	11ab	11 b	24.61 a	108 b	23 c	23.31 a	5.56bc
	SL-58	103bc	138 b	75.14 e	11 b	10 b	22.70 c	108 b	16 d	23.67 a	6.31 a
	BRRI dhan28	103bc	138 b	93.93 a	13 a	12 a	23.57 b	108 b	15 d	23.11ab	6.03ab
Satkhira	SL-28	104ab	139 ^{NS}	78.25 c	11 b	10 b	23.37 ^{NS}	108 b	30 a	22.66 ^{NS}	5.43 b
	SL-51	105 a	141	83.46 b	14 a	13 a	24.61	84 c	29 a	22.86	5.27 b
	SL-57	103ab	139	83.30 b	12ab	11ab	24.56	114 a	22 b	23.09	5.85 a
	SL-58	105 a	138	76.39 d	11 b	10 b	22.79	118 a	17 c	23.58	5.97 a
	BRRI dhan28	103 b	139	94.99 a	13ab	12ab	23.15	109 b	14 c	22.76	5.8 a
Mean over location	SL-28	104 a	140 b	78.23 d	10 c	10 c	23.64bc	119 a	32 a	22.51 b	5.47 c
	SL-51	105 a	142 a	84.62 b	13 a	13 a	24.20ab	83 d	29 b	22.50 b	5.37 c
	SL-57	103 b	139 b	83.00 c	11 b	11 b	24.62 a	113 b	23 c	23.17ab	5.81 b
	SL-58	105 a	139 b	75.74 e	11bc	10bc	22.81 c	109 c	16 d	23.51 a	6.26 a
	BRRI dhan28	103 b	139 b	94.24 a	13 a	12 a	23.56bc	108 c	15 e	22.87ab	5.93 b

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

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

An experiment was carried out with four early and high yielding rice lines to assess the earliness and yield performance over four different locations of Bangladesh. BRRI dhan-28 and BRRI dhan-58 were used as a check variety at *Boro* season. Seeds were sown on 17-20th December 2019 and transplanted on 04 February to 05th February 2020 at different locations (Table 10a). 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 various characters such as plant height, number of effective tillers plant^{-1}, panicle length (cm), and filled grains panicle^{-1} were recorded after harvest from five randomly selected competitive plants. Days to Fifty % flowering and days to maturity was assessed by plot basis. Grain yield data were recorded from an area of 1.0 m^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 10 b.

Table 10 a: Date of seed sowing and seedling transplanting of five rice lines and the check varieties

Locations	Date of sowing	Date of transplanting	Seedling age (Days)
BINA HQ farm, Mymensingh	17 December 2019	03 February 2020	48
BINA Substation farm, Sunamganj	17 December 2019	03 February 2020	48
BINA Substation farm, Rangpur	20 December 2019	04 February 2020	46
Farmers field, Panchagarh	20 December 2019	05 February 2020	47

From the Table 10, in combined effect of varieties /lines, IRTON-5 had taller plant height (99.84) than others and similar result was found in Mymensingh and Rangpur. Shortest plant height was found in IRTON-2 (92.91) and it was similar in Panchagarh.

There were no significant difference in effective tillers per plant at Rangpur and Panchagarh. IRTON-2 (17.33) produced significantly highest number of effective tillers at Mymensingh while BRRI dhan-28 (11.33) had produced lowest number of effective tillers.

Table 10 b: Mean performance of four IRTON lines along with check varieties grown at different locations during Boro season 2019-20.

Lines/variety	Days to 50% flowering	Days to maturity	Plant height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled Grains panicle $^{-1}$ (no.)	Grain yield (t ha^{-1})
Sunamganj							
BRRI dhan58	116 a	155 a	86.33 ab	12 ab	22.17 b	100 b	5.96 b
IRTON 11	106 c	144 c	84.67 ab	13 a	22.33 ab	111 a	6.24 a
IRTON 5	114 a	154 a	85.33 ab	12 a	20.33 b	104 b	5.89 b
BRRI dhan28	108 b	142 d	87 a	12 a	23 ab	100 b	5.9 b
IRTON 2	105 c	144 c	83.67 ab	12 ab	23 ab	101 b	5.3 c
CV	1.87	0.46	2.47	5	4.69	2.27	1.1
SE	1.9	0.5511	1.7062	0.5092	0.8682	1.9071	0.0528

Rangpur

IRTON 13	126 ab	153 c	100.47b	12 a	25.47 a	120 b	6.83 d
BRRI dhan58	131 a	160 ab	93.27 c	11 a	21.5 b	128 a	7.89 a
IRTON 11	124 b	150.33 d	102.93 ab	12 a	24.53 a	110 c	7.33 bc
IRTON 5	130 ab	161.67 a	107.47 a	13 a	23.13 ab	111 c	7.01 cd
BRRI dhan28	123 b	150 d	103 ab	12 a	24.4 a	132 a	7.54 b
IRTON 2	131 a	158 b	95.33 c	12 a	23.8 ab	104 d	6.87 d
CV	1.9	0.54	1.71	5.49	3.67	1.86	1.63
SE	1.987	0.6831	1.3983	0.5583	0.7124	1.7927	0.0964
Panchagarh							
IRTON 13	128 b	153 b	101.67 a	11 a	26.2 a	114 b	6.87 c
BRRI dhan58	132 a	163.33 a	95.73 b	11 a	21.27 c	124 a	7.5 a
IRTON 11	123 c	151.33 b	102.27 a	11 a	24.4 b	131 a	6.93 bc
IRTON 5	133 a	162 a	100.33 a	12 a	23.73 b	113 b	7.2 abc
BRRI dhan28	123 c	151 b	101.53 a	11 a	24.47 b	131 a	7.23 ab
IRTON 2	132 a	159 a	93.87 b	12 a	23.73 b	110 b	7.17 abc
CV	0.6	1.21	1.3	5.21	1.17	2.06	1.67
SE	0.6266	1.5468	1.0503	0.5057	0.229	2.0367	0.0978
Combined means over locations							
IRTON 13	122	151 c	95.90 ab	13 a	26.08 a	116 b	6.34
BRRI dhan58	126	158 ab	93.08 b	13 ab	22.54 d	135 a	6.58
IRTON 11	118	147 d	96.47 ab	12 abc	24.15 bc	117 b	6.36
IRTON 5	128	159 a	99.84 a	12 bc	22.91 cd	116 b	6.40
BRRI dhan28	117	146 d	96.72 ab	12 c	24.20 b	118 ab	6.44
IRTON 2	123	155 b	92.91 b	11 c	23.76 bcd	111 b	6.29
CV	2.43	1.7	3.65	9.27	4.43	11.7	5.69
SE	1.2192	1.0613	1.4283	0.4781	0.4334	5.7001	0.14
Location Means							
Sunamganj	114 c	148 c	84.67 b	12 b	22.70 c	103 c	5.85 b
Rangpur	127 a	155 a	100.41 a	12 b	23.81 b	118 b	7.24 a
Panchagarh	128 a	156 a	99.23 a	11 b	24.00 b	121 b	7.15 a

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

For panicle length, IRTON-13 had longer panicle length at all locations while BRRI dhan-58 had produced shortest length except Mymensingh. Significantly longer panicle length was found in Mymensingh while shortest panicle length was found in Sunamganj. BRRI dhan-58 had produced highest number of filled grains at all locations.

For maturity, the Check variety BRRIdhan-28 matured 1-2 days earlier (142-151) than other lines. The line IRTON-11 was significantly same with check variety BRRIdhan-28 at all locations except Sunamganj. IRTON-11 took 144 -151days to mature. IRTON-2 and IRTON-5 took longer period to mature.

At Rangpur and Panchagarh the check variety BRRI dhan-58 produced the highest yield for its longer maturity time. IRTON-13 produced the highest yield (5.88 t ha^{-1}) at Mymensingh and IRTON-11 produced the highest yield (6.24 t ha^{-1}) at Sunamganj. The grain size of the lines (IRTON-13 and IRTON-11are is slender. These two lines IRTON-13 and IRTON-11 have been selected for their higher yield and short duration and grain quality. These two lines (IRTON-13 and IRTON-11) have been selected for next year evaluation.

Preliminary yield trial of Brown Plant Hopper (BPH) resistant rice lines

This experiment was carried out to assess insect resistant with high yield attributes of eight rice lines along with two check varieties Binadhan-17 and BRRI dhan49 tested in T. Aman season during 2019-20 at BINA Sub-station Ishurdi and Rangpur. Seeds were sown on 20 July 2019 and transplanted to the field on 22 August 2019. The experiment followed RCB design with three replications. The size of 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 days to flowering, days to maturity, plant height, total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length, filled and unfilled grains panicle^{-1}, 1000 grain weight and grain yield were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 11.

The results revealed from preliminary yield trials of individual location and mean over locations for all characters are presented in Table 11. Results mean over locations; all characters showed significant differences among the lines and checks for both individual locations and mean over locations. Among the lines and check varieties, BPH-P-020 performed better in terms of plant height (118.87cm, 130.67cm, and 124.77cm), panicle length (26.10cm, 27.07cm, and 26.58cm) and filled grain panicle^{-1} (150, 157, and 153) at Ishurdi, Rangpur and mean over the locations respectively. BPH-P-057 produced the highest effective tillers plant^{-1} at Rangpur (11) and mean over locations followed by check varieties Binadhan-17 and BRRIdhan 49. Between the two locations, yield performance of BPH-P-043 was better at Ishurdi (7.02 t ha^{-1}) and mean over locations (6.33 t ha^{-1}). From the above discussions, considering effective tillers plant^{-1}, panicle length, filled grain panicle^{-1} and yield performance, BPH-P-020 (slender grain), BPH-P-043 and BPH-P-057 are recommended for advanced trial in next T. Aman season.

Table 11: Agronomic performance of BPH rice lines along with check varieties at BINA Sub-station Ishurdi and Rangpur during aman season 2019

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha-1)
Ishurdi	BPH-P-009	87 d	120 e	90.87cde	11ab	10 b	21.87 bc	88 bc	16 cd	29.78 a	5.95 abc
	BPH-P-020	98 bc	132 a	118.87 a	13 ab	11 ab	26.10 a	150 a	40 abc	20.97 g	4.43 de
	BPH-P-023	99 ab	128 bc	90.87 cde	9 b	9 b	24.07abc	100 bc	41 ab	28.20 b	6.60 ab
	BPH-P-034	100 a	129 ab	95.20 bc	12 ab	12 ab	23.73 abc	96 bc	33 abcd	27.43 bc	5.27 bcd
	BPH-P-043	97 c	126 cd	90.77 cde	14 a	12 ab	22.67 abc	82 bc	22 bcd	25.90 de	7.02 a
	BPH-P-047	98bc	127 cd	96.00bc	12ab	11 ab	24.73 ab	83 bc	40 abc	26.93 f	4.88 cd
	BPH-P-057	100 ab	129 bc	100.30 b	12 ab	11 ab	21.53 bc	96 bc	18 bcd	24.17 f	5.95 abc
	BPH-P-065	86 e	118 e	93.97 bcd	15 a	14 a	21.43 bc	75 c	12d	25.60 e	3.50 e
	Binadhan-17	90 d	124 d	84.87 e	12 ab	10 ab	22.60 abc	111 b	49 a	24.50 f	4.38 de
	BRRI dhan49	97c	130 ab	86.33 de	11 ab	10 b	20.11 c	110 b	35 abcd	22.00 g	4.13 de
Rangpur	BPH-P-009	86 f	121 e	104.30 b	10 abc	9 abcd	24.30 bc	124 b	18 c	31.00	4.84 c
	BPH-P-020	101 b	132 b	130.67 a	9bcd	9 bcd	27.07 a	157 a	40 a	21.00	4.60 c
	BPH-P-023	99 c	128 c	94.40 d	10 abcd	9 bcd	22.13 de	97c	19 c	29.00	5.16 bc
	BPH-P-034	99 bc	128 c	99.87 c	9 abcd	9 bcd	24.57 b	116 bc	19 bc	29.00	5.26 bc
	BPH-P-043	96 d	128 c	93.23 d	10 abc	10 abc	21.80 ef	111 bc	18c	27.00	5.65 ab
	BPH-P-047	100 bc	127 d	92.67 d	7 d	7 d	23.10 cd	123 b	15 c	28.00	4.89 c
	BPH-P-057	96 d	129 c	100.70 c	12 a	11 a	25.47 b	130 b	19 bc	26.00	5.85 ab
	BPH-P-065	87 ef	119 f	100.27 c	9 cd	8 cd	20.43 g	111 bc	16 c	28.00	5.14 bc
	Binadhan-17	88 e	123 e	82.33 e	11 abc	10 abc	20.67 fg	121 b	17 c	25.00	6.20 a
	BRRI dhan49	107 a	136 a	81.23 e	11ab	11 ab	20.73 fg	124 b	31 ab	22.00	4.63 c
Mean over location	BPH-P-009	87 f	121 f	97.58 bc	11 ab	10 abc	23.08 bcd	106 bc	17 cd	30.39 a	5.39 bc
	BPH-P-020	100 b	132 a	124.77 a	11 ab	10 abc	26.58 a	153 a	40 a	20.98 g	4.51 de
	BPH-P-023	99 b	128 bcd	92.63 de	10 b	9 c	23.10 bcd	99 bc	30 abc	28.60 b	5.88 ab
	BPH-P-034	100 b	129 b	97.53 bc	11 ab	10 abc	24.15 b	106 bc	26 abcd	28.22 b	5.26 bcd
	BPH-P-043	96 d	127 cd	92.00 e	12a	11 ab	22.23 bcde	96 bc	20 bcd	26.45 d	6.33 a
	BPH-P-047	99 b	127 d	94.33 cde	10 ab	9 bc	23.92 b	103 bc	27abcd	27.47 c	4.89 cde
	BPH-P-057	98 c	129 bc	100.50 b	12 ab	11.33 a	23.50 bc	113 bc	19 bcd	25.08 e	5.90 ab
	BPH-P-065	87 f	119 g	97.12 bcd	12 a	11 ab	20.93 de	93 c	14d	26.80 d	4.32 e
	Binadhan-17	89 e	124 e	83.60 f	11 ab	10 abc	21.63 cde	116 b	33 ab	24.75 e	5.29 bc
	BRRI dhan49	102 a	133 a	83.78 f	11 ab	10 abc	20.42 e	117 b	33 ab	22.00 e	4.38 e

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

Preliminary yield trial of introgressed bacterial leaf blight resistant rice lines

This experiment was carried out to assess high yield attributes of eleven BLB resistant rice lines along with two check varieties Binadhan-17 and BRRI dhan49 tested in Aman season during 2019-20 at BINA HQ's farm, Mymensingh and BINA Sub-station Sunamgonj. Seeds were sown on 20 July 2019 and transplanted to the field on 27 August 2019. The experiment followed RCB design with three replications. The size of 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 days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000 grain weight (g) and grain yield (t ha-1) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 12.

The results obtained from preliminary yield trials of individual location and mean over locations for all characters are presented in Table 12. Results mean over locations; all characters showed significant differences among the lines and checks for both individual locations and mean over locations. Among the lines and check varieties, BLB-P-049 produced the highest plant height at Mymensingh (105.80 cm), Sunamgonj (104.33 cm) and mean over the locations (105.07 cm). On the other hand, among the lines and check varieties, BLB-P-055 showed better and more or less same performance in terms of effective tillers plant^{-1} (10, 10 and 10), panicle length (25.93 cm, 26.0cm and 25.97cm), filled grain panicle^{-1} (170, 164, 160) and yield performance (5.54 t ha-1, 5.45 t ha-1 and 5.45 t ha-1) in two individual locations and mean over the locations, respectively followed by BLB-P-019. From the above discussions, considering effective tillers plant^{-1}, panicle length, filled grain panicle^{-1} and yield performance, BLB-P-055, BLB-P-049 and BLB-P-019 are proposed for advanced trial in next T. Aman season.

Table 12: Agronomic performance of BLB rice lines along with check varieties at BINA HQ's farm, Mymensingh and BINA Sub-station Sunamgonj during aman season 2019

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha-1)
Mymensingh	BLB-P-004	82 g	126 c	95.20 c	9 cd	8 bcd	21.80 def	102 de	25 de	24.27 b	5.01 abcd
	BLB-P-012	84 f	130 b	93.78 c	9 cd	7 cd	19.23 gh	75 f	57 a	23.10 cde	3.13 f
	BLB-P-019	88 e	126 c	94.90 c	8 cd	7 d	25.13 ab	160 a	35 cde	25.07 a	5.27 abc
	BLB-P-026	93 b	121 d	87.67 d	9 cd	9 abc	21.60 ef	73 f	25 de	23.00 cde	4.10 e
	BLB-P-028	95 a	127 c	95.13 c	8 cd	7 d	18.37 h	86 ef	53 ab	22.73 de	3.23 f
	BLB-P-042	85 f	121 d	96.07 c	9 cd	9 ab	23.07 cde	115 cd	38 bcde	22.57 e	4.14 e
	BLB-P-044	91 c	121 d	96.47 c	9 cd	9 abc	21.07 f	105 de	37 cde	21.30 f	5.00 bcd
	BLB-P-047	87 e	119 e	88.47 d	10 ab	9 abc	23.37 cd	128 bc	24 e	21.70 f	4.68 d
	BLB-P-049	88 e	126 c	105.80 a	9 cd	9 abc	24.53 abc	165 a	47 abc	24.10 b	5.45 ab
	BLB-P-055	90 d	126 c	102.47 ab	10 ab	10 a	25.93 a	170 a	40 bcd	23.27 cd	5.54 a
	Binadhan-17	91 c	120 de	84.80 d	11 a	9 ab	24.27 bc	139 b	34 cde	23.63 bc	5.43 ab
	BRRI dhan49	96 a	133 a	98.53 bc	8 d	8 bcd	20.87 fg	112 cd	27 de	20.58 g	4.86 cd
Sunamgonj	BLB-P-004	81f	127 b	95.73 de	10 bc	9 abc	22.83 cd	103f	26 cd	23.80 a	4.94 bcd
	BLB-P-012	85 e	131 a	95.90 de	10 bc	9 bc	20.07 ef	74 i	22 e	22.70 b	3.22 g
	BLB-P-019	88 cd	127 b	97.33 cd	10 ab	9 bc	24.67 ab	154 a	36 b	24.17 a	5.10 abc
	BLB-P-026	93 b	121 de	87.17 f	11 a	10 a	21.37 de	93 g	24 de	19.30 f	4.24 ef
	BLB-P-028	96 a	128 b	95.03 e	8 d	7 d	18.80 f	84 h	51 a	19.50 ef	3.80 f
	BLB-P-042	87 d	122 d	97.47 cd	10 ab	9 bc	22.70 cd	111 de	27 cd	20.50 cde	4.47 de
	BLB-P-044	92 b	122 d	98.57 c	9 cd	9 bc	21.40e	106 ef	36 b	20.63 cd	4.99 abc
	BLB-P-047	88 cd	120 e	94.53 e	10 ab	9 abc	23.48 bc	135 b	21 e	20.87 c	4.74 cd
	BLB-P-049	88 cd	125 c	104.33 a	10 ab	10 a	25.27 a	160 a	38 b	23.54 ab	5.26 ab
	BLB-P-055	89 c	127 b	101.93 b	10 ab	10 a	26.00 a	164 a	30 c	24.33 a	5.45 a
	Binadhan-17	93 b	118 f	85.27 f	10 ab	9 ab	24.77 ab	155 a	28 c	23.53 ab	5.16 abc
	BRRI dhan49	96 a	133 a	98.43 c	9 cd	8 cd	21.67 d	134 b	21 e	19.73 def	4.49 de
Mean over location	BLB-P-004	82 g	126 cd	95.47 bc	9 cd	9 ab	22.32 cde	103 e	26 de	24.03 abc	4.98 bc
	BLB-P-012	85 f	131 b	94.84 c	9 cd	8 bc	19.65 f	74 f	39 bc	22.90 d	3.18 f
	BLB-P-019	88 d	126 cd	96.12 bc	9 cd	9 ab	24.90 ab	150 a	36 bc	24.62 a	5.19 ab
	BLB-P-026	93 b	121 ef	87.42 e	10 ab	10 a	21.48 de	83 f	24 de	21.15 e	4.17 e
	BLB-P-028	96 a	128 c	95.08 c	8 d	7 c	18.58 f	85 f	52 a	21.12 e	3.52 f
	BLB-P-042	86 e	121 e	96.77 bc	10 ab	9 ab	22.88 cd	113 de	32 cd	21.53 e	4.30 de
	BLB-P-044	92 b	121 e	97.52 bc	9 cd	9 ab	21.23 e	105 de	37 bc	20.97 e	4.99 bc
	BLB-P-047	88 d	119 fg	91.50 d	10 ab	9 ab	23.42 bc	132 bc	22 e	21.29 e	4.71 c
	BLB-P-049	88 d	126 d	105.07 a	10 ab	9 ab	24.77 ab	153 a	42 b	24.22 ab	5.40 a
	BLB-P-055	90 c	127 cd	102.20 a	10 ab	10 a	25.97 a	160 a	35 bc	23.40 cd	5.45 a
	Binadhan-17	92 b	119 g	85.03 e	11 a	9 ab	24.65 ab	155 a	31 cde	23.58 bcd	5.30 ab
	BRRI dhan49	96 a	133 a	98.48 b	8 d	8 bc	21.27 e	136 d	24 de	20.15 f	4.67 cd

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

Preliminary yield trial of BN resistant rice lines

This experiment was carried out to assess high yield attributes of thirteen BN resistant rice lines along with two check varieties Binadhan-17 and BRRI dhan49 tested in T. Aman season during 2019-20 at BINA HQ's farm, Mymensingh and BINA Sub-station Sunamgonj. Seeds were sown on 20 July 2019 and transplanted to the field on 27 August 2019. The experiment followed RCB design with three replications. The size of 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 days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000 grain weight (g) and grain yield (t ha-1) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 13

The results revealed from preliminary yield trials of individual location and mean over locations for all characters are presented in Table 13. Results mean over two locations, on an average, all other characters showed significant differences among the lines and checks for both individual locations and mean over locations. Among the lines and check varieties, BN-P-219 produced the highest plant height at Mymensingh (109.0 cm), Sunamgonj (116 cm) and mean over the locations (109.00 cm). On the other hand, among the lines and check varieties, BN-P-303 showed better and more or less same performance in terms of effective tillers plant^{-1} (12, 12 and 12), panicle length (25.90 cm, 26.2 cm and 26.05 cm), filled grain panicle^{-1} (148, 150 and 149) and yield (6.75, 5.6 and 6.03 t ha^{-1}) in two individual locations and mean over the locations respectively followed by BN-P-219 and BN-P-211. So, considering better performance of effective tillers plant^{-1}, panicle length, filled grain panicle^{-1} and yield, BLB-P-055, BLB-P-049 and BLB-P-019 are suggested for advanced yield trial in next T. Aman season.

Table 13: Agronomic performance of BN rice lines along with check varieties at BINA HQ's farm, Mymensingh and BINA Sub-station Sunamgonj during T. Aman season

Location	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	Total tiller plant^{-1} (no.)	Effective Tillers plant^{-1} (no.)	Panicle length (cm)	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	1000grain weight (g)	Grain yield (t ha$^{-1)}$
Mymensingh	BN-P-102	87 fg	122 g	97.00 cdefg	10 bc	10 a	23.30 ab	135 ab	41 bcd	22.20 bcde	6.00 ab
	BN-P-104	97 c	128 de	101.80 abcde	12 ab	11 a	24.00 ab	109 cd	31 cdef	23.15 bc	5.83 abc
	BN-P-110	86 h	119 h	97.50 cdefg	11 ab	10 ab	22.50 ab	111 cd	19 fgh	22.90 bc	5.25 abcd
	BN-P-114	82 i	116 i	95.00 defg	12 ab	10 a	22.30 ab	148 a	28 defg	19.90 fgh	5.25 abcd
	BN-P-119	85 h	119 h	92.00 fg	11 b	10 ab	20.50 b	122 bcd	39 bcde	20.45 efgh	3.38 d
	BN-P-205	88 f	124 f	96.00 cdefg	14 a	11 a	24.40 ab	104 d	26 efgh	21.20 cdefg	5.50 abc
	BN-P-209	83 i	117 i	91.00 g	8 c	7 b	22.80 ab	139 ab	42 bc	18.70 h	4.00 cd
	BN-P-211	103 b	138 a	105.20 abc	12 ab	11 a	24.00 ab	138 ab	15 gh	23.15 bc	6.25 ab
	BN-P-219	96 d	129 cd	109.00 a	14 a	11 a	23.75 ab	135 ab	19 fgh	23.15 bc	6.25 ab
	BN-P-303	98 c	124 f	107.05 ab	11 b	12 a	25.90 a	148 a	13 h	25.40 a	6.75 a
	BN-P-310	86 gh	122 g	99.30 bcdefg	11 ab	10 a	22.40 ab	128 abc	29 cdef	22.75 bcd	4.38 bcd
	BN-P-311	98 c	130 c	101.70 abcde	12 ab	11 a	23.15 ab	129 abc	78 a	21.50 bcdef	5.63 abc
	BN-P-312	97 c	128 e	100.30 abcdef	10 bc	9 ab	23.60 ab	104 d	68 a	23.50 ab	4.73 bcd
	Binadhan-17	90 e	124 f	93.20 efg	12 ab	11 a	24.00 ab	144 ab	47 b	20.70 defgh	6.25 ab
	BRRI dhan49	105 a	134 b	102.85 abcd	11 ab	10 a	21.10 b	143 ab	18 fgh	19.21 gh	5.75 abc
Sunamgonj	BN-P-102	89 ef	124 de	99.00 bcd	12 ab	10 a	23.75 abc	134 bcd	42 a	22.00 bc	5.20 bcd
	BN-P-104	99 cd	129 c	101.80 bcd	12 ab	10 a	21.50 cd	114 f	33 cd	21.35 c	5.00 de
	BN-P-110	89 ef	120 fg	99.50 bcd	12 ab	10 a	22.50 bcd	116 ef	12 j	22.15 bc	5.50 ab
	BN-P-114	82 h	115 h	94.00 cd	11 b	10 a	23.00 bcd	101 g	28 ef	19.05 ef	4.95 de
	BN-P-119	85 g	120 g	92.50 d	11 b	10 a	20.70 d	122 def	37 b	21.05 cd	5.20 bcd
	BN-P-205	89 ef	124 de	98.00 bcd	13 a	12 a	25.05 ab	111 fg	24 gh	22.10 bc	5.45 abc
	BN-P-209	81 h	120 fg	91.50 d	8 c	7 b	23.20 bcd	136 bc	44 a	18.40 fg	4.00 g
	BN-P-211	102 ab	138 a	105.90 abc	11 b	10 a	25.20 ab	139 abc	15 j	22.55 b	5.30 abcd
	BN-P-219	98 d	131 bc	116.90 a	13 a	10 a	23.70 abc	138 bc	36 bc	24.15 a	5.3abcd
	BN-P-303	98 d	131 bc	106.00 abc	11 b	12 a	26.20 a	150 a	12 j	22.00 bc	5.60 a
	BN-P-310	87 fg	122 ef	99.25 bcd	12 ab	11 a	21.50 cd	128 cde	27 efg	17.80 g	4.45 f
	BN-P-311	101 bc	132 b	108.05 ab	12 ab	11 a	23.90 abc	129 cd	27 efg	19.95 de	5.05 d
	BN-P-312	97 d	129 c	101.25 bcd	12 ab	10 a	23.85 abc	100 g	25 fgh	21.65 bc	5.10 cd
	Binadhan-17	90 e	126 d	91.70 d	11 b	10 a	24.35 ab	142 ab	30 de	21.05 cd	5.20 bcd
	BRRI dhan49	104 a	133 b	103.10 bcd	12 ab	11 a	21.50 cd	143ab	19 i	18.55 fg	4.65 ef
Mean over location	BN-P-102	88 gh	123 fg	98.00 cdefg	11 c	9 ab	23.53 abc	135 abc	41 bc	22.10 bc	5.60 abc
	BN-P-104	98 de	128 de	101.80 abcde	12 abc	10 a	22.75 abc	111 efg	32 def	22.25 b	5.41 abc
	BN-P-110	87 h	120 i	98.50 bcdefg	11 abc	10 a	22.50 abc	113 defg	12 j	22.53 ab	5.38 abc
	BN-P-114	82 j	115 j	94.50 defg	11 bc	10 a	22.65 abc	103 g	28 efg	19.48 ef	5.10 bcde
	BN-P-119	85 i	119 i	92.25 fg	11 c	10 a	20.60 c	122 cdef	38 cd	20.75 d	4.29 ef
	BN-P-205	89 g	124 fg	97.00 cdefg	13 ab	11 a	24.73 ab	107 fg	25 fgh	21.65 bc	5.48 abc
	BN-P-209	82 j	119 i	91.25 g	8 d	7 b	23.00 abc	137 abc	43 bc	18.55 f	4.00 f
	BN-P-211	102 b	138 a	105.55 abc	11 bc	10 a	24.60 ab	138 abc	15 ij	22.85 ab	5.78 abc
	BN-P-219	97 e	130 cd	109.30 a	13 a	11 a	23.73 abc	136 abc	33 de	23.65 a	5.93 ab
	BN-P-303	98 cd	127 e	107.50 ab	11 c	12 a	26.05 a	149 a	21 ghi	23.70 a	6.03 a
	BN-P-310	87 h	122 h	99.28 bcdefg	11 abc	10 a	21.95 bc	128 bcde	28 efg	20.28 de	4.41 def
	BN-P-311	99 c	131 c	107.55 ab	12 abc	11 a	23.53 abc	129 bcd	52 a	20.73 de	5.34 abc
	BN-P-312	97 de	128 e	100.78 abcdef	11 c	9 ab	23.73 abc	102 g	46ab	22.58 ab	4.91 cde
	Binadhan-17	90 f	125 f	92.45 efg	11 bc	10 a	24.18 abc	143 ab	38 cd	20.88 cd	5.73 abc
	BRRI dhan49	104 a	133 b	102.97 abcd	11 abc	10 a	21.30 bc	143ab	19 hij	18.88 f	5.20 abcd

Preliminary Yield Trial of Blast Nursery Rice Lines (IRBN) in *Boro* season

This experiment was conducted with seven IRBN rice lines to select desirable lines having Blast resistance, higher grain yield, short duration, suitable for *Boro* season. The popular short duration *Boro* variety BRRIdhan-28 and high yielding BRRIdhan-58 were used as check varieties. at BINA Headquarter farm, Mymensingh. The seeds were sown on 20 December 2019 and transplanted to the field on 10 February 2020. The experiment was laid out in RCBD with three replications. Unit plot size was 3m x 2m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on plant height, effective tillers hill^{-1} (no.), filled grains penicle $^{-1}$ and panicle length (cm) 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 6.0 m^2. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 14.

Table 14: Mean performance of IRBN rice lines along with check varieties during *Boro* season 2019-20

Lines/ check varieties	Days to 50% Flowering	Days to maturity	Plant height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled Grains panicle^{-1} (no.)	Grain yield plot^{-1} (kg)
IRBN-3	129.33 a	155.33 cd	102.11 abcd	13.89 a	24.223 ab	116.89 d	3.9 a
IRBN-6	122.33 b	154.33 d	104 abc	10.44 abc	26.443 ab	145.22 bcd	2.4 c
IRBN-9	121.33 b	151.67 e	100.22 bcde	13.78 ab	28.167 a	125.78 cd	3.8 ab
IRBN-14	123 b	157 bc	102.78 abc	8.89 c	24.78 ab	175.89 ab	2.8 bc
IRBN-18	129.33 a	157.67 b	105.33 ab	7.61 c	23.553 b	140.89 cd	3.4 abc
IRBN-32	129.33 a	160 a	108.56 a	14.00 a	22.78 b	121.78 cd	4.1 a
IRBN-34	128 a	156.33 bc	93.11 e	10.22 bc	24.28 ab	182 a	3.8 ab
BRRIdhan-28	112 c	142 g	94.22 de	11.11 abc	23 b	122.78 cd	2.8 bc
BRRIdhan-58	122 b	149 f	96.67 cde	9.78 c	24.497 ab	153.33 abc	2.4 c
CV	0.58	0.39	2.8	11.32	6.12	8	11.7
SE	0.5827	0.4779	2.3027	1.02	1.2303	9.3276	0.2989

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

From the Table 14, it is observed that IRBN-32 had the highest plant height (108.56 cm) whereas IRBN-34 had the lowest. The highest number of effective tillers plant^{-1} (14.00) was observed in IRBN-32 which was significantly similar with IRBN-3 (13.89) followed by IRBN-9, IRBN-6 and BRRI dhan-28. The lowest number of effective tillers plant^{-1} (7.61) was found in IRBN-18. The panicle length ranged 22.78 cm to 28.17 cm. The longest panicle length (28.16cm) was observed in IRBN-9 while shortest panicle length (22.78 cm) observed in IRBN-32. The number of filled grains panicle^{-1} ranged from 116.89 to 182.00. IRBN-34 had produced significantly higher number of filled grains while IRBN-3 had the lowest. Both check varieties took the lowest time to mature than the all IRBN lines and IRBN-32 took the highest time. There are five lines (IRBN-3, IRBN-9, IRBN-18, IRBN-32 and IRBN-34) had produced higher grain yield than check varieties BRRI dhan-28 and BRRIdhan-58. Grain yield (kg) ranged from 2.4 kg to 4.1 kg. IRBN-32 had maximum yield (4.1kg) while IRBN-6 had minimum yield per plot (2.4 kg).

Based on higher seed yield 5 IRBN rice lines (IRBN-3, IRBN-9, IRBN-14, IRBN-18, IRBN-32 and IRBN-34) have been selected and will be evaluated in next Boro season.

Preliminary yield trial of Blast Nursery Rice Lines (IRBN) in *T. Aman* season

This experiment was conducted to select desirable lines having Blast resistance, higher grain yield, short duration suitable for *T. Aman* season. Seven IRBN rice lines along with two check varieties Binadhan-7 and Binadhan-17 tested in *T. Aman* season of 2019 at BINA Headquarter farm, Mymensingh. Seeds were sown on 31 July 2019 and transplanted to the field on 28 August 2019. 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 plant height (cm), effective tillers hill-^{1}(no.), number of filled grains penicle^{-1} and panicle length (cm) were recorded from five randomly selected plants from each plot. Days to fifty % flowering and days to maturity were assessed by plot basis. Grain yield data were recorded from an area of 6.0 m^2. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 15.

Table 15: Mean performance of IRBN rice lines along with check varieties during T. Aman season 2019.

Lines/ checkvariety	Days to 50% flowering	Days to maturity	Plant height (cm)	Effective tillersplant^{-1} (no.)	Panicle length (cm)	Filled Grains panicle^{-1} (no.)	Grain yield plot^{-1} (kg)
IRBN-2	85.00 d	122.00 d	87.11 de	8.11 ab	21.89 bc	72.89 d	4.65 c
IRBN-5	85.33 cd	120.00 de	91.06 d	7.11 bcd	22.77 bc	110.11 bc	4.56 c
IRBN-6	88.00 bcd	131.33 c	105.11 a	7.55 bc	24.05 b	83.89 cd	4.94 bc
IRBN-11	88.00 bcd	119.00 e	91.94 cd	6.19 d	22.66 bc	71.89 d	5.91 a
IRBN-16	110.00 a	140.00 a	97.22 bc	5.81 d	28.16 a	147.89 a	4.61 c
IRBN-18	88.67 bc	133.00 bc	98.22 b	5.77 d	23.33 bc	106.67 bcd	5.48 ab
IRBN-25	86.00 bcd	134.00 b	83.11 ef	6.33 cd	22.44 bc	122.44 ab	4.30 c
Binadhan-7	86.67 bcd	118.67 e	85.55 ef	9.00 a	22.22 bc	83.56 cd	4.93 bc
Binadhan-17	89.00 b	120.33 de	81.56 f	6.66 cd	21.00 c	135.56 ab	4.44 c
CV	1.33	0.71	2.04	6.72	3.58	12.02	5.87
SE	0.69	0.52	1.52	0.68	0.6768	10.194	0.23

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

From the Table 15, it appears that IRBN-6 had the highest plant height (105.11 cm) and none is shorter plant height than check varieties. Binadhan-17 had produced the shortest height (81.56 cm). Binadhan-7 had produced significantly higher number of effective tillars which was similar with IRBN-2, while IRBN-18 had produced lowest number of effective tillers (5.77). The panicle length ranged 21.00 cm to 28.16 cm. IRBN-16 had produced longer panicle length (28.16 cm) while, shortest panicle length (21.0) was found in Binadhan-17. The number of filled grains panicle^{-1} ranged from 71.89 to 147.89. IRBN-16 had the highest number of filled grains panicle^{-1} (147.89) which was followed by Binadhan-17 and IRBN-25. IRBN-11 had the lowest number of filled grains per panicle (71.89). The check variety Binadhan-7 took shortest time to mature which is significantly similar with the line IRBN-11 and IRBN-5. For yield IRBN-11 had produced higher yield (5.91 kg) than others and this lines also took shorter time (119 days) to mature.

Based on short duration and higher yield five lines (IRBN-2, IRBN-5, IRBN-6, IRBN-11 and IRBN-18) have been selected for next year evaluation.

Observation trial of Brown plant hopper resistant rice lines in *Boro* season

This experiment was conducted to evaluate rice lines for insect resistance with high yield attributes. Nine rice lines along with two check variety BRRI dhan-28 and BRRI dhan-58 tested in *Boro* season at BINA

Headquarter farm, Mymensingh. Seeds were sown on 20th December 2019 and transplanted to the field on 4th February 2020. The experiment followed RCB design with three replications. The size of a unit plot was 3.0 m × 2.0 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 (cm), number of effective tiller plant^{-1}, panicle length (cm), and filled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Days to 50% flowering and maturity were assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 16.

From the Table 16, it was observed that the average range of plant height among the lines and check varieties were 91.55 cm to 109.33 cm. The line IRBPH-24 had the highest plant height (109.33 cm) which was significantly similar with IRBPH-44 where as IRBPH-5 had the lowest. For effective tillers plant^{-1}, there was no significantly difference among the rice lines and check varieties. The panicle length ranged 21.33 cm to 26.89 cm. There were 3 lines (IRBPH-24, IRBPH-35 and IRBPH-44 had longer panicle length than check varieties. The longest panicle length (26.89cm) was observed in IRBPH-35 while the shortest panicle length (21.33) in IRBPH-5. There were no lines earlier than check varieties. Grain yield plot^{-1} ranged from 2.1kg to 3.93kg. IBPHN-5 had maximum yield (3.93kg) where as BRRIdhan-58 had minimum yield (2.1 kg). There are four lines (IRBPH-2, IRBPH-5, IRBPH-18 and IRBPH-44) produced higher grain yield (kg/plot) than check variety BRRI dhan-28.

Based on higher grain yield 4 lines (IRBPH-2, IRBPH-5, IRBPH-18 and IRBPH-38) have been selected for preliminary yield trial in next *Boro* season.

Table 16: Mean performance of IBPHN rice lines along with check varieties at BINA Hqs, Mymensingh during Boro season 2019-20

Lines/ check varieties	Days to 50 % flowering	Days to maturity	Plant height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled Grains Panicle^{-1} (no.)	Grain yield plot^{-1} (kg)
IRBPHN-2	122.33 bc	157.33 d	93.11 cd	15.00 ^{NS}	23.67 ab	99.78 b	3.8 a
IRBPHN-5	127 abc	158.33 cd	91.55 d	11.44	21.33 b	168.44 a	3.93 a
IRBPHN-18	129 a	165 b	102.11 abc	12.89	24.89 ab	120.56 ab	3.8 a
IRBPHN-21	129 a	166 ab	105.22 ab	11.44	24.5 ab	126.78 ab	3.43 ab
IRBPHN-23	128.33 a	165.33 ab	101 abcd	13.00	24.45 ab	110.33 ab	2.87 bc
IRBPHN-24	130.33 a	167 a	109.33 a	10.78	26.44 a	97 b	3.47 ab
IRBPHN-35	128 ab	155 e	105 ab	12.22	26.89 a	128.67 ab	2.47 c
IRBPHN-38	128 ab	160 c	96.22 bcd	13.67	23.72 ab	122.67 ab	3.43 ab
IRBPHN-44	131 a	160 c	106.44a	12.45	26.11a	133.11 ab	3.33 ab
BRRI dhan-28	115.67 d	143.33 f	95.33 cd	12.33	25.11 a	110.33 ab	3.43 ab
BRRI dhan-58	121.33cd	153.33 e	95.89 bcd	12.33	23.39 ab	161.34 a	2.1 c
CV	1.6	0.38	3.2	14.44	5.15	16.46	8.54
SE	1.17	0.35	2.62	1.48	1.03	16.85	0.23

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

Observation trial of Bacterial blight nursery rice lines (IRBBN) in *Boro* season

This experiment was carried out to assess disease tolerance, earliness with high yield attributes of eleven rice lines along with two check variety BRRIdhan-28 and BRRIdhan-58 tested in *Boro*' 2019-20 season at BINA Headquarter farm, Mymensingh. Seeds were sown on 15th December 2019 and transplanted to the field on 2nd February 2020. The experiment followed RCB design with three replications. The size of a unit plot was 3.0m × 2.0m. 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 (cm), number of effective tiller plant^{-1}, panicle length (cm) and number of filled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Days to 50% flowering and days to maturity were assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 17.

Table 17: Mean performance of IRBBN rice lines along with check variety at BINA Hqs, Mymensingh during *Boro* season 2019-20

Lines/ check variety	Days to 50 % flowering	Days to maturity	Plant Height (cm)	Panicle length (cm)	Effective tillers plant^{-1} (no.)	Filled grains panicle^{-1} (no.)	Grain yield plot^{-1} (6 m$^{2)}$ (kg)
IRBBN-6	120.67	145 e	101 bcde	27.39 ab	12.56^{NS}	146.67 cdef	3.67 cd
IRBBN-9	122.67	147.33 d	97.89 cde	26.39ab	14.78	115.56 g	4 abcd
IRBBN-14	130	157.33 a	110.11 a	25.39 ab	11.00	157.89 abcd	4.4 abc
IRBBN-17	125 abcd	158 a	103.89 abc	26.887 ab	8.89	160.45 abc	4.27 abc
IRBBN-18	122.33 d	155 b	94.22 e	27.557 ab	13.56	149.11 bcde	4.33 abc
IRBBN-21	123.67 bcd	147.67 d	98.44 bcde	23.72 b	11.22	149.56 bcde	4.47 ab
IRBBN-22	122.67 cd	156.33 ab	103 abcd	24.833 ab	11.56	163.33 abc	4.27 abc
IRBBN-26	123.33 cd	148.67 d	94.22 e	28.057 a	10.45	136.22 ef	4.1 abc
IRBBN-28	129 ab	158 a	103.89 abc	28.11 a	9.56	141.22 def	4 abcd
IRBBN-31	128 abc	154.33 b	106.22 ab	26.277 ab	12.89	130.56 fg	4.6 a
IRBBN-32	123 cd	154.67 b	97.22 cde	24.053 b	11.00	140.56 ef	4.6 a
BRRIdhan-28	115.67 e	142.33 f	99.67 bcde	26.11 ab	12.33	172.33 a	3.83 bcd
BRRIdhan-58	122 d	151 c	95.45 de	25.39 ab	11.33	165.11 ab	3.3 d
CV	0.58	0.39	2.8	6.12	31.87	8	11.7
SE	1.5224	0.5598	2.1609	1.0883	2.61	4.6135	0.2051
HSD	5.5724	2.0491	7.9096	3.9836	9.55	16.887	0.7509

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

From the Table 17, it appeared that IRBBN-18 and IRBBN-26 had shorter plant height than others and IRBBN-18 had longer plant height (110.11 cm) which is significantly similar with IRBBN-17, IRBBN-28 and IRBBN-31. There was no significant difference in effective tillers. Days to maturity among the IRBBN lines and check varieties ranged from 142.33 days to 158.00 days. There were no earlier lines than check variety BRRIdhan-28. Four lines IRBBN-6, IRBBN-9, IRBBN-21 and IRBBN-26 took the lowest time to mature than other check variety BRRIdhan-58. All the IRBBN lines had produced higher grain yield than check variety BRRI dhan-28 and BRRIdhan-58 except IRBBN-6. Grain yield (kg) ranged from 3.3 kg to 4.6kg. IRBBN-31 and IRBBN-32 had maximum yield (4.6kg) while BRRIdhan-28 had minimum yield (3.3 kg).

Based on higher grain yield and early maturity 7 lines (IRBBN-6, IRBBN-9, IRBBN-21 IRBBN-22, IRBBN-26, IRBBN-31 and IRBBN-32) have been selected and will be evaluated in the preliminary yield trial in next *Boro* season.

Observation trial of upland (IURON) rice lines

Fifteen IURON rice lines were evaluated through this observation trial to assess the performance of improved yield component for *Boro* season. This experiment was conducted at the BINA substation, Khagrachari during Boro season 2019-20. Seeds were sown on 15 December 2019 and transplanted to the field on 13 Febuary 2020. 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 plant height (cm), effective tillers hill-^{1}(no.), number of filled grain plant^{-1} and panicle length (cm) were recorded from five randomly selected plants from each plot. Days to 50% flowering and days to maturity were assessed by plot basis. Grain yield data was recorded from an area of 6.0 m^2. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 18.

Table 18: Mean performance of IURON rice lines during *Boro* season 2019-20

Lines/ check varieties	Days to 50 % of flowering	Days to maturity	Plant Height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Grains yield plot^{-1} (6 m$^{2)}$ (kg)
IURON-4(17)	121cdef	148 def	97.07 abc	10 de	23 abc	19 ab	2.95 E
IURON-5(16)	123 bcde	152 a	91.53 cde	10 de	23.4 ab	18 abc	3.77 ab
IURON-5(17)	124 abcd	152 abc	93 bcde	15 a	24.33 a	19 ab	4.12 a
IURON-8(17)	120 ef	149 def	101.2 a	12bc	23.53 ab	19 ab	3.21cde
IURON-14 (16)	126 a	153 a	100 a	8 f	20.8 bcd	18 abc	2.96 e
IURON-15 (17)	122 bcde	149cde	89.93 de	11cd	21.93 abcd	19 ab	3.85 ab
IURON-17 (16)	123 bcde	150 bcd	97.4 abc	13 b	22.2abcd	18 ab	3.87 ab
IURON -19(17)	124 ab	152 abc	88.27 de	13 b	22.27 abcd	18 abc	3.05 e
IURON -21 (17)	120 efg	149 def	92.07 cde	9 ef	20.2 cd	20 a	4.12 a
IURON -28(17)	117 g	147 def	99 ab	10de	22.27 abcd	19 ab	3.27cde
IURON -29(17)	120 efg	147 def	91.47 cde	9 ef	20.07 d	18 ab	3.29cde
IURON -30 (17)	118 fg	147 fg	88.07 de	10de	22.07 abcd	19 ab	3.08 de
IURON -35 (17)	124abc	152 ab	87.07 e	9 ef	21.6 abcd	16 c	3.18cde
IURON -36 (17)	121 def	145 g	96.8 abc	12 b	21.93 abcd	17 bc	3.48bcd
IURON -38 (17)	120 ef	147 efg	93.47 bcd	13 b	22.13 abcd	18 ab	3.57 bc
CV	0.85	0.54	2.13	4.18	4.21	4.24	4.02
SE	0.8483	0.6635	1.6277	0.3904	0.7605	0.6501	0.1134
HSD	3.1426	2.458	6.0302	1.4462	2.8175	2.4086	0.42

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

It appeared that IURON-8 (17) had the highest plant height (101.2 cm) whereas IURON-35(17) had the lowest. The highest number of effective tillers/hill (15.44) was found in IURON-5(17) and lowest number (8.4) was in IURON-14(16). The panicle length ranged 20.07 cm to 24.33 cm. The longest panicle length was found in IURON-5(17) while shortest panicle length (20.07cm) observed in IURON-29(17). IURON-

21(17) had the highest number of filled grains per panicle and IURON-35(17) had the lowest number of filled grains per panicle. Days to maturity ranged from 145 days to 153 days. IURON-36(17) took the shorter period to mature which was significantly similar with IURON-30(17) and IURON-38(17). Grain yield (kg) ranged from 2.95kg to 4.12kg. IURON-21(17) and IURON-5(17) had maximum yield (4.12kg) while IURON-4(17) and IURON-14(17) had minimum yield per plant (2.95 kg).

Based on early maturity and higher seed yield 7 IURON rice lines (IURON-5(17) IURON-15(17), IURON-17(16), IURON-21(17), IURON-30(17), IURON-36 (17) and IURON-38(17) have been selected and will be evaluated in next Boro season.

Observation trial of brown plant hopper resistant rice lines in *T. Aman* season

This experiment was carried out to assess insect resistant with high yield attributes of ten rice lines along with two check varieties Binadhan-7 and Binadhan-17 tested in T. Aman at BINA HQ farm, Mymensingh. Seeds were sown on 27th July 2019 and transplanted to the field on 20th August 2019. The experiment followed RCB design with three replications. The size of a unit plot was 3.0m × 2.0m. Plant to plant distance was 15 cm and row to row distance was 20cm. 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 (cm), number of effective tiller plant^{-1}, panicle length (cm), number of filled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Days to fifty 50% flowering and days to maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 19.

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

Lines/ variety	Days to fifty % flowering	Days to maturity	Plant height (cm)	Effective tiller plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Grain yield plot^{-1} (kg)
IRBPHN-2	99 ef	136 f	93.55 f	9 a	23.56 bcd	80d	4.66bcd
IRBPHN-5	86 g	121 h	99.00 de	6 cde	20.78 d	135b	4.58cd
IRBPHN-18	103 c	140 ab	106.0 bc	7 cde	24.00 bcd	79 d	5.24ab
IRBPHN-21	102 cd	139bcd	107.00 bc	7 bcde	25.05 abc	135b	4.64bcd
IRBPHN-23	107 ab	138 de	109.45 b	8 abc	27.50 ab	125b	5.48a
IRBPHN-26	100 de	139 bc	95.33 ef	7 bc	26.61 abc	104c	2.88e
IRBPHN-35	107 ab	138 cde	107.11 bc	8 abc	27.55 ab	139b	3.21e
IRBPHN-38	106 b	141a	102.33 cd	9 ab	26.72 abc	124 b	4.58cd
IRBPHN-44	109 a	140 a	112.11 a	5 e	28.27 a	158a	4.39cd
IRBPHN-46	98 f	137ef	110.78 b	7 bcd	27.38 ab	137 b	4.04d
Binadhan-7	78 i	125 g	96.11 ef	9 ab	22.83 cd	90 cd	4.80bc
Binadhan-17	82 h	124 g	86.11 g	6 de	22.55 cd	158 a	4.13d
CV	0.69	0.33	1.73	7.58	5.59	5.14	4.86
SE	0.56	0.47	1.45	0.48	1.15	5.15	0.17

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

From the Table 19, it is observed that the average range of plant height among the lines was 86.11 cm to 112.11cm. IRBPH-44 had the highest plant height (112.11 cm) whereas IRBPH-2 had the lowest. The panicle length ranged 20.78 to 28.27 cm. The longest panicle length (28.27cm) was observed in IRBPH-44 which was significantly similar with IRBPH-46, while shortest panicle length (20.77) observed in IRBPH-5.

The panicle length of check variety was 22.83 cm for Binadhan-7 and 22.55cm for Binadhan-17. There were 7 lines had longer panicle length than check variety. The number of filled grains panicle^{-1} ranged from 79 to 158. Binadhan-17 had the highest number of filled grains panicle^{-1} (158) and IRBPH -18 had the lowest number of filled grains panicle^{-1} (79).

There were only one line (IRBPHN-5) took shorter maturity period (121 days) than others. The check variety Binadhan-7 took 124 days and Binadhan-17 took 125 days.

Grain yield ranged from 2.88 kg to 5.48kg. IBPHN- 23 had maximum yield plot^{-1} (5.48kg) which was followed by IBPHN-18 (5.24 kg). IBPHN-26 had minimum yield plot^{-1} (2.88 kg).

Based on higher grain yield and shorter duration 07 lines (IRBPH-2, IRBPH-5, IRBPH-18, IRBPH-21, IRBPH-23, IRBPH-38 and IRBPH-44) have been selected and will be evaluated in the preliminary yield trial in next T. Aman season.

Observation trial of Bacterial blight nursery rice lines (IRBBN) in *T. Aman* season

This experiment was carried out to assess disease tolerant, short duration with high yield attributes of five rice lines along with two check variety Binadhan-7 and Binadhan-17 tested in T. Aman’ 2019 at BINA Headquarter farm, Mymensingh. Seeds were sown on 31st July 2019 and transplanted to the field on 25th August 2018. The experiment followed RCB design with three replications. The size of a unit plot was 3.0 m × 2.0 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 (cm), number of effective tiller plant^{-1}, panicle length (cm) and number of filled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Days to 50% flowering and days to maturity were assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 20.

Table 20: Mean performance of IRBBN rice lines along with check varieties at BINA Hqs, Mymensingh during *T. Aman* season 2019

Lines/ variety	Days to 50 % flowering	Days to maturity	Plant Height (cm)	Panicle length (cm)	Effective tillers plant^{-1} (no.)	Filled grains panicle^{-1} (no.)	Grain yield plot^{-1} (6 m$^{2)}$ (kg)
IRBBN-6	89.67a	124.67 bc	106.89 ab	24.78 a	6.44 a	113.22 ab	5.57 ab
IRBBN-9	89.30a	120.00 cd	103.78 ab	25.44 a	6.56 a	84.33 cd	5.10 ab
Binadhan-7	87.33a	119.67 d	90.67 d	22.78 a	6.67 a	66.89 d	4.64 b
IRBBN-17	87.33a	131.00 a	108.22 ab	25.33 a	5.78 a	131.11 a	5.72 a
Binadhan-17	87.00a	123.33 bcd	92.11 cd	23.78 a	6.78 a	119.66 a	5.22 ab
IRBBN-31	86.67a	125.67 b	110.89 a	24.22 a	6.78 a	95.67 bc	5.19 ab

IRBBN-18	82.00b	132.33 a	100.89 bc	25.11 a	7.11a	134.11 a	4.95 ab
CV	1.68	1.32	3.32	5.34	14.56	7.28	6.54
SE	1.19	1.34	2.7657	1.0687	0.78	6.3222	0.2776
HSD	4.16	4.71	9.66	3.74	2.73	22.10	0.97

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

There were no significant variations among the characters in days to fifty % flowering, effective tillers plant^{-1} and panicle length. All IRBBN lines had had produced longer plant height than both check varieties. IRBBN-18 had produced higher number of filled grains panicle^{-1}. The grain yield plot^{-1} ranged 4.64 kg to 5.72 kg, highest yield was found in IRBBN-17 while lowest yield was found in Binadhan-7. The IRBBN-6 took significantly same time (124 days) to mature but produced higher yield than Binadhan-17.

Based on higher grain yield and short duration the lines IRBBN-6, IRBBN-9, IRBBN-17 and IRBBN-31 have been selected for next year observation.

Screening of BLB introgressed rice lines for coastal saline and submergence prone areas

This experiment was carried out to assess yield performance of twenty-three BLB rice lines along with two check varieties BRRI dhan49 and Binadhan-11 tested in T. Aman season during 2019-20 at BINA HQ's farm, Mymensingh, BINA Sub-station Jamalpur and Sunamgonj. Seeds were sown on 25 July 2019 and transplanted to the field on 28 August 2019. The experiment followed RCB design with three replications. The size of 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 days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000 grain weight (g) and grain yield (t ha-1) were recorded after harvesting from 5 randomly selected competitive plants hills^{-1}. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 21.

It is observed that the results of BLB introgressed rice lines and check varieties of individual location are presented in Table 21. Among the lines and check varieties CSA-2 had the highest plant hieght at Mymensingh (122 cm) whereas, SW-15 had the highest plant height (127cm) at Jamalpur and Sunamgonj. Among the lines and check variety, SW-24 showed best performance in respect of effective tillers plant^{-1} (13, 13 and 14), panicle length (26.65, 27.00 and 26.50 cm), filled grain panicle^{-1} (186, 151, 195) and yield performance (1.96 kg plot^{-1}, 1.93 kg plot^{-1}, 2.09 kg plot^{-1},) at BINA HQ's farm, Mymensingh**,** BINA Sub-station Jamalpur and Sunamgonj respectively followed by SW-11 SW 13, SW14 and CSA 1. So, considering effective tillers plant^{-1}, panicle length, filled grain panicle^{-1} and yield performance, SW 24, SW-11 SW 13, SW14 and CSA 1 should be recommended for preliminary yield trial in next T. Aman season.

Table 21: Agronomic performance of twenty three BLB rice lines along with two checks varieties at BINA HQ's farm, Mymensingh, BINA Sub-station Jamalpur and Sunamgonj in T. Aman 2019

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Fresh weight Yield/plot (2 m^{2}) (kg)
	CSA-1	105	136	108.65	11	10	24.25	118	24	25.25	1.35
	CSA-2	89	133	122.00	7	7	24.80	142	24	25.05	1.20
	CSA-3	81	133	113.75	10	9	26.00	112	23	23.50	1.21
	CSA-4	82	150	95.75	10	9	23.00	87	28	22.45	0.54
	CSA-5	82	153	93.50	8	7	24.25	85	11	22.80	0.77
	CSA-6	80	153	90.75	10	9	23.90	94	24	21.95	0.68
	CSA-7	84	155	90.80	10	10	22.80	96	20	22.67	0.87
	CSA-8	81	153	92.00	9	9	23.90	90	29	22.30	0.66
	CSA-9	80	153	90.90	11	10	22.70	99	17	22.15	0.91
	SW-10	81	131	112.80	9	9	26.20	120	18	24.95	1.58
	SW-11	103	137	94.80	11	10	23.70	162	35	20.90	1.82
	SW-13	105	135	92.05	9	9	22.50	188	41	18.50	1.59
Mymensingh	SW-14	80	137	98.50	10	10	22.70	138	46	22.25	1.67
	SW-15	92	138	94.35	11	11	24.95	172	52	20.70	1.51
	SW-16	101	137	86.90	10	9	22.90	159	17	19.50	1.42
	SW-17	103	140	88.65	11	11	21.70	124	33	21.65	1.44
	SW-19	99	134	93.15	12	12	24.00	133	45	24.95	1.70
	SW-20	86	156	96.70	13	12	24.85	173	35	19.90	1.54
	SW-21	104	137	95.85	12	11	24.00	144	41	20.97	1.55
	SW-22	104	135	96.90	10	10	23.00	139	28	20.75	1.46
	SW-24	99	134	95.85	14	13	26.65	186	17	25.00	1.96
	SW-27	102	135	102.50	11	10	23.50	176	32	24.75	1.62
	SW-28	103	134	96.70	13	12	23.90	162	36	19.25	1.51
	Binadhan-11	88	132	93.00	22	10	8.50	85	21	28.05	1.64
	BRRI dhan49	100	134	96.50	24	10	8.50	123	19	25.00	1.81

Continued Table 21

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Fresh weight Yield/plot (2 m$^{2)}$ (kg)
	CSA-1	106	135	83.00	12	10.00	22	175	35	24.80	1.77
	CSA-2	87	133	110.00	12	11.50	27	103	20	24.15	1.52
	CSA-3	83	133	100.50	12	10.00	25	77	24	23.40	0.99
	CSA-4	79	154	78.50	10	11.00	23	70	14	22.55	0.33
	CSA-5	81	156	79.00	11	10.00	24	59	23	22.25	0.66
	CSA-6	79	153	75.50	14	11.50	27	85	35	22.10	0.50
	CSA-7	81	154	75.50	12	10.50	24	64	28	22.95	0.86
	CSA-8	79	153	78.00	14	12.00	25	125	29	22.65	0.50
	CSA-9	78	152	73.50	13	12.00	25	109	23	22.05	0.71
	SW-10	82	128	81.00	10	9.00	25	76	11	24.50	1.79
	SW-11	103	135	84.00	13	11.00	23	117	28	25.30	1.86
	SW-13	106	137	87.50	13	10.00	23	84	30	20.00	1.69
Jamalpur	SW-14	77	136	93.00	10	9.50	25	99	52	21.05	1.88
	SW-15	90	137	127.00	11	10.00	25	99	19	20.40	1.35
	SW-16	104	135	81.50	13	10.50	23	64	28	20.95	1.76
	SW-17	106	140	81.00	12	11.00	25	125	34	21.60	1.37
	SW-19	99	135	81.00	12	10.00	23	152	26	24.90	1.80
	SW-20	86	157	94.50	12	11.00	24	95	44	20.20	1.18
	SW-21	105	135	78.50	11	10.00	22	79	30	21.15	1.68
	SW-22	104	135	80.50	12	9.50	26	131	29	20.50	1.17
	SW-24	99	132	90.50	14	12.50	27	151	17	25.65	1.93
	SW-27	101	135	97.00	11	9.50	23	96	23	20.10	1.60
	SW-28	102	134	82.50	12	9.50	22	113	44	19.80	1.70
	Binadhan-11	88	131	94.00	11	9.00	23	84	19	26.00	1.51
	BRRI dhan49	99	133	95.50	10	9.00	23	122	21	25.20	1.73

Continued Table 21

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Fresh weight (2 m$^{2)}$ (kg) Yield/plot
	CSA-1	105	135	83.00	18	13	22.50	94	19	27.00	1.74
	CSA-2	85	132	106.00	15	13	25.50	116	31	27.35	1.55
	CSA-3	83	134	101.00	14	11	27.50	120	17	24.80	1.25
	CSA-4	79	154	74.00	15	12	19.50	85	50	32.40	0.61
	CSA-5	80	154	73.50	14	13	19.50	109	48	25.50	0.93
	CSA-6	78	152	88.50	18	14	22.75	100	52	28.20	1.16
	CSA-7	79	153	91.50	15	14	23.50	103	14	30.86	1.04
	CSA-8	79	149	91.00	15	12	24.50	108	10	29.05	0.83
	CSA-9	80	153	104.50	20	10	26.25	109	15	28.65	1.04
	SW-10	80	129	99.00	17	12	26.50	133	26	31.10	1.88
	SW-11	100	136	94.50	17	13	22.36	157	44	29.55	1.89
	SW-13	105	135	98.00	21	12	25.50	130	78	26.05	1.84
Sunamgonj	SW-14	78	135	95.00	13	11	23.25	171	45	24.65	1.99
	SW-15	89	135	140.00	14	12	26.00	183	40	25.75	1.53
	SW-16	102	133	78.00	18	14	23.50	157	47	25.95	1.86
	SW-17	104	137	85.00	21	16	23.50	184	36	25.75	1.64
	SW-19	99	135	95.00	19	16	23.50	193	39	25.15	1.81
	SW-20	86	156	101.50	18	15	25.50	167	35	25.10	1.37
	SW-21	102	137	85.00	14	13	22.25	150	21	24.95	1.76
	SW-22	104	135	95.00	15	12	24.00	171	38	27.05	1.34
	SW-24	99	131	85.00	15	14	26.50	195	10	26.00	2.09
	SW-27	101	136	97.00	12	10	24.00	169	40	23.10	1.71
	SW-28	102	136	102.00	21	16	22.50	177	30	21.75	1.71
	Binadhan-11	89	133	90.00	15	13	23.50	129	32	28.05	1.67
	BRRI dhan49	99	134	89.50	11	10	21.50	128	15	24.50	1.84

Evaluation of premium quality rice lines

The yield trials were carried out with a premium quality mutant rice lines, SSS along with check variety, Binadhan-11 at BINA HQ, Mymensingh and Chapainawabganj sub-station during T. Aman season 2019. Seeds were sown at 29-31 July 2019 and transplanted to the field at 3-5 September 2019 at both locations. The experiment was laid out in RCBD with three replications. Unit plot size was 2m x 3m and spacing between hills and rows were 15 cm x 20 cm. Intercultural practices were done as and when necessary. Data on days to maturity, plant height, no. effective tillers hill^{-1}, no. filled grains panicle^{-1}, 1000 grain weight (g) and grain yield plot^{-1}(kg) were recorded from five randomly selected plants from each plot. 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 and are presented in table 22.

It is observed from the table 22 that the mutant line had taller plant height than the check variety at all locations. From mean over locations, the check variety matures earlier than mutant. This mutant had the highest panicle length (26.62cm) and yield (4.91t ha^{-1}) than the check variety. In respect of thousand grain weight, this mutant had the lower thousand grain weight (20.70 g) than check variety which indicates slender grain. Application will be made to release this mutant (SSS) as a variety.

Table 22: Agronomic performance of rice line along with a check variety at BINA HQ' farm, Mymensingh and BINA Sub-station Chapainawabganj in T. Aman 2019

Location	Genotypes	Days to flowering	Days to maturity	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.)	1000grain weight (g)	Grain yield (t ha^{-1})
Mymensingh	SSS	90a	125 b	97.93 a	10 a	9 a	24.27 a	104 a	23 a	21.93 a	4.90 a
	Binadhan-11	88a	126 a	97.80 a	10 a	9 a	22.73 a	102 a	20 a	23.10 a	4.59 a
Chapainababganj	SSS	94	129 a	118.33 a	12 a	10 a	28.97 a	94 a	27 a	21.37 a	4.91 a
	Binadhan-11	89 a	126 b	99.57 b	11 a	10 a	23.30 b	104 a	17 a	22.90 a	4.91 a
Mean over location	SSS	92 a	127 a	108.13 a	11 a	9 a	26.62 a	99 a	25 a	21.65 a	4.91 a
	Binadhan-11	89 b	126 a	98.68 b	11 a	10 a	23.02 b	103 a	19 a	23.00 b	4.75 a

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

Growing of M_2 populations of rice cultivars for earliness and higher yield

To select high yielding premium quality, the seeds of irradiated populations derived from Noor Basmoti were sown 15th July 2019 and transplanted on 12th August at BINA HQ farm, Mymensingh along with the parent. The experiment followed non-replicated design with the spacing 10cm and 15cm. 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. Based on earliness, plant height, grain quality 55 individual plants have been selected and will be grown in next T. Aman season.

Advanced yield trial with a M_8 Kasalath mutant

Seeds of a M_8 mutant of Kasalath, derived from 80Gy carbon ion beams irradiation, were sown at five locations during 11 to 25 July 2019 and seedlings were transplanted during 8 to 22 August 2019 along with a check variety BRRI dhan51 at 15cm distance within rows of 20 cm apart. The experiment was followed RCB design with three replications. The size of the unit plots were 6.0 m × 5.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed as and when necessitated. Data on plant height, number of effective tillers plant^{-1}, panicle length, and filled and unfilled grains panicle^{-1} were recorded after harvest from 5 randomly selected competitive plants. Maturity was assessed plot basis. Grain yield was recorded from an area of 1.0 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 24.

Table 23: Date of sowing and transplanting of the short duration, high yielding M_8 Kasalath mutant and check variety at different locations of Bangladesh

Location	Date of sowing	Date of transplanting	Seedling age (days)
BINA Hqs farm, Mymensingh	11 July 2019	8 August 2019	28
BINA sub-station farm, Rangpur	25 July 2019	22 August 2019	27
BINA sub-station farm, Magura	15 July 2019	12 August 2019	28
BINA sub-station farm, Iswardi	20 July 2019	20 August 2019	31
BINA sub-station farm, Chapai Nawbabgonj	21 July 2019	22 August 2019	32

Results showed significant variation among the mutants and check for most of the characters in combined over locations and individual locations. Combined over locations, it was observed that plant height of RM-Kas-80(c)-1 and BRRI dhan51 was recorded ranged from 97.67 to 110.20cm. Panicle length of RM-Kas-80(c)-1 and BRRI dhan51 was recorded ranged from 22.04 to 23.22cm, Panicle length of RM-Kas-80(c)-1 is higher than the respective check. Significant variation was found in panicle length, filled grain panicle^{-1} and unfilled grain panicle^{-1}. The mutant RM-Kas-80(c)-1 produced higher yield 5.37 t ha-1 than BRRI dhan51 gave yield 4.88 t ha-1. Among the five locations yield performance of RM-Kas-80(c)-1 was better than the respective check. Considering the yield performance of the mutant further trial will be needed for releasing as a variety.

Table 24: Yield and yield attributes of the M_8 Kasalath mutant along with BRRI dhan51 in T. T. Aman season, 2019-20

Location	Mutants/Variety	Plant height (cm)	Effective tiller	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/Panicle	Yield (t ha-1^{-1})
Rangpur	RM-Kas-80(C)-1	96.07 a	10.33 a	23.07 a	110.67 a	28.07 b	5.50 a
	BRRI Dhan51	82.60 b	9.33 b	20.17 a	91.33 b	34.80 a	4.77 b
Magura	RM-Kas-80(C)-1	118.20 a	14.33 a	23.67 a	102.53 a	8.43 b	5.70 a
	BRRI Dhan51	105.40 b	11.79 b	21.08 b	101.63 a	14.67 a	5.37 a
Ishwardi	RM-Kas-80(C)-1	103.67 a	11.93	22.27 a	111.90 a	16.20 b	5.30 a
	BRRI Dhan51	84.67 b	11.33	20.40 a	105.80 b	28.27 a	4.73 b
Chapai	RM-Kas-80(C)-1	116.47 a	15.20 a	25.13 a	105.67 a	26.67 a	5.21 a
Nawbabgonj	BRRI Dhan51	114.13 a	14.17 a	23.20 b	85.83 b	24.33 b	5.00 a
Mymensingh	RM-Kas-80(C)-1	116.60 a	10.27 a	23.93 a	122.47 b	37.67 a	5.13 a
	BRRI Dhan51	101.53 b	10.07 b	23.33 a	151.40 a	30.67 b	4.57 b
Combined mean over	RM-Kas-80(C)-1	110.20 a	12.20 b	23.22 a	110.47 a	23.08 b	5.37 a
location	BRRI Dhan51	97.67 b	11.46 a	22.04 b	115.88 b	26.05 a	4.88 b

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

Advanced yield trial with some high yielding deepwater rice mutants

Seeds of nine mutants and the parent cv. Laksmidigha were sown on 26 April 2019 at BINA HQs Farm, Mymensingh. Seedlings were transplanted on 30 May and 31 May 2019 at BINA sub-station farms, Sunamganj and Gopalganj, respectively, following RCB designs at 20cm 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 1.0m^2 land which was converted later to t ha^{-1}. Maturity was assessed plot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 26.

Table 25: Date of sowing and transplanting of the short duration, high yielding M_8 Laksmi digha mutant and check variety at different locations of Bangladesh

Location	Date of sowing	Date of transplanting	Seedling age (days)
BINA HQs farm, Mymensingh	26 April 2019	30 May 2019	34
BINA sub-station farm, Rangpur	26 April 2019	31 May 2019	35

Results showed significant variation among the mutants and check for most of the characters in combined over locations and individual locations. Combined over locations, it was observed that plant height of all the genotypes ranged from 159-178.90 cm. From then Table 4, the mean performance of effective tillers was lowest (12.05) in the mutant LD-200-1-3-2-1 and highest (16.78) in LD-200-1-3-2-9. Panicle length was higher in the mutants LD-200-1-3-2-2, LD-200-1-3-2-4, LD-200-1-3-3-5, LD-200-1-3-2-9 compared to the Luxmidigha parent. Significant variation was found in panicle length, filled grain panicle^{-1} and unfilled grain panicle^{-1}. The mutant LD-200-1-3-2-4, LD-200-1-3-3-5, LD-200-1-3-3-8 and LD-200-1-3-3-9 produced higher

3.03 to 3.25 t ha-1 yield over the respective Luxmidigha parent. Considering the yield performance of the mutant further trial will be needed for releasing as a variety.

Table 26: Grain yield and yield components of some deepwater rice mutants at Gopalganj and Sunamganj

Location	Mutants/Variety	Plant height (cm)	Effective tiller	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/Panicle	Yield (t ha-1^{-1})
Gopalganj	LD-200-1-3-2-1	160.07 bc	12.00 b	26.59 bc	124.20 ab	46.33 abc	1.73 d
	LD-200-1-3-2-2	158.33 c	16.667 a	28.08 ab	100.43 abc	62.66 ab	2.16 cd
	LD-200-1-3-2-4	171.67 abc	15.667 a	29.68 a	100.00 abc	76.30 a	3.17 a
	LD-200-1-3-3-5	161.67 abc	16.00 a	27.70 ab	131.89 a	57.33 abc	320a
	LD-200-1-3-3-8	173.33 ab	14.00 ab	27.42 ab	111.00 abc	48.00 abc	305 ab
	LD-200-1-3-3-9	175.67 a	14.33 ab	27.63 ab	110.00 abc	52.30 abc	2.76 abc
	LD-200-1-3-2-13	166.33 abc	12.00b	27.32 bc	80.33 c	41.563 bc	2.46 bc
	LD-200-1-3-2-9	173.00 ab	15.66 a	26.24 bc	123.00 ab	51.667 abc	2.80 ab
	LD-200-1-3-2-10	169.33 abc	11.00 b	27.10 bc	117.67 abc	42.00 bc	2.16 cd
	Luxmidigha (Parent)	174.00 ab	13.66 ab	25.03 c	90.33 bc	27.26 c	2.73 abc
Sunamganj	LD-200-1-3-2-1	161.20 b	12.11 b	27.69 ab	137.00 a	51.78 ab	1.93 e
	LD-200-1-3-2-2	159.67 b	14.66 ab	27.89 ab	111.67 abc	39.88 ab	2.96 b
	LD-200-1-3-2-4	170.00 ab	13.33 ab	29.57 a	83.98 bc	71.55 a	3.33 a
	LD-200-1-3-3-5	163.67 ab	15.66 ab	26.33 bc	137.33 a	42.89 ab	305 b
	LD-200-1-3-3-8	176.40 ab	13.11 ab	26.26 bc	130.33 ab	49.133 ab	300 b
	LD-200-1-3-3-9	182.13 a	10.66 b	28.22 ab	124.78 abc	54.84 ab	2.76 bc
	LD-200-1-3-2-13	161.13 b	13.33 ab	27.32 abc	102.00 abc	57.44 a	2.23 d
	LD-200-1-3-2-9	171.07 ab	17.89 a	26.24 bc	129.00 abc	54.72 ab	2.66 c
	LD-200-1-3-2-10	171.80 ab	14.19 ab	27.25 abc	142.22 a	38.77 ab	2.16 de
	Luxmidigha (Parent)	174.87 ab	13.44 ab	25.12 c	83.11 c	17.11 b	2.73 bc
Combined mean over location	LD-200-1-3-2-1	160.64 c	12.05 c	27.14 bc	130.60 a	49.05 b	1.83 d
	LD-200-1-3-2-2	159.00 c	15.67 ab	27.98 b	106.05 bc	51.28 b	2.57 abc
	LD-200-1-3-2-4	170.83 b	14.50 abc	29.63 a	91.99 c	73.93 a	3.25 a
	LD-200-1-3-3-5	162.74 c	15.83 ab	27.00 bc	134.61 a	50.11 b	3.13 a
	LD-200-1-3-3-8	174.87 ab	13.55 abc	26.84 bc	120.67 ab	48.66 b	3.03 ab
	LD-200-1-3-3-9	178.90 a	12.50 bc	27.92 b	117.39 ab	53.57 b	2.75 ab
	LD-200-1-3-2-13	163.73 c	12.66 bc	27.32 bc	91.16 c	49.50 b	2.35 bcd
	LD-200-1-3-2-9	172.04 b	16.78 a	26.24 cd	126.00 ab	53.19 b	2.72 ab
	LD-200-1-3-2-10	170.57 b	12.59 bc	27.17 bc	129.95 a	40.39 b	2.17 cd
	Luxmidigha (Parent)	174.44 ab	13.55 abc	25.07 d	86.72 c	22.19 c	2.72 abc

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

Advance yield trial with some mutants derived from BR11

Seeds of five M_6 mutants derived from irradiating the seeds of highly BLB susceptible BR11 variety of T. T. Aman rice with 300 Gy dose of gamma rays were sown on 08 July and seedlings were transplanted on 8 to 12 August 2019 along with the parent BR11 at BINA HQs farm, Mymensingh and Rangpur. The experiment conducted by RCB designs at distances between plants was 15cm and between rows were 20cm apart. 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 10 m^2

which later converted to t ha^{-1}. The recorded data were finally subjected to proper statistical analysis and are presented in Table 27.

Table 27: Grain yield and yield components of some bacterial leaf blight tolerant M_6 mutants of BR11

Location	Mutants/Variety	Plant height (cm)	Effective tiller	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/Panicle	Yield (t ha-1^{-1})
Mymensingh	BR11	104.53 bc	6.53 e	20.46 de	97.60 f	29.2 b	5.23 c
	BR-11-300-2-1	102.33 c	7.86 cd	20.93 d	120.93 e	24.33 b	5.2 c
	BR-11-300-2-2	117.40 a	9.66 b	24.06 b	199 b	23.80 b	5.5 b
	BR-11-300-2-3	105.33 b	8.53 c	22.53 c	135.93 d	36.53 a	4.33 d
	BR-11-300-2-4	98.47 d	7.20 d	19.86 e	164.27 c	27.60 b	5.63 b
	BR-11-300-2-5	119.27 a	10.66 a	25.33 a	292.40 a	23.00 b	6.91 a
Rangpur	BR11	104.57 bc	6.33 d	20.70 c	99.67 e	27.00 b	5.33 c
	BR-11-300-2-1	103 cd	8.00 c	21.30 c	123.67 d	25.13 b	5.57 bc
	BR-11-300-2-2	119 a	10.67 a	26.40 a	195.67 b	24.26 b	5.72 b
	BR-11-300-2-3	106.67 b	9.23 bc	22.96 bc	136.67 d	37.33 a	5.78 b
	BR-11-300-2-4	100.33 d	8.33 c	20.43 c	165.67 c	25.00 b	6.75 a
	BR-11-300-2-5	121 a	10.33 ab	25.43 ab	249.33 a	23.30 b	5.57 bc
Combined mean over location	BR11	104.55 d	6.43 c	20.58 c	98.63 a	28.10 b	5.25 bc
	BR-11-300-2-1	102.66 e	7.93 b	21.11 c	122.30 de	24.73 cd	5.38 bc
	BR-11-300-2-2	118.20 b	10.17 a	25.23 a	197.33 b	24.03 cd	5.61 b
	BR-11-300-2-3	106.00 c	8.88 b	22.75 b	136.30 cd	36.93 a	5.05 c
	BR-11-300-2-4	99.40 f	7.76 b	20.97 c	164.97 bc	26.30 bc	6.19 a
	BR-11-300-2-5	120.14 a	10.50 a	25.38 a	270.87 a	23.15 d	6.24 a

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

Results showed significant variation among the mutants and check for all of the characters in combined over locations and individual locations. Combined over locations, it was observed that plant height of all the genotypes ranged from 99.40 to 120.14cm. From the above Table, the mean performance of effective tiller was lowest (6.43) in check variety BR11 and highest (10.50) in mutant BR-11-300-2-5. Significant variation was found in panicle length, filled grain $panicle^{-1}$ and unfilled grain $panicle^{-}1$. The mutant BR-11-300-2-1, BR-11-300-2-2, BR-11-300-2-4 and BR-11-300-2-5 produced higher yield over the respective check BR11. Considering the yield performance of the mutant further trial will be needed for releasing as a variety.

Preliminary yield trial with some mutants of BR 11

Seeds of nine mutants derived from re-irradiating the seeds of 150 Gy gamma ray irradiated seeds of BR11 with 250 Gy dose of gamma conducted as Preliminary yield trail were sown on 08 July and seedlings were transplanted on 06 to 10 August 2019 along with the parent BR11 at BINA HQs farm, Mymensingh and Rangpur. The experiment followed RCB design. The distances between plants were 15 cm and between rows were 20 cm. A unit plot size was 1.5m × 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. The recorded data were finally subjected to proper statistical analysis and are presented in Table 28.

Table 28: Grain yield and yield components of some M_3 R_1 mutants of BR11

Location	Mutants/Variety	Plant height (cm)	Effective tiller	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/panicle	Yield (t ha-1)
Mymensingh	BR11	100.90 e	7.00 c	20.20 e	99.60 g	43.40 ab	4.98 cd
	BR-11-P-18	127.67 a	10.26 a	23.60 c	146.73 ef	32.80 cde	5.16 bc
	BR-11-P-19	121.47 b	8.00 b	22.00 d	143.60 f	29.733 e	5.05 bcd
	BR-11-P-20	116.73 d	8.26 b	21.73 d	137.93 f	30.06 e	5.21 b
	BR-11-P-21	118.27 cd	8.40 b	24.20 bc	194.60 a	28.53 e	4.95 d
	BR-11-P-26	119.20 c	9.80 a	24.93 a	180.07 b	31.73 de	5.53 a
	BR-11-P-32	119.20 c	6.13 d	23.86 bc	153.87 de	37.26 bcd	4.68 e
	BR-11-P-33	119.87 bc	6.60 cd	24.26 b	164.47 c	48.267 a	4.58 e
	BR-11-P-37	119.27 c	6.53 cd	24.13 bc	168.67 c	38.60 bc	4.65 e
	BR-11-P-38	117.27 d	6.93 c	23.73 bc	159.20 cd	41.66 ab	4.58 e
Rangpur	BR11	99.53 d	7.33 cd	23.33 ab	123.40 a	49.46 b	5.97 b
	BR-11-P-18	119.60 a	10.93 a	23.10 ab	122.00 a	41.46 c	5.04 d
	BR-11-P-19	112.47 bc	7.66 cd	22.80 b	112.75 ab	50.26 b	4.87 d
	BR-11-P-20	108.60 c	8.33 c	22.86 b	106.87 ab	57.66 a	5.93 b
	BR-11-P-21	110.13 bc	7.33 cd	22.73 b	86.87 b	49.80 b	4.88 d
	BR-11-P-26	116.00 ab	9.66 b	24.40 a	123.73 a	49.06 b	6.25 a
	BR-11-P-32	113.07 bc	6.66 d	22.53 b	128.53 a	50.66 b	5.34 c
	BR-11-P-33	110.60 bc	6.66 d	23.20 ab	120.27 ab	51.33 b	5.46 c
	BR-11-P-37	112.67 bc	6.66 d	23.86 ab	122.87 a	49.26 b	5.90 b
	BR-11-P-38	109.87 bc	7.33 cd	23.50 ab	122.87 a	50.40 b	5.50 c
Combined mean over location	BR11	100.22 c	7.16 def	21.76 b	111.5 d	46.43 a	5.47 ab
	BR-11-P-18	120.80 a	10.93 a	23.21 ab	130.23 c	39.03 c	5.03 b
	BR-11-P-19	116.74 ab	7.73 cd	22.33 b	129.28 cd	39.37 c	4.98 b
	BR-11-P-20	112.66 b	8.30 c	22.30 b	122.40 d	43.87 b	5.57 ab
	BR-11-P-21	114.20 b	7.86 cd	23.46 ab	140.74 c	39.16 c	4.92 b
	BR-11-P-26	117.60 ab	9.73 b	24.66 a	151.90 a	40.40 bc	5.89 a
	BR-11-P-32	116.14 ab	6.40 f	23.20 ab	141.20 bc	43.97 b	5.01 b
	BR-11-P-33	115.24 ab	6.63 ef	23.73 ab	142.37 bc	49.80 a	5.02 b
	BR-11-P-37	115.97 ab	6.60 ef	24.00 ab	145.77 b	43.93 b	5.27 ab
	BR-11-P-38	112.94 b	7.4 cde	23.61 ab	150.90 a	47.93 a	5.03 b

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

Results showed significant variation among the mutants and check for most of the characters in combined over locations and individual locations. Combined over locations, it was observed that plant height of all the genotypes ranged from 100.22 to 120.80 cm. From the above table, mean performance of effective tillers was lowest (6.60) in the mutant BR-11-P-37 and highest (10.93) in BR-11-P-18. Significant variation was found in panicle length, filled grain panicle^{-1} and unfilled grain panicle^{-1}. The mutant BR-11-P-20 and BR-11-P-26 produced higher yield than the BR11 parent. Considering the yield performance of the mutant further trial will be needed for releasing as a variety.

Advanced yield trial with some mutants of Biroi

Seeds of six mutants derived from irradiating the seeds of local Biroi rice with 250 Gy dose of gamma rays were sown on 8 July and seedlings were transplanted on 06 to 10 August 2019 along with the parent Biroi at BINA HQs farm, Mymensingh and BINA Substation, Nalitabari. The experiment followed RCB design. The distances between plants were 15 cm and between rows were 20 cm. A unit plot size was 3.0m × 2.0 m. 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 t ha^{-1}.The recorded data were finally subjected to proper statistical analysis and are presented in Table 29.

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

Location	Mutants/Variety	Plant height (cm)	Effective tiller	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/Panicle	Yield (t ha-1^{-1})
Mymensingh	Biroi	141.73 b	10.93 b	21.86 c	126.93 d	44.33 ab	3.91 d
	Biroi-250-2-1	140.47 b	9.66 bc	25.20 a	207.33 a	39.06 ab	4.01 d
	Biroi-250-2-2	92.73 d	10.20 bc	24.73 ab	177.07 abc	39.06 ab	6.10 a
	Biroi-250-2-3	87.67 d	9.20 cd	25.13 a	200.73 a	39.80 ab	6.23 a
	Biroi-250-2-4	98.33 c	8.20 d	23.53 b	161.93 bc	30.60 b	5.56 b
	Biroi-250-2-5	154.00 a	14.40 a	26.06 a	191.00 ab	47.26 a	3.95 d
	Biroi-250-2-6	142.59 b	13.39 a	24.86 ab	156.95 cd	41.95 ab	4.59 c
Nalitabari	Biroi	120.93 a	10.40 b	24.36 a	91.60 a	32.73 ab	3.96 c
	Biroi-250-2-1	153.00 a	9.93 b	24.80 a	106.73 a	34.00 ab	4.13 bc
	Biroi-250-2-2	130.70 a	10.46 b	25.43 a	96.67 a	16.66 b	6.03 a
	Biroi-250-2-3	114.67 a	8.86 b	22.93 a	89.93 a	23.40 ab	6.06 a
	Biroi-250-2-4	116.47 a	10.60 b	23.00 a	98.60 a	19.26 ab	5.66 a
	Biroi-250-2-5	133.73 a	9.93 b	24.30 a	105.73 a	29.20 ab	4.10 bc
	Biroi-250-2-6	137.40 a	25.03 a	21.26 b	109.47 a	37.06 a	4.56 b
Combined mean over location	Biroi	131.33 abc	10.66 ab	23.12 b	109.27 b	38.53 a	3.94 d
	Biroi-250-2-1	146.74 a	9.33 b	25.00 a	157.03 a	36.53 ab	4.07 d
	Biroi-250-2-2	109.49 abc	10.15 b	25.36 a	138.63 ab	26.13 ab	6.02 a
	Biroi-250-2-3	101.29 c	8.93 b	23.96 b	145.47 ab	31.70 ab	6.03 a
	Biroi-250-2-4	107.40 bc	9.40 b	23.26 b	130.26 ab	24.93 b	5.62 b
	Biroi-250-2-5	143.87 ab	12.16 ab	25.18 a	148.37 ab	38.23 a	4.02 d
	Biroi-250-2-6	139.57 ab	19.08 a	17.06 c	135.40 ab	39.03 a	4.54 c

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

Results showed significant variation among the mutants and check for most of the characters in combined over locations and individual locations. Combined over locations, it was observed that plant height of all the genotypes ranged from 101.29 to 146.74 cm. From the above table, mean performance of effective tillers was lowest (8.93) in the mutant Biroi-250-2-3 and highest (19.08) in Biroi-250-2-6 Significant variation was found in panicle length, filled grain panicle^{-1} and unfilled grain panicle^{-1}. All the mutants produced significantly higher yield than the Biroi parent. Considering the yield performance and lodging tolerant ability of the mutant further trial will be needed for releasing as a variety.

BC_1F_3 generation of Binadhan-18 x Luxmidigha cross

The seeds of 37 BC_3F_1 populations derived from crossing between Laksmidigha and Binadhan-18 were sown on 05 February 2020 at BINA HQs farm, Mymensingh. The parents were also included in this experiment. Seedlings were transplanted on 12 February 2020 at 15 cm distances within rows of 20 cm 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} were recorded from randomly selected five competitive hills at maturity. Maturity was assessed plot basis. The recorded data were finally subjected to proper statistical analysis and are presented in table 30.

Most of the back-cross population had significantly taller plant height than the parent Laksmidigha Plant no. RC-2-4-7-1 had the highest plant height. Number of effective tillers ranged from 7-34 with Luxmidigha (P) being the lowest while RC-5-4-3-2 the highest. All the populations had significantly higher number of effective tillers and twenty had longer panicle length than both the parents. Twenty-one populations had significantly higher number of filled grains panicle^{-1} than the recipient parent. All the populations had significantly higher grain yield hill^{-1} than both the parents (Table 30). All these high yielding cross populations with Luxmidigha (parent) will be screened in Deep water Rice Screening Tank (DWRST) to check the floatability, stem elongation ability in the next growing season.

Table 30: Grain yield and yield components of some BC_1F_3 generation of Laksmidigha X Binadhan-18 cross

Mutants/Variety	Plant height (cm)	Effective tiller	Panicle length (cm)	Filled grain/ panicle	Unfilled grain/Panicle	Yield (t ha-1^{-1})
RC-4-1-15-1	127	14	25	145	45	30.09
RC-4-1-15-2	139	26	22	122	27	44.71
RC-4-1-15-3	157	12	28	95	45	29.7
RC-4-1-15-4	146	19	25	102	37	31.5
RC-4-1-15-5	113	16	26	91	36	28.5
RC-2-7-6-1	121	19	22	95	31	26.1
RC-2-7-6-2	124	23	24	102	28	25.9
RC-2-7-6-3	158	14	28	105	45	26.6
RC-2-7-6-4	127	13	27	125	39	28.2
Rc-1-1-11-3	148	11	25	135	50	25.7
RC-3-7-5-1	141	8	27	131	38	22.1
RC-3-7-5-2	138	15	25	136	35	24.2
RC-3-3-2-1	126	13	24	125	28	18.2
RC-2-5-3-1	158	14	27	139	22	19.5
RC-2-5-3-2	121	10	21	131	16	22.4
RC-2-5-3-3	160	11	27	135	23	23.1
RC-2-6-4-1	148	24	24	136	25	29.7
RC-2-6-4-2	132	14	23	130	29	27.6
RC-2-6-4-3	130	14	22	132	26	25.1
RC-2-6-4-4	133	17	26	129	34	28.1
RC-5-4-3-1	111	12	23	136	38	33
RC-5-4-3-2	130	34	21	125	40	29.1
RC-1-6-1-1	122	19	23	122	39	28
RC-1-6-1-2	127	12	22	115	31	26.7

RC-1-6-1-3	138	15	24	121	29	27
RC-2-6-3-1	124	15	24	138	32	26.7
RC-2-6-3-2	152	24	28	128	35	24.6
RC-1-6-9-1	117	15	24	125	29	18.6
RC-1-6-9-2	117	12	24	129	32	21.5
RC-1-6-9-3	135	13	23	133	25	22
RC-3-7-3-1	155	15	26	145	29	27.6
RC-4-5-6-1	158	23	28	139	41	28.6
RC-4-5-6-2	136	15	23	141	35	29.5
RC-2-4-7-1	163	16	29	138	42	34.1
RC-2-4-7-2	153	16	29	120	35	27.6
RC-2-4-7-3	149	18	28	128	33	26.1
RC-2-4-7-4	157	16	28	118	40	18.6
Binadhan-18(P)	108	14	23.2	156.8	50	31.5
Luxmidigha(P)	145	7	24.6	125	39	17.9
Mean ± SE	**137.02 ±3.25**	**15.84 ±1.09**	**24.94±0.48**	**126.25± 3.06**	**34.17±1.60**	**26.55±1.05**

Screening of F_3 population of Binadhan-7 × Biroi crosses

Seventy-two F_3 populations were developed from Binadhan-7 × Biroi cross to select high yielding, short duration, and lodging resistant plant/progenies. This experiment was conducted T. Aman season, 2019 for selecting desirable characters at BINA HQ farm, Mymensingh. From them a total of 25 lines have been selected for further generation of F_4.

Growing of M_1 generations of BR22, BRRI dhan76 and BRRI dhan77

To create variability for tallest seedling height, taller plant, short duration with bolder seeds and higher grain yield, seeds of BR22, BRRI dhan76 and BRRI dhan77 were irradiated with 250, 300, 350, 400 and 450 Gy of gamma rays was conducted during T. Aman season, 2019 for selecting desirable characters at BINA HQ farm, Mymensingh. From the experiment M_2 seeds from each plant were collected and bulk them to grow M_2 population.

Advance yield trial with M_4 mutants of heavy ion (nitrogen) beam irradiated population of NERICA-4

Two promising M_4 mutants of heavy ion (nitrogen) beam (RM-16(N)-8-1 and RM-16(N)-10-1) along with two check varieties BRRI dhan28 and BRRI dhan29 were evaluated at BINA HQs farms, Magura and Rangpur substation farms through this trial. This trial was carried out with high temperature tolerant, short duration, high yielding with non shattering grains mutant to assess the yield potential over locations. Seeds were sown during 08 December to 10 December, 2019 and transplanted during 20 January to 02 February 2020 (Table 31). The experiments in the trial followed RCB designs with three replications. The size of the unit plots were 4.0 m × 5.0 m. 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 tillers 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 50% of flowering and days to maturity were assessed on plot basis. Grain yield was recorded from an area of 10m^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 32.

Table 31: Date of sowing and transplanting of the short duration, high yielding with non shattering grains rice mutant and check variety at different locations of Bangladesh

Location	Date of sowing	Date of transplanting	Seedling age (days)
BINA Hqs farm, Mymensingh	08 December 2019	20 January 2020	43
BINA sub-station farm, Rangpur	10 December 2019	29 January 2020	50
BINA sub-station farm, Magura	08 December 2019	02 February 2020	56

Results showed significant variation among the mutants and check for most of the characters in individual locations and combined over locations (Table 32). On an average, it was observed that plant height of RM-16(N)-8-1 and RM-16(N)-10-1 was recorded ranged from 82.38 to 84.00cm which is apart from the check BRRI dhan28 and BRRI dhan29. Panicle length of RM-16(N)-8-1 and RM-16(N)-10-1 was recorded ranged from 22.81 to 25.38cm, panicle length of RM-16(N)-10-1 is higher than the respective checks. Maturity period of BRRI dhan28 was 151.78 days which are statistically shorter days than RM-16(N)-8-1 and RM-16(N)-10-1 was recorded ranged from 157.33 to 155.78 days, again maturity period of BRRI dhan29 was 166.89 days which are higher days required than two mutants. The mutants RM-16(N)-10-1 produced higher yield 7.24 t ha^{-1} and BRRI dhan29 gave yield 6.78 t ha^{-1}. Among the three locations yield performance was better in RM-16(N)-10-1 and RM-16(N)-8-1 than the respective checks. Considering the yield performance of the mutant further trial will be needed for releasing as a variety.

Table 32: Yield and yield components of rice mutants with check varieties at different locations

Location	Mutants/ Variety	Plant Height (cm)	Effective Tiller	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	50% Flowering	Day of Maturity	Yield (t ha-1^{-1})
Rangpur	RM-16(N)-8-1	80.47b	12.73 a	21.43a	152.07 bc	40.80 a	126.67 b	158.67 b	7.20 b
	RM-16(N)-10-1	79.47b	12.13 a	24.33a	159.93 ab	32.67 a	125.33 b	155.33 c	8.23 a
	BRRI Dhan28	91.73a	13.33 a	24.00a	122.40 c	8.43 a	122.33 c	151.00 d	6.14 c
	BRRI Dhan29	97.40a	8.80 a	24.00a	195.59 a	34.20 a	135.33 a	167.67 a	7.10 b
Magura	RM-16(N)-8-1	82.87 b	12.67 a	24.00 a	77.07 b	35.33 a	131.33 b	158.00 b	5.03 b
	RM-16(N)-10-1	86.20 b	8.93 b	27.27 a	119.33 a	28.50 a	128.67 b	156.00 b	6.32 a
	BRRI Dhan28	97.13 a	8.60 b	25.07 a	144.07 a	17.27 b	123.33 c	153.33 c	5.47 b
	BRRI Dhan29	97.13 a	9.47 b	26.20 a	123.53 a	28.93 a	136.33 a	167.33 a	6.22 a
Mymensingh	RM-16(N)-8-1	83.80 b	10.80 a	23.00 a	128.80 a	44.667 a	97.67 b	155.33 b	9.00 a
	RM-16(N)-10-1	86.33ab	11.47 a	24.53 a	126.60 a	52.467 a	98.00 b	156.00 b	7.16 b
	BRRI Dhan28	96.13 a	10.53 a	24.27 a	143.27 a	38.600 a	96.00 b	151.00 c	5.08 c
	BRRI Dhan29	94.80 a	10.55 a	23.00 a	133.60 a	40.133 a	104.67 a	165.67 a	7.02 b
Combined mean over location	RM-16(N)-8-1	82.38 b	12.07 a	22.81 b	119.31 c	40.27 a	118.56 b	157.33 b	7.08 a
	RM-16(N)-10-1	84.00 b	10.84 b	25.38 a	135.29 b	37.87 a	117.33 b	155.78 b	7.24 a
	BRRI Dhan28	95.00 a	10.82 b	24.44 a	136.58 b	21.43 b	113.89 c	151.78 c	5.56 c
	BRRI Dhan29	96.44 a	9.60 c	24.40 a	150.91 a	34.42ab	125.44 a	166.89 a	6.78 b

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

Evaluation Jumlimarshi for cold tolerance in early Boro season

The seeds of cold tolerant rice Jumlimarshi and along with check varieties BRRI dhan28 were evaluated at BINA Headquatter farms, Mymensingh through this trial. This trial was carried out with low temperature tolerant, short duration, high yielding with cold tolerant mutant to assess the yield potential. Seeds were sown during 11 November, 2019 and transplanted during 04 December, 2020. The experiments in the trial followed RCB designs with three replications. The size of the unit plots were 3.0 m × 2.0 m. Seedlings were transplanted at 15cm distance within rows of 20cm apart (Table 33). 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 hill^{-1}, panicle length, and number of filled and unfilled grains panicle^{-1} were recorded after harvest from five randomly selected competitive hills. Days 50% of flowering and days to maturity was assessed on plot basis. Grain yield was recorded from an area of 10m^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 34.

Table 33: Date of sowing, transplanting 50% days of flowering and days of maturity of cold tolerant rice Jumlimashi and BRRI dhan28.

Variety	Date of sowing	Date of transplanting	Seedling age (days)	50% days of Flowering	Days of Maturity	Duration
Jumlimashi	14 November 2019	4 December 2020	19	20 March, 2020	13 April 2020	151 day
BRRI dhan28	14 November 2019	4 December 2020	19	18 March, 2020	15 April 2020	153 day

Results showed significant variation among the Jumlimashi and check BRRI dhan28 for most of the characters in BINA HQs farms, Mymensingh**.** On an average, it was observed that plant height of Jumlimashi was recorded from 141.87cm which is statistically different from the check BRRI dhan28. From the Table 10, number of effective tillers hill^{-1} was 10.07 which is lower than BRRI dhan28. Panicle length of Jumlimashi was recorded from 22.87 cm was higher than the respective checks. The number of unfilled grains in Jumlimashi was 31.53 which is lower than the check variety BRRI dhan28. Jumlimashi produced lower yield 4.05 t ha^{-1} and BRRI dhan28 gave yield 5.05 t ha^{-1}. Considering the yield performance of the Jumlimashi that required further advanced techniques to improved its quality and quantity for development of cold tolerant rice variety.

Table 34: Yield and yield components of rice mutants with check variety at BINA Headquatter farms, Mymensingh.

Mutant	Plant Height (cm)	EffectiveTiller	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Yield (t ha-1^{-1})
Jumlimashi	141.87 a	10.07 b	22.87 a	133.00 a	31.53 b	4.05 b
BRRI dhan28	79.13 b	15.93 a	21.20 a	134.30 a	54.67 a	5.03 a

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

Growing of M_1 population of cold tolerant Boro rice

The experiment was conducted to observe the radio sensitivity of Jumlimashi at BINA HQ farm Mymensingh. The well dried seed of Jumlimashi was taken to observe the effect of gamma irradiation on emergence (%) and seedling height. The parameters were taken into consider on seedling emergence percentage, seedling height, shoot weight and root weight. Germination test was performed before irradiation of seed. A number of 100seed was germinated in petridishes. After the germination percentage 100 seeds were exposed to 5 doses of Gama rays (250, 300, 350, 400 and 450 Gy) on Jumlimashi. Prior to mutagenic treatment seeds were kept in dececators for moisture equilibration. Seeds were subjected to gamma rays ^{60}Co irradiator at BINA, Mymensingh. The germinated seed were observed daily from 1st day of germination. Germination date was recorded at 7th to 35 th days and other data was taken at 21th to 35 th days after sowing. The results indicated differences for germination percentages to different ray different at different days interval (Fig:1)

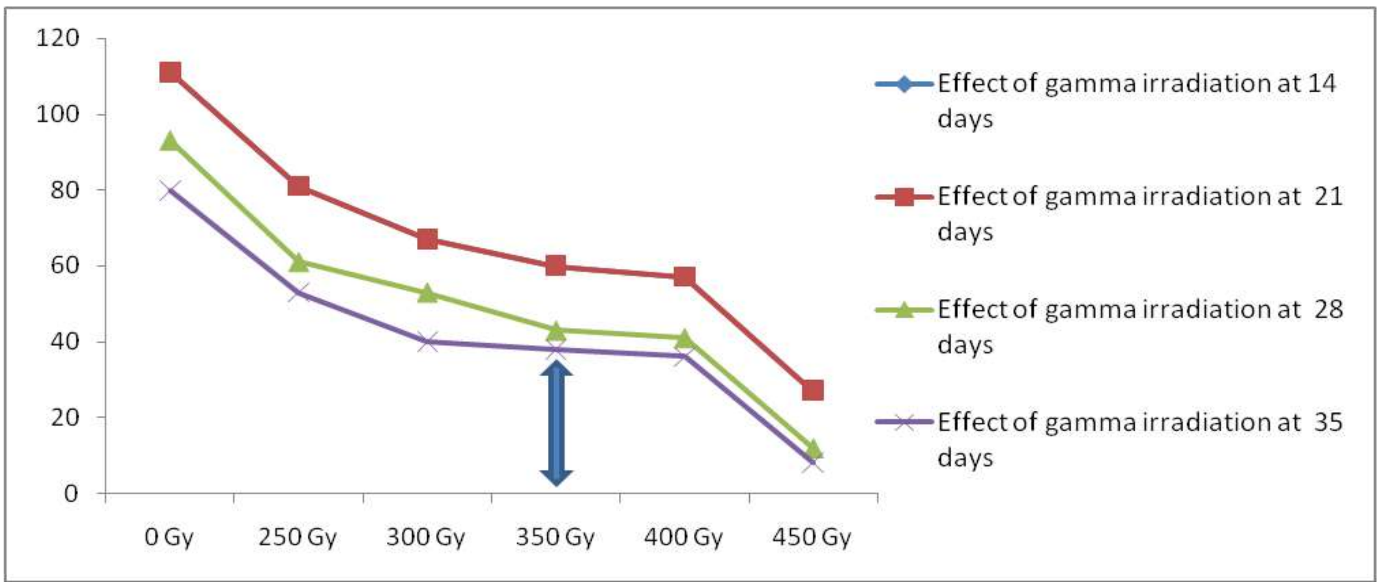


Fig. 1: Estimination of the lethal dose on seed germination at 50 % for Jumlimashi

The seedling receiving no irradiation produced the highest seedling height 80 cm, Lowest seedling height was observed at 450 Gy (8.0 cm) shown at Fig.2. As from above discussion 350 Gy was determined as a LD_{50} for Jumlimashi and further research will be done to utilized this finding. To create the genetic variability, seeds of irradiated Jumlimashi, M_2 seeds from each plant were collected and bulk them to grow M_2 population.

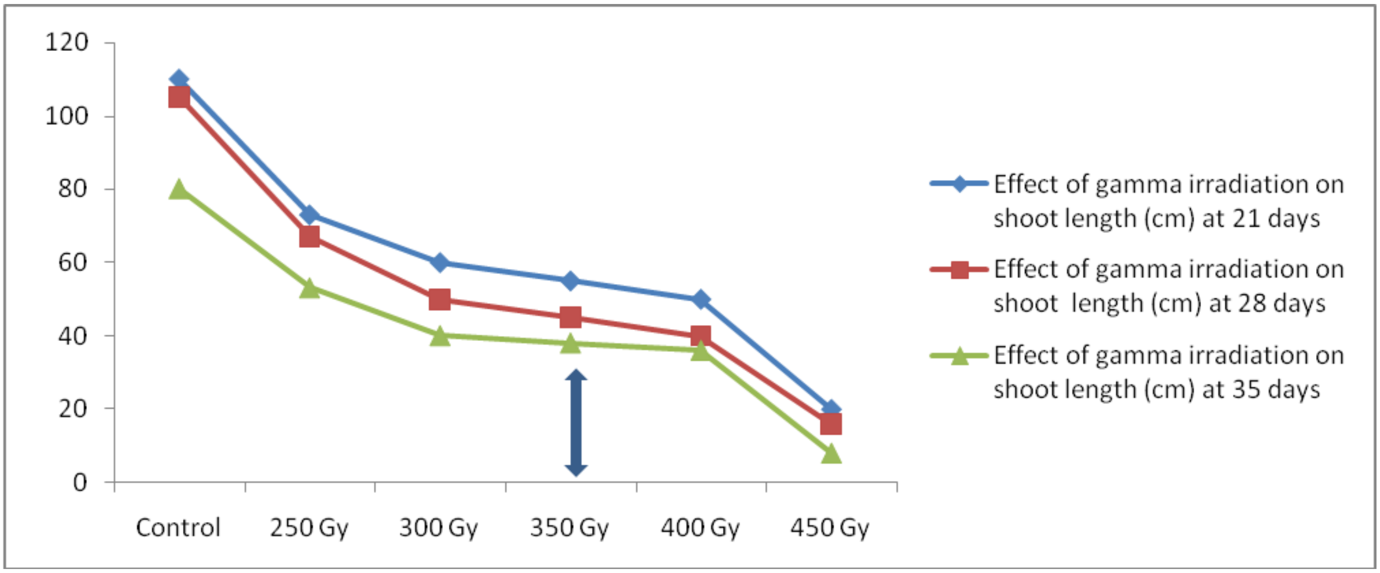


Fig. 2: Estimination of the lethal dose on shoot length at 50 % for Jumlimashi

Growing of locally collected germplams for agronomic performance and yield attributing characters for using as breeding material

Seeds of locally collected nine rice germplasms were sown on 22 December, 2019 and seedlings were transplanted on 11 February, 2020 along with the BRRI dhan29 at BINA HQs farm, Mymensingh. The experiment was laid out in RCB design. The distances between plants were 15cm and between rows were 20cm. A unit plot size was 3m × 2m. 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, total tillers hill^{-1}, effective tillers hill^{-1}, 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 35.

Table 35: Mean performance of some rice lines along with a check variety for different quantative characters.

Mutant	Plant Height (cm)	Total tillers (no)	Effective tillers (no)	Panicle length (cm)	Filled grains panicle^{-1}(no)	Unfilled grains panicle^{-1} (no)	1000-seed-weight(g)	Yield (t ha-1^{-1})
LIRG-2	108.53 e	10.63 ab	9.6 ab	27.60a	204.6 b	111.43 ab	22.71 c	9.057b
LIRG-2-1	120.73 bc	8.87 abc	8.33 c	27.87 a	219.23 ab	107.9b	22.63 c	8.397c
LIRG-2-2	119.03 c	8.07 c	7.6 c	26.93 ab	227.07 a	111.03 ab	24.1 ab	9.813a
LIRG-3	123.87 ab	8.53 bc	8.0 c	26.67abc	210.67 ab	121.87ab	24.43 ab	6.81d
LIRG-3-1	122.07 bc	7.07 c	7.87c	25.4bc	180.0 c	105.47b	21.16 d	5.483f

LIRG-3-2	127.53 a	9.13 abc	8.67bc	28.07 a	205.87 b	131.8ab	22.86 c	5.06 fg
LIRG-4	112.60 d	9.2 abc	8.33c	25.13 c	210.93ab	138.0 ab	24.05 ab	10.01 a
LIRG-4-1	122.73 b	8.33 bc	7.67c	27.93 a	217.93 ab	119.13ab	23.87 b	4.93gh
LIRG-4-3	120.33 bc	8.47 bc	8.07c	25.87 bc	178.93 c	151.13a	24.86 a	4.52 h
BRRI dhan29	105.47 e	11.33 a	10.33a	26.53 abc	118.67 d	38.07c	22.07cd	6.2 e

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

From the table plant height ranged from 105.47 to 127.53 cm where LIRG-3-2 was tallest and BRRI dhan29 was shortest. The table showed although total tillers hill^{-1} and effective no of tillers hill^{-1} was higher in BRRI dhan29 but no of filled grain was higher in local germplasm. Panicle length, 1000-seed weight and yield were also higher in the germplasm than check variety BRRI dhan29. LIRG-2-2 and LIRG-4 showed 9.813 and 10.01 t ha^{-1} yield respectively. But the Locally collected germplasms had long awn. For further improvement irradiation will done in the next season.

Evaluation of BC_1F_2 generation of Binadhan-17× Monjusree-2 cross

The seeds of 21 BC_1F_1 populations derived from crossing between Binadhan-17 and Monjushee-2 were sown on 20 December 2019 at BINA Hqs farm, Mymensingh. The parents were also included in this experiment. Seedlings were transplanted on 1 February, 2020 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, total tiller hill^{-1}, 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 plot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 36.

Table 36. Grain yield and yield components of some BC_1F_2 generation of Binadhan-17 × Monjusree-2 cross

Plant No	Plant height (cm)	Total tillars (no)	Effective tillers (no)	Panicle length (cm)	Filled grains panicle^{-1}(no)	Unfilled grains panicle^{-1}(no)	Yield hill^{-1} (g)
B-17XM2-P-1	117	20	20	24	150	60	48.14
B-17XM2-P-2	108	13	13	26	144	41	34.79
B-17XM2-P-3	112	16	16	27	175	105	35.12
B-17XM2-P-4	118	12	11	24	89	44	19.14
B-17XM2-P-5	120	11	11	26	115	85	26.52
B-17XM2-P-6	123	13	13	26	112	50	30.19
B-17XM2-P-7	116	12	12	25	163	28	26.25
B-17XM2-P-8	115	12	12	25	175	65	30.35
B-17XM2-P-9	121	10	10	25	142	31	18.06
B-17XM2-P-10	125	16	16	25	136	30	43.82
B-17XM2-P-11	112	14	14	25	175	40	41.89

B-17XM2-P-12	113	11	8	24	120	38	18.48
B-17XM2-P-13	118	15	11	26	126	84	27.7
B-17XM2-P-14	108	15	14	23	145	50	36.31
B-17XM2-P-15	113	14	14	22	125	35	38.43
B-17XM2-P-16	108	8	8	24	149	49	19.4
B-17XM2-P-17	102	16	16	22	134	24	35.21
B-17XM2-P-18	121	9	9	24	120	45	21.77
B-17XM2-P-19	115	10	10	27	143	37	30.09
B-17XM2-P-20	103	15	14	22	112	68	24.04
B-17XM2-P-21	116	13	12	25	120	100	36.2
Binadhan-17(P)	98.4	14.8	13.8	23.8	156.8	48.4	32.5
Monjusree-2(P)	98.4	8.8	7.8	27.4	113.2	42.5	15.51
Mean	113.08±1.45	12.98± 0.58	12.42± 0.60	24.70± 0.31	136.52± 4.79	52.17± 4.80	30.00± 1.78

All the back cross population had significantly higher plant height than both parent Binadhan-17 and Monjushee-2. Seven back cross population had significantly higher number of tillers than both parents where parents total tiller number were 8 and 14. Number of effective tillers ranges 8 to 20 in BC_1F_2 with seven back cross population were higher than both parents and others crosss are higher than the lower parents. All the back cross population had significantly longer panicle length than Binadhan-17. Four populations had significantly higher number of filled grains panicle^{-1} than both parents and other crosses are significantly higher than recipient parents. Eight populations had significantly higher grain yield hill^{-1} than both parents (Table 36). All these populations will be further evaluated and screened in the next growing season.

Evaluation of BC_1F_2 generation of Binadhan-17× Komol-7 cross

The seeds of 10 BC_1F_2 population derived from crossing between Binadhan-17 and Komol-**7** were sown on 20 December 2019 at BINA Hqs farm, Mymensingh. The parents were also included in this experiment. Seedlings were transplanted on 1 February, 2020 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, total tiller hill^{-1}, 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 plot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 37.

Table 37: Grain yield and yield components of some BC_1F_2 generation of Binadhan-17 × Komol-7 cross

Plant No	Plant height (cm)	Total tillars (no)	Effective tillers (no)	Panicle length (cm)	Filled grains panicle^{-1} (no)	Unfilled grains panicle^{-1} (no)	Yield hill^{-1} (g)
B-17x K-7-P-1	132	24	22	22	127	32	48.49
B-17x K-7-P-2	123	24	24	24	129	25	56.8
B-17x K-7-P-3	150	16	16	28	156	56	56.55
B-17x K-7-P-4	111	25	24	23	139	42	63.42
B-17x K-7-P-5	142	16	16	24	151	115	54.12
B-17x K-7-P-6	112	19	18	22	148	41	47.5
B-17x K-7-P-7	133	18	17	27	202	56	46.34
B-17x K-7-P-8	118	30	30	27	190	52	88.51
B-17x K-7-P-9	124	14	14	25	168	30	44.6
B-17x K-7-P-10	152	19	16	30	229	32	68.48
Binadhan-17(P)	98.4	14.8	13.8	23.8	156.8	48.4	32.5
Komol-7(P)	99.4	8.2	7.6	22.6	103.4	24.3	12.51
Mean	124.57± 5.17	19.00± 1.70	18.2 ± 1.71	24.87± 0.74	158.27± 10.07	46.14± 7.07	51.66± 5.40

All the back cross population had significantly higher plant height than both parent Binadhan-17 and Komol-7. Nine back cross population had significantly higher number of total tillers than both parents and others had significantly higher number of tillers than recepient parent. Number of effective tiller ranges 14-24 for BC_1F_2 progeny. Nine back cross population had highest effective tillers than both parents (Table 37). Seven back cross population had significantly longer panicle length than both parents and others three population had significantly longer panicle length than recipient parent. Four populations had significantly higher number of filled grains panicle^{-1} than both parents and others crosses are significantly higher than recipient parent. All the back cross populations had significantly higher grain yield hill^{-1} than both parents (37). All these populations will be further evaluated and screened in the next growing season.

Evaluation of BC_1F_2 generation of Binadhan-17× Komol-9 cross

The seeds of 18 BC_1F_1 populations derived from crossing between Binadhan-17 and Komol-9 were sown on 20 December 2019 at BINA Hqs farm, Mymensingh. The parents were also included in this experiment. Seedlings were transplanted on 1 February, 2020 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, total tillers hill^{-1}, effective tillers 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 plot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 38.

From the back cross population nineteen had significantly higher plant height than both parent Binadhan-17 and Komol-9 (Table 38). Thirteen back cross population had significantly higher number of tillers than both parents and the others had significantly higher number of tillers than recipient parent. Number of effective tillers ranges 7 to 34 in BC_1F_2 populations. Among them twelve back cross population produced higher effective tillers than both parents (Table 38). Thirteen back cross population had significantly higher panicle length than both parents. Two populations had significantly higher number of filled grains panicle^{-1} than both parents and the other eight crosses are significantly higher than recipient parents. Eleven back cross populations had significantly higher grain yield hill^{-1} than both parents and others eight crosses are significantly higher than recipient parent (Table 38). All these populations will be further evaluated and screened in the next growing season.

Table 38: Grain yield and yield components of some BC_1F_2 generation of Binadhan-17 × Komol-9 cross

Plant No	Plant Height (cm)	Total Tillar	Effective Tiller	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Yield hill^{-1} (g)
B-17x K-9-P-1	126.00	42.00	34.00	26.00	157.00	83.00	117.90
B-17x K-9-P-2	121.00	24.00	23.00	23.00	120.00	25.00	45.14
B-17x K-9-P-3	103.00	27.00	21.00	28.00	112.00	66.00	48.07
B-17x K-9-P-4	92.00	27.00	25.00	24.00	76.00	43.00	29.40
B-17x K-9-P-5	130.00	25.00	23.00	22.00	74.00	24.00	45.99
B-17x K-9-P-6	139.00	21.00	20.00	25.00	112.00	28.00	41.13
B-17x K-9-P-7	127.00	26.00	25.00	29.00	161.00	54.00	62.48
B-17x K-9-P-8	119.00	12.00	11.00	26.00	83.00	24.00	21.11
B-17x K-9-P-9	124.00	16.00	15.00	26.00	74.00	77.00	36.37
B-17x K-9-P-10	131.00	20.00	13.00	24.00	147.00	40.00	26.08
B-17x K-9-P-11	122.00	19.00	17.00	25.00	113.00	74.00	33.74
B-17x K-9-P-12	110.00	16.00	16.00	20.00	108.00	30.00	33.98
B-17x K-9-P-13	135.00	8.00	8.00	25.00	75.00	44.00	18.73
B-17x K-9-P-14	125.00	10.00	10.00	24.00	108.00	31.00	27.28
B-17x K-9-P-15	121.00	26.00	23.00	25.00	61.00	77.00	36.97
B-17x K-9-P-16	128.00	23.00	23.00	25.00	118.00	78.00	64.26
B-17x K-9-P-17	75.00	7.00	7.00	17.00	56.00	12.00	18.61
B-17x K-9-P-18	116.00	11.00	11.00	22.00	82.00	47.00	19.27
Binadhan-17(P)	98.40	14.80	13.80	23.80	156.80	48.40	32.50
Komol-9(P)	89.00	7.60	6.60	23.20	87.00	42.40	10.23
Mean	118.02± 3.77	19.73± 1.96	17.83± 1.64	24.20± 0.59	104.94± 7.28	47.65± 4.86	39.95± 5.24

Growing of F_1 generation of Binadhan-17 X Chandanath-3 cross

To introgression, short duration with cold tolerant gene to the yield potential genotype, seeds of Binadhan-17 and Chandanath-3 were sown and crossing was done during December, 2019. The F_1 plants was harvested separately and collected them to grow BC_1F_1 population next year.

Growing of M_1 generation of rice for salinity and drought responses

To identify salinity and drought responses, seeds of collected rice lines were irradiated with different doses of gamma rays (150, 200, 250, 300 and 350 Gy) during December 2019 to May 2020. M_1 seeds from each plant were collected and bulk them to grow M_2 population next year.

Evaluation of BC_2F_1 population BRAUS rice variety Binadhan-14

To introgression non shattering grain trait for growing even under low temperature with shorter duration and higher yield but keeping the parent quality same as parent, Binadhan-14 BC_1F_1 plants were crossed with non-shattering parents. Seedlings were transplanted at 20 December 2019 and harvested at 29 April 2020. Seeds of BC_2F_1 population harvested to grow further generation of BC_3F_1 next year at pot condition.

Growing of M_1 generation

To create genetic variability, seeds of two local cultivar Kotrapari and Sompa kataribog were irradiated with 200, 250, 300, 350 and 400Gy of gamma rays. Seeds were sown on 27th November 2019 at BINA HQ farm, Mymensingh. The parent was also included in this experiment. The experiment was followed by non replicated design and sown separately (variety and dose wise). At harvest the survived plants that produced seeds were harvested separately for growing M_2 population.

WHEAT

Improvement of Binagom-1 through hybridization

To introgress short duration, heat tolerance, lodging resistance traits in Binagom-1 during November 2019. Binagom-1 was crossed with BARI Gom-33 and produced F1 seeds. The F_1 seeds of Binagom-1 × BARI Gom-33 from each plant of each cross were collected them to grow BC_1F_1 population next year.

RAPESEED-MUSTARD

On-station and on-farm yield trial with M_8 rapeseed (*B. rapa* var. yellow sarson) mutants

Four M_8 rapeseed mutants were evaluated to assess their performance through on-station and on-farm trials. For on-station trial, the experiment was conducted at BINA HQ farm, Mymensingh and BINA sub-station farms at Nalitabari, Ishwardi, Chapainawabgonj, Rangpur and Magura. For on-farm trial, the experiment was conducted at the farmers' field of Mymenshing, Jamalpur, Rangpur, Nalitabari, Manikganj and Magura. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown within 5 to 15 November 2019. Unit plot size was $20m^2$ ($5m \times 4m$) and line to line distance was maintained 25cm. Recommended production packages i.e., application of fertilizers and pesticide, weeding, thinning, irrigation etc. were followed to ensure normal growth and development of the plants. Data on 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 in a plot. Seed yield of each plot was recorded after harvest and converted into kg ha^{-1}. Appropriate statistical analysis was performed for comparison of means of each character.

Results obtained from the trial of individual location and combined over locations for all the characters are presented in Table 39. Significant variations were observed among the mutants and check varieties for most of the characters in both of 12 individual locations and combined over locations. On an average, maturity period ranged from 87 to 90 days. Among the genotypes BARI Sarisha-15 and BARI Sarisha-17 required the shortest maturity period of 87 days and RM-07 required the longest of 90 days. Mutant RM20 produced the highest plant height (101cm) having significant difference with all other mutants and checks whilst, RM07 produced the shortest plant height (92cm) having non-significant difference with RM10 and BARI Sarisha-17. All the mutants except RM07 and BARI Sarisha-17 produced significantly higher number of branches plant^{-1} (4.0).

On an average, RM18 produced the highest number of siliquae plant^{-1} (87) having non-significant difference with BARI Sarisha-15 (86) and BARI Sarisha-17 produced the lowest number (68). Mutant RM18 and RM20 (30) produced the highest number of seeds siliquae^{-1} closely followed by BARI Sarisha-17 which produced 29 seeds siliqua^{-1}.

Table 39: Mean of M_8 rapeseed mutants and check varieties for different characters

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliquae length (cm)	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})
BINA HQ, Mymensingh	RM07	91ab	92e	3.0b	104ab	6.3ab	18.0b	995e
	RM10	91ab	100c	3.0b	106a	6.5a	19.0b	1185c
	RM18	92a	96d	3.0b	93d	6.0b	26.0a	1298a
	RM20	92a	99cd	4.0a	103b	6.0b	25.0a	1232b
	BRS-15	85b	102b	4.0a	94d	5.9b	19.0b	1008d
	BRS-17	84b	104a	3.0b	98.0c	6.0b	20.0b	905f
Farmer's field Mymensingh	RM07	92b	85e	3.0b	95.0b	5.6b	16.0b	965e
	RM10	80e	95b	4.0a	85.0d	5.2d	17.0b	1078e
	RM18	94a	93c	3.0b	97.0a	5.8a	17.0b	1268a
	RM20	81de	97a	3.0b	89.0c	5.6b	18.0b	1150c
	BRS-15	82d	92cd	4.0a	94.0b	5.3cd	23.0a	1090d
	BRS-17	84c	89d	3.0b	84.0d	5.4c	24.0a	1202b
Farmer's field Manikganj	RM07	95a	90d	2.0b	103.0ab	5.8b	18.0c	985e
	RM10	83e	100ab	3.0a	93.0d	5.4c	19.0b	998d
	RM18	93b	98b	2.0b	105.0a	6.0a	19.0b	1175c
	RM20	84de	102a	2.0b	97.0c	5.5c	20.0b	895f
	BRS-15	85d	97b	3.0a	102.0b	5.5c	25.0a	1222b
	BRS-17	87c	94c	2.0b	92.0d	5.5c	26.0a	1288a
Ishwardi Sub-Station	RM07	94bc	95ab	7.0a	45.0c	4.0^{NS}	25.0b	1325e
	RM10	91c	91b	4.0b	46.0c	4.0	24.0b	1898b
	RM18	91c	91b	6.0ab	81.0a	4.0	22.0c	1947a
	RM20	103a	103a	4.0b	60.0b	4.0	28.0a	1835d
	BRS-15	101ab	101a	5.0ab	44.0c	4.0	21.0c	1305f
	BRS-17	99b	99ab	6.0ab	40.0c	4.0	27.0a	1874c
Magura Sub-station	RM07	81c	100b	3.0b	72.0b	4.0^{NS}	22.0c	960e
	RM10	90a	91d	3.0b	84.0a	4.0	22.0b	1137b
	RM18	82c	102ab	3.0b	74.0b	4.0	44.0a	1305a
	RM20	82c	105a	4.0a	72.0b	4.0	42.0a	1111c
	BRS-15	88b	95c	4.0a	55.0c	4.0	26.0bc	887f

	BRS-17	88b	100b	4.0a	55.0c	4.0	31.0b	1028d
Farmer's field Magura	RM07	83c	97c	3.0c	87.0bc	4.0^{NS}	40.0c	1075f
	RM10	92a	91d	4.0b	96.0bc	4.0	40.0c	1281c
	RM18	84c	99b	5.0a	111.0ab	4.0	51.0a	1917a
	RM20	89b	102a	4.0b	108.0b	4.0	40.0c	1805b
	BRS-15	91a	92d	4.0b	121.0a	4.0	44.0b	1175d
	BRS-17	90b	97c	3.0c	80.0c	4.0	40.0c	1144e
Rangpur sub-station	RM07	85a	95bc	3.0c	82.0d	3.0b	21.0c	1137c
	RM10	83b	94bc	4.0b	91.0c	3.0b	30.0b	1167c
	RM18	83b	103b	4.0b	103.0b	3.0b	31.0b	1951a
	RM20	83b	107a	5.0a	106.0ab	4.0a	32.0ab	1820b
	BRS-15	84ab	102b	4.0b	116.0a	3.0b	21.0c	1190c
	BRS-17	79c	93c	3.0c	75.0e	3.0b	35.0a	1187c
Farmer's field Rangpur	RM07	90a	98c	3.0c	87.0cd	3.0b	22.0c	1137e
	RM10	89a	97c	4.0b	96.0c	3.0b	31.0b	1163d
	RM18	87b	110a	5.0a	111.0ab	4.0a	33.0ab	1433a
	RM20	87b	107ab	4.0b	108.0b	4.0a	32.0ab	1278b
	BRS-15	88b	105b	4.0b	121.0a	3.0b	22.0c	1190c
	BRS-17	88b	96c	3.0c	80.0d	3.0b	36.0a	1187c

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliquae length (cm)	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})
Jamalpur sub-station	RM07	81a	85bc	2.0b	53.0a	7.0a	22.0c	1160c
	RM10	80ab	86b	3.0ab	54.0a	6.0b	22.0c	1157c
	RM18	78b	91a	3.0ab	39.0bc	5.0c	44.0a	1777a
	RM20	78b	92a	4.0a	46.0b	5.0c	42.0a	1775a
	BRS-15	78b	85bc	4.0a	41.0bc	6.0b	26.0bc	1186b
	BRS-17	79ab	81c	3.0ab	33.0c	5.0c	31.0b	1188b
Chapainawabgonj sub-station	RM07	91a	98bc	3.0c	87.0cd	3.0b	22.0c	1137e
	RM10	91a	97bc	4.0b	96.0c	3.0b	31.0b	1163d
	RM18	92a	107ab	5.0a	111.0ab	4.0a	33.0ab	1567a
	RM20	92a	110a	4.0b	108.0b	4.0a	32.0b	1483b
	BRS-15	85b	105b	4.0b	121.0a	3.0b	22.0c	1190c
	BRS-17	84b	96c	3.0c	80.0d	3.0b	36.0a	1187c
Nalitabari sub-station	RM07	96a	85c	4.0b	89.0b	5.0a	16.0b	950f
	RM10	94b	95ab	5.0a	79.0d	5.0a	17.0b	1207c
	RM18	94b	93b	4.0b	91.3a	5.0a	17.0b	1397a
	RM20	90d	97a	4.0b	83.0c	4.0b	18.0ab	1260b
	BRS-15	92c	92b	5.0a	88.0b	4.0b	23.0a	1087e
	BRS-17	88e	89bc	4.0b	78.0d	5.0a	24.0a	1153d
Farmer's field Nalitabari	RM07	95ab	86b	4.0ab	80.0a	6.0a	17.0d	1033e
	RM10	93bc	85b	4.0ab	70.0b	5.b	21.0bc	1267c
	RM18	94b	91a	3.0b	31.0e	4.0c	24.0b	1533a
	RM20	94b	92a	5.0a	48.0c	5.0b	28.0a	1300b
	BRS-15	92c	85b	4.0ab	39.0d	5.0b	19.0c	1200d
	BRS-17	96a	80c	3.0b	31.0e	5.0b	24.0b	867f
Combined means over	RM07	90a	92c	3.0b	82cd	4.7a	22.0c	1072e
	RM10	88b	93c	4.0a	83c	4.5b	25.0b	1224c

locations	RM18	89ab	98b	4.0a	87.0a	4.5b	30.0a	1776a
	RM20	88b	101a	4.0a	85.0b	4.5b	30.0a	1651b
	BRS-15	87bc	96b	4.0a	86.0ab	4.3c	25.0b	1144d
	BRS-17	87bc	93c	3.0b	68.0d	4.4bc	29.0a	1184d
Location means								
BINA HQ, Mymensingh		89bc	99b	3.0c	99.0a	6.1a	21.0bc	1104c
Farmer's Field Mymensingh		85d	92d	3.0c	90.0ab	5.4b	19.0c	1126c
Farmer's Field Manikganj		87bc	97c	2.0d	98.0a	5.6ab	21.0bc	1093d
Ishwardi sub-station		96a	97c	5.0a	52.0cd	4.1cd	24.0bc	1696a
Magura sub-station		85bc	99b	3.0c	68.0c	4.2c	31.0b	1071d
Farmer's Field Magura		88c	96c	3.0c	100.0a	4.0cd	43.0a	1400b
Rangpur sub-station		82d	99b	3.0c	95.0ab	3.1d	28.0bc	1622a
Farmer's Field Rangpur		88c	103a	4.0b	100.0a	3.3cd	29.0bc	1621a
Jamalpur sub-station		79e	87e	3.0c	44.0d	5.6ab	31.0b	1374b
Chapainawabgonj sub-station		89bc	102a	4.0b	100.0a	3.3cd	29.0bc	1621a
Nalitabari sub-station		92b	92d	4.0b	85.0b	4.6bc	19.0c	1176c
Farmer's Field Nalitabari		94ab	86e	4.0b	50.0cd	5.0bc	22.0bc	1200bc

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

BRS-15 means BARI Sarisha-15 and BRS-17 means BARI Sarisha-17

Considering all the agronomic characters mutant RM18 produce highest seed yield of 1776 kg ha^{-1} followed by the mutant RM20 (1651 kg ha^{-1}). Mutant RM07 produced the lowest seed yield of 1072 kg ha^{-1}. There was non-significant difference between two popular check varieties BARI Sarisha-15 and BARI Sarisha-17 and produced seed yield of 1144 and 1184 kg ha^{-1}, respectively. Location-wise performance showed that the highest seed yield was produced at Ishwardi sub-station closely followed by sub-station Rangpur, farmer's field Rangpur and sub-station Chapainawabgonj. From the trial it is observed that RM-18 was the best performer among the mutants and two checks. Further trials will be needed to confirm the result.

On-station and on-farm yield trial with one advanced M_8 rapeseed (*B. napus*) mutant

A M_8 rapeseed mutant along with two check varieties Binasarisha-9 and BARI Sarisha-14 were evaluated through this trial. For on-station, the trial was conducted at BINA HQ farm, Mymensingh and BINA sub-station farms at Rangpur, Gopalganj and Magura. For on-farm trial, the same experiment was conducted at the farmers' field at Mymenshingh, Ishwardi, Magura and Manikgonj. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown within 1 to 15 November 2019. Unit plot size was 20m^2 (5m × 4m) and line to line distance was 25cm. Recommended production packages i.e., application of fertilizers, irrigation and pesticide, weeding, thinning etc. were followed to ensure normal plant growth and development. Data on 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 in a plot. Seed yield of each plot was recorded after harvest and converted into kg ha^{-1}. Appropriate statistical analysis was performed for comparison of means of each character.

Results obtained from the trial of individual location and combined over locations for all the characters are presented in Table 40. Significant variations were observed among the mutant and check varieties for most of the characters in both of individual location and combined over eight locations. On an average, mutant RM005 matured earlier than both check varieties. RM005 required 84 days to mature which is statistically similar with BARI Sarisha-17 (85 days) and Binasarisha-9 took 92 days to mature. Binasarisha-9 produced the highest plant height of 111cm followed by BARI Sarisha-17 (102cm) and mutant RM005 produced the shortest plant height of 87cm. Number of branch plant^{-1} varied from location to location due to environmental effects. Binasarisha-9 produced the highest number of siliquae plant^{-1} (145.0) followed by RM-005 (113 siliquae plant^{-1}) and BARI Sarisha-17 produced the lowest number of 87.

Table 40: Mean of M_7 rapeseed mutants and check variety for different characters

Locations	Mutant/ checks	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliqua length (cm)	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})
BINA HQ, Mymensingh	RM005	81c	77c	4.0b	83.0b	7.0a	26.0b	2204b
	BNS-9	87a	110a	5.0a	137.0a	6.6a	28.0c	2400a
	BRS-17	84b	89b	4.0b	69.0c	4.2b	33.0a	1665c
Farner's field Mymensingh	RM005	86b	82c	4.0b	91.0b	7.1a	31.0c	2454b
	BNS-9	89a	115a	5.0a	145.0a	6.6b	33.0b	2650a
	BRS-17	87b	94b	4.0b	77.0c	4.2c	38.0a	1915c
Farner's field Manikganj	RM005	83c	92c	4.0b	96.0b	7.1a	33.0c	2654b
	BNS-9	96a	125a	5.0a	130.0a	6.6b	35.0b	2850a
	BRS-17	86b	104b	4.0b	82.0c	4.3c	38.0a	2115c
Magura sub-station	RM005	85c	89c	5.0b	155.0a	6.4a	40.0a	1717b
	BNS-9	94a	113a	4.0b	152.0a	5.9b	34.0c	1883a
	BRS-17	91b	102b	8.0a	121.0b	3.5c	36.0b	1683c
Farmer's field Magura	RM005	85b	88c	4.0b	144.0b	4.7b	33.0b	2550b
	BNS-9	89a	116a	4.0b	167.0a	4.9a	43.0a	2650a
	BRS-17	83c	110b	7.0a	119.0c	4.1c	32.0b	1150c
Rangpur sub-station	RM005	86b	87c	4.0b	89.0b	6.8a	30.0b	2634b
	BNS-9	94a	93b	5.0a	143.0a	6.3a	32.0b	2830a
	BRS-17	85b	120a	3.0c	75.0c	3.9b	37.0a	2193c
Farmer's field Rangpur	RM005	88b	87c	4.0b	89.0b	6.8a	30.0c	1834b
	BNS-9	96a	120a	5.0a	143.0a	6.3b	32.0b	2230a
	BRS-17	87b	105b	3.0c	87.0b	4.9c	36.0a	1481c
Gopalganj sub-station	RM005	85b	89b	5.0a	155.0a	6.4a	40.0a	1717b
	BNS-9	94a	93a	5.0a	143.0b	6.3a	32.0b	2830a
	BRS-17	84b	89b	4.0b	69.0c	4.2b	33.0b	1665c
Combined means over locations	RM005	84c	87c	4.0b	113.0b	6.5a	32.0b	2221b
	BNS-9	92a	111a	5.0a	145.0a	6.1a	33.0b	2541a
	BRS-17	85b	102b	5.0a	87.0c	4.1b	35.0a	1733c
Location means								
BINA HQ farm, Mymensingh		84c	92c	4.0b	96.0c	5.9ab	29.0c	2090c
Farmer's field Mymensingh		87b	97bc	4.0b	104.0bc	5.9ab	34.0ab	2340b
Farmer's field Manikganj		88ab	107a	4.0b	102.0c	6.0a	35.0ab	2540a
Magura sub-station		90a	101b	5.0a	142.0c	5.2bc	36.0a	1761d

Farmer's field Magura	85bc	105ab	5.0a	143.0c	4.5c	36.0a	2117bc
Rangpur sub-station	88ab	100b	4.0b	109.0bc	5.6b	33.0ab	2553a
Farmer's field Rangpur	90a	104ab	4.0b	106.0bc	6.0a	32.0b	1849cd
Gopalganj sub-station	87b	90c	4.0b	122.0b	5.6b	35.0ab	2071c

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

BNS-9 means Binasarisha-9 and BRS-17 means BARI Sarisha-17

Length of siliquae ranged from 4.1 to 6.5cm. Check variety BARI Sarisha-17 produced the highest number of 35 seeds siliquea^{-1} whereas the mutant and parental check Binasarisha-9 produce statistically similar number of seeds siliquae^{-1} (32 and 33, respectively). Finally, check variety Binasarisha-9 produced the highest seed yield of 2541 kg ha^{-1} and another check variety BARI Sarisha-17 produced only 1733 kg ha^{-1} seed yield, which was statistically and significantly lower than RM005 (2221 kg ha^{-1}). Mutant RM005 matured earlier than both check varieties. Considering seed yield and maturity period RM005 can be considered for registration as a new variety. Among the locations, yield performance was better at Rangpur and Manikgonj districts (2553 and 2540 kg ha^{-1}, respectively).

Regional yield trial with three M_5 rapeseed (*B. rapa* var. yellow sarson) mutants

Three M_5 rapeseed mutants were evaluated through this trial to assess their performance. The experiment was conducted at BINA HQ farm Mymensingh and BINA sub-station farms at Magura, Ishwardi, Rangpur & Khagrachari. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown within 6 to 16 November 2019. Unit plot size was 20m^2 (5m $\times$ 4m) and line to line distance was 25cm. Recommended production packages i.e., application of fertilizers, irrigation and pesticide, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data on 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 in a plot. Seed yield of each plot was recorded after harvest and converted into kg ha^{-1}. Appropriate statistical analysis was performed for comparison of means of each character.

Results obtained from the trial of individual location and combined over locations for all the characters are presented in table 41. Significant variations were observed among the mutants and check varieties for most of the characters in both of individual location and combined over locations. On an average, maturity period ranged from 87 to 89 days. BARI Sarisha-14 and BARI Sarisha-15 required the highest maturity period of 89 days. Mutants RM-13 and RM-15 required the shortest maturity period of 87 days. RM-13 and RM15 produced the highest plant height of 108cm and BARI Sarisha-14 produced the shortest plant height (83cm). All the mutants produced equal number of branches plant^{-1} (5.0), where as BARI Sarisha-14 and BARI Sarisha-15 produced lower number of branches plant^{-1} (4.0 no.). Mutants RM-11 and RM-13 produced the lowest number of siliquae plant^{-1} (85 & 86). On an average, mutant RM-15 produced the highest number of 92 siliquae plant^{-1} which is the important yield component. BARI Sarisha-15 produced the lowest number of 81 siliquae plant^{-1}. BARI Sarisha-14 produced the highest number of 30 seeds siliquae^{-1} closely followed by RM13 with 28 seeds siliqua^{-1}.

RM15 produced 26 seeds siliqua^{-1} and, RM11 and BARI Sarisha-15 produced the lowest number of 20.

Table 41: Mean of M_5 rapeseed mutants and check varieties for different characters

Locations	Mutants/ checks	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliquae length (cm)	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})
BINA HQ, Mymensingh	RM11	88b	107b	6.0a	96.0b	4.5a	22.0bc	1126c
	RM13	87b	108b	7.0a	96.0b	3.1b	33.0a	1118c
	RM15	88b	115a	6.0a	111.0a	2.9c	34.0a	1132c
	BRS-14	89a	80d	4.0b	69.0d	1.5d	26.0b	1392a
	BRS-15	90a	92c	3.0b	87.0c	1.5d	16.0c	1232b
Magura sub-station	RM11	89b	91c	5.0a	81.0d	4.4d	16.04e	1151b
	RM13	87c	101b	4.0b	94.0b	5.2a	30.0b	1143c
	RM15	89b	94bc	5.0a	88.0c	4.7c	20.0d	1157b
	BRS-14	90ab	82d	4.0b	78.0e	4.0e	32.0a	1217a
	BRS-15	91a	112a	5.0a	115.0a	5.0b	24.0c	1107d
Ishwardi sub-station	RM11	87c	112b	7.0a	103.0b	7.0a	25.0c	1151c
	RM13	86d	113b	8.0a	103.0b	5.6b	36.0a	1143c
	RM15	87c	120a	7.0a	118.0a	5.4b	37.0a	1257b
	BRS-14	88b	85d	5.0b	46.0d	4.0c	29.0b	1417a
	BRS-15	89a	97c	4.0b	54.0c	4.0c	19.0d	1107d
Rangpur sub-station	RM11	88a	110ab	3.0b	85.0a	3.8c	21.0c	1151c
	RM13	87a	114a	3.0b	76.0c	4.6a	24.0b	1143d
	RM15	83c	109ab	4.0a	81.0b	3.8c	24.0b	1157c
	BRS-14	86b	88c	4.0a	71.0d	3.6d	35.0a	1317a
	BRS-15	85b	106b	4.0a	86.0a	4.1b	24.0b	1237b
Khagrachari sub-station	RM11	92b	101ab	4.0ab	66.0a	3.0ab	16.4c	1101b
	RM13	90c	105a	3.0b	57.0c	3.0b	19.6b	1093c
	RM15	92b	100ab	3.0b	62.0b	3.0ab	19.3b	1007d
	BRS-14	93ab	79c	5.0a	52.0d	4.0a	30.3a	1267a
	BRS-15	94a	97b	4.0ab	67.0a	3.0ab	19.6b	1087c
Combined means over locations	RM11	88ab	104b	5.0a	86.0b	4.5a	20.0c	1136bc
	RM13	87b	108a	5.0a	85.0bc	4.3ab	28.0ab	1128c
	RM15	87b	108a	5.0a	92.0a	3.9b	26.0b	1142b
	BRS-14	89a	83d	4.0b	86.0b	3.4c	30.0a	1322a
	BRS-15	89a	101c	4.0b	81.0c	3.5c	20.0c	1122d

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

BRS-14 means BARI Sarisha-14 and BRS-15 means BARI Sarisha-15

Considering all the yield contributing characters BARI Sarisha-14 produced the highest seed yield of 1322 kg ha^{-1}. Mutants RM11, RM13 & RM15 and BARI Sarisha-15 produced statistically equal yield which were 1136, 1128, 1142 and 1122 kg ha^{-1}, respectively.

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

Seven rapeseed mutants along with mother variety, Binasarisha-9 and check variety Tori-7 were evaluated to assess their overall performance for earliness and yield attributes. The trial was conducted at BINA HQ farm, Mymensingh and BINA sub-station farm at Magura. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown within 5 to 15 November 2019. Unit plot size was $20m^2$ (5m × 4m) and line to line spacing was 25cm. Recommended production packages i.e., application of fertilizers, irrigation and pesticide, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data on 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 in a plot. Seed yield of each plot was converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

Results obtained from the trial of individual location and combined over locations for all the characters are presented in table 42. Significant variations were observed among the lines and check varieties for most of the characters in both of individual location and combined over locations. On an average, maturity period ranged from 71 to 92 days. All the mutants matured earlier than the mother check variety Binasarisha-9 and the other check variety Tori-7 required 71 days to mature. Mutant RM26 produced the tallest plant (131cm) followed by RM23 (107cm). RM21, RM22, RM25 and RM27 had statistically equal plant height. Mutant RM24 was comparatively dwarfed having 92cm plant height. Check variety Tori-7 produced the highest number of branches (6) which is significantly higher than all the mutants and Binasarisha-9. Except RM22 and RM26 (with 4.0 branches plant^{-1}) all other genotypes produce statistically similar number of 5.0 branches plant^{-1}. Among the mutants and checks, Tori-7 produced the highest number of siliquae plant^{-1} (141.0) followed by RM25, RM22, RM26 and Binasarisha-9 with 111, 110, 110 and 109 siliquae plant^{-1}, respectively. Seeds Siliquae^{-1} and siliquae length are also indicators contributing seed yield. Seeds siliquae^{-1} and siliquae length of all the genotypes differed significantly. Comparatively longer siliquae was found in RM24 (4.6cm) whereas the shorter one was found in RM26 with 3.8cm. Mutant RM23 produced the highest seed yield than its mother Binasarisha-9. Mother variety Binasarisha-9 produced the second highest seed yield of 1750 kg ha^{-1} having statistically similar yield with other four mutants. Considering yield performance RM22, RM23 and RM26 were selected for future trial.

Table 42: Mean performance of mutants and checks for different character

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliquae length (cm)	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})
BINA HQ, Mymensingh	RM21	89b	110bc	4.0b	107.0c	3.9bc	13.0de	1743d
	RM22	89b	108c	3.0c	114.0b	3.8bc	14.0de	1790b
	RM23	91a	112b	4.0b	98.0e	4.0b	25.0b	2223a
	RM24	89b	97e	4.0b	103.0d	4.3a	17.0c	1480f
	RM25	89b	110bc	4.0b	115.0b	4.0b	18.0c	1680e
	RM26	91a	136a	3.0c	114.0b	3.5c	27.0a	1773c
	RM27	91a	107cd	4.0b	85.0f	3.6c	15.0d	1380g
	BNS-9	91a	104d	4.0b	114.0b	4.3b	27.0a	1800b
	Tori-7	74c	104d	5.0a	149.0a	3.6ab	12.0h	1213h
Magura Sub-station	RM21	84c	101c	5.0b	99.0c	4.6ab	15.0g	1643d
	RM22	84c	99d	4.0c	106.0b	4.5ab	16.0f	1690b
	RM23	86b	103b	5.0b	90.0e	4.7ab	27.0b	2123a
	RM24	84c	88g	5.0b	95.0d	5.0a	19.0d	1380f
	RM25	84c	101c	5.0b	107.0b	4.7ab	20.0c	1580e
	RM26	86b	127a	4.0c	106.0b	4.2b	29.0a	1673c
	RM27	86b	98d	5.0b	77.0f	4.4ab	17.0e	1280g
	BNS-9	92a	95e	5.0b	107.0b	4.3b	29.0a	1701b
	Tori-7	69d	90f	6.0a	134.0a	4.6ab	13.0h	1247h
Combined means over locations	RM21	86c	105bc	5.0b	103.0bc	4.2b	14.0e	1693c
	RM22	86c	103bc	4.0c	110.0b	4.1ab	15.0de	1740b
	RM23	88b	107b	5.0b	94.0bc	4.3ab	26.0b	2173a
	RM24	86c	92c	5.0b	99.0bc	4.6a	18.0c	1430d
	RM25	86c	105bc	5.0b	111.0b	4.3ab	19.0cd	1630c
	RM26	88b	131a	4.0c	110.0b	3.8c	28.0a	1723b
	RM27	88b	102bc	5.0b	81.0c	4.0bc	16.0d	1330e
	BNS-9	92a	99c	5.0b	109.0b	4.3ab	18.0c	1750b
	Tori-7	71d	97cd	6.0a	141.0a	4.1bc	12.0f	1230f
Location means								
BINA HQ, Mymensingh		88a	109a	4.0b	108.6a	3.8b	18.0b	1649a
Magura Sub-station		83b	100b	5.0a	99.8b	4.5a	20.0a	1574b

N.B.: In a column, values with same letter(s) for individual location/combined means do not differ significantly at 5% level.
BNS-9 means Binasarisha-9

Preliminary yield trial with F_6 lines of rapeseed (*B. rapa*) lines

Seven rapeseed lines along with mother variety Binasarisha-9 and one check variety BARI Sarisha-14 were evaluated to assess overall performance for earliness and yield attributes. The trial was conducted at BINA HQ farm, Mymensingh and BINA sub-station farms at Ishwardi and Gopalganj. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on mid November 2020 at both locations. Unit plot size was 20m^2 (5m × 4m) and line to line distance was 25cm. Recommended production packages i.e., application of fertilizers, irrigation and pesticide, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data on plant height, branches plant^{-1}, siliquae plant^{-1}, siliqua length and seeds siliqua^{-1} was taken from 10 randomly selected plants from each plot. Maturity period was counted when 90% siliquae were matured in a plot. Seed yield of each plot was recorded after harvest and proper drying and then converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

Results obtained from the trial of individual location and combined over locations for all the characters are presented in Table 43. Significant variations were observed among the lines and check varieties for most of the characters in both of three individual locations and combined over three locations. On an average, maturity period ranged from 84 to 94 days. Binasarisha-9 required longest maturity period of 94 days and BARI Sarisha-14 required the shortest (84 days). All other lines under evaluation required maturity period from 87 to 91 days. RL14 produced is the tallest plant (104cm) followed by RL13 (99cm). The line RL15 produced the highest number of branches (8.0 no.) which is significantly higher than the all other genotypes. Line RL15 produced the highest number of 150 siliquaes plant^{-1} followed by RL17, RL14 and RL12 which produced 120, 118 & 109 siliquaes plant^{-1}, respectively. Number of seeds siliquae^{-1} and siliquae length is good indicator contributing seed yields. Seeds Siliquae^{-1} and siliquae length of all the genotype significantly differ from each other. The longest siliquae was found in Binasarisha-9 (5.5cm) whereas the shortest (4.0cm) was found in RL15 & RL16. Among the genotypes, line RL13 produced higher seed yield of 1676 kg ha^{-1} which was statistically similar to seed yield of mother check variety Binasarisha-9 (1683 kg ha^{-1}). Higher seed yielder lines RL11, Rl12, RL13 and RL16 have been selected for future trial.

Table 43: Mean performance of mutants and checks for different character

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliquae length (cm)	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})
BINA HQ, Mymensingh	RL11	88bc	104ab	10.0a	173.0b	5.4a	41.0a	1187e
	RL12	89b	106ab	6.0c	144.0d	4.3d	39.0ab	1200b
	RL13	89b	101b	8.0b	96.0g	4.6c	34.0bc	1677a
	RL14	88bc	111a	7.0bc	144.0d	4.3d	30.0c	1097f
	RL15	88bc	100b	9.0ab	187.0a	3.8e	30.0c	1107e
	RL16	89b	110a	4.0d	145.0d	3.9e	33.0bc	1133d
	RL17	89b	101b	8.0b	124.0e	4.6c	31.0c	863g
	BNS-9	91a	101b	8.0b	162.0c	4.9b	36.0b	1683a
	BRS-14	85c	94c	9.0ab	106.0f	4.9b	38.0ab	1130d
Ishwardi Sub-station	RL11	87c	96d	5.0b	79.0e	4.9a	35.0b	1157b
	RL12	88bc	103c	5.0b	84.0de	3.8d	35.0b	1170b
	RL13	88bc	122a	7.0a	153.0b	4.1c	35.0b	1647a
	RL14	86cd	114b	5.0b	132.0c	3.8d	33.0bc	1067d
	RL15	86cd	103c	6.0a	182.0a	3.3e	36.0ab	1077d
	RL16	88bc	111bc	4.0b	97.0d	3.4e	33.0bc	1103c
	RL17	91b	98cd	4.0b	124.0c	4.1c	31.0c	833e
	BNS-9	95a	102c	4.0b	96.0de	4.4b	38.0a	1653a
	BRS-14	83d	79e	4.0b	59.0f	4.4b	36.0ab	1100c
Gopalganj Sub-station	RL11	90c	74d	7.0a	71.0d	5.6b	14.0c	1216b
	RL12	91bc	78c	7.0a	100.0b	5.0b	15.0bc	1229b
	RL13	91bc	73de	5.0b	74.0cd	4.3c	17.0bc	1706a
	RL14	89cd	87a	6.0ab	77.0cd	4.7bc	14.0c	1126c
	RL15	89cd	69ef	7.0a	83.0c	5.1b	15.0bc	1136c

	RL16	91bc	68f	6.0ab	72.0d	4.9b	18.0b	1162c
	RL17	94b	71e	6.0ab	112.0a	4.5c	14.0c	892d
	BNS-9	98a	84b	5.0b	61.0e	7.3a	25.0a	1712a
	BRS-14	86d	56g	3.0c	61.0e	4.3c	23.0ab	1159c
Combined Means Over Locations	RL11	88c	91b	7.0b	108.0bc	5.3ab	30.0ab	1186c
	RL12	89bc	95ab	6.0c	109.0bc	4.3bc	29.0b	1200b
	RL13	89bc	99ab	7.0b	108.0bc	4.3bc	28.0bc	1676a
	RL14	87cd	104a	6.0c	118.0b	4.2bc	25.0c	1096e
	RL15	87cd	91b	8.0a	150.0a	4.0c	27.0bc	1106e
	RL16	89bc	96ab	5.0d	104.0bc	4.0c	28.0bc	1133d
	RL17	91b	90b	6.0c	120.0b	4.4b	25.0c	863f
	BNS-9	94a	96ab	5.0d	106.0bc	5.5a	33.0a	1683a
	BRS-14	84c	77c	6.0c	65.0c	4.4b	32.0ab	1130d
Locations mean								
BINA HQ, Mymensingh		89b	103a	7.0a	142.0a	4.5b	34.0a	1253b
Ishurdi sub-station		88b	103a	4.0b	111.0b	4.0c	34.0a	1223c
Gopalganj sub-station		91a	74b	6.0a	76.0c	5.0a	17.0b	1282a

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

BNS-9 means Binasarisha-9 and BRS-14 means BARI Sarisha-14

Evaluation of promising salt tolerant genotypes through hydroponic culture

One promising mutant RM005 along with five mustard varieties Binasarisha-4, Binasarisha-9, Tori-7, BARI Sarisha-14 and BARI Sarisha-17 were evaluated to see the performance in saline condition through this experiment. The experiment was conducted at glasshouse of BINA HQ, Mymensingh during November to December 2019. This experiment was laid out in complete randomized design with three replications. After germination (5-6 days after placing the seeds in petri-dishes), seedlings were placed in hydroponic culture solutions. Salinity treatments were applied after 7 days to 21 days in hydroponic system and nutrient solution was changed after every seven days. Data on various characters such as plant height, number of leaves plant^{-1} and leaf area was recorded from 5 randomly selected plants of each doses. Comparing with duration and impose salinity level, plant height as well as leaf numbers was decreased. Tori-7 survive at 8 dS/m up to 14 days and after 14 days it was died where as Binasarisha-8 survived up to 10 dS/m and then showed susceptible to salinity. On the other hand, Binasarisha-9 and RM005 performed moderately tolerance to highly tolerance up to 28 days on 6 dS/m, 8 dS/m and 10 dS/m (Table 44).

Table 44: Visual salt injury at seedling stage

Varieties/ mutant	7 days after salinity treatment			14 days after salinity treatment			21 days after salinity treatment		
	6 dS/m	8 dS/m	10dS/m	6 dS/m	8 dS/m	10dS/m	6 dS/m	8 dS/m	10dS/m
RM005	HT	HT	HT	HT	T	T	HT	MT	MT
Binasarisha-9	HT	HT	HT	HT	T	T	HT	MT	MT
Binasarisha-8	HT	HT	MT	MT	S	HS	S	HS	D
BARI Sarisha-14	MT	S	HS	S	HS	D	D	D	D
BARI Sarisha-14	MT	S	HS	S	HS	D	D	D	D
Tori-7	T	T	ST	HS	D	D	D	D	D

N.B.: HT= Highly tolerant, T= Tolerant, MT= Moderately tolerant, S= Susceptible, HS= highly susceptible and D= Died.

Growing M_5 population

A large number of M_5 variants developed from Binasarisha-9 and Tori-7 were grown in plant progeny rows for selecting desirable mutant at BINA HQ farm, Mymensingh. From them, a total of 7 true breeding mutants have been selected primarily for future selection in M_6 generations on the basis of their agronomic performances.

Growing M_4 population

A large number of M_4 variants developed from BARI Sarisha-14 and BARI Sarisha-15 were grown for selecting desirable mutant at BINA HQ farm, Mymensingh. From them, a total of 5 true breeding mutants have been selected primarily for further selection in M_5 generations.

Growing of F_5 population

F_5 population developed from the cross between BARI Sarisha-14 × Tori-7 and BARI Sarisha-15 × Tori-7 were grown at BINA HQ 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 × Binasarisha-4 and MRH × Tori-7 were grown at BINA HQ farm, Mymensingh. From them 15 lines were selected primarily for further selection in F_5 generation.

Growing of M_3 population

To select early maturing and high yielding rapeseed mutants, seed derived from three irradiated population were sown on 15th November 2020 at BINA HQ farm, Mymensingh. The parent Tori-7 was also includes in this experiment. The experiment was followed non-replicated design. Unit plot size was $6m^2$ (2m × 3m) with 25cm line to line spacing and 6-8cm from plant to plant within a line. Recommended production packages i.e., application of fertilizers, irrigation and pesticide, weeding, thinning etc. were followed to ensure normal plant growth and development.

Based on maturity period and seed yield a total of 13 mutant variants have been selected for further selection in subsequent generations.

Growing of M_2 population (Chemical mutagen)

To create genetic variability for earliness with yellow seed coat colour, seed derived from three mutagenic (0.1%, 0.3% and 0.5% EMS) populations were sown on 15th November 2020 at BINA HQ farm, Mymensingh. The parent Tori-7 and BARI Sarisha-17 were also included in this experiment. The experiment was followed by non replicated design and sown separately (variety and dose wise). Unit plot size was $6m^2$ (2m × 3m) with 25cm line to line distance 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. From them, considering overall performance primarily a total of 11 mutants have been selected for further selection in subsequent generations.

Growing of M_1 population (using attenuator)

To create genetic variability, seeds of two popular rapeseed varieties Tori-7 and BARI Sarisha-17 were irradiated with 250, 300, 350 and 400Gy of gamma rays using 50% and 75% attenuator. Seed were sown on 27th November 2020 at BINA HQ farm, Mymensingh. The experiment was followed by non replicated design and sown separately (variety and dose wise). Finally, the survived plants that produced seeds were harvested separately for growing M_2 population.

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_2 generations.

Groundnut

Advance yield trial with some M_6 mutants of groundnut

With a view to identify higher yielding mutant(s) than Binachinabadam-4, the experiment was conducted field at Mymensingh head quarter farm, Rangpur substation farm and Ishwardi substation farm with 4 M_5 mutant lines of groundnut were evaluated 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 was followed RCB design with three replicates. A unit plot size was 2.0 m × 3.0 m. Seeds were sown on 09 January to 02 February 2020 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 t ha-1. Shelling percentage was calculated using the following formula-

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

Table 45: Date of sowing and day of maturity of the groundnut mutant and check variety at different locations of Bangladesh

Location	Date of sowing	Date of Maturity	Duration (days)
BINA Hqs farm, Mymensingh	8 December 2020	20 January 2020	43
BINA sub-station farm, Rangpur	10 December 2020	29 January 2020	50
BINA sub-station farm, Ishwardi	8 December 2020	2 February 2020	56

Finally, the data were analyzed following proper statistical design and are presented in Table 46. Results showed significant variations among the mutants and check for most of the characters in individual locations and combined over locations. On average, it was observed that plant height of B6/282/64, B6/282/80 and B6/282/63 was recorded ranged from 54.17 to 62.17 cm. Another mutant RG-KHA-19-1 was recorded hieght plant height 73.07 cm than the check variety Binachinabadam-4 was 54.67 cm. From the table showed podplant-1 mutant B6/282/64 was 23.37 higher than the check variety Binachinabadam-4 was 21.86.

Table 46: Yield and yield components of groundnut mutants with check varieties at different locations

Location	Mutants/ Variety	Plant height (cm)	Pod plant^{-1}	Pod weight plant^{-1} (g)	Shelling %	100 Pod weight (g)	100 kernel Weight (g)	Yield (kg/ha)
Mymensingh	B6/282/63	40.07b	25.3 a	18.30 b	69.43 a	78.91 a	36.08 ab	2.30 b
	B6/282/64	36.00 b	26.17 a	19.65 a	67.61 ab	80.05 a	40.33 a	2.83 a
	B6/282/80	42.53 b	19.73 b	12.56 c	65.61 bc	66.58 a	32.53 b	2.63 a
	RG-KHA-19-1	55.23 a	12.27 c	11.03 d	48.10 d	70.29 a	33.26 b	1.88 c
	Binachinabadam-4	37.47 b	18.67 b	17.7 b	63.99 c	65.5 a	34.21 b	2.3 b
Rangpur	B6/282/63	96.67 a	22.33 ab	11.53 a	80.42 a	71.17 d	31.83 c	2.08 a
	B6/282/64	84.00 b	26.00 a	11.71 a	82.10 a	76.72 c	33.48 bc	1.76 b
	B6/282/80	76.73 b	24.13 ab	11.94 a	70.70 b	88.90 b	35.43 b	2.04 a
	RG-KHA-19-1	102.80 a	10.67 b	10.42 a	69.00 b	141.12 a	43.44 a	1.58 c
	Binachinabadam-4	81.20 b	29.27 a	12.08 a	81.55 a	72.62 cd	31.12 c	1.71 b
Ishwardi	B6/282/63	49.77 bc	18.07 a	11.10 bc	66.57 a	32.88 bc	32.88 bc	1.98 ab
	B6/282/64	43.77 c	17.93 a	12.38 b	67.37 a	39.35 a	39.35 a	1.93 b
	B6/282/80	52.63 b	18.50 a	14.55 a	65.63 a	35.23 b	35.23 b	2.07 a
	RG-KHA-19-1	61.17 a	12.33 b	9.80 c	62.04 a	29.97 c	29.97 c	1.57 c
	Binachinabadam-4	45.33 c	17.63 a	11.40 b	59.57 b	32.09 bc	32.09 bc	1.86 b
Combined mean over location	B6/282/63	62.17 b	21.90 a	13.64 a	72.14 a	72.24 bc	33.60 c	2.12 a
	B6/282/64	54.59 b	23.37 a	14.58 a	72.36 a	76.00 b	37.72 a	2.17 a
	B6/282/80	57.30 b	20.79 a	13.01 a	67.31 a	72.76 bc	34.39 bc	2.25 a
	RG-KHA-19-1	73.07 a	11.76 b	10.41 b	55.49 b	91.15 a	35.56b	1.68 b
	Binachinabadam-4	54.67 b	21.86 a	13.72 a	68.37 a	67.17 c	32.48c	1.96 ab

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

Pod weight of the mutant B6/282/64 was 14.58 showed higher than the check variety Binachinabadam-4. From the table 46 also showed the shelling percentage of the mutant B6/282/64 was 72.36 higher than the check variety Binachinabadam-4. 100 pod- weights of B6/282/64, B6/282/80 and B6/282/63 ranged from 72.24 to 76.0 gm. Another mutant RG-KHA-19-1 was recorded highest 100 pod- weights 91.15 gm than the check variety Binachinabadam-4 was 67.15gm. 100 kennel- weights was observed that B6/282/64 34.72gm recorded highest than the check variety Binachinabadam-4 was 32.48 gm, B6/282/80 and B6/282/63 were also higher kernel weights than the check. Yield of the mutants of B6/282/80, B6/282/64 and B6/282/63 was recorded ranged from 2.25kgha^{-1}, 2.17 kg ha^{-1} and 2.12 kg ha^{-1} which were higher than the check variety Binachinabadam-4 was 1.96kgha^{-1}. Considering the yield performance of the mutant further trial will be needed at Kharif-II season.

Screening F_2 populations for long and bigger pods with 3-4 kernels

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 non-replicated. A unit plot comprised a row of six plants. Seeds were sown on 02 August 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 randomly selected 15 competitive plants at maturity 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 47: 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	29.53	21.80	19.60	11.25	57.41	43.30	76.96
G2×G1	39.33	26.13	24.20	14.22	58.78	52.01	73.13
G1	33.93	16.00	14.40	7.76	53.89	23.37	60.23
G2	44.00	27.33	25.00	16.67	62.70	57.50	73.37
Mid parent(MP)	38.97	21.67	19.70	12.22	58.30	40.44	66.80
G1×G3	35.67	19.13	17.20	11.90	69.19	45.43	76.35
G3×G1	40.27	22.93	19.60	17.54	89.49	65.55	74.74
G1	33.93	16.00	14.40	7.76	53.89	23.37	60.23
G3	39.47	18.87	15.80	11.80	74.68	41.68	70.64
Mid parent(MP)	36.70	17.43	15.10	9.78	64.29	32.53	65.44
G1×G4	37.47	15.73	14.00	9.68	69.23	37.95	78.31
G4×G1	31.00	20.93	19.40	17.14	88.35	55.26	64.48
G1	33.93	16.00	14.40	7.76	53.89	23.37	60.23
G4	27.67	26.27	23.20	25.64	110.53	96.90	75.57
Mid parent(MP)	30.80	21.13	18.80	16.70	82.21	60.14	67.90
G2×G3	34.07	17.73	14.60	6.88	47.15	25.69	74.64
G3×G2	31.93	22.87	19.80	14.19	71.69	50.65	71.37
G2	44.00	27.33	25.00	16.67	62.70	57.50	73.37
G3	40.27	15.27	11.80	11.48	97.29	42.88	74.70
Mid parent(MP)	42.13	21.30	18.40	14.08	80.00	50.19	74.04
G2×G4	41.80	20.73	18.60	9.98	53.66	36.17	72.48
G4×G2	33.80	34.73	32.60	22.43	68.82	70.64	62.98
G2	34.80	40.80	37.80	17.43	46.12	50.65	58.10
G4	27.67	26.27	23.20	25.64	110.53	96.90	75.57
Mid parent(MP)	31.23	33.53	30.50	21.54	78.33	73.78	66.84
G3×G4	38.87	25.20	21.67	18.10	97.31	63.77	70.46
G4×G3	33.67	13.80	12.00	13.68	114.00	51.99	76.01
G3	40.27	15.27	11.80	11.48	97.29	42.88	74.70

G4	27.67	26.27	23.20	25.64	110.53	96.90	75.57
Mid parent(MP)	33.97	20.77	17.50	18.56	103.91	69.89	75.14

The cross $G_3 \times G_4$, and the reciprocal cross $G_4 \times G_1$ and $G_2 \times G_1$ showed heterosis for plant height (Table 47). But the cross $G_1 \times G_4$ and $G_3 \times G_4$ and reciprocal cross $G_4 \times G_2$, $G_3 \times G_1$ and G2×G1 the showed heterobeltiosis. For pod plant^{-1}, the crosses G1×G2, G3×G4 and the reciprocal crosses G2×G1, G4×G2, G3×G2 and G2×G1 showed heterosis for pod plant^{-1} (Table 47). But the cross G1×G3 and reciprocal cross G3×G1 heterobeltiosis. Mature pod plant^{-1}, showed heterobeltiosis for the cross G1×G2 and G3×G4 and the reciprocal cross G2×G1, G3×G2, G3×G2 and G4×G2 showed heterosis. But the cross G1×G3 and reciprocal cross G3×G1 showed heterobeltiosis. For 100-pod weight the crosses G1×G3 and the reciprocal cross G2×G1, G4×G1, G3×G2, G4×G2 and G4×G3 showed heterosis on the other hand the reciprocal crosses G3×G1 showed heterobeltiosis.. For pod yield plant^{-1} the reciprocal cross G2×G1, G3×G2 and G4×G2 showed heterosis on the other hand G1×G3 and reciprocal cross G3×G1 showed heterobeltiosis. For 100-kernel weight, the cross G1×G2 reciprocal cross G2×G1 and $G_3 \times G_2$ showed heterosis and the cross G1×G3 and reciprocal cross G3×G1 showed heterobeltiosis. Finally, shelling percentage showed G2×G3 and G2×G4 and the reciprocal cross G2×G1 showed heterosis, other hand the cross G1×G2, G1×G3 and G1×G4 and the reciprocal cross G3×G1 and G4×G3 showed heterobeltiosis. The results from most of the crosses/reciproprocal crosses had heterosis/heterobeltiosis for at least one trait which confirms them as F_2s seeds. Therefore, these F_2s will be evaluated and selected in F_3 generation based on large seed and higher shelling percentage in the coming Rabi season.

Maintenance of groundnut mutant germplasm

Fifty germplasm were grown at of BINA Headquaters the farms, Mymensingh. After harvest, seeds of all these germplasm were collected and have been preserved as breeding materials.

SESAME

Regional yield trial with promising M_8 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 BINA sub-station farms at Ishwardi, Magura & Chapainawabgonj during March to June 2020. The mutants and check varieties were laid out in a randomized complete block design with three replications. Unit plot size was 20m^2 (4m × 5m) and line to line spacing was maintained 25cm. Seeds were sown within second week of March 2020. Recommended production packages like application of recommended doses of fertilizers, irrigation and pesticide, weeding, thinning, 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 converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

Table 48: Mean performance of sesame lines along with check varieties for different quantitative characters

Location	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Capsules plant^{-1} (no.)	Capsule length (cm)	Seeds capsaules^{-1} (no.)	Seed yield (kg ha^{-1})
Sub-station Ishwardi	SM-005	88a	94b	0.0	82d	2.6a	53ab	920c
	SM-006	84bc	106a	0.0	92a	2.4a	56a	920c
	SM-008	86ab	97ab	0.0	90b	2.4a	51ab	1020b
	Binatil-2	82c	97ab	3.0a	87c	2.5a	50b	1085a
	BARI Til-4	85ab	102a	2.0b	88c	1.6b	54ab	920c
Sub-station Chapainawa-bgonj	SM-005	85ab	143^{NS}	0.0	112a	2.5^{NS}	75ab	1215b
	SM-006	87ab	135	0.0	98b	2.4	68cd	1265a
	SM-008	89a	135	0.0	106c	2.4	71bc	1215b
	Binatil-2	83b	143	2.0b	89d	2.2	65d	1215b
	BARI Til-4	85ab	134	2.6a	109b	2.5	79a	1065c
Combined means over locations	SM-005	86a	119ab	0.0^{NS}	97a	2.55^{NS}	64b	1068b
	SM-006	85ab	121a	0.0	95ab	2.4	62c	1085b
	SM-008	87a	116c	0.0	98a	2.4	61c	1118b
	Binatil-2	82b	120a	2.5	88b	2.4	57d	1150a
	BARI Til-4	85ab	118b	2.3	98a	2.1	67a	993c
Location means								
Sub-station Ishwardi		85^{NS}	99 b	1.0^{NS}	99b	2.1^{NS}	53b	973b
Sub-station Chapainawabgonj		85	138a	0.9	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.

Results obtained from the trial of individual location and combined over locations for all the characters are presented in Table 48. Significant variations were observed among the mutants and check varieties for most of the characters in both of individual locations and combined over locations. On an average, days to maturity ranged from 82 in Binatil-2 to 87 in SM-008. Mutant SM-006 produced the tallest (121cm) plant and SM-008 produced the shortest height (116cm). Both check varieties produced branched but all the three mutants were uniculm type. Mutants SM-005 and SM-008 produced the significantly higher number of capsules plant^{-1} compared to the check variety Binatil-2. On an average, Binatil-2 produced the highest seed yield of 1150 kg ha^{-1} followed by the mutants SM-008, SM-006 & SM-005 and produced seed yields of 1118, 1085 & 1068 kg ha^{-1}, respectively. Check variety BARI Til-4 produced the lowest seed yield (993 kg ha^{-1}).

Growing M_4 population

A large number of M_4 populations from China Black, China White and Pahari Til were grown in plant progeny rows for selecting desirable mutants at BINA HQ farm, Mymensingh. From them primarily, a total of 12 mutants have been selected for further selection in subsequent generations.

Growing M_3 population

A large number of M_3 population from Pahari Til (from three different doses) were grown in plant progeny rows for selecting desirable mutants at BINA HQ farm, Mymensingh. From them primarily a total of 8 mutant variants have been selected for further selection in subsequent generations.

Growing of M_1 population

To create genetic variability, seeds of two popular sesame variety Binatil-2 and Binatil-4 were irradiated with 600, 700, 800 and 900Gy of gamma rays. Seed were sown on 27th March 2020 at BINA HQ farm, Mymensingh. The experiment was followed by non replicated design and sown separately (variety and dose wise). Finally, the survived plants that produced seeds were harvested separately for growing M_2 population.

Maintenance of germplasm (mutants, local and exotic collections)

Twenty five germplasm lines along with five stable mutants were grown in BINA HQ farm, Mymensingh. After harvest, collected all of these seeds and germplasm were preserved as breeding materials for future research programme.

SOYBEAN

Preliminary yield trial with selected M_5 soybean mutant

Five promising mutants (SBM-02, SBM-07, SBM-08, SBM-09 and SBM-10) along with two check varieties Binasoybean-2 and BARI Soybean-6 were evaluated through this trial. The experiment was conducted at BINA HQ farm, Mymensingh and BINA sub-station farms at Magura, Noakhali and Rangpur and farmers' field at Noakhali and Chandpur during January to April 2020. The experiment was laid out in a randomized complete block design with three replications. Sowing was done within first week of January. Spacing between rows was 30cm and 5-8cm 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 into kg ha^{-1}. Data recorded from the experiment were analyzed following appropriate statistical design.

Results obtained from the trial of individual location and combined over locations for all the characters are presented in Table 49. Significant variations were observed among the mutants and check varieties for most of the characters in both of individual locations and combined over locations. Due to heavy rainfall during flowering and maturity stages, it was not possible to take data from the experiment conducted at Noakhali sub-station.

On an average, maturity period ranged from 108 days in SBM-02 & Binasoybean-2 to 121 days in SBM-08. Plant height and branches plant^{-1} ranged from 47cm in Binasoybean-2 to 85cm in SBM-02. Branches plant^{-1} ranged from 3.0 in SBM-07 & BARI Soybean-6 to 5.0 in

Binasoybean-2, respectively. The mutant SBM-08 produced the highest number of pods plant^{-1} (106) followed by the mutant SBM-02 (86) and lowest was recorded in SBM-07 (68). Two check varieties Binasoybean-2 and BARI Soybean-6 produced pods plant^{-1} 82 and 79, respectively. Pod length ranged from 3.3cm in BARI Soybean-6 to 3.8cm in SBM-10 and Binasoybean-2. Binasoybean-2 produced the highest seed yield of 2554 kg ha^{-1} followed by SBM-09 (2549 kg ha^{-1}) and SBM-07 (2502 kg ha^{-1}). Check variety BARI Soybean-6 produced the lowest seed yield of 2003 kg ha^{-1}.

Among four locations the highest seed yield of 2914 kg ha^{-1} at farmer's field of Laxmipur followed by 2428 kg ha^{-1} at farmer's field of Haimchar. The lowest seed yield of 1865 kg ha^{-1} was obtained BINA sub-station farm, Magura.

Table 49: Mean performance of soybean mutants along with check varieties for different quantitative characters

Locations	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})
BINA	SBM02	125b	123a	5a	43c	3a	3.5ab	1333b
Substation	SBM-07	107bc	68b	3b	42c	2b	3.5ab	2033ab
Magura	SBM-08	152a	69b	3b	71b	3a	4.5a	1366b
	SBM-09	124b	78b	4ab	102a	3a	3.8ab	3300a
	SBM-10	103c	29c	4ab	43c	2b	3.8ab	2066ab
	Bina Soybean-2	103c	23c	5a	58bc	3a	3.7ab	2100ab
	BARI Soybean-6	124b	67b	3b	56bc	2ab	2.8b	860b
BINA	SBM02	106c	68b	3.0b	108b	3bc	3.4ab	2420a
Substation	SBM-07	109bc	95a	4.0ab	99c	4ab	3.8a	2493a
Rangpur	SBM-08	106c	39cd	5.0a	137a	5a	3.3b	1803b
	SBM-09	114b	68b	3.0b	75e	3bc	3.5ab	2357a
	SBM-10	106c	36d	3.0b	96c	3bc	3.7ab	1630b
	Bina Soybean-2	106c	49c	5.0a	98c	2c	3.8a	2157ab
	BARI Soybean-6	118a	49c	3.0b	86d	3bc	3.4ab	1690b
Farmer's	SBM02	100c	72bc	3.0bc	104b	3bc	3.4ab	2733c
Field	SBM-07	115.0a	89a	2.0c	63f	4ab	3.8a	3133b
Lakhipur	SBM-08	102c	74b	5.0a	133a	5a	3.2b	3416a
	SBM-09	109b	58d	3.0bc	71e	2c	3.5ab	2783c
	SBM-10	109b	72bc	3.0bc	100bc	3bc	3.7ab	2667c
	Bina Soybean-2	102c	65cd	4.0ab	94c	3bc	3.8a	2833c
	BARI Soybean-6	104bc	70c	3.0bc	82d	3bc	3.4ab	2833c
Farmer's	SBM02	101c	76ab	3.0ab	90.0a	3^{NS}	3.8b	1967e
Field	SBM-07	115bc	51b	2.0b	67.0b	3	3.6c	2347d
Hymchar	SBM-08	124a	73ab	3.0ab	81.0ab	3	3.8b	2557c
	SBM-09	101c	51b	4.0a	81.0ab	3	3.6c	1757f
	SBM-10	119b	67ab	4.0a	90.0a	3	4.1a	2617b
	Bina Soybean-2	119b	51b	4.0a	76.0ab	2	4.0a	3127a
	BARI Soybean-6	100c	79a	3.0ab	91.0a	3	3.8b	2627b

Combined mean over locations	SBM02	108c	85a	4ab	86b	3^{NS}	3.5bc	2113d
	SBM-07	112b	76b	3b	68d	3	3.7ab	2502b
	SBM-08	121a	64cd	4ab	106a	4	3.7ab	2283c
	SBM-09	112b	64cd	4ab	82bc	3	3.6b	2549ab
	SBM-10	109c	51d	4ab	82bc	3	3.8a	2245c
	Bina Soybean-2	108c	47d	5a	82bc	3	3.8a	2554a
	BARI Soybean-6	112b	66c	3b	79c	3	3.3c	2003e
Location mean								
BINA Substation, Magura		120a	65ab	4^{NS}	59d	3^{NS}	3.6ab	1865d
BINA Substation, Rangpur		109c	58c	4^{NS}	100a	3	3.5b	2078c
Farmer's Field, Lakhipur		106d	71a	3^{NS}	92b	3	3.5b	2914a
Farmer's Field, Hymchar		111b	64b	3^{NS}	82c	2	3.8a	2428b

N. B.: In a column, values with same letter(s) for individual location/combined means do not differ significantly at 5% level.
BNSB-2 means Binasoybean-2 & BRSB-6 means BARI Soybean-6

On-station yield trials with advance soybean mutants during Rabi 2020

Five promising mutants (SMB-01, SMB-02, SMB-03, SMB-04 and SMB-05) along with check variety Binasoybean-2 were evaluated through this trial. The experiment was conducted at the experimental field of BINA Head quarters farm, Mymensingh during January to April 2020. The experiments were laid out in randomized complete block design with three replications. Sowing was done within first week of January. 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 into kg ha^{-1}. Data recorded from the experiment were analyzed following appropriate statistical design.

On an average, maturity period ranged from 111 days in SMB-03, SMB-04, SMB-05 to 115 days in Binasoybean-2 (Table 50). Plant height and branches/plant ranged from 36.7cm to 61.7cm and 3.7 to 8.3. The mutant SMB-01 gave the highest plant height of 61.7cm followed by check variety Binasoybean-2. Mutant SMB-02 had shortest plant height of 36.7cm. The mutant SMB-02 produced highest pods/plant (56.0) where the check variety Binasoybean-2 produced 46 pods/plant. The mutant SMB-04 and SMB-05 produced highest number of seeds/pod (2.7) followed by mutant SMB-01 (2.4) and SMB-03 (2.3). Seed yield obtain from the mutant and check were significantly differ from each other's. The mutant SMB-05 produced the highest seed yield of 3475.3 kgha^{-1} followed by SMB-04 (3407.4 kgha^{-1}) and Binasoybean-2 produced the lowest seed yield (2583 kgha^{-1}).

Table 50: 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.)	Pod length (cm)	100-seed weight (g)	Seed yield (kg ha^{-1})
SMB-01	112ab	62a	6ab	55bc	2^{NS}	3.6b	128c	3327ab
SMB-02	113ab	37d	8a	56b	2	3.8a	118d	2975b
SMB-03	111b	47b	5b	60ab	2	3.7ab	160a	3333ab
SMB-04	111b	42c	6ab	65a	3	3.6b	127c	3407ab
SMB-05	111b	47bc	6ab	49bc	3	3.5bc	134b	3475a
Binasoybean-2	115a	49b	4c	46c	2	3.4c	134b	2583c

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

Eight soybean varieties (Sohag, Binasoybean-2, Binasoybean-3, Binasoybean-4, Binasoybean-5, Binasoybean-6, BUSoybean-1 and BARI Soybean-6) were evaluated through this trial. The experiment was conducted at the farmer fields at laxmipur to find out overall performance of these varieties at saline soil. The experiment was laid out in randomized complete block design with three replications. Sowing was done within first week of January 2020. Spacing between rows was 30cm and 5-8cm 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 into kg ha^{-1}. Data recorded from the experiment were analyzed following appropriate statistical design.

Table 51: Mean performance of soybean varieties for different quantitative characters during Rabi 2019

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})
Sohag	115a	85b	4a	73de	3^{NS}	3.6d	1700d
Binasoybean-2	95e	49de	4a	105b	3	4.1b	3200a
Binasoybean-4	100d	55d	3ab	90c	3	3.8c	2800bc
Binasoybean-3	98de	96a	4a	121a	3	4.8a	3100a
Binasoybean-6	106c	74c	3ab	91c	3	3.8c	2850b
Binasoybean-5	99de	69cd	4a	90c	2	3.8c	2750bc
BU Soybean-1	105c	36e	2b	86cd	3	3.8c	1800d
BARI Soybean-6	110b	86b	4a	81d	3	4.0b	2200c

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

Results obtained from the trial for all the characters are presented in Table 51. Significant variations were observed among the mutants and check varieties for most of the characters. On an average, maturity period ranged from 95 to 115 days. It was observed that all BINA developed varieties matured earlier than others. Sohag required the highest days to mature (115 days) followed by BARI Soybean-6 (110 days). Among the varieties Binasoybean-2 matured earlier than others and it required only 95 days. Plant height and branches plant^{-1} ranged from 36.0cm to 95.8 and 4.0 to 2.0, respectively. Binasoybean-3 produced the tallest plants of 96cm followed by BARI Soybean-6 (86cm) and Sohag (86cm). BU Soybean-1 had the shortest plant height of 36cm followed by Binasoybean-2 (49cm). BU Soybean-1 produced the lowest number of 2.0 branches plant^{-1}, whereas other varieties produce 3.0 to 4.0 branches plant^{-1}. Binasoybean-3 produced the highest number of pods plant^{-1} (121) followed by Binasoybean-2 (105) and Sohag produced the lowest number (73).

Number of seeds pod^{-1} and pod length is also indicators to contribute seed yield. Even though seeds pod^{-1} of all the genotypes did not differ significantly from each other, but pod length had a wide range and it was from 3.6 to 4.8cm Longer pod was found in Binasoybean-3 (4.8cm) followed by Binasoybean-2 (4.1cm) and BARI Soybean-6 (4.0cm). Sohag produced the smallest pod (3.6cm). Binasoybean-2 produced the highest seed yield of 3200 kg ha^{-1} followed by Binasoybean-3 (3100 kg ha^{-1}). Seed yield of Binasoybean-4, Binasoybean-5 and Binasoybean-6 were statistically similar (2750 -2850 kg ha^{-1}). Considering the agronomic performances of all varieties it can concluded that BINA developed varieties especially Binasoybean-2, Binasoybean-3 and Binasoybean-6 are the best variety for the soybean growing areas as well as salt affected areas.

Growing of M_4 and M_5 population

A large number of M_4 and M_5 population from BARI Soybean-5, Binasoybean-2, Lokon and Sohag were grown in plant progeny-row for selecting desirable mutants at BINA HQ farm, Mymensingh. From them primarily, a total of 9 mutants have been selected based on their agronomic performances for subsequent generations.

Growing M_3 population

A large number of M_3 population from Binasoybean-3, Lokon and Taiwan-141 were grown in plant progeny-row for selecting desirable mutants at BINA HQ farm, Mymensingh. From them primarily a total of 19 mutant variants have been selected based on their agronomic performances for subsequent generations.

Growing M_2 population

To create genetic variability, seeds of two popular soybean varieties GC480 and BU soybean-1 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.

Growing M_1 population

To create genetic variability, seeds of two popular soybean variety BU soybean-2 and Binasoybean-2 were irradiated with 150, 200, 250, 300 and 400Gy of gamma rays. Seed were sown on 27th January 2020 at BINA HQ farm, Mymensingh. The experiment was followed non-replicated design and sown separately (variety and dose wise). At harvest the survived plants that produced seeds were harvested separately for growing M_2 population.

Maintenance of germplasm (mutants, local and exotic collections)

Fifty germplasm lines 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.

Crossing among BU Soybean-1, Binasoybean-2 & 3 and GC-840

BU Soybean-1 was crossed with Binasoybean-2 and F_1 seeds were harvested to grow F_2 generations.

SUNFLOWER

Growing M_2 population

To select early maturing, strong and dwarf type plant with high yielding sunflower mutants, M_2 population (492) from BARI Surjomukhi-2 at three different doses were grown in plant progeny-rows at BINA HQ farm, Mymensingh. Seed were sown on 28 December 2020. The parent BARI Surjomukhi-2 was also includes in this experiment. The experiment was followed non-replicated design. Unit plot size was $24m^2$ ($4m \times 6m$) with 50cm line to line spacing and 25cm from plant to plant within line. Recommended production packages i.e., application of fertilizers, irrigation and pesticide, weeding, thinning etc. were followed to ensure normal plant growth and development. Finally, a total of 23 mutant variants have been selected for further selection in subsequent generations.

Maintenance of germplasm (local and exotic collections)

25 germplasm lines were grown at BINA HQ farm, Mymensingh. Considering various desirable characters from these germplasms, 10 lines were selected for future advanced trial. Rests of all were preserved as breeding materials for future research programme.

MUNGBEAN

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

On-farm trials were carried out with two mutants along with one check varieties BARI Mung-6) at BINA sub-station Ishurdi and Magura, during Kharif-1 season of 2020. 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. 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 t ha^{-1}. Mean values are presented in Table …...

It is observed from Table 52 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} (39) and pod length (9.2cm) was found in MBM-427-87-3. In respect of seed yield, MBM-427-87-3 produced the highest seed yield of 1.81t ha-1followed by BARImoog-6 (1.67t ha^{-1}).Among this lines, MBM-427-87-3 already has been released as Binamoog-10.

Table 52: Mean performance of mutants along with the check varieties grown at Ishurdi and Magura during 2020

Mutants/varieties	Days to maturity	Plant height (cm)	Pods plant^{-1} (no)	Pods length (cm)	Seeds pod^{-1} (no)	Seed yield (t ha^{-1})
Ishurdi (Sub-station)						
MBM-656-51-2	66a	49	37a	8.2b	12	1.60b
MBM-427-87-3	63a	53	39a	9.2a	13	1.78a
BARI Mung-6	71b	52	32ab	8.1b	11	1.62c
Magura (Sub-station)						
MBM-656-51-2	68a	42ab	35a	8.9ab	13a	1.64a
MBM-427-87-3	66a	54a	35a	9.2b	13a	1.81a
BARI Mung-6	72ab	51a	31ab	8.3a	10ab	1.67b
Mean over locations						
MBM-656-51-2	67a	45ab	36a	8.5a	12a	1.62b
MBM-427-87-3	65a	53a	37a	9.0a	13a	1.79a
BARI Mung-6	71ab	51a	31ab	8.2ab	10ab	1.64b

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

Screening of some mungbean genotypes under salt in pot culture

This pot experiment was conducted using 26 mungbean genotypes and exposure to salt stress (EC = 8.0 dS/m) applied at the reproductive stage, just before the opening of the first flowers to evaluate reproductivestage specific salt tolerance as well as investigate the inherent variability of mungbean genotypes with respect to seed yields and yield-related traits.The experiment involved maintaining 100% field capacity for three weeks and used a randomized complete block design with three replicates. Data were collected, included days to maturity, plant height (cm), number of pod-bearing branches perplant, number of pods per plant, pod length (cm), the number of seeds per pod, 100-seed weight (g) and seed yield per plant (g).

Effect of salt stress on various morphological traits of mungbean genotypes

Days to maturity

The highest number of days to maturity (79.43 days) was recorded in the genotype BMX 11122, whereas the least (49.66days) was recorded in the genotype BMX 11116, under control conditions (Table 53). Under salt stress conditions, the highest number of days to maturity (69.50 days) was recorded in the genotype BMX 11140, whereas the leastnumber of days (45.18 days) was found in the genotype BMX 11116. Salt stress led to a significant decrease in days to maturity. The greatest reduction (29.15%) in days to maturity was recorded for the genotype BMX 1157, followed by 29.09, 27.70 and 22.35%in BMX 11122, BMX 11106 and BMX 11107, respectively. The least reduction (6.00%) was found for the genotype Binamoog-9 (Table 53).

Plant height (cm)

The greatestplant height (47.58 cm) was recorded forthe genotype BMX 11122, whereas the least plant height (14.66 cm) was recorded forthe genotype BMX 11116,under control conditions. Under salt stress conditions, the greatestplant height(46.12 cm) was recorded in the genotype BMX 11165, whereas the least(4.56 cm) was found in the genotype BMX 11116. Salt stress caused a significant reductionin plant height forall the genotypes compared to control plants. The greatestreduction (33.52%) was recorded for the genotype BMX 11122, followed by BMX 11106 (31.38%), BMX 11154 (30.88%), Binamoog-9 (21.28%), BMX 11144 (21.28%), BMX 11116 (21.11%), BMX 11111 (20.70%), BMX 1131 (20.55%) and BMX 1157 (20.54%), with the least reduction (6.05%) found forthe genotype BMX 11163 (53).

Number of pod-bearing branches per plant

Under control conditions the greatestnumber of pod-bearing branches per plant (7.22) was recorded forthe genotype BMX 11122, whereas the least (2.44) was recorded forthe genotype BMX 11154. Under salt stress condition, the greatestnumber of pod-bearing branches per plant (3.89) was recorded forthe genotype BMX 11140 whereas the least (1.46) was found forthe genotype BMX 1157. Imposition of salt stress resulted in a significant decrease in the number of pod-bearing branches per plant, with the greatest reduction observed in the genotype BMX 1157 (59.50%), followed by BMX 11122, BMX 11157, BMX 11159, BMX 11154, BMX 1137, BMX 11131, Binamoog-5, BMX 11141, BMX 11106 and BARI Mung-6(56.16, 43.25, 37.11, 34.65, 33.55, 33.22, 30.94, 28.86, 28.79 and 27.88%, respectively) and the least reduction observed forthe genotype BMX 11176 (6.55%) as compared to control (Table 53).

Number of pods per plant

The greatestnumber of pods per plant (23.72) was recorded in the genotype BMX 11122, whereas the least (3.50) was recorded forthe genotype BMX 1137under control conditions. Under salt stress condition the highest number of pods per plant (7.56) was recorded in the genotype BMX 11122 whereas the least number of pods per plant(2.45)was found forthe genotype BMX 1137.A significant decrease in thenumber of pods per plant in response to salt stresswas found,with the greatest reduction (80.47%) for the genotype BMX 11159, followed by 68.14, 63.95, 61.37, 60.33, 53.23, 46.30, 45.69, 41.24, 41.22, 40.04and 39.57% for the genotypesBMX 11122, BMX 1157, Binamoog-9, BMX 11144, BMX 11154, BMX 11106, BMX 1141,Binamoog-8, BMX 11111, BMX 11148 and BMX 11157, respectively. The smallest decrease (20.15%) was found forBARI Mung-6 (Table 53).

Pod length (cm)

Under control conditions the greatestpod length (8.73 cm) was recorded forthe genotype BMX 1131, whereas the lowest (5.52 cm) was recorded forthe genotype BMX 11108. Under salt stress conditions the greatestpod length (7.95 cm)was recorded forthe variety BARI Mung-6,whereas the smallestpod length (4.75 cm) was found forthe genotype BMX 11108. Salt stress led to a significant reduction in pod length, as compared to controls, the greatest reduction(27.03%) was for genotype BMX 11159 followed by BMX 11122 (21.70%), BMX 11140 (18.99%), BMX 1131 (17.72%), BMX 11116 (16.10%), BMX 11106 (15.82%), BMX 11165 (14.73%), Binamoog-9 (14.66%), BMX 1157 (13.37%), Binamoog-8 (13.33%).The least reduction (6.17%) was recorded for the genotype BMX 1153 (Table 53).

Number of seeds per pod

The greatestnumber of seeds per pod (10.61) was recorded forthe genotype BMX 11106, whereas the lowest (5.76) was recorded forthe genotype BMX 11116, under control conditions. Under salt stress conditions the greatestnumber of seeds per pod was recorded forthe genotype BMX 1157, whereas the leastwas found in the genotype BMX 11154. Imposition of salt stress resulted in a significant decrease in number of seeds per pod for all the genotype as compared to control. The greatest percentage of reduction (49.91%) in numberof seeds per pod was recorded for the genotype BMX 11111, followed by BMX 11159, BMX 11165, BMX 11154, BMX 1153, BMX 11157, BMX 11106, Binamoog-8, BMX 11148, Binamoog-9 (47.22, 46.59, 44.87, 43 61, 41.05, 38.45, 31.73, 30.66 and 30.12%, respectively) and least percentage reduction (9.93%) was recorded for genotype BMX 11144 (Table53).

100-seed weight (g)

Under control conditions the greatest 100-seed weight (8.12 g) was recorded forthe genotype BMX 1153, whereas the least (2.40 g) was recorded in the genotype BMX 11159. Under salt stress condition, the greatest 100-seed weight (6.21 g) was recorded forthe genotype BMX 1137, whereas the least (1.78 g) was found in the genotype BMX 11159. A significant reduction in 100-seed weight was observed in response to salt stress, the greatest reduction(54.90%) was recorded forthe genotype BMX 11106 followed by 50.60, 45.41, 39.14, 37.41, 36.48, 35.53, 32.70, 31.26, 31.02, 30.62, 30.60 and 30.53% for the genotypes BMX 11111, BMX 11144, BMX 11148, BMX 1141, BMX 1157, BARI Mung-6, BMX 11108, Binamoog-8, BMX 11122, BMX 11107, BMX 1153 and Binamoog-9, respectively. The leastreduction (9.85%) was recorded for the genotype BMX 11176 (Table 53).

Seed yield per plant (g)

Under control conditions the highest seed yield per plant 3.39 (g) was recorded in the genotype BMX 11140, whereas the lowest 1.40 (g) was recorded in the genotype BMX 11108. Under salt stress condition the highest seed yield per plant (2.35 g) was recorded forthe genotype BMX 11140, whereas the lowest (0.79 g) was found in the genotype BMX 11159. Imposition of salt stress resulted in a significant decrease in seed yield per plant for all the genotypes compared to control. Thegreatest reduction in seed yield per plant was recorded forthe genotype BMX 11159

(83.05%), followed by BMX 1157 (72.03%), BMX 11153 (70.53%), BMX 11144 (65.59%), BMX 11148 (60.70%), Binamoog-8 (57.53%), BMX 1153 (56.46%), BMX 11106 (55.47%), BMX 11122 (55.38%), Binamoog-9 (51.30%), BMX 11157 (50.10%). The lowest reductionwas recorded forthe genotype BMX 11116 (18.01%) (Table 53).

Based on their stress tolerance indices BARI Mung-6, BMX 11176, BMX 11116, and BMX 11140 were categorized as tolerant genotypes, were selected for further study under direct field conditions and are recommended for the genetic improvement of salt stress tolerance in mungbean.

Table 53: Combined effect of genotypes and treatment interaction on seed yield and yield-related traits of mungbean

Genotypes × Treatment		Days to maturity	Plant height (cm)	Pod-bearing branches^{-1}	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	100-seed weight (g)	Yield plant^{-1} (g)
BARI Mung-6	Control	56.30g-l	29.22j-n	3.44b-h	6.42c-j	8.47ab	7.73a-h	5.00c-i	3.33ab
	Salt	51.26pq	24.76p-u	2.48d-h	5.13e-p	7.95a-e	6.13f-m	3.22h-o	1.76i-r
Binamoog-9	Control	63.95c	29.61j-m	4.72bc	9.22c	8.03a-d	7.71a-h	5.15c-h	3.07abc
	Salt	60.11def	23.31r-u	3.56b-g	3.56j-p	6.88c-m	5.34g-m	3.58g-o	1.49n-u
Binamoog-5	Control	57.88fgh	31.55g-j	3.11c-h	6.37c-k	7.11b-l	7.22d-k	4.37d-k	2.29c-m
	Salt	54.14i-p	26.56m-r	2.15fgh	5.30e-p	6.30h-n	5.54f-m	3.30h-o	1.48n-u
Binamoog-8	Control	52.95m-q	24.72p-u	2.89c-h	4.66f-p	8.03a-d	7.50b-i	3.75f-o	1.86g-r
	Salt	49.66q	26.60stu	2.33e-h	2.74op	7.11b-l	5.12g-m	2.58j-o	0.79t-x
BMX 11159	Control	60.22def	39.91bc	5.39ab	12.63b	6.52f-n	10.43ab	2.40k-o	2.93a-d
	Salt	52.160pq	33.72fgh	3.39b-h	2.47p	5.52mno	5.50f-m	1.78o	0.49x
BMX 11148	Control	63.27cd	26.20n-r	2.81c-h	4.80e-p	6.56e-n	6.95d-k	6.45a-d	1.81h-r
	Salt	59.15efg	23.41r-u	2.50d-h	2.88nop	6.56e-n	4.82h-m	3.92f-o	0.68vwx
BMX 11165	Control	60.29def	46.12a	3.33b-h	4.73e-p	7.15b-k	8.02a-g	5.59b-g	2.48c-j
	Salt	55.19h-o	40.57bc	2.51d-h	3.83g-p	6.75d-n	4.28klm	4.42c-k	1.52m-u
BMX 11163	Control	57.72fgh	30.90h-k	2.67c-h	6.45c-i	7.37a-j	7.15d-k	4.32d-k	2.44c-j
	Salt	53.08l-p	29.03 j-o	2.44e-h	5.83d-m	6.73d-m	6.42e-l	3.86f-o	1.58l-t

BMX 1141	Control	61.56cde	35.23def	3.28c-h	5.84d-m	7.08b-l	6.07f-m	5.75b-f	2.54b-i
	Salt	56.48g-k	31.42g-j	2.33e-h	3.17m-p	6.71d-n	4.36j-m	3.59g-o	1.52m-u
BMX 11153	Control	69.19b	37.20cde	3.11c-h	6.02d-m	7.01c-l	7.67a-h	4.09e-m	2.50c-j
	Salt	56.06g-n	34.56efg	2.41e-h	4.06g-p	6.50f-n	5.47f-m	3.39h-o	0.74u-x
BMX 1137	Control	59.80ef	30.45h-l	3.03c-h	3.50k-p	7.78a-g	8.03a-g	7.41ab	2.48c-j
	Salt	56.04g-n	25.50p-t	2.01fgh	2.45p	6.65d-n	6.11f-m	6.21a-e	1.44o-v
BMX 11122	Control	79.43a	47.58a	7.22a	23.72a	6.28h-n	7.36c-j	2.88i-o	1.46o-v
	Salt	56.32g-l	31.63g-j	3.17c-h	7.56cde	5.74l-o	5.78f-m	1.99mno	0.65wx
BMX 11107	Control	72.33b	30.41h-l	3.30c-h	5.66e-n	6.15h-o	7.60b-i	3.53g-o	2.01e-q
	Salt	56.17g-m	25.69o-t	2.97c-h	4.78e-p	5.98j-o	6.16f-m	2.45j-o	1.28q-x
BMX 11157	Control	57.32f-j	30.18i-l	2.69c-h	4.70e-p	6.75d-n	9.43a-e	4.00f-m	1.74j-r
	Salt	53.18k-p	27.86k-p	1.53gh	2.84nop	6.11h-o	5.56f-m	2.89i-o	0.87s-x
BMX 11170	Control	57.74fgh	27.50l-q	3.11c-h	5.35e-o	7.51a-h	10.31abc	3.21h-o	2.42c-k
	Salt	54.04j-p	23.18r-u	2.39e-h	3.63i-p	6.40g-n	8.36a-f	2.33k-o	1.31q-w
BMX 11176	Control	57.85fgh	26.41m-r	2.44e-h	6.52c-h	7.81a-f	8.45a-f	3.76f-o	2.61a-g
	Salt	53.05l-p	24.41q-u	2.28e-h	5.50e-o	7.30b-k	7.55b-i	3.39h-o	1.88f-r
BMX 11116	Control	49.66q	14.66w	3.33b-h	6.45c-i	6.15h-o	5.76f-m	3.88f-o	2.56b-h
	Salt	45.18r	11.56w	3.09c-h	5.83d-m	5.41no	5.03g-m	3.29h-o	2.20d-o
BMX 11108	Control	56.33g-l	22.35tuv	2.89c-h	5.34e-o	5.52mno	6.35f-l	5.08c-h	1.40p-w
	Salt	52.12opq	19.12v	2.44e-h	3.39m-p	4.75o	4.62i-m	3.42h-o	0.76u-x
BMX 11106	Control	79.16a	35.87def	3.28c-h	6.62c-g	7.16b-k	10.61a	4.01f-m	1.77i-r
	Salt	57.23f-j	24.62p-u	2.33e-h	3.56j-p	6.11h-o	6.53e-l	1.81no	0.79t-x
BMX 11154	Control	57.43f-i	38.27cd	2.44e-h	6.29d-k	6.77d-n	5.85f-m	3.13h-o	2.67a-f
	Salt	53.17l-p	26.45m-r	1.60gh	2.94nop	5.91k-o	3.22m	2.48j-o	1.39p-w
BMX 11140	Control	69.50b	27.82k-p	4.28b-e	7.17c-f	7.95a-e	9.55a-d	4.55c-j	3.39a

	Salt	63.25cd	25.97n-s	3.89b-f	6.33d-k	6.64d-m	7.99a-g	3.94f-n	2.35c-l
BMX 11111	Control	57.41f-i	27.36l-q	4.00b-f	6.27d-l	6.66d-n	7.65a-h	4.14e-l	2.27d-n
	Salt	51.32pq	21.70u	3.06c-h	3.68h-p	6.50f-n	3.83lm	2.05l-o	1.48n-u
BMX 11144	Control	57.65fgh	42.52b	4.55bcd	8.61cd	6.63d-n	7.99a-g	3.34h-o	2.16d-p
	Salt	53.81k-p	33.47f-i	3.52b-h	3.42l-p	6.05i-o	7.19d-k	1.82no	0.74u-x
BMX 1153	Control	57.14f-j	26.56m-r	2.78c-h	4.83e-p	8.22abc	7.85a-g	8.12a	2.79a-e
	Salt	52.80n-q	23.24r-u	2.20e-h	3.32m-p	7.44a-i	7.85a-g	5.64b-g	1.21r-x
BMX 1131	Control	61.37cde	34.45efg	3.00c-h	5.48e-o	8.73a	7.42c-i	5.22c-h	2.63a-g
	Salt	55.04h-o	27.37l-q	2.00fgh	4.15g-p	7.46a-h	7.42c-i	3.80f-o	1.63k-s
BMX 1157	Control	79.35a	34.77efg	3.61b-g	7.32c-f	7.01c-l	8.43a-f	6.52abc	2.30c-m
	Salt	56.22g-m	27.62k-q	1.46h	2.64op	6.15h-o	8.43a-f	4.14e-l	0.64wx

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

Growing of M_3 generation of mungbean for synchronous pod maturity

For synchronous pod maturity, seeds of Binamoog-8 variety were irradiated with Cobalt^{60} gamma rays. Irradiation doses were 20, 40, 60 and 80 Gy. A large number of M_3 population were grown in plant progeny rows for selecting desirable mutant at BINA Head quarters farm, Mymensingh during Kharif-1 season 2020. A total of 23 mutants have been selected primarily for future selection in M_4 generations.

Growing of M_3 generation of mungbean

A large number of M_3 population were developed from BARI Mung-6 were using induced mutation grown in plant progeny rows for selecting desirable mutant at BINA Head quarter farm, Mymensingh. From them a total of 15 mutants have been selected primarily for future selection in M_4 generations.

CHICKPEA

On-farm trial of two chickpea mutants

Two mutants along with two check varieties were put into on-farm trial at Ishurdi and Chapainawabganj during 2019-2020. The experiment was carried out in a randomized complete block design (RCBD) with three replications. Unit plot size was 4 m × 5 m. Distances between rows and plants were 40 and 10 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 54.

Table 54: Mean performance of two promising mutants of chickpea during 2019-20

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	124	70.12	7.00	58	1.71	22.97	1.68
CPM-8-300	127	61.98	6.89	66	1.92	23.19	1.83
BARI Sola-7 (Check)	129	58.73	5.12	42	1.69	16.86	1.71
Chapainawabganj							
CPM-8-200	123	72.58	6.21	56	1.64	23.72	1.73
CPM-8-300	126	67.37	7.00	65	1.78	23.59	1.84
BARI Sola-7 (Check)	128	56.59	5.44	45	1.52	17.67	1.69
Mean Over Location							
CPM-8-200	123	71.35	6.60	57	1.67	23.34	1.70
CPM-8-300	126	64.67	6.94	65	1.85	23.39	1.83
BARI Sola-7 (Check)	128	57.66	5.28	42	1.60	17.26	1.70

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 (71.35cm) 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 byCPM-8-200. The 100-seed weight of CPM-8-300 was the highest, 23.39 (g) followed by CPM-8-200, 23.34 (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.

Growing of M_3 generation of chickpea

Seeds of three chickpea varieties (Binasola-4, CPM-8) were irradiated with Cobalt^{60} gamma rays. Irradiation doses were 300, 350 and 400 Gy. Dose wise Bulk seed of each variety were grown at BINA sub-station farm Ishurdi and Chapainawabganj during 2019. Nine lines were selected based on bolder seed size, higher yield and disease tolerance.

LENTIL

On-station yield trial of three promising lentil mutants along with a check variety

On-stations yield trials were conducted with three mutant lines along with a check variety Binamasur-8 at BINA sub-stations Magura and Chapainawabganj during 2019-2020. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20m^2 (5 m × 4 m) with 30cm 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 55.

Results revealed that significant variations were observed among the mutants and the check variety for days to maturity, pods per plant and seed yield at the two locations. On an average, maturity period varied from 100 days to 107 days. The shortest duration for maturity was found in the mutant LM-99-8 followed by the check variety Binamasur-8. The mutant LM-99-8 produced the highest number of pods plant^{-1} as well as the highest seed yield 2223 kg ha^{-1} followed by LM-206-5 with 2133 kg ha^{-1} at Magura. The mutant LM-99-8 produced the highest seed yield followed by LM-118-9 at Chapainowabgonj. This experiment will be carried out in the next season for confirmation of the trials.

Table 55: On-station trial with three lentil mutants/line along with a check variety, Binamasur-8 at two locations Magura, and Chapainawabgonj during 2019-20

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	100-seed weight (g)	Yield plot^{-1} (kg ha^{-1})
Magura						
LM-99-8	103b	48.6	2.5	79.8a	2.1	2223a
LM-118-9	107a	46.7	2.4	63.0ab	2.0	1912b
LM-206-5	104b	47.4	2.9	76.0a	2.1	2133ab
Binamasur-8	103b	46.0	2.4	65.4ab	2.0	1990ab
		NS	NS		NS	
CV%	1.9	4.5	14.4	8.8	10.6	5.06
Chapainawabgonj						
LM-99-8	100c	39.4	1.2	70a	2.18	1701a
LM-118-9	103b	37.4	1.3	61.3ab	2.01	1560b
LM-206-5	105a	37.4	1.5	59.6b	2.07	1437c
Binamasur-8	101c	36.4	1.2	64a	2.07	1580b
		NS	NS		NS	
CV (%)	0.9	5.5	19.2	5.9	3.7	2.7

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

On-farm yield trial of some selected lentil mutants

On-station yield trials were conducted with three mutant lines along with a check variety, Binamasur-8 at BINA sub-stations, Magura and Chapainawabganj during 2019-20. 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 and pesticide weeding, thinning, irrigation 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 56.

Results revealed that significant variations were observed among the mutants and the check variety for pods plant^{-1} and seed yield at the three locations. On an average, maturity period varied from 99 days to 105 days. The mutant line LM-99-8 produced the highest number of pods plant^{-1} as well as the highest seed followed by Binamasur-8 yield in three locations. Further trial will be conducted in the next season.

Table 56: On-farm trial of three lentil mutants/line along with a check variety, Binamasur-8 at three locations, Magura, Natore and Chapainawabgonj during 2019-20

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	100 seed weight (g)	Yield plot^{-1} (kg/ha)
Magura						
LM-99-8	102	36	2.1	89.3a	2.0	1772a
LM-118-9	104	38.3	1.6	69b	1.9	1466b
LM-206-5	104	36	1.5	66.8b	1.8	1468b
Binamasur-8	102	36.1	1.8	86.3a	2.0	1722a
CV(%)	2.6	10.6	24.2	8.5	7.7	6.6
Natore						
LM-99-8	99c	31.5	2.2	78.9a	2.1	1767a
LM-118-9	102b	30.9	2.2	61b	1.8	1610b
LM-206-5	103ab	31.8	2.3	70.6ab	1.9	1720ab
Binamasur-8	105a	30.4	2.4	72b	2.0	1730ab
CV(%)	0.78	4.1	5.9	6.0	8.2	2.6
Chapainawabgonj						
LM-99-8	100b	41a	2.4a	85.3a	2.2	1762a
LM-118-9	104ab	40.2ab	1.7b	75.6ab	1.8	1630ab
LM-206-5	103ab	35.7bc	2.2ab	73.3bc	1.8	1564b
Binamasur-8	104a	34.5c	2.6a	81.3ab	2.1	1640b
CV(%)	1.18	4.8	10.7	13.2	10.2	3.0

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

Advanced yield trial of some selected mutants of lentil

The advanced yield trials were conducted with three mutants along with a check variety, Binamasur-8 at Chapainawabgonj and Ishurdi during 2019-2020. Seeds were sown in a randomized complete block design with three replications. Unit plot size was 5m x 4m and rows were 30cm apart. Normal cultural practices were followed. 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 accessions and the check are presented in the Table 57.

Results revealed that significant variations were observed among the mutants and check varieties for most of the characters in the two locations. On an average, maturity period varied from 98 days in LM-185-2 to 110 days in LM-20-4. The mutant LM-20-4 produced the highest number of pods as well as highest seed yield (1992 kgha^{-1}) followed by LM-138-3 (1888 kgha^{-1}) and Binamasur-8 (1874 kgha^{-1}) at Chapainawabganj. The highest number of pods plant^{-1}(113.4) and seed yield (2072 kgha^{-1}) were also found in LM-20-4 followed by Binamasur-8 at Ishurdi. These mutants will be evaluated in the next season at different lentil growing areas.

Table 57: Yield and yield contributing characters of three promising mutants along with a check variety, Binamasur-8 at Chapainawabgonj and Ishurdi during 2019-20

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches/ plant (no.)	Pods/plant (no.)	Yield (kg/ha)
Chapainawabgonj					
LM-20-4	108a	46a	2.2	89a	1992a
LM-138-3	99b	43ab	2.7	82ab	1888ab
LM-185-2	98c	42ab	2.2	71b	1740c
Binamasur-8	100b	40b	2.4	76 ab	1874b
CV (%)	0.8	4.1	12.4	10.50	3.85
Ishwardi					
LM-20-4	110a	41a	2.4	113a	2072a
LM-138-3	102	40ab	2.7	83ab	1741c
LM-185-2	100	35bc	2.6	92b	2006ab
Binamasur-8	103	34c	2.6	101b	2030b
CV (%)	0.8	4.8	9.3	7.10	5.14

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

Preliminary yield trial with some selected mutants of lentil

The preliminary yield trial was conducted with nine mutants along with a check variety, Binamasur-10 at Magura during 2019-2020. Seeds were sown in a randomized complete block design with three replications. Unit plot size was 3m x 2m and rows were 30 cm apart. Normal cultural practices were followed. 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 accessions and the check are presented in the Table 58.

Results unveiled that significant variations were observed among the mutants and check varieties for pods plant^{-1} and seed yield at Magura. On an average, maturity period varied from 101 days in LM-317-2 to 108 days in LM-126-2 and Binamasur-10. The highest number of pods plant^{-1}(105) and seed yield (2077 kg ha^{-1}) were found in LM-317-2 followed by LM-331-2 (1973 kg ha^{-1}), LM-162-1 (1917 kg ha^{-1}) and Binamasur-10 (1916 kg ha^{-1}). These mutants will be evaluated in the next season at different lentil growing areas.

Table 58: Yield and yield contributing characters of nine promising mutants along with a check variety, Binamasur-10 at Magura during 2019-2020

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Yield (kg ha^{-1})
LM-126-2	108a	42.4	4.1	79c	1740bc
LM-127-1	104	45.1	2.9	86bc	1804bc
LM-162-1	106b	41.3	3.7	92b	1917b
LM-244-4	105ab	38.8	3.6	78bc	1729bc
LM-245-5	106b	42.6	3.9	83bc	1773bc
LM-314-5	105ab	42.2	3.4	76c	1591c
LM-316-3	104c	40	3.7	73c	1563c
LM-317-2	101d	42.5	3.6	105a	2077a
LM-331-2	104c	43.2	3.2	99b	1973b
Binamasur-10	108a	43.6	3.0	94b	1916b
		NS	NS		
CV (%)	1.8	9.7	16.5	23.4	15.5

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

Effect of DAP and Boron spraying on lentil yield

A field experiment was conducted to investigate the effect of foliar application of DAP and Boron on yield and yield attributing characters of lentil during 2019-20 at BINA headquarters farm, Mymensingh. Foliar application of DAP and Boron was performed at flowering and pod formation stages of lentil. The experimental field was well prepared and laid out in a randomized block design with three replications. Treatment combinations were T1= control (no foliar application of DAP and Boron), T2= foliar application of DAP and T3= foliar application of Boron T4= foliar application of DAP and Boron. The unit plot size was 2m × 1.6m. The fertilizer applied was 20, 40, 40 kg N, P_2O_5, K_2O per hectare as basal in the form of urea, single super phosphate and muriate of potash. All the fertilizers were applied before sowing of lentil seed. Three per cent (3%) DAP (di-ammonium phosphate) and 0.2% Boron (solubor Boron) were applied at flowering and pod formation stages of lentil. Normal cultural practices were adopted to raise a good crop. Ten plant samples from each plot were randomly selected at 50% flowering stage for collecting data on plant height, number of branch plant^{-1} , fresh weight plant^{-1} (g), nodule number plant^{-1}, nodule dry weight plant^{-1} (mg). Data also recorded at harvest stage for plant height, number of pods per plant^{-1} , number of effective pod plant^{-1} , 100- seed weight (g) and seed yield plot-^{1}. Plot seed yield was converted into (kgha^{-1}). Statistical analysis of different characters of the variety and the check are presented in the table 59.

Results revealed that maximum fresh weight of plant, nodule number and dry weight of nodule were recorded in T_4 treatment at 50% flowering stage of lentil. The highest effective pods plant^{-1} and seed yield (2109 kgha^{-1}) were found in T4 treatments. It was noticed that spraying of DAP and Boron can increase 9.76% yield.

Table 59: Effects of foliar application of DAP and Boron on yield attributing characters of lentil

Treatment	50% flowering stage					Harvest stage				
	Plant height (cm)	Primary Branch No.	Fresh weight plant^{-1} (g)	Nodule no. plant^{-1}	Nodule dry weight plant^{-1} (mg)	Plant height	Pods plant-1	Effective pod plant-1	100 seed weight (g)	Seed yield
T1	44.4	1.0	17.3c	33.4b	20.0b	45.0	84.4b	70.6c	1.9	1903c
T2	46.5	1.2	18.3bc	44.3ab	26.8ab	47.2	98.2ab	88.6ab	2.0	1930c
T3	44.3	1.5	21.8ab	45.2ab	25.2ab	45.9	106.6a	100ab	2.1	2050b
T4	43.9	1.3	23.8a	54.6ab	30.7a	45.6	112a	107.6a	2.4	2109a
CV (%)	7.0	16.8	7.8	11.96	12.5	4.4	6.1	6.7	12.4	0.50

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

Growing of M_4 generation of lentil

To create variability Binamasur-5 and a new drought tolerant variety, 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-row at Chapainawabganj sub-station and BINA Headquarters farm 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, number of pods plant-^{1}, seed yield and erect plant type and disease reactions. A total of 34 M_3 lines were grown at BINA Headquarters farm, Mymensingh and 10 M_4 lines were selected on the basis of higher yield, earliness and disease reactions. All these lines will be grown for further selection in the next generation. Characteristics of the selected lines and the check are presented in the table 60.

Table 60: Characteristics of the selected mutant lines of lentil

Sl. No.	Mutant lines	Plant height(cm.)	Primary branch(no.)	Pods plant $^{-1}$(no.)	Characteristics
1	Binamasur-10, 300Gy, P2	57.1	2.16	383	More pods
2	Binamasur-10, 300Gy, P1	53.1	1.8	310	More pods
3	Binamasur-5, 250Gy, P16	40	2.2	76	Early
4	Binamasur-5, 250Gy, P15	37.5	1.0	70.2	Short stature
5	Binamasur-5, 250Gy, P4	44.1	1.8	81.8	Early
6	Binamasur-5,	35.8	1.6	81	Early

	250Gy, P7				
7	Binamasur-5, 250Gy, P17	36.0	1.8	75	Short stature
8	Binamasur-5, 250Gy, P22	45	1.6	83.2	Early
9	Binamasur-5, 250Gy, P15	35.9	2	289	More pods
10	Binamasur-5, 250Gy, P5	53.3	1.0	95.8	Tall plants
11	Binamasur-5 (Check)	49.8	1.4	161.6	
12	Binamasur-10 (Check	49.92	2	176	
Grand mean		44.8	1.6	156.8	
Range		35.8-53.12	1-2.2	70.2-383	

BLACKGRAM

On-station yield trial with two promising blackgram mutants along with a check variety

The trials were conducted with two promising blackgram mutants along with a check variety. BARI Mash-3 at two locations, BINA sub-station Magura and BINA Headquarters, Mymensingh. 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). Plant to plant distance was 5 - 6 cm in a row while line to line distance was 40 cm. 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}, pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight were recorded 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 statiatics-10 software. Statistical analysis of different characters of the accessions and the check are presented in the Table 61.

Table 61: Mean of yield and yield contributing characters of two promising mutants of blackgram grown at two locations, Magura and Mymensingh during 2019

Variety	Plant height (cm)	Primary branches plant^{-1} (no.)	Pods plant^{-1}(no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed Yield (kg ha^{-1})
Mymensingh						
BM-404	40.13b	2.5	47.8a	7.2a	4.25 a	1208a
BM-108	48.46a	2.2	44.6ab	7.0a	3.53b	1125b
BARI Mash-3	41.2 b	2.1	35.6 b	6.5b	4.08a	1115b
		NS				

CV%	23.75	20.13	2.87	1.67	4.69	1.83
Magura						
BM-404	40.86b	3.06a	37.06a	6.93a	4.29a	1221a
BM-108	46.50a	2.26ab	29.83ab	6.46ab	3.5b	1131b
BARI Mash-3	42ab	1.86b	27.0b	6.2b	3.8a	1108b
CV%	4.85	15.59	10.22	3.31	6.74	2.33

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

Results unveiled that there were significant differences for most of the characters except number of primary branches at Magura. BM-404 was the shortest among the mutants and check at Magura and Mymensingh. In case of primary branches per plant, BM-404 had the highest number of branches per plant at both location, although it was statistically non-significant. The pods plant^{-1} and seeds pod^{-1} was higher in both the mutants than the check. In case of 100-seed weight, the mutant line BM-404 and check variety showed higher 100-seed weight than the mutant, BM-108. Seed yield was the highest for BM-404 in both the locations followed by BM-108. Because the mutant BM-404 had higher 100-seed weight and number of pods plant-^{1}. Further trial will be carried out in the next season.

On-farm yield trial with two promising blackgram mutants along with a check variety

The trial was conducted with two promising blackgram mutants along with a check variety. BARI Mash-3 at Magura during 2019. 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). Plant to plant distance was 4- 5 cm in a row while line to line distance was 40 cm. Intercultural operations such as 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}, pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight were recorded from 10 randomly selected plants of each plot. Seed yield plot $^{-1}$ was recorded and converted into kg ha^{-1}. Appropriate statistical analyses were performed by statiatics-10 software. Statistical analysis of different characters of the accessions and the check are presented in the Table 62.

Table 62: On-farm trial with two blackgram mutants/line along with a check variety BARI Mash-3 at Magura during 2019

Variety	Plant height (cm)	Primary branches plant^{-1} (no.)	Pods plant $^{-1}$(no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed Yield (kg/ha)
BM-404	40.50	2.40	36.13 a	6.10a	4.62 a	1204a
BM-108	45.46	2.33	27.66b	5.53b	3.45c	1125b
BARI Mash-3	41.20	2.26	23.66c	4.30b	4.31b	1116b
	NS	NS				
CV%	7.86	3.36	2.14	1.67	6.73	2.22

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

Results revealed that there were significant differences for most of the characters among the tested mutants and the check variety except plant height and number of branches per plant. The mutant, BM-404 was the shortest among the mutants and check. From the table it was shown that, BM-404 had the highest number of pods plant^{-1}, seeds pod^{-1} and 100-seed weight among the mutants and check variety, BARI Mash-3. Seed yield was the highest for BM-404 because of its bigger seed size and higher number of pods plant-^{1}. Further trial will be carried out in the next season.

Preliminary yield trial with ten promising blackgram mutants along with a check variety

The trials were conducted with 10 promising blackgram mutants along with a check variety, BARI Mash-3 at Magura. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 2m × 1.6m. Plant to plant distance was 3 to 4cm in a row while line to line distance was 40 cm. 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 recorded from 10 randomly selected plants of each plot. Seed yield plot^{-1} was recorded and converted into Kg ha^{-1}. Appropriate statistical analyses were performed by statistics 10 software. Statistical analysis of different characters of the accessions and the check are presented in the Table 63.

Table 63: Mean of yield and yield contributing characters of ten promising mutants of blackgram at Magura during 2019

Variety	Plant height (cm)	Primary branches plant^{-1} (no.)	Pods plant $^{-1}$(no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield (kg/ha)
BM-63	50.6a	2.3	23.8a	5.5ab	4.82a	1186a
BM-105	47.5b	1.7	22.9a	6.2a	4.91a	1132a
BM-45	48.2b	2.1	18.1ab	6.0a	4.23b	1012cd
BM-42	42.3b	2.3	21.2a	4.8b	4.24b	1050bc
BM-41	46.9b	2.0	21.7a	4.7b	4.57ab	1040cd
BM-81	60.4a	1.6	10.1b	4.8b	4.20b	900d
BM-74	47.9	1.9	18.1ab	5.1ab	4.31b	1090ab
BM-73	50.1a	1.2	16.5b	6.2a	4.59ab	1043bc
BM-72	58.2a	1.1	15.1b	5.7a	4.69	1039bc
BM-46	47.8b	2.1	20.2a	6.2a	4.89a	1180a
BARI Mash-3	57.3a	1.9	15.4b	5.5ab	4.27b	1072bc
		NS				

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

Results revealed that there were significant differences for most of the characters except number of branches per plant. BARI Mash-3 was the tallest among the mutants and the check. In case of number of pods plant^{-1} BM-63 had the highest number of pods plant^{-1} than the other mutants and the check variety, BARI Mash-3 followed by BM-105. The highest number of seeds pod^{-1} and the highest 100-seed weight was observed in BM-105 followed by BM-46. Seed yield was the highest for BM-63 followed by BM-105 because of their higher number of pods per plant, seeds pod^{-1} and 100-seed weight. The three mutants BM-63, BM-46 and BM-105 will be put into advanced yield trials in the next season.

Growing M_4 generation of blackgram

Seeds of 23 M_3 plants were grown in plant-progeny-rows at BINA Headquarters farm during 2019. In M_4 generation 15 lines were selected based on higher number of pods, earliness, plant type, synchronous in pod maturity and disease and insect pest reactions. These selected 15 lines will be grown in plant progeny- rows in the next season.

Growing M_5 generation of blackgram

In M4 generation a total of 12 lines were selected. Seeds of these 12 M_4 plants were grown in plant-progeny-rows at BINA Headquarters farm during 2019. In M_5 generation, 9 lines were selected based on higher number of pods, earliness and plant type, synchronous in pod maturity and disease and insect-pest reactions (table 64). These lines will be grown in plant- progeny-rows in the next season.

Table 64: Mean of yield and yield contributing characters of blackgram mutants

Sl. No.	Plant height (cm)	Primary branches plant^{-1} (no.)	Pods plant $^{-1}$(no.)	Seeds/pod (no.)
1.Barimash-3, 600 Gy	34.3	1.6	14.2	6.8
2.Barimash-3, 600 Gy	34.8	0.80	20.4	7.0
3.Barimash-3, 700 Gy	45.6	1.0	14	6.8
4.BARI Mash-3, 700 Gy	29.8	1.4	15.4	6.4
5. BARI Mash-3, 700 Gy	33.6	1.2	15.2	6.2
6.BARI Mash-3, 700 Gy	29.6	1.8	18.4	6.8
7.BARI Mash-3, 800 Gy	28	0.6	10.6	6.8
8.BARI Mash-3, 800 Gy	29.4	0.0	13.4	6.4
9. BARIMash-3, 800 Gy	24.6	0.6	12.0	5.8
10. BARI Mash-3 (Check)	41.2	1.6	12.0	5.6
Range	28-45.6	0-1.8	10.6-20.4	5.6-7.0
Mean	33.09	1.06	14.56	6.46

GRASSPEA

Regional yield trial with four selected mutants of grasspea along with two checks

Regional yield trials were carried out with four mutants along with two check varieties (Binakheshari-1 and BARI khasari-2) at BINA Sub-stations, Magura, Chapainawabgonj, Ishwardi and BINA Headquarters, Mymensingh during 2019-2020. The experiment was conducted in a randomized complete block design with three replications. Unit plot size was 3m × 2m and rows were 40cm apart. 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 kg ha^{-1}. Statistical analysis of different characters of the mutants and the check are presented in the Table 65.

Results revealed that significant variations were present for all the characters except plant height and number of primary branches plant^{-1} at all the locations. It was observed that mutant GM-102 was the earliest in maturity and was the tallest plant among the mutants and checks. Mutant GM-108 produced the highest number of pods and highest seed yield at Ishurdi followed by the mutant GM-250. Mutant GM-108 produced the highest number of pods and the highest seed yield at Chapainawabgonj, Ishurdi and Mymensingh. These three mutant lines will be put into further trial in the next growing season.

Table 65: Mean of yield and yield contributing characters of four promising mutants of grasspea grown at four locations, Mymensingh, Magura, Chapainawabgonj and Ishwardi during 2019-2020

Variety/ mutants	Days to maturity	Plant height (cm)	No of primary branches plant-^{1}	No of pods plant-^{1}	100-seed weight (gm)	Seed yield (kgha^{-1})
Magura						
GM -102	102c	109	5.3	26.1 ab	5.3 b	1210 bc
GM-250	103 b	101	5.06	41.1 ab	5.7 ab	1398a
GM-105	103 b	99	4.26	29.5 b	5.1 b	1280 b
GM-108	104 b	103	5.13	45.1 a	6.5a	1407 a
Binakhasari-1	107 a	103	4.8	24.2 ab	5.6ab	1195 c
BARI Khasari-2	108 a	105	4.2	22.4 ab	5.4 b	1170c
		NS	NS			
CV (%)	0.67	9.4	1.2	20.46	0.46	17.8
Chapainawabgonj						
GM -102	102 c	98.3	3.73	36.4ab	4.4ab	1395ab
GM -250	103 c	90.6	4.13	32.4bc	5.01ab	1330b
GM -105	104bc	93	4.06	38.0ab	5.2a	1405ab
GM -108	104 c	98	3.06	46.6a	4.2b	1590a
Binakhasari-1	106 a	92.6	2.3	29.6bc	5.21a	1312b
BARI Khasari-2	109 a	95	2.73	24.0c	4.6ab	1108c
		NS	NS			
CV (%)	0.69	7.6	20.2	20.8	11.48	12.55
Ishurdi						
GM -102	103 c	103	4.26	40.0 b	4.2b	1460bc
GM-250	105 bc	96.07	3.86	53.6 a	5.0 ab	1705ab

GM-105	106bc	100.13	3.73	46.5 ab	5.3 a	1605 b
GM -108	106 bc	93.73	3.8	57.8 a	4.6ab	1790a
Binakhasari-1	107 b	99.33	4.3	40.2 bc	5.01ab	1280c
BARI Khasari-2	110 a	83.73	3.9	37.6 c	4.6ab	1205c
		NS	NS			
CV (%)	0.66	8.49	18.35	22.9	10.48	2.53
Mymensingh						
GM -102	102c	89.3	2	30.1 a	5.5 b	1130ab
GM-250	103c	83.3	2	28.1 ab	5.9ab	1105ab
GM-105	104 c	82	1.86	27.5 ab	5.1 b	1098b
GM-108	104bc	81.5	2.4	32.1 a	6.5a	1210 a
Binakhasari-1	106 b	84.96	1.53	24.2 ab	5.64b	1078bc
BARI Khasari-2	109 a	83.8	2.6	22.4 ab	5.43b	1050c
		NS	NS			
CV (%)	0.73	11.7	23.4	20.93	0.46	14.8

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

Growing of M_3 generation of grasspea

A total of 28 M_2 mutants were grown in plant- progeny-rows at BINA Headquarters farm. Each row was 2 m long with 45 cm row to row distance. Normal cultural practices were followed. A total of 5 M_3 mutants were selected on the basis of earliness and more number of pods (table 66). Selection will be done in the next generation.

Table 66: Mean values of different characters of the selected M_3 mutants of grasspea during 2019-2020

SL No	Plot	Plant height (cm)	No of primary branches plant-1	No of pods plant-1	Characteristics
1	BARIkhesari-2, 250Gy, p-11	71.2	2.2	22.4	Early
2	BARIkhesari-2, 250 Gy, p-7	78.6	2.0	20.8	Early
3	BARIkhesari-2, 250Gy, p-17	84.4	2.4	33.4	More pods
4	BARIkhesari-2, 250 Gy, p-26	73.8	1.6	18.6	Short plant
5	BARIkhesari-2, 250Gy, p-29	82.6	1.6	30.3	More pods
6	BARIkhesari-2 (check)	80.8	2.2	17	
	Range	73.8	1.6-2.4	17-33.4	
	Grand Mean	78.56	2	23.75	

Growing of M_4 generation of grasspea

A total of 12 M_3 mutants were grown at BINA HQ farm, Mymensingh and three M_4 mutant lines were selected on the basis of earliness, more number of pods and disease reactions (table 67). Further selection will be done in the next generation.

Table 67: Mean values of different characters of the selected M_4 mutants of grasspea during 2019-20

SL. No	Plot	Plant height (cm)	Branch/plant (no.)	Pods/ plant(no.)	Characteristics
1	BARI Khesari-2, 300Gy, P7	87.33	2.6	35.2	Morte pods
2	BARI Khesari-2,300Gy, p4	90.8	1.2	22.6	Early
3	BARI Khesari-2,300Gy, p-43	101.4	2	27	More pods
4	BARI Khesari -2 (check)	83.2	1.8	18	
	Range	83.2-101.4	1.2-2.6	18-35.2	
	Grand mean	90.6825	1.9	25.7	

GARDEN PEA

Growing of M_3 generation of garden pea

Seeds of BARI garden pea-3 were irradiated with Cobalt^{60} gamma rays. Irradiation doses were 20, 40, 60, 100, 200, 400Gy. A large number of M_3 population were grown in plant-progeny rows for selecting desirable mutant at BINA Headquarters farm, Mymensingh during Rabi season 2019. From them a total of 15 plants have been selected primarily for future selection in M_4 generations.

Growing of M_1 generation of garden pea

Seeds of BARI Garden pea-1, BARI Garden pea-2 and BARI Garden pea-3 was were irradiated with Cobalt^{60} gamma rays. To create genetic variability, seeds of three gardenpea varieties were irradiated with 100, 200 and 400 Gy of gamma rays. M_2 seeds from each plant-progeny rows were collected to grow M_2 population.

PIGEON PEA

Growing of M_1 generation of Pigeon pea

To create genetic variability, seeds of three pigeon pea germplasm were irradiated with 100, 200 and 400 Gy of gamma rays and grown at BINA Headquarters farm Mymensingh during 2019-20. M_2 seeds from each plant were collected to grow M_2 population in plant-progeny rows.

Jute

Evaluation of some M_5 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 7cm 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 kg plant^{-1}.

Table 68: Yield and yield components of jute mutants with check varieties at different

Location	Mutant/ Variety	Plant height (m)	Base diameter (cm)	Green weight with leaves(Kg)	Green weight without leaves(Kg)	Stick weight (Kg)	Fibre weight (kg)
Magura	JR0-1000-8	3.88 b	1.54 b	3.07 a	2.00 ab	0.33 b	0.19 b
	JR0-1000-9	3.97 a	1.69 a	3.00 ab	2.07 a	0.50 a	0.24 a
	JR0-1000-10	3.52 f	1.66 a	2.43 c	2.17 a	0.32 b	0.19 b
	JR0-700-3	3.64 e	1.58 ab	2.67 bc	1.80 a	0.33 b	0.17 bc
	JR0-524	3.82 c	1.57 ab	2.80 ab	1.83 b	0.33 b	0.14 c
	BJRI Tosa Pat-8	3.80 d	1.59 ab	2.93 ab	2.10 a	0.31 b	0.20 ab
Rangpur	JR0-1000-8	3.53 bc	1.51 b	3.43 ab	2.90 a	0.30 c	0.54 c
	JR0-1000-9	3.46 bc	1.66 a	3.07 b	2.87 a	0.50 a	0.62 b
	JR0-1000-10	3.42 c	1.61 ab	3.10 b	2.73 b	0.36 b	0.65 a
	JR0-700-3	3.51 bc	1.58 ab	3.23 b	2.70 b	0.33 bc	0.52 c
	JR0-524	3.58 b	1.47 b	3.43 ab	2.17 c	0.34 bc	0.60 b
	BJRI Tosa Pat-8	3.72 a	1.60 ab	3.77 a	2.37 c	0.32 bc	0.60 b
Mymensingh	JR0-1000-8	3.21	0.84 b	5.03 b	1.87 ab	0.60 b	0.30 b
	JR0-1000-9	3.45	1.21 a	4.36 bc	2.04 a	0.70 ab	0.37 ab
	JR0-1000-10	3.38	1.24 a	5.53 ab	2.00 a	0.93 a	0.41a
	JR0-700-3	3.36	1.28 a	4.72 bc	1.73 c	0.71 ab	0.33 ab
	JR0-524	3.18	1.22 a	6.55 a	1.85 ab	0.75 ab	0.35 ab
	BJRI Tosa Pat-8	3.21	1.40 a	3.50 c	1.93 b	0.70 ab	0.29 b
Combined mean over location	JR0-1000-8	3.54	1.30 b	3.84 b	2.25 ab	0.41 b	0.35 b
	JR0-1000-9	3.62	1.52 a	3.48 ab	2.32 ab	0.57 a	0.41 a
	JR0-1000-10	3.44	1.51 a	3.69 ab	2.30 ab	0.54 ab	0.42 a
	JR0-700-3	3.50	1.48 a	3.54 ab	2.07 b	0.46 ab	0.33 b
	JR0-524	3.53	1.43 a	4.26 a	2.28 ab	0.48 ab	0.37 ab
	BJRI Tosa Pat-8	3.58	1.53 a	3.40 c	2.47 a	0.45 ab	0.37 ab

N. B.: In a column, values with same letter (s) within location or mean over location did not differ significantly at 5% level

Results showed significant variations among the mutants and check for most of the charecters in individual locations and combined over locations (table 68). On average, it was observed that plant height of the mutant JRO-524-1000-8, JRO-524-1000-9, JRO-524-1000-10 and JRO-524-700-3 was recorded ranged from 3.44 to 3.62 m. The mutants JRO-524-1000-9 had significantly longer plant height than the parent JRO-524, although, JRO-524-1000-9, JRO-524-1000-10 and JRO-524-700-3 none of the mutants had broader base diameter. For green weight with leaves and green weight without leaves the mutants are not significantly lower than JRO-524 parents. For dry fibre yield, JRO-524-1000-9 and JRO-524-1000-10 had significantly higher than the parent JRO-524. Stick yield was significantly higher than the parent JRO-524 in mutant JRO-524-1000-9 and JRO-524-1000-10. Consdering plant height, dry fiber yield and stick yield mutants JRO-524-1000-9 and JRO-524-1000-10 were selected and will be put into advance yield trial in the next growing season.

Growing M_1 generation of BJRI TOSA PAT-8 (RABI-1)

Seeds of collected BJRI TOSA PAT-8 (RABI-1) were irradiated different dose of 250, 450, 650, 850 and 1050 Gy gamma rays during April, 2020 to August, 2020, to create variabilities for fiber and stick yield, maturity period and fiber quality parameter. From the experiment M_2 seeds from each plant were collected and bulk them to grow M_2 population next year.

Plant Genetic Resources

Collection and growing of rice landraces for seed

Collection: During 2019-20 a total of 111 germplasm of different crops were collected from nine districts of Mymensingh, Tangail, Sherpur, Jamalpur, Netrakona, Kishoreganj, Sylhet and Sunamganj ollectors visited those areas and recorded passport information of the germplasm at the time of collection. Seeds of different germplasm were cleaned, processed, dried and stored in short term storage of BINA germplasm collection room for seed multiplication and characterization. Eight teams such as *MM, F, ST, M, MI, SA, H and A* were formed comprising 1 member in each team. Each expedition was conducted for 1-4 days. The teams were equipped with ice box, plastic carton, GPS, compass, digital camera, hand lens, envelop, knife, scissors, drying sheet, pencil, stapler etc. Germplasm of rice were collected from farmers' field/farm store/threshing floor and market especially from floating seed traders.

Targeted farmers for collection of specific germplasm were located with the help of field level worker of the Department of Agriculture Extension (DAE) and direct contact. Collector's name, number and date were recorded during collection. Name of crop species along with English, Bangla, local and cultivar name were recorded. Name of donor with ethnic group, village, union, upazila/thana, district, latitude and longitude were noted. Type of soil, topography, sample status, sample source, habitat, frequency, type of materials, cultural practices, season, sole or mixed with, sample type, sampling method, insect and disease, agronomic score and plant characteristics were noted. A 'Passport Data Form' having passport information was filled up during germplasm collection. The samples were registered in conservation book immediately after collection and conserved in short term conservation storage of following appropriate procedure. Number of upazilas explored and number of germplasms collected from each district is shown in table 1. Passport information of collected germplasm of assigned crops is shown in tables 69-73.

Table 69: Passport information of collected rice (*Oryzae sativa*) germplasm

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
1.	FA-01	Binnatoa Boro T. Aman	Baten Mia Village : Kathgola Union : Khagdoho Upazila : Mymensingh Sadar District : Mymensingh	2019 24.43ºN 90.79 ºE	
2.	FA-02	Gourohati Boro	Baten Mia Village : Kathgola Union : Khagdohor Upazila : Mymensingh Sadar District : Mymensingh	2019 24.43ºN 90.79 ºE	
3.	FA-03	Begunbichi Boro	Baten Mia Village : Kathgola Union : Khagdohor Upazila : Mymensingh Sadar District : Mymensingh	2019 24.43ºN 90.79 ºE	
4.	FHS-01	Rati Boro (local Aromatic rice) Boro	Md. Abdul Latif Village : Chander chor Union : Gojaria Upazila : Bhairab District : Kishorganj	2019 25.09°N 90.53°E .	
5.	FHS-02	Lafaya Boro	Md. Liton Village : Duoj Union : Duoj Upazila : Atpara District : Netrokona	2019 24.52ºN 90.44 ºE	
6.	FM-01	Chengri T. Aman	Md. Golam Azam Village : Saitola Union : Sreemangal Upazila : Sreemangal District : Moulvibazar	2019 24.31ºN 91.73 ºE	
7.	FM-02	Arai T. Aman	Md. Golam Azam Village : Saitola Union : Sreemangal Upazila : Sreemangal District : Moulvibazar	2019 24.31ºN 91.73 ºE	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
8.	FMM-01	Laldinga Boro	Siddik Mia Village : Babigao Union : Surma Upazila : Sunamganj Sadar District : Sunamganj	2019 25.07ºN 91.40 ºE	
9.	FMM-02	Local (Boro)	Siddik mia Village : Saidpur Union : Surma Upazila : Sunamganj Sadar District : Sunamganj	2019 24.90°N 91.02°E	
10.	FS-01	Lalkumri T. Aman	Md. Wasim Village : Shimultoli Union : Bakaljora Upazila : Durgapur District : Netrokona	2019 25.12°N 90.68°E.	
11.	FS-02	Bishalibinni T. Aman	Md. Wasim Village : Shimultoli Union : Bakaljora Upazila : Durgapur District : Netrokona	2019 25.12°N 90.68°E.	
12.	FS-03	Paijam T. Aman	Siddik mia Village : Terapur Union : Surma Upazila : Sunamganj Sadar District : Sunamganj	2019 25.07ºN 91.40 ºE	
13.	FS-04	Gobinda T. Aman	Abul Kalam Village : Bottola Union : Goatola Upazila : Dhobaura District : Mymensingh	2019 25.097°N 90.533°E	
14.	FS-05	Tulsimala T. Aman	Ali Hossain Village : Ghosgao Union : Ghosgao Upazila : Dhobaura District : Mymensingh	23 June 2019 25.091°N 90.533°E	
15.	FS-06	Biroi T. Aman	Ali Hossain Village : Ghosgao Union : Ghosgao Upazila : Dhobaura District : Mymensingh	23 June 2019 25.09°N 90.533°E	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
16.	FS-07	Chanmoni T. Aman	Md. Baten Village : Shimultoli Union : Bakaljora Upazila : Durgapur District : Netrokona	9 May 2019 25.12°N 90.68°E.	
17.	FS-08	Hashemirri T. Aman	Hanif Mia Village : Arapara Union : Kullagora Upazila : Durgapur District : Netrokona	9 May 2019 25.120°N 90.687°E.	
18.	FS-09	Lal paijam T. Aman	Baset Ali Village : Uttor Gamaritola Union : Gamaritola Upazila : Dhobaura District : Mymensingh	23.6.2019 25.0917°N 90.5333°E	
19.	FS-10	Boroabji Aman T. Aman	Mohammad Ali Village : Arapara Union : Kullagora Upazila : Durgapur District : Netrokona	09.01.2019 25.1250°N 90.6875°E..	
20.	FS-11	Chinisail T. Aman	Mohammad Ali Village : Nethpara Union : Kullagora Upazil : Durgapur a : Netrokona District	09.05.2019 25.1250°N 90.6875°E.	
21.	FS-12	Kalojira T. Aman	Mokhlesh Village : Goatola Union : Goatola Upazila : Dhobaura District : Mymensingh	23 June 2019 25.0917°N 90.5333°E	
22.	FS-13	Bashiraj T. Aman	Motaleb Rahman Village : Chandigar Union : Chandigar Upazila : Durgapur District : Netrokona	9 May 2019 25.1250°N 90.6875°E.	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
23.	FS-14	Lombaail T. Aman	Motaleb Rahman Village : Chandigar Union : Chandigar Upazila : Durgapur District : Netrokona	9 May 2019 25.1250°N 90.6875°E.	
24.	FS-15	Nagra T. Aman	Rasel Mia Village : Dharmapasha Union : Dharmapasha Sadar Upazila : Dharmapasha District : Sunamganj	25 May 2019 24.900°N 91.017°E	
25.	FS-16	Maloti T. Aman	Hashem Ali Village : Monjurabad Union : Golapganj Sadar Upazila : Golapganj District : Sylhet	25 May 2019 24°54′N 91°52′E	
26.	FS-17	Guamouri T. Aman	Rasel Mia Village : Dharmapasha Union : Dharmapasha sadar Upazila : Dharmapasha District : Sunamganj	25 May 2019 24.900°N 91.016°E	
27.	FS-18	Chinisail-3 T. Aman	Rasel Mia Village : Dharmapasha Union : Dharmapasha Sadar Upazila : Dharmapasha District : Sunamganj	25 May 2019 24.900°N 91.016°E	
28.	FS-19	Molaireti T. Aman	Rasel Mia Village : Dharmapasha Union : Dharmapasha Sadar Upazila : Dharmapasha District : Sunamganj	25 May 2019 24.900°N 91.016°E	
29.	FS-20	Putibirun T. Aman	Rasel Mia Village : Dharmapasha Union : Dharmapasha Sadar Upazila : Dharmapasha District : Sunamganj	25 May 2019 24.900°N 91.016°E	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
30.	FS-21	Kutimurar Birun T. Aman	Rasel Mia Village : Dharmapasha Union : Dharmapasha Sadar Upazila : Dharmapasha District : Sunamganj	25 May 2019 24.9000°N 91.0167°E	
31.	FS-22	Guarchara T. Aman	Rasel Mia Village : Dharmapasha Union : Dharmapasha Sadar Upazila : Dharmapasha District : Sunamganj	25 May 2019 24.9000°N 91.0167°E	
32.	FS-23	Chinigura T. Aman	Rasel Mia Village : Mainpur Union : Surma Upazila : Sunamganj Sadar District : Sunamganj	23 May 2019 24.90°N 91.016°E	
33.	FS-24	Soragotobirun T. Aman	Wali ullah Village : Habibpur Union : Habibpur Upazila : Shalla District : Sunamganj	24 May 2019 24.900°N 91.016°E	
34.	FS-25	Chakloshi T. Aman	Wali ullah Village : Habibpur Union : Habibpur Upazila : Shalla District : Sunamganj	24 May 2019 24.9000°N 91.0167°E	
35.	FS-26	Ojana birun T. Aman	Aziz Rahman Village : Sukhaipur Union : Sukhair Rajpur uttor Upazila : Dharmapasha District : Sunamganj	24 May 2019 24.90°N 91.016°E	
36.	FS-27	Biroi dhan T. Aman	Mokhlesh Village : Goatola Union : Goatola Upazila : Dhobaura District : Mymensingh	23 June 2019 25.091°N 90.533°E	
37.	FS-28	Mukta T. Aman	Wali Ullah Village : Habibpur Union : Habibpur Upazila : Shalla District : Sunamganj	24 May 2019 24.900°N 91.016°E	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
38.	FS-29	Deshi-32 T. Aman	Wali Ullah Village : Habibpur Union : Habibpur Upazila : Shalla District : Sunamganj	24 May 2018 24.900°N 91.016°E	
39.	FS-30	Hashakalo T. Aman	Wali Ullah Village : Habibpur Union : Habibpur Upazila : Shalla District : Sunamganj	24 May 2019 24.900°N 91.016°E	
40.	FS-31	Shonajuri T. Aman	Keramot Ali Village : Bolorampur Union : Shalla Sadar Upazila : Shalla District : Sunamganj	24 May 2019 24.900°N 91.016°E	
41.	FS-32	Hasa sada T. Aman	Azmat Ali Village : Badaghat Union : Badaghat Upazila : Tahirpur District : Sunamganj	24 May 2019 24.900°N 91.016°E	
42.	FS-33	Chenger muri T. Aman	Md. Rasel Village : Islampur Union : Badaghat Upazila : Tahirpur District : Sunamganj	24 May 2019 24.9000°N 91.0167°E	
43.	FS-34	Parbotjira T. Aman	Keramot Ali Village : Bolorampur Union : Shalla Sadar Upazila : Shalla District : Sunamganj	24 May 2019 24.900°N 91.016°E	
44.	FS-35	Noliguar Chara T. Aman	Keramot Ali Village : Bolorampur Union : Shalla Sadar Upazila : Shalla District : Sunamganj	24 May 2019 24.9000°N 91.0167°E	
45.	FS-36	Paijam T. Aman	Taimur Ali Village : Dolua Union : Rajanogor Upazila : Dirai District : Sunamganj	25 May 2019 24.783°N 91.350°E	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
46.	FS-37	Laal cheng T. Aman	Taimur Ali Village : Dolua Union : Rajanogor Upazila : Dirai District : Sunamganj	25 May 2019 24.783°N 91.350°E	
47.	FS-38	Ailaguta T. Aman	Md. Akkas Village : Modhupur Union : Rajanogor Upazila : Dirai District : Sunamganj	25 May 2019 24.783°N 91.350°E	
48.	FS-39	Kalobirun T. Aman	Md. ALi Village : Dhapkai Union : Rajanogor Upazila : Dirai District : Sunamganj	25 May 2019 24.7833°N 91.3500°E	
49.	FS-40	Moinashail T. Aman	Md. ALi Village : Dhapkai Union : Rajanogor Upazila : Dirai District : Sunamganj	25 May 2019 24.783°N 91.350°E	
50.	FS-41	Faijam T. Aman	Md. ALi Village : Dhapkai Union : Rajanogor Upazila : Dirai District : Sunamganj	25 May 2019 24.783°N 91.350°E	
51.	FS-42	Bedabirun T. Aman	Latifa Banu Village : Noagaon Union Dharmapasha Sadar Upazila : Dharmapasha District : Sunamganj	24 May 2019 24.54°N 91.10°E	
52.	FM-3	Chollish (40) T. Aman	Md. Shahjahan Village : Kandigaon Union : Dokkhinpara Upazila : Rongarchor District : Sunamganj	27November 2019 25.75°N 91.26°E	
53.	FM-4	Chechollish (46) T. Aman/ B.Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	25 November 2019 24.9000°N 91.0167°E	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
54.	FM-5	Bolok T. Aman/ B.Aman	Md.Abul Kashem Village : Buristhol Union : Mollapara Upazila : Sunamganj sadar District : Sunamganj	25November 2019 24.9000°N 91.0167°E	
55.	FM-6	Biroi T. Aman/ B.Aman	Md.Abul Kashem Village : Buristhol Union : Mollapara Upazila : Sunamganj sadar District : Sunamganj	25November 2019 24.9000°N 91.0167°E	
56.	FM-07	Abdul Halim dhan T. Aman/ B.Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	25November 2019 24.9000°N 91.0167°E	
57.	FM-08	Asamyo birun T. Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	25November 2019 24.9000°N 91.0167°E	
58.	FM-09	Kalo Birun T. Aman	Motiur Rahman member Village : Sadokpur Union : Mollapara Upazila : Sunamganj sadar District : Sunamganj	25November 2019 25°04′N 91°24′E.	
59.	FM-10	Laal birun T. Aman	Motiur Rahman Village : Rampur Union : Mannargaon Upazila : Sunamganj sadar District : Sunamganj	25November 2019 25°04′N 91°24′E.	
60.	FM-11	Puti birun T. Aman	Md.Abul Kashem Village : Buristhol Union : Mollapara Upazila : Sunamganj sadarr District : Sunamganj	25November 2019 25.11°N 91.26°E	
61.	FM-12	Vinno birun T. Aman	Motiur Rahman Village : Rampur Union : Mannargaon Upazila : Sunamganj sadar	24November 2019 25°04′N 91°24′E.	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
			District : Sunamganj		
62.	FM-13	Birun T. Aman	Hafijul Islam Village : Puraton Gudigaon Union : Zahangirnogor Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25°66′N 91°44′E.	
63.	FM-14	Birun T. Aman	Abul Kashem Village : Kandigaon Union : Rongarchor Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25°75′N 91°26′E.	
64.	FM-15	Caplash T. Aman	Abul Kashem Village : Kandigaon Union : Rongarchor Upazla : Sunamganj sadar Distrct : Sunamganj	24November 2019 25°75′N 91°26′E.	
65.	FM-16	Chenger muri T. Aman	Motiur Rahman Village : Rampur Union : Mannargaon Upazila : Doarbazar Disrict : Sunamganj	24November 2019 25°65′N 91°26′E.	
66.	FM-17	Chenger muri-2 T. Aman	Abul Kashem Village : Kandigaon Union : Rongarcho Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25.75°N 91.26°E	
67.	FM-18	Cinigura T. Aman	Abul Kashem Village : Kandigaon Union : Rongarchor Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25.75°N 91.26°E	
68.	FM-19	Deshi kalojira T. Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	24November 2019 24.90°N 91.01°E	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
69.	FM-20	Deshi-32 T. Aman	Motiur Rahman Village : Rampur Union : Mannargaon Upazila : Sunamganj sadar District : Sunamganj	24/11/2019 25.36°N 91.30°E	
70.	FM-21	Desi Kalojira T. Aman	Motiur Rahman Village : Rampur Union : Mannargaon Upazila : Sunamganj sadar District : Sunamganj	24/11/2019 25.36°N 91.30°E	
71.	FM-22	Desi paijam T. Aman	Jainal Abedin Village : Laalpur Union : Mollapara Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25.11°N 91.26°E	
72.	FM-23	Laal paijam T. Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25.06°N 91.44°E	
73.	FM-24	Dshi paijam T. Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25.06°N 91.44°E	
74.	FM-25	Sada paijam T. Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25.06°N 91.44°E	
75.	FM-26	Painjab T. Aman	Abul Kalam Village : Konagaon Union : Surma Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25.06°N 91.44°E	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
76.	FM-27	Goarchara T. Aman	Abul Kashem Village : Kandigaon Union : Dokkhinpara Upazila : Rongar chor District : Sunamganj	24November 2019 25.75°N 91.26°E	
77.	FM-28	Goarchara-2 T. Aman	Motiur Rahman Village : Rampur Union : Mannargaon Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25.06°N 91.44°E	
78.	FM-29	Khudbadal/ Chinigura T. Aman	Abul Kalam Village : Konagaon Union : Surma Upazila : Sunamganj sadar District : Sunamganj	24November 2019 25.06°N 91.44°E	
79.	FM-30	Kotkoti T. Aman	Abul Kashem Village : Kandigaon Union : Dokkhinpara Upazila : Rongar chor District : Sunamganj	24November 2019 25.75°N 91.26°E	
80.	FM-31	Maloti T. Aman	Abul Kashem Village : Kandigaon Union : Dokkhinpara Upazila : Rongar chor District : Sunamganj	24 November 2019 25.75°N 91.26°E	
81.	FM-32	Maloti T. Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	25 November 2019 25.06°N 91.44°E	
82.	FM-33	Maloti T. Aman	Md. Shahjahan Village : Kandigaon Union : Dokkhinpara Upazila : Rongar chor District : Sunamganj	27 November 2019 25.75°N 91.26°E	
83.	FM-34	Murabadal T. Aman	Abul Kalam Village : Konagaon Union : Surma Upazila : Sunamganj sadar	27 November 2019 25.06°N 91.44°E	

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
			District : Sunamganj		
84.	FM-35	Birushail T. Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	27 November 2019 25.06°N 91.44°E	
85.	FM-36	Laittashail T. Aman	Almas Ali Village : Kandigaon Union : Rongar chor Upazila : Sunamganj sadar District : Sunamganj	27 November 2019 25.75°N 91.26°E	
86.	FM-37	Atonishail T. Aman	Chan Mia Village : Muslimpur Union : Surma Upazila : Sunamganj sadar District : Sunamganj	27 November 2019 25.06°N 91.44°E	
87.	FM-38	Gandhishail T. Aman	Md. Shahjahan Village : Kandigaon Union : Dokkhinpara Upazila : Rongar chor District : Sunamganj	227 November 2019 25.75°N 91.26°E	
88.	FM-39	Moinashail T. Aman	Md.Abul Kashem Village : Buristhol Union : Mollapara Upazila : Sunamganj sadar District : Sunamganj	27 November 2019 25.11°N 91.26°E	

Table 70: Passport information of collected Spices germplasm Ginger (*Zingiber officinale*) and Turmeric (*Curcuma longa*)

Sl.#	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photograph
89	H-06	Turmeric (Local)	Abdul Gani Village : Bhairab Union : Bhairab Upazila : Bhairab Dist. Kishoreganj	19 October 2018 25.14ºN 90.19 ºE	
90.	FM-11	Ginger Haluaghat local Kharif	Abed Ali Village : Dhara Union : Dhara Upazila : Haluaghat District : Mymensingh	23 February 2019 25.0917°N 90.5333°E	
91	FM-12	Ginger Modhupur local Kharif	Taimur Ali Village : Oronkhola Union : Oronkhola Upazila : Madhupur District : Tangail	23 February 2019 24.900 0°N 91.0167°E	
92.	FM-13	Turmeric Modhupur local Kharif	Md. Abdul Latif Village : Golabari Union : Golabari Upazila : adhupur District : Tangail	20 January 2019 24.9000°N 91.0167°E.	

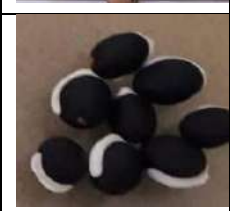
*MM= Mirza Mofazzal Islam, CSO& Head, PBD; F= Fahmina Yasmine, SSO, PBD; ST= Sadia Tasmin, SSO, HRD; M= Mehedi Hasan, SO, HRD; MI= Majharul Islam, SO, SSD; SA= Md.Shahjahan Ahmed, ASO, PBD; H= Md. Habibur Rahman Mridha SA-1, PBD and Md. Aktar Hossain, SA-2, PBD.

Table 71: Passport information of collected Bittergourd (*Momordica charantia*), Eggplant (*Solanum melongena)* White gourd (*Benincasa hispida*), Sweetgourd (*Cucurbita moschata*), bottle gourd (*Lagenaria siceraria*) and Sponge gourd (*Luffa aegyptiaca*) germplasm

Sl.#	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photograph
93	FMM-11	Singnath Rabi	Mobarak Village : Fenibil Union : Jahangirnagar Upazila : Sunamganj Sadar District : Sunamganj	23 May 2019 24.9000°N 91.0167°E	
94..	FMM-12	Mohisasing Rabi	Chanmia Village : Fenibil Union : Jahangirnagar Upazila : Sunamganj sadar District : Sunamganj	23 May 2019 24.9000°N 91.0167°E	
95.	FMM-14	White gourd local (Sunamganj)	Ayesha Khatun Village : Muslimpur Union : Surma Upazila : Surma District : Sunamganj	23.02.2019 24.9000°N 91.0167°E	
96.	FM-03	White gourd Local (Vabokhali) Rabi	Shafikul Islam Village : Oronkhola Union : Oronkhola Upazila : Madhupur District : Tangail	23.02.2019 24.9000°N 91.0167°E	
97.	FM-04	White gourd Local (Sinha) (Modhupur) Summer	Amzad Ali Village : Oronkhola Union : Oronkhola Upazila : Madhupur District : Tangail	23.02.2019 24.6167°N 90.0250°E	
98	FM-06	Sweet gourd / matilau Kharif	Amzad Ali Village : Oronkhola Union : Oronkhola Upazila : Madhupur District : Tangail	23.02.2019 24.6167°N 90.0250°E	
99.	FM-07	Sweet gourd Local Modhupur Oron khola Kharif	Amzad Ali Village : Oronkhola Union : Oronkhola Upazila : Madhupur	23.02.2019 24.6167°N 90.0250°E	

Sl.#	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photograph
			District : Tangail		
100.	FM-09	Sweet gourd Zolchotro lau/khet lau Kharif	Milton Kumar Village : Alokdia Union : Alokdia Upazila : Madhupur District : Tangail	23.02.2019 24.6167°N 90.0250°E	
101.	FM-08	Bottle gourd Modhupur lau Kharif	Md Helal Village : Oronkhola Union : Oronkhola Upazila : Madhupur District : Tangail	23 February 2019 24.6167°N 90.0250°E	
102	FM-10	Spongegourd Sogorika Kharif	Mamun Sarkar Village : Oronkhola Union : Oronkhola Upazila : Madhupur District : Tangail	23 February 2019 24.6167°N 90.0250°E	

Table 72: Passport information of collected French bean (*Phaseolus vulgaris*) and hyacinth bean (*Lablab purpureus*) germplasm

Sl.#	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photograph
103	FMM-03	Forasi sim Rabi	Siddik Mia Village: Dhalagao Union: Surma Upazila: Sunamganj Sadar District: Sunamganj	23.05.2019 24.9000°N 91.0167°E	
104	FMM-04	Khoilla sim Rabi	Abul Kalam Village : Haluargaon Union : Surma Upazila: Sunamganj Sadar District : Sunamganj	23.05.2019 24.9000°N 91.0167°E	
105	FMM-05	Sada nag Rabi	Asmani Village : Shologhor Union : Surma Upazila : Sunamganj Sadar District : Sunamganj	23.05.2019 24.9000°N 91.0167°E	

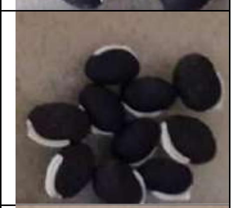
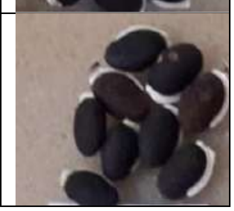
Sl.#	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photograph
106	FMM-06	Ankhi sim Rabi	Abul Kalam Village : Haluargaon Union : Surma Upazila : Sunamganj Sadar District : Sunamganj	23.05.2019 24.9000°N 91.0167°E	
107	FMM-07	Hatir kani/ Goal gadda Rabi	Raghunath Village : Kalengar par Union : Hatkhola Upazila : Sylhet Sadar District : Sylhet	23.05.2019 24.9000°N 91.0167°E	
108	FMM-08	Kaikka sim Rabi	Asma Khatun Village : Shologhor Union : Surma Upazila : Sunamganj Sadar District : Sunamganj	23.05.2019 24.9000°N 91.0167°E	
109	FMM-09	Chitagaia sim Rabi	Abdul Momen Village : Bagmara Union : Surma Upazila : Sunamganj Sadar District : Sunamganj	23.05.2019 24.9000°N 91.0167°E	
110	FMM-10	Bampata sim Rabi	Asma Khatun Village : Ibrahimpur Union : Surma Upazila : Sunamganj Sadar District : Sunamganj	23.05.2019 24.9000°N 91.0167°E	

Table 73. Passport information of collected mustard (*Brassica sp.*)

Sl. #	Collector's Number	Cultivar /local name/cultural practice	Donor's name and address	Collection year & geographical position	Photographs
111	FMM-13	Deshi sorisha Rabi	Shafikul Islam Village: Vati tahirpur Union: Tahirpur Sadar Upazila: Tahirpur District: Sunamganj	23 May 2019 24.9000°N 91.0167°E	

*MM= Mirza Mofazzal Islam, CSO& Head, PBD; F= Fahmina Yasmine, SSO, PBD; ST= Sadia Tasmin, SSO, HRD; M= Mehedi Hasan, SO, HRD; MI= Majharul Islam, SO, SSD; SA= Md.Shahjahan Ahmed, ASO, PBD; H= Md. Habibur Rahman Mridha SA-1, PBD and Md. Aktar Hossain, SA-2, PBD.

B. Characterization:

Experiment 1: Morphological characterization of chilli germplasm

A total of 5 local chilli germplasm have been characterized at morphological level during 2019. The genetically pure and physically healthy seeds of these germplasm were collected from the Horticulture Division, BINA. They have collected these germplasms from local area of Mymensingh. The experiment was set at BINA Head Quarters Farm, Mymensingh. Data were recorded from experimental field according to IBPGR (1995) descriptor and evaluation form. Out of 63 observations, 43 qualitative and 20 quantitative characters were recorded. The seed beds were prepared by mixing vermi-compost. Seeds were sown on 28th September' 2019 in separate bed uniformly at a depth of 2-3cm. Out of forty two-days old uniform growth and healthy seedlings were transplanted on 10th November 2019in the pots at the evening and immediately after transplanting light irrigation were given. The pots were 17cm × 30cm with small holes to drain excess water. After transplanting subsequent irrigations were provided as and when required for growth and development of plants. Three random competitive plants per variety were selected; tagged and recorded data for quantitative and qualitative characters. Five local chilli germplasm exhibited a wide variation for several morphological characters studied. The frequency percentage of each parameter is presented in Table 74.

Table 74: Qualitative descriptors of Chilli

Sl. No.	Qualitative characters	Observed Characters	Number of germplasm	Name of germplasm	Percent of germplasm
1	Hypocotyl colour	Purple	4	Balijhuri (Kagmari), Chata morich, Balijhuri (shayampur) , Super hot master	80
		White	1	Ulta morich	20
2	Hypocotyl pubescence	Intermediate	5	-	100
3	Cotyledonous leaf color	light green	3	Ulta morich, Balijhuri (shayampur), Balijhuri (Kagmari),	60
		Green	2	Super hot master, Chata morich	40
4	Cotyledonous leaf shape	Ovate-2	2	Super hot master, Ulta morich	40
		Lanceolate-3	3	Balijhuri (Kagmari), Chata morich, Balijhuri (shayampur)	60
5	Life cycle	Annual	4	Balijhuri (Kagmari), Chata morich, Balijhuri (shayampur)	80
		Biennial	1	Ulta morich	20
6	Stem colour	Green	5		100
7	Nodal anthocyanin	Green	5		100
8	Stem shape	Angular	5		100
9	Stem pubesscence	Intermediate	2	Super hot master, Ulta morich	20
		Dense	2	Balijhuri (Kagmari), Balijhuri (shayampur)	20
10	Plant growth	Erecct	2	Super hot master, Ulta morich	40

Sl. No.	Qualitative characters	Observed Characters	Number of germplasm	Name of germplasm	Percent of germplasm
	habit	Intermediate	3	Chata morich, Balijhuri (Kagmari), Balijhuri (shayampur)	60
11	Branching habit	Intermediate	4	Balijhuri (Kagmari), Balijhuri (shayampur) ,Super hot master, Ulta morich	80
		Sparse	1	Chata morich,	20
12	Tillering	Intermediate	3	Balijhuri (Kagmari), Balijhuri (shayampur) ,Super hot master,	60
		Sparse	1	Chata morich,	20
		Dense	1	Ulta morich	20
13.	Leaf density	Dense	3	Super hot master, Ulta morich, Chata morich	60
		Intermediate	2	Balijhuri (Kagmari), Balijhuri (shayampur)	40
14	Leaf colour	Green	4	Super hot master , Chata morich, Balijhuri (shayampur), Balijhuri(Kagmari)	80
		Light green	1	Ultamorich	20
15	Leaf shape	Deltoid	2	Super hot master, Ulta morich	40
		Lanceolate	2	Balijhuri (shayampur), Balijhuri(Kagmari)	40
		Ovate	1	Chata morich	20
16	Leaf margin	Entire	3	Super hot master, Ulta morich, Chata morich	60
		Undulate	2	Balijhuri (shayampur), Balijhuri(Kagmari)	40
17	Leaf pubescence	Sparse	5		100
18	Number of flowers per axil	2	1	Super hot master	20
		3 or more	4	Balijhuri (shayampur), Balijhuri(Kagmari), Chata morich, Ultamorich	80
19	Flower position	Pendant	4	Super hot master , Balijhuri (shayampur), Balijhuri (Kagmari), Chata morich	80
		Erect	1	Ultamorich	20
20	Corolla color	Yellow-	1	Super hot master	20
		Light yellow	3	Balijhuri (shayampur), Balijhuri (Kagmari), Chata morich	60
		White	1	Ultamorich	20
21	Corolla spot color	Purple	1	Super hot master	20
		Green	2	Balijhuri (shayampur), Balijhuri(Kagmari)	40
		White	2	Ultamorich, Chata morich	40
22	Corolla shape	Rotate	5		100
23	Anther colour	Blue	1	Super hot master	20
		Pale blue	4	Balijhuri (shayampur), Balijhuri(Kagmari), Ultamorich, Chata morich	80

Sl. No.	Qualitative characters	Observed Characters	Number of germplasm	Name of germplasm	Percent of germplasm
24	Filament colour	Purple	1	Super hot master	20
		Light purple	4	Balijhuri (shayampur), Balijhuri(Kagmari), Ultamorich, Chata morich	80
25	Stigma excertion	Same level	2	Super hot master , Chata morich	40
		Exerted	3	Balijhuri (shayampur), Balijhuri(Kagmari), Ultamorich	60
26	Male sterility	absent	4	Super hot master , Chata morich, Balijhuri (shayampur), Balijhuri(Kagmari),	80
		present	1	Ulta morich	20
27	Calyx pigmentation	Absent	5		100
28	Calyx margin	Intermediate	3	Super hot master , Chata morich, Ulta morich	60
		Entire	2	Balijhuri (shayampur), Balijhuri(Kagmari),	40
29	Calyx annular constriction	Absent	3	Super hot master , Chata morich, Ulta morich	60
		Present	2	Balijhuri (shayampur), Balijhuri(Kagmari),	40
30	Anthocyanin spots or stripes	Absent	5		100
31	Fruit color at intermediate stage	Green	3	Super hot master , Chata morich, Balijhuri (shayampur)	60
			2	Balijhuri(Kagmari), Ulta morich	40
32	Fruit set	Intermediate	5		100
33	Fruit color at mature stage	Red	5		100
34	Fruit shape	Elongate	5		100
35	Fruit shape at pedical attachment	Obtuse	5		100
36	Neck at base of fruit	Absent	2	Chata morich, Ulta morich	40
		present	3	Super hot master , Balijhuri (shayampur), Balijhuri(Kagmari),	60
37	Fruit shape at blossom end	Pointed	4	Super hot master , Chata morich, Balijhuri (shayampur), Balijhuri(Kagmari)	80
38	Fruit blossom end appendage	Absent	5		100
39	Fruit cross-sectional corrugation	Intermediate	4	Super hot master , Chata morich, Balijhuri (shayampur), Balijhuri(Kagmari)	80
		Slightly corrugated	1	Ulta morich	20

Sl. No.	Qualitative characters	Observed Characters	Number of germplasm	Name of germplasm	Percent of germplasm
40	Fruit surface	Semi wrinkle	5		100
41	Seed colour	Brown	1	Super hot master	20
		Deep yellow	4	Chata morich, Balijhuri (shayampur), Balijhuri(Kagmari), Ulta morich	80
42	Seed surface	Wrinkle	3	Super hot master, Balijhuri (shayampur), Balijhuri(Kagmari)	60
		Smooth	2	Chata morich, Ulta morich	40
43	Seed size	Intermediate	5		100

All germplasm performed same for the characters of hypocotyl pubescence, stem colour, nodal anthocyanin, stem shape, leaf pubescence, corolla shape, calyx pigmentation, anthocyanin spots or stripes, fruit set, fruit color at mature stage, fruit shape, fruit shape at pedical attachment, fruit blossom end appendage, fruit surface and seed size. Hypocotyl colour observed purle and white. Cotyledon leaf colour ranged from light green to green with ovate to lanceolate shape. Stem pubescence had shown dense and intermediate with sparse character. Two modes of plant growth were observed. Leaf shape varied between deltoid, ovate and lanceolate. Yellow-green corolla was common among the germplasm with filament colour mostly white. Anther colour varied from pale blue to blue. Fruit colour at intermediate stage ranged from green to pale green.

Table 75 shows the mean performance for all the quantitative traits measured. Cotyledon leaf length ranged from 11mm in Balijhuri (Shyampur) to 20 mm in Super hot master with an average of 15.4 mm. Cotyledon leaf widths is ranging from 5-10 mm. The heights of the chilli germplasms ranged from 45.00-108 cm with the average of 66.2 cm. Days to flowering ranged from 89-150 days after sowing was done. Fruit length and width ranged from 3.5-9 cm and 0.75-1.4 cm, respectively. The mean fruit length was 6.26 cm with Ulta morich and Super hot master having the shortest and longest fruit lengths. Fruit weight which is the most economic trait ranged from 0.86 -1.75g with Ulta morich and Super hot master. Seed diameter ranged from 3mm -5mm in Super hot master to Ultamorich with an average of 3.8 mm.

Superhot master and Chatamorich was the promising germplasm for higher yield, fruit shape and color. The germplasm ulta morich was good for getting year round chilli yield.

Table 75: Quantitative descriptors of Chilli

SL. No.	Name of the Qualitative characters	Measurable indicators					Mean
		Super hot master	Balijhuri (shayampur)	Chata morich	Balijhuri (Kagmari)	Ulta morich	
1	Cotyledonous leaf length (mm)	20	11	17	10	19	15.4
2	Cotyledonous leaf width (mm)	10	5	7	6	9	7.4
3	Plant height(cm)	72	49	57	45	108	66.2
4	Plant canopy width (cm)	50	57	70	36	57	54
5	Stem length(cm)	20	17	18	18	29	20.4
6	Stem diameter (cm)	2.0	1.5	1.75	1.25	2.5	1.8
7	Mature leaf length (cm)	6.0	4.0	5.2	5.0	12.0	6.44
8	Mature leaf width	2.2	1.4	1.8	1.8	5.4	2.52
9	Days to flowering	101	85	83	79	150	99.6
10	Corolla length (cm)	1.5	0.75	1.2	0.80	1,1	1.07
11	Anther length (mm)	0.75	0.5	0.65	0.6	0.45	0.59
12	Filament length (mm)	5	5	4	6	6	5.2
13	Days to fruiting	105	99	87	86	110	97.4
14	Fruit bearing period (d)	150	160	150	140	322	-
15	Fruit length (cm)	9	7	5	6.8	3.5	6.26
16	Fruit width (cm)	1.4	0.95	1.5	0.90	0.75	1.1
17	Fruit weight (g)	1.75	1.0	1.6	1.2	0.86	1.28
18	Seed diameter(mm)	3	3.5	4	3.5	5	3.8
19	1000 seed weight (g)	4.8	4.0	4.8	4.5	4.8	4.58
20	Number of seeds per fruit	70	59	93	77	12	62.2

Molecular characterization of rice germplasm

A total of 20 rice germplasm were characterized at molecular level. This experiment was conducted at Molecular Laboratory of Plant Breeding Division. Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Twenty germplasm of rice were characterized using RAPD markers.

Frequency of polymorphic loci among 20 rice germplasm

On the basis of the presence and absence of the bands of the PCR product with three primers, the polymorphism of the DNA of 20rice germplasm from the collected samples was detected. Results showed that the highest gene frequency was 0.950 and the lowest gene frequency was 0.0500 (Table 76). The ability to resolve the genetic variation may be more directly related to the number of polymorphism detected by marker techniques and the percentage of polymorphic bands. However, it does not correlate with the influence of rare and common alleles on the genetic diversity as a fragment of the lowest frequency has the same importance as a fragment with the highest frequency across the genome.

Table 76: Frequency of polymorphic loci of amplified DNA of rice plant with three primers

Loci	Gene frequency
OPA-01	0.9500
OPA-05	0.9500
OPC-01	0.0500
Total loci= 3	Average gene frequency = 0.6500

Genetic diversity and frequency of polymorphic loci in 20 rice germplasm

Rice germplasm showed the genetic diversity for the three primers was given in Table 77. The mean of Nei's (1972) gene diversity and Shannon's information index in 20 rice germplasm were 0.0950 and 0.1985 respectively. Among the germplasm, the highest level of gene diversity was 0.0950, while the other primers also gave the same results.

Table 77: Genetic diversity and frequency of polymorphic loci for three primers among 20 rice germplasm

Loci	Sample size	na*	ne*	h*	i*
OPA-01	20	2.0000	1.1050	0.0950	0.1985
OPA-05	20	2.0000	1.1050	0.0950	0.1985
OPC-01	20	2.0000	1.1050	0.0950	0.1985
Mean	20	2.0000	1.1050	0.0950	0.1985
St. Dev	-	0.0000	0.0000	0.0000	0.0000

na*: Observed number of alleles, ne*: Effective number of alleles, h*: Nei's (1973) gene diversity, i*: Shannon's Information index

Gene flow and co-efficient of gene differentiation among 20 rice germplasm

Gene diversity by Nei's analysis among 20 rice germplasm estimated the gene flow (Nm) value (Table 78). Hardy-Weinberg expectation of average heterozygosity (Ht) in the sample was 0.0950 while obtained average heterozygosity (Hs) of Hardy-Weinberg for those germplasm was 0.0000.

The highest level of co-efficient of gene differentiation was 1.0000. High degree of differentiation of samples also supports the presence of sufficient polymorphisms in the different germplasm.

Table 78: Gene flow (Nm) and the proportion of total genetic diversity (Gst) across with three primers among 20 rice germplasm

Loci	Sample size	Ht	Hs	Gst	Nm*
OPA-01	20	0.0950	0.0000	1.0000	0.0000
OPA-05	20	0.0950	0.0000	1.0000	0.0000
OPC-01	20	0.0950	0.0000	1.0000	0.0000
Mean	20	0.0950	0.0000	1.0000	0.0000
St. Dev	-	0.0000	0.0000	1.0000	0.0000

Ht: Hardy-Weinberg average heterozygosity expected in pathotypes

Hs: Hardy-Weinberg average heterozygosity obtained in pathotypes

Gst: Co-efficient of gene differentiation,

Nm: Estimate of gene flow from Gst or Gcs. E.g., Nm= 0.5 (1-Gst)/Gst

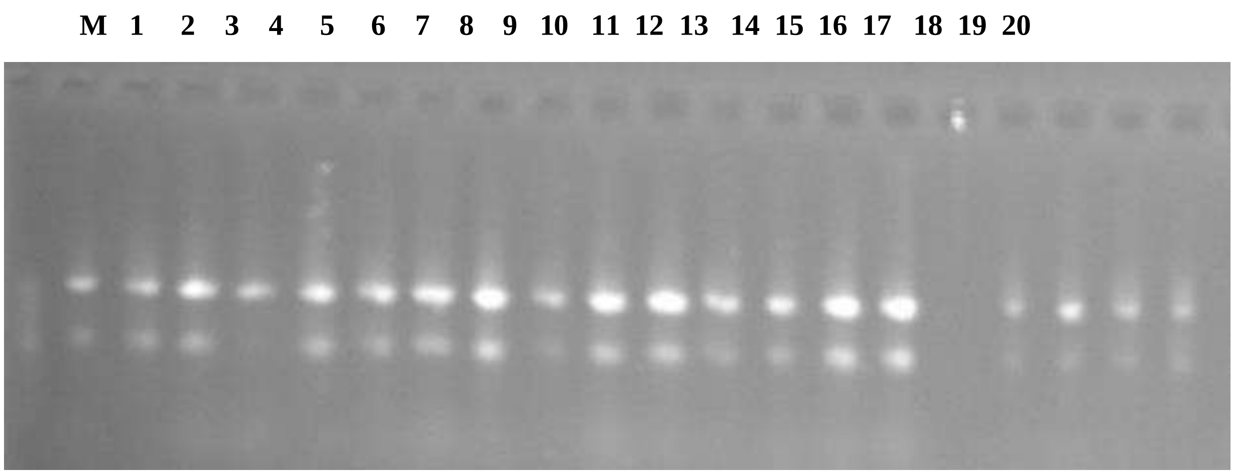


Fig. 3. RAPD profiles of different 20 rice germplasm using primer OPA 1. (M) 100bp DNA ladder

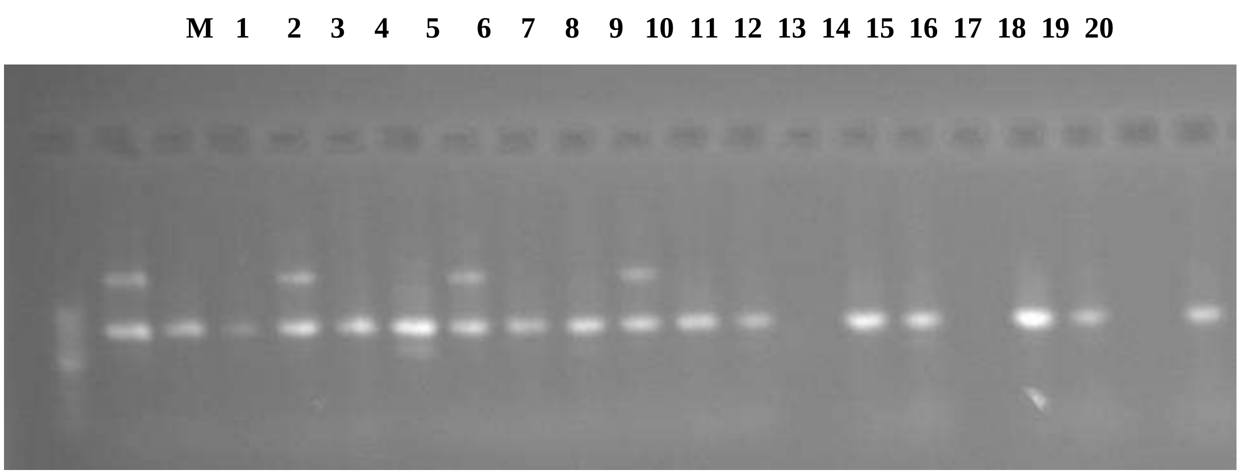


Fig. 4. RAPD profiles of different 20 rice germplasm using primer OPA 5. (M) 100bp DNA ladder

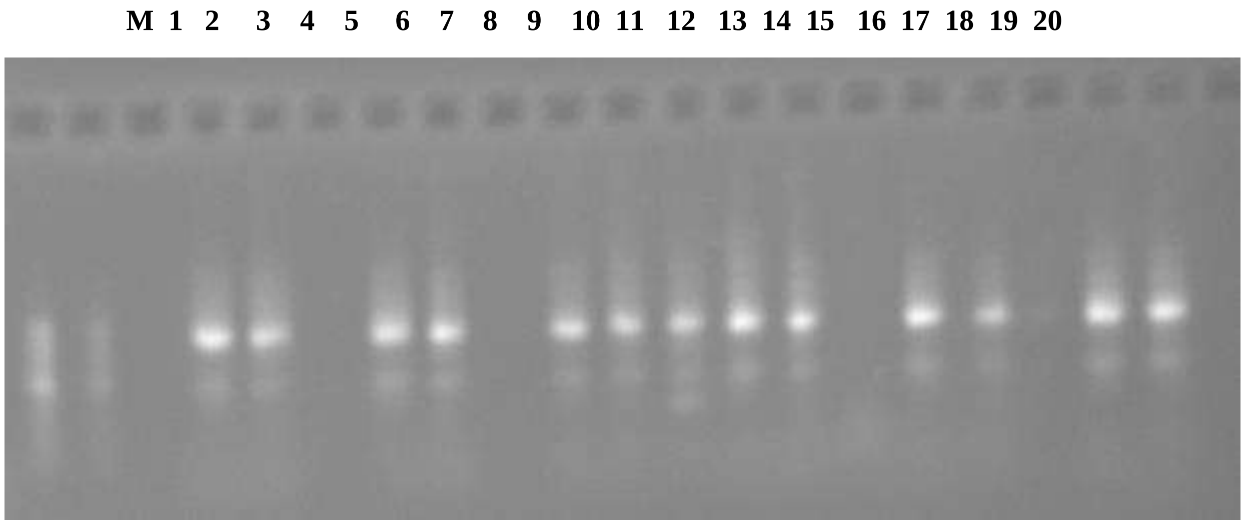


Fig. 5. RAPD profiles of different 20 rice germplasm using primer OPC 1. (M) 100bp DNA ladder

UPGMA dendogram

A dendrogram was constructed based on the Nei's (1972) genetic distance following the Unweighted Pair Group Method of Arithmatic Means (UPGMA) calculated by three RAPD markers among the 20 rice germplasms (Figure 14). All 20 rice germplasms could be easily distinguished. The Unweighted Pair Group Method with Arithmetic Means (UPGMA) cluster tree analysis led to the grouping of the 20 rice germplasms in four clusters (Table 79). The cluster I produced two Sub cluster. Sub cluster I comprised of three germplasms (Leda binni, Motamarang and Sentu-9). Sub cluster II comprised of seven germplasms (Fullota, Merigold, Sentugold¸ SotoSornolota, Pairjaat, Chapal and Sentu-15). Cluster II comprised of one germplasm named Purabinni. The cluster III produced three sub clusters. Sub cluster I comprised of five germplasms (Biroi, Lalcinishail, Gaindha, Dudhbinniand and Shongbinni). Sub cluster II comprised of one germplasms named Sentu-19. Sub cluster III comprised of two germplasms named Bishalibinni and Markabinni. The cluster IV comprised of one germplasms named Goatibinni.

The genotypes, showing comparatively same banding patterns were grouped into same cluster. From this study, the dendrogram revealed that the genotypes that are derivatives of genetically similar type formed cluster together. The genotypes which were collected from same geographic character grouped together in single cluster.

Table 79: List of genotypes in different cluster

Cluster	Sub Cluster	No. of Germplasm Found	Germplasms
C.I	S.C. I	3	Leda binni, Motamarang and Sentu-9
	S.C. II	7	Fullota, Merigold, Sentugold¸ SotoSornolota, Pairjaat, Chapal and Sentu-15
C.II		1	Purabinni.
C.III	S.C. I.	5	Biroi, Lalcinishail, Gaindha, Dudhbinniand and Shongbinni
	S.C. II.	1	Sentu-19
	S.C. III.	2	Bishalibinni and Markabinni
C.IV		1	Goatibinni

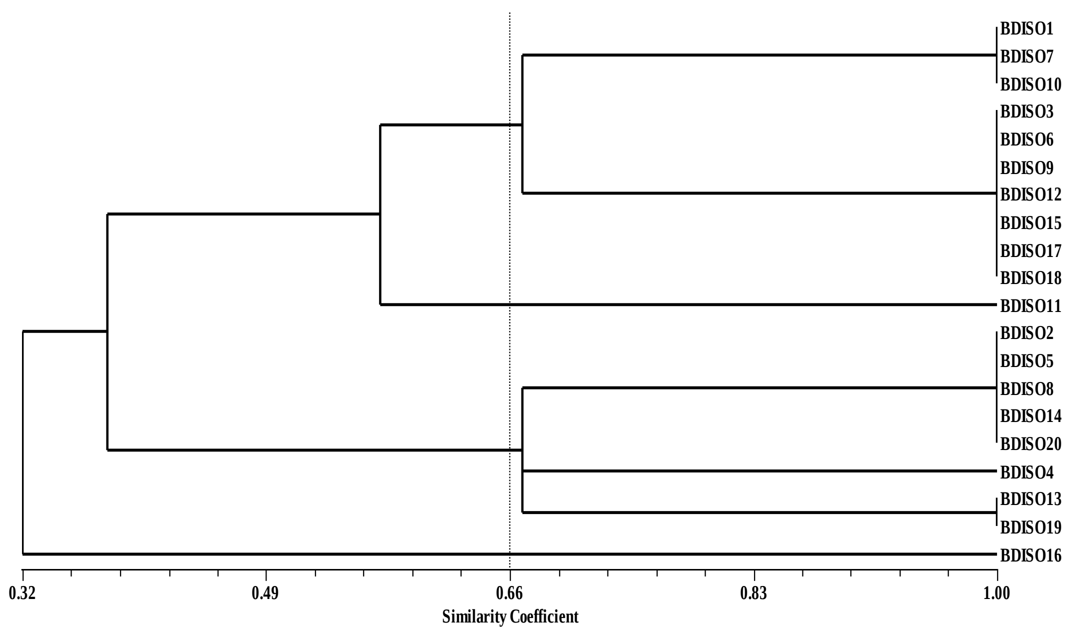


Figure 6: UPGMA dendrogram based on Nei's (1972) genetic distance summarizing the data on differentiation among 20 rice germplasms, according to RAPD analysis.

Conservation:

Collected germplasm were multiplied in respective season and preserved in mid /short term storage room at BINA. A total of 92 germplasm have been preserved with accession number in short term storage.

Table 80: Conservation status of different germplasm collected under PBRG-PGR project

Sl.#	Name of crop	Collector's Number	Quantity of seeds conserved (g)	Moisture content (%)	Germination rate (%)	Date of conservation	Accession Number
1.	Gaindha	MM-30	200g	12	100	March 2019	BINA-1780
2.	Purabinni	MM-1	200g	12	100	March 2019	BINA-1781
3.	Fulkainja	MM-26	200g	12	100	March 2019	BINA-1782
4.	Rupashail	MM-23	200g	12	100	March 2019	BINA-1783
5.	Leda binni	MM-19	200g	12	100	March 2019	BINA-1784
6.	Biroi	MM-17	200g	12	100	March 2019	BINA-1785
7.	Chapal	MM-16	200g	12	100	March 2019	BINA-1786
8.	Sentu-15	MM-29	200g	12	100	March 2019	BINA-1786
9.	Sentu-19	MM-22	200g	12	100	March 2019	BINA-1787
10.	Lalchinishail	MM-07	200g	12	100	March 2019	BINA-1788
11.	Dudhbinni	MM-27	200g	12	100	March 2019	BINA-1789
12.	Champamashuri	MM-24	200g	12	100	March 2019	BINA-1790
13.	Chotosornolota	MM-28	200g	12	100	March 2019	BINA-1791
14.	Motamorang	MM-08	200g	12	100	March 2019	BINA-1792
15.	Pairjaat	MM-12	200g	12	100	March 2019	BINA-1793
16.	Sentu gold	MM-15	200g	12	100	March 2019	BINA-1794
17.	Markabini	MM-05	200g	12	100	March 2019	BINA-1795
18.	Bishalibini	MM-06	200g	12	100	March 2019	BINA-1796
19.	Goatibinni	MM-04	200g	12	100	March 2019	BINA-1797
20.	Shongbini	MM-18	200g	12	100	March 2019	BINA-1798
21.	Sentu-18	MM-21	200g	12	100	March 2019	BINA-1799
22.	Fullota	MM-20	200g	12	100	March 2019	BINA-1800
23.	Mery gold	MM-10	200g	12	100	March 2019	BINA-1801
24.	Lalmatia	MM-32	200g	12	100	March 2019	BINA-1802
25.	Chapal-2	MM-14	200g	12	100	March 2019	BINA-1803
26.	Sentu-6	MM-31	200g	12	100	March 2019	BINA-1804
27.	Sentushail	MM-13	200g	12	100	March 2019	BINA-1779
28.	Sentu-17	MM-25	200g	12	100	March 2019	BINA-1778
29.	Sentu-16	MM-09	200g	12	100	March 2019	BINA-1777
30.	Ranishail	MM-11	200g	12	100	March 2019	BINA-1776
31.	Sentu-5/Malonchi	MM-02	200g	12	100	March 2019	BINA-1775
32.	Kalahapa	H-01	200g	12	100	January 2020	BINA-1772
33	Binnatoa	FA-01	200g	12	100	January 2020	BINA-1770
Sl.#	Name of crop	Collector's Number	Quantity of seeds conserved (g)	Moisture content (%)	Germination rate (%)	Date of conservation	Accession Number

34	Gourohati	FA-02	200g	12	100	January 2020	BINA-1769
35	Begunbichi	FA-03	200g	12	100	January 2020	BINA-1768
36	Rati Boro (local Aromatic rice)	FHS-01	200g	12	100	January 2020	BINA-1767
37	Lafaya	FHS-02	200g	12	100	January 2020	BINA-1766
38	Chengri	FM-01	200g	12	100	January 2020	BINA-1765
39	Arai	FM-02	200g	12	100	January 2020	BINA-1764
40	Laldinga	FMM-01	200g	12	100	January 2020	BINA-1763
41	Local (Boro)	FMM-02	200g	12	100	January 2020	BINA-1762
42	Lalkumri	FS-01	200g	12	100	January 2020	BINA-1761
43	Bishalibinni	FS-02	200g	12	100	January 2020	BINA-1760
44	Paijam	FS-03	200g	12	100	January 2020	BINA-1759
45	Gobinda	FS-04	200g	12	100	January 2020	BINA-1758
46	Tulsimala	FS-05	200g	12	100	January 2020	BINA-1757
47	Biroi	FS-06	200g	12	100	January 2020	BINA-1756
48	Chanmoni	FS-07	200g	12	100	January 2020	BINA-1755
49	Hashemirri	FS-08	200g	12	100	January 2020	BINA-1754
50	Lal paijam	FS-09	200g	12	100	January 2020	BINA-1753
51	Boroabji	FS-10	200g	12	100	January 2020	BINA-1752
52	Chinisail	FS-11	200g	12	100	January 2020	BINA-1751
53	Kalojira	FS-12	200g	12	100	January 2020	BINA-1750
54	Bashiraj	FS-13	200g	12	100	January 2020	BINA-1749
55	Lombaail	FS-14	200g	12	100	January 2020	BINA-1748
56	Nagra	FS-15	200g	12	100	January 2020	BINA-1747
57	Maloti	FS-16	200g	12	100	January 2020	BINA-1746
58	Guamouri	FS-17	200g	12	100	January 2020	BINA-1745
59	Chinisail-3	FS-18	200g	12	100	January 2020	BINA-1744
60	Molaireti	FS-19	200g	12	100	January 2020	BINA-1743
61	Putibirun	FS-20	200g	12	100	January 2020	BINA-1742
62	Kutimurar birun	FS-21	200g	12	100	January 2020	BINA-1741
63	Guarchara	FS-22	200g	12	100	January 2020	BINA- 1740
64	Chinigura	FS-23	200g	12	100	January 2020	BINA-1739
65	Soragotobirun	FS-24	200g	12	100	January 2020	BINA-1738
66	Superhot master	S-01	20g	10	100	November 2019	BINA-2007
67	Balijhuri morich (Shampur)	S-02	20g	10	100	November 2019	BINA-2006
68	Balijhuri (Kagmari)	S-03	20g	10	100	November 2019	BINA-2005
69	Chatamorich	S-04	20g	10	100	November 2019	BINA-2004
70	Ulto morich	S-05	20g	10	100	November 2019	BINA-2003
71	Matikorla	M-01	75g	9	98	November 2019	BINA-2023

Sl.#	Name of crop	Collector's Number	Quantity of seeds conserved (g)	Moisture content (%)	Germination rate (%)	Date of conservation	Accession Number
72	Bolder usta	M-02	75g	9	98	November 2019	BINA-2022
73	Soto elachibadam	H-02	300g	7.5	98	September 2019	BINA-955
74	Boro elachibadam	H-03	300g	7.5	98	September 2019	BINA-954
75	Tridanabadam	H-04	300g	7.5	98	September 2019	BINA-953
76	Matilau (Sweet gourd)	FM-06	300g	6-8	98	January-2020	BINA-2058
77	Local Modhupur (Oron khola) (Sweet gourd)	FM-07	300g	6-8	98	January-2020	BINA-2057
78	Zolchotro lau/khet lau (Sweet gourd)	FM-08	300g	6-8	98	January-2020	BINA-2056
79	White gourd local (Sunamganj)	FMM-14	300g	6-8	98	January-2020	BINA-2068
80	White gourd Local (Vabokhali)	FM-03	300g	6-8	98	January-2020	BINA-2067
81	White gourd Local (Sinha) (Modhupur)	FM-04	300g	6-8	98	January-2020	BINA-2066
Bottle gourd							
82	Modhupur lau	FM-08	300g	6-8	98	January-2020	BINA-2095
Spongegourd							
83	Sogorika	FM-10	250g	6-8	98	January-2020	BINA-3004
84	Turmeric (Kishoreganj local)	H-06	500g	65	98	January-2020	BINA-1911
85	Turmeric (Modhupur local	FM-13	500g	65	98	January-2020	BINA-1910
86	Ginger local Haluaghat	FM-11	500g	65	98	January-2020	BINA-1981
87	Ginger Modhupur local	FM-12	500g	65	98	January-2020	BINA-1980
88	Taal Begun	M-03	100g	12	98	January-2020	BINA-2068
89	Local Begun (Norshingdi)	M-4	100g	12	98	January-2020	BINA-2067
90	Local Begun	M-5	100g	12	98	January-2020	BINA-2071
91	Singnath	FMM-11	100g	12	98	January-2020	BINA-2070
92	Mohisasing	FMM-12	100g	12	98	January-2020	BINA-2069

Biotechnology Division

CONTENTS

Research Highlights

Genetic Engineering:

- The expression of different salinity/drought/submergence tolerant genes in FA13A and Binadhan-11 were studied under 150mM of NaCl stress. The results indicated that expressions of *OsARP, OsSAP, OsSOS1, OsNHX1, OsNHX2 OsMGD, OsDREB, and OsSalT g*enes were up-regulated until 72h salinity stress in salt tolerant cultivar FR13A. On the other hand, the levels of expression of these genes in Binadhan-11 were also consistent in most of the genes where up-regulation was detected in 24h and 72h.

- *In vitro* response were observed in five *indica* rice varieties on MS media with different concentration of 2, 4-D and result was found highest callus induction (90%) in IR64 when 2, 4-D used 3.5 mg/l but in case of BRRI dhan28 and BRRI dhan29 callus induction was found higher (75% and 79%) when 2, 4-D used 2.5 mg/l. In BRRI dhan48 and BRRI dhan58, higher number of callus induction was found (58% and 64%) when 2, 4-D used 3.0 mg/l.

- Callus growth and regeneration capacity were found to be decreased with increasing level of gamma rays on rice callus. The doses of 4 Gy to be the 50% inhibition dose for callus growth and plant regeneration in Sadamota and Kachamota local rice cultivar.

- The best shoot regeneration response (86.66%) was found in Binatomato-12 in T_3 medium (MS basal salt including vitamins + 2.0 mg/l BAP+ 0.5 mg/l IAA) followed by BARI Tomato19 (80%), Binatomato-11 (66%) and BARI Tomato18 (46.66%).

Molecular breeding:

- In T. Aman 2019, a total of 62 F_1 plants were selected through polymorphic primer out of 210 F_1 plants for tidal tolerant variety development.

- In Boro 2019-20, a total of 200 F_3 plants were selected from 167 segregated F_2 generation on the basis of better plant type for salt tolerant variety development

- For breaking yield ceiling and high yielding variety development, a total of 18 F_4 and 33 BC_2F_3 plants were transplanted. Out of these only 11 F_4 and 26 BC_2F_2 plants were selected on the basis of better plant type and good agronomic characteristics.

- For the development of cold tolerance genotypes, in Boro 2019-20, 33 plants of BC_1F_2 and 105 lines of F_3 & F_4 generations were selected through cold screening.

- For the development of submergence tolerance genotypes, in Aman and Boro 2019-20, 38 plants of BC_1F_1 and 50 lines of F_3 generations were selected through artificial submergence screening tank.

- Three Rhizobial strain and their mixed culture (BL 129, BL 153, BL 460) found promising for increasing growth and yield of lentil, pea and grasspea.

- Five advance rice mutants along with one natural mutant were evaluated at field condition.

- In Boro season 2019-20 five mutants were evaluated duration and yield and yield contributing characters. One rice mutant RM-ch-zao-LD-1 showed maximum yield (8.43t/ha) within short maturation time (139 days). Thus, DUS test will be done for this mutant in next boro season (2020-21).

- Two promising *Baceillus* bacterial strains were found to be effective for controlling wheat blast at pot condition a field trial will be conducted next season 2020-21 with this promising strains (G01 and B22) for further confirmation

- One arsenic tolerant bacterial strain (28mM) was isolated and identified at molecular level. This strain will be used to mitigate arsenic uptake in rice.

Programme Area I: Genetic Engineering and Tissue Culture

Project 1: Development of salinity/drought tolerant crop varieties

Expression and detection of salinity and drought induced genes through RT-PCR

Hydroponic plant culture

Two rice cultivars FR13A and Bindhan-11 were used in this study. Rice seeds were kept in oven to break the dormancy and soaked with distilled water in the Petridis. The radical of the pre-germinated rice seeds were carefully sown and inserted in nylon mesh in each hole of the styrofoam seeding float, then placed in the water. The water was replaced with nutrient solution (Yoshida solution and Ferrous sulphate) after three days. The salinity level was measured through electrical conductivity (EC) using the EC meter. New solution was added every eight days and the pH was monitored everyday and maintained at pH 5.2. Seedlings were grown in a controlled environment chamber (Glass house) with day/night temperatures of 25/21°C under 14h of light ($300\mu Em^{-2}s^{-1}$); humidity was approximately 50%. Afterwards, the plants were stressed by adding NaCl at a final concentration of 150mM to the nutrient solution for control (0h), 1h, 6h, 24h and 72h. Non-stressed control plants were grown concurrently and harvested at the same time. After harvesting, all samples were stored in $-80^{0}C$ freezer before being subjected to RNA isolation.

Total RNA isolation

Total RNA extraction was done using shoots and leaves of rice cultivar cvs. FR13A and Binadhan-11 using PureLink™ RNA Mini Kit (ambion, USA) for these stress treatments in accordance with the manufacturer's protocol. Visualization of the quality of total RNA was achieved with the use of 1.2% agarose gel electrophoresis with 2µl ethidium bromide per 100ml 1X TAE buffer. Electrophoresis was performed at an unvarying voltage of 70V for the duration of 70 min. The quantification of total RNA was accomplished with the utilization of a NanodropND1000 spectrophotometer (Nanodrop, USA).

cDNA synthesis and semi-quantitative RT-PCR analysis

Total RNA extracted from treated and non-treated leaves and shoot tissues was converted to complementary DNA (cDNA). A Reverse Transcription System was employed for carrying out first-strand cDNA synthesis using Superscript III 1st strand cDNA synthesis kit (Invitrogen, USA) according to manufacturer's protocol. Semi qRT-PCR of *OsARP, OsSAP, OsSOS1, OsNHX1, OsNHX2 OsMGD, OsDREB, and OsSalT g*enes was carried out using specific primers for amplification of PCR products around 180–300 bp length. Rice Actin gene was used as an internal reference in PCR reactions. The PCR products (10µl) were analysed through 1.5 % agarose gel electrophoresis with the use of ethidium bromide.

Results

Expression of *OsARP, OsSAP, OsSOS1, OsNHX1, OsNHX2 OsMGD, OsDREB, and OsSalT genes* of rice

To assess the effect of salt on the expression of *OsARP, OsSAP, OsSOS1, OsNHX1, OsNHX2 OsMGD, OsDREB, and OsSalT g*enes, total RNA was isolated from tissues of NaCl FR13A and

Binadhan-11. The expression levels of these genes in tissues were evaluated by semi-quantitative RT-PCR. The results indicated that expressions of *OsARP, OsSAP, OsSOS1, OsNHX1, OsNHX2 OsMGD, OsDREB, and OsSalT g*enes were up-regulated until 72h salinity stress in salt tolerant cultivar FR13A. On the other hand, the levels of expression of these genes in Binadhan-11 were also consistent in most of the genes where up-regulation was detected in 24h and 72h (Fig 1). In both of the cultivars, stable expression was detected in *OsSAP, OsSOS1* and *OsMGD*. These are major genes conferring tolerance to long term salinity, drought and submergence stress. The gene *OsSAP* in responsible for tolerance in seedling stage and also confer tolerance in longterm salinity stress. The *OsMGD* maintained choloroplast integrity in high salt and drought stress. As a result, higher photosynthesis is also maintained in these stresses. The *OsSOS1* protein is a plasma-membrane antiporter of Na^+/H^+ responsible for extruding excess Na^+ form cytosol. The expression of these genes indicates that FR13A as well as Binadhan-11induced major salt/drought/submergence tolerant genes under salinity stress.

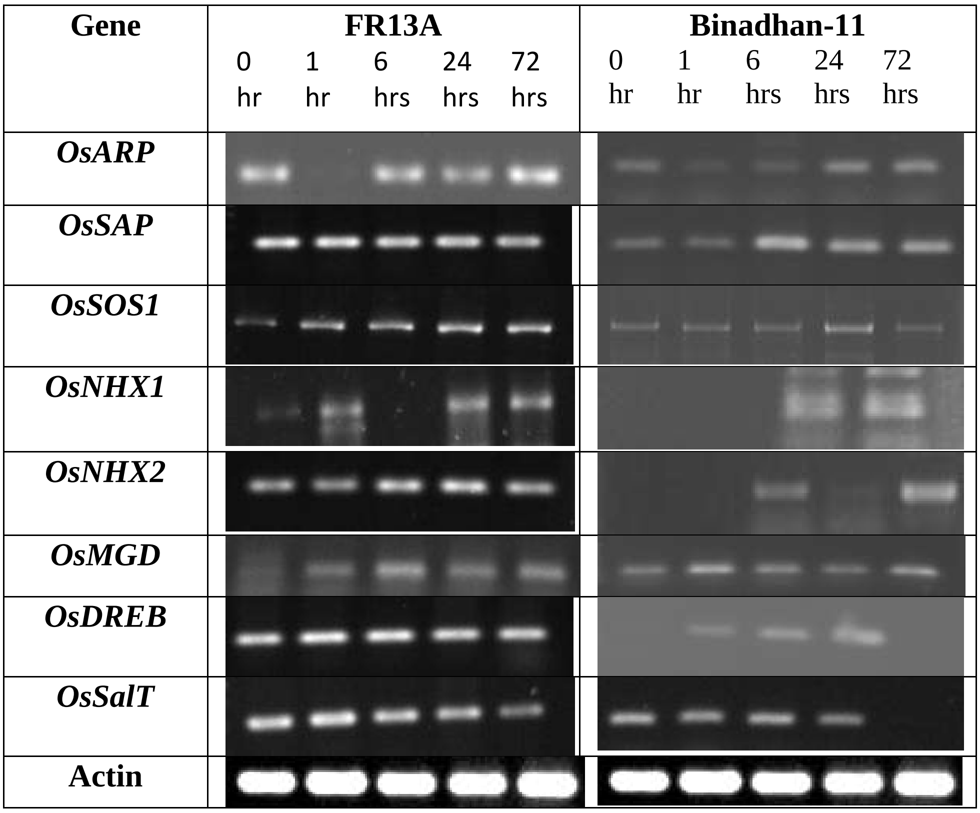


Fig 1. Expression patterns of the novel salinity/drought tolerant genes of rice. Semi-quantitative RT-PCR was carried out with specific primers using the RNA isolated from shoots (rice seedlings) subjected to salinity stress for various time points. Actin amplification was used as the internal control.

Effect of 2 4-D on *indica* rice (*Oryza sativa L.*) for embrygenic callus development and subsequent plant regeneration

Among the different factors influencing callus induction and regeneration, genotype and nutrient media as well as growth regulators (2 4-D) composition are the major factors that decide the fate of *in vitro* raised cultures. Despite a large number of reports on rice tissue culture, there is a significant genotype-dependence, and *in vitro* regeneration of *indica* rice is still a challenging task. In this regard, *in vitro* regeneration of induced callus from mature embryos of five *indica* rice (*Oryza sativa* L.) varieties was investigated in this study. The experiment was accompanied using five varieties of *indica* rice named IR-64, BRRI dhan28, BRRI dhan29, BRRI dhan48 and BRRI dhan58. To meet this purpose, callus induction potentiality of mature embryo on MS media (MS salts, containing B5 vitamins, Ducefa, 30.0 gm/l sucrose, 6.0 gm gelrite/l) supplemented with different concentration of 2 4-D like 2.0, 2,5, 3.0 and 3.5 mgl^{-1}. The effect of different concentrations of 2, 4-D on five varieties is given below (Table1):

Table 1. Genotype and growth regulators effect on callus induction of different rice genotypes

Genotype	Concentration of 2, 4-D (mgl^{-1})			
	2.0	2.5	3.0	3.5
IR64	80	83	88	**90**
BRRI dhan28	63	**75**	65	57
BRRI dhan29	69	**79**	62	59
BRRI dhan48	49	55	**58**	**58**
BRRI dhan58	54	57	**64**	58
CV (%)	13			
LSD (0.05)	15			

The above results indicate that the callus induction of different rice varieties depends on both genotype and growth regulators. The highest callus induction (90%) was found in IR64 when 2, 4-D used with 3.5 mgl^{-1} but in case of BRRI dhan28 and BRRI dhan29 callus induction was found higher (75% and 79%) when 2, 4-D was used 2.5 mgl^{-1}. On the other hand, BRRI dhan48 and BRRI dhan58 had higher number of callus induction (58% and 64%) when 2, 4-D was used 3.0 mgl^{-1}. 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. Since genetic engineering of crop plants greatly depends on the development of efficient methods for the regeneration of viable shoots from cultured tissues, this findings will be followed in future for genetic transformation of *indica* rice.

Effect of gamma irradiation on the embryogenic calli for development the tidal tolerant rice variety

In vitro response of four local *Indica* rice cultivars viz. Sadamota, Kachamota, Moulata and Dudhkalam was evaluated. The aim of this study was to develop an efficient protocol for callus induction, plant regeneration and to observe the effect of gamma radiation on plant regeneration for creating possible genetic variability. In different concentrations of 2 4-D and growth regulators were supplemented with MS medium (Murashige and Skoog) to observe their callus induction frequency using mature embryo as explants. Among the cultivars, the highest primary callus (92.55%) as well as embryogenic callus induction (56.26%) were found in Sadamota flowed by Kachamota (91.96%), Moulata (91.52%) and Dudkalam (88.96%).

Table 2. Callus induction of four cultivars at 3.0 mgl^{-1} 2 4-D and 10 mgl^{-1} kinetin under dark condition

Cultivars	Callus induction (%)
Moulata	91.52
Sadamota	92.55
Dudkalam	88.96
Kachamota	91.96

Twenty-one-day old embryogenic calli were exposed to 0, 2, 4 and 6Gy of gamma rays and transferred to regeneration medium. Both callus growth and regeneration capacity were found to be decreased with increasing level of exposure to gamma rays. The dose of 4Gy of gamma radiation was found to be the 50% inhibition dose for callus growth and plant regeneration in Sadamota and Kachamota; whereas, the 50% inhibition dose for Moulata and Dudkalam was at 2Gy. Finally, we got three irradiated mutant plants from Sadamota irradiated calli and the plants were flowered and subsequently work will be done in next generation. These results indicate that sensitivity of gamma radiation on rice callus depends on genotype of rice.

Table 3. Survival rate, plant regeneration and number of regenerated shoots per callus of irradiated calli developed from different *indica* rice.

Genotypes	Irradiation dose (Gy)			
	0Gy	2Gy	4Gy	6Gy
Survival rate (%)				
Moulata	71.36bc	67.00c	53.00c	23.46c
Sadamota	81.00a	76.93a	72.43a	48.00a
Dudhkalam	69.00c	66.50c	49.93c	21.00c
Kachamota	77.50ab	72.06b	62.63b	37.00b
Level of sig.	**	**	**	**
Regeneration (%)				
Moulata	33.53b	26.46b	15.00c	0.000c
Sadamota	48.86a	41.10a	33.00a	20.73a
Dudhkalam	30.00b	18.00c	7.200d	0.000c
Kachamota	44.03a	39.00a	27.83b	15.73b
Level of sig.	**	**	**	**
Shoot/callus				
Moulata	5.00	5.33a	2.26bc	0.00c
Sadamota	5.60	5.10b	4.46a	3.10a
Dudhkalam	4.53	4.10c	1.46c	0.00c
Kachamota	5.80	1.73d	2.53b	1.33b
Level of sig.	NS	**	**	**

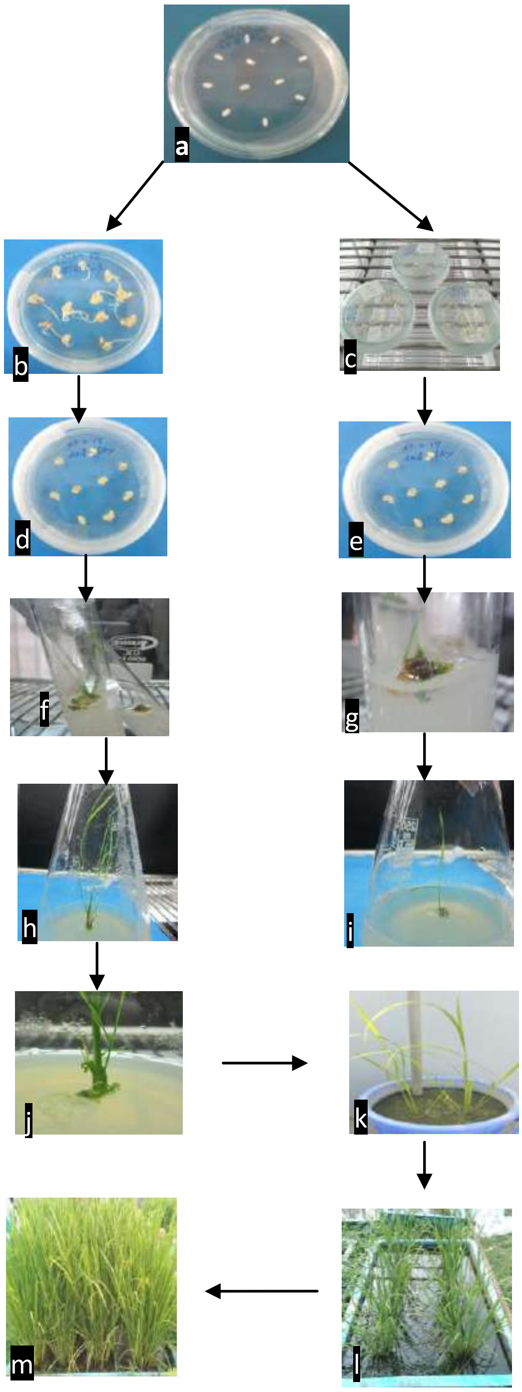


Figure 2. *In vitro* regeneration from mature embryo of irradiated embryogenic callus of rice cultivars (a-m). Schematic representation of mature embryo culture on callus inducing medium (a), 21 days old embryogenic calli (b), 21 days old irradiated embryogenic calli (c), 21 days sub-cultured embryogenic calli on shooting medium (d), 21 days irradiated sub-cultured embryogenic calli on shooting medium (e), established selected calli on shooting medium (f), irradiated established selected calli on shooting media (g), shoot regenerated from non-irradiated calli (h), shoot regenerated from irradiated calli (i), regenerated plants transferred on rooting media (j), established regenerated plants in pot (k), mature plants established on soil (l), flowering of regenerated plants

Transfer of *OsASR* and *OsNHX1/OsNHX2* genes into elite tomato cultivars

Tomato, a member of Solanaceae family, is a major vegetable crop and consumed all over the world. Tomatoes are sensitive to salts that they cannot survive under high salinity condition or only survive with decreased yields. We know a vast saline area in our country but due to high salinity these area are kept fellow every year. So, we need to develop salt tolerant variety(s) for that region if we want bring this area under cultivation. For this purpose, an experiment was undertaken for the development salt tolerant tomato variety through *Agrobacterium* mediated gene transfer techniques.

A total of four varieties of tomato namely, BARI tomato18, BARI tomato19, Binatomato-11, and Binatomato-12 were used in this study. Cotyledonary leaf was used as explants. MS medium supplemented with different concentrations and combinations of BAP and IAA were used for induction of multiple shoots. Plant hormones indole-3-acetic acid (IAA- 0.1 and 0.5mgl^{-1}) and 6-benzylaminopurine (BAP) (0.5, 1.0 and 2.0mgl^{-1}), Zeatin (1.0mgl^{-1}) were added in the MS basic medium to optimize the plantlet regeneration from the explants. Elongated shoots (2-3cm) were transferred to the ½ MS basic medium (alone), supplemented with IAA (0.2 and 0.5mgl^{-1}) for rooting.

The comparative effect of different growth hormones of four tomato varieties on callus and shoot inductions are presented below (Table 4).

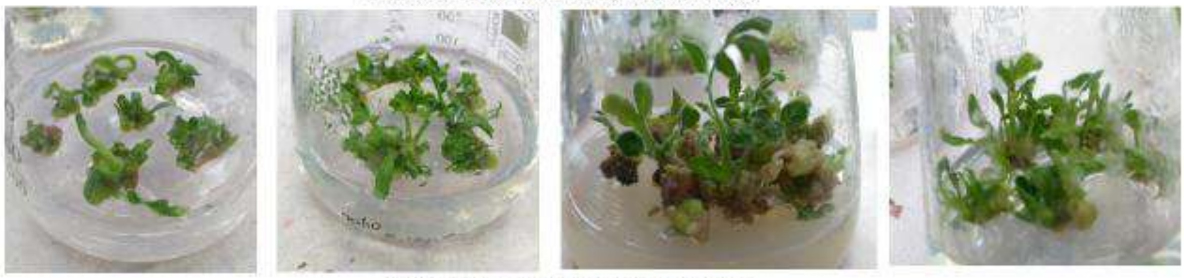
Table 4. Comparative effect of different growth hormones of four tomato varieties on callus and shoot induction from cotyledon explants

Name of variety	Treatment	Number of explant cultured	No of calli obtained	Days taken for shoot bud initiation	No of explants producing shoot bud	Shooting frequency (%)
BARI Tomato 18	T1	60	57	14	21	35.00
	T2	60	57	14	22	36.00
	T3	**60**	59	14	28	**46.66**
	T4	60	56	14	22	36.00
BARI Tomato 19	T1	60	58	12	44	73.33
	T2	60	58	13	44	73.33
	T3	**60**	57	12	48	**80.00**
	T4	60	54	12	46	76.66
Binatomato- 11	T1	60	54	12	23	38.33
	T2	60	54	14	38	63.00
	T3	**60**	56	12	40	**66.00**
	T4	60	56	12	38	63.00
Binatomato- 12	T1	60	53	14	32	53.33
	T2	60	53	13	50	83.33
	T3	**60**	54	13	52	**86.66**
	T4	60	56	13	40	66.00

T1-BAP+IAA (0. mgl^{-1}+0.5 mgl^{-1}), T2- BAP+IAA (1.0 mgl^{-1}+0.5 mgl^{-1}), T3 BAP+IAA (2.0 mgl^{-1}+0.5 mgl^{-1}),T4- Zeatin+IAA (1.0 mgl^{-1}+0.1 mgl^{-1})

The best shoot regeneration response (86.66%) was found in Binatomato-12 in T_3 medium followed by BARI Tomato19 (80%), Binatomato-11 (66%) and BARI Tomato18 (46.66%) (Table 4). In four plant growth regulator combinations, T3 medium (2.0 mg/l BAP+ 0.5 mg/l IAA) showed better response compared to all other in case of all varieties.

Callus and shoot in four tomato varieties



Multiple shoot in four tomato varieties

Rooted plantlets of four tomato varieties

Fig 3. Rooted plantlets transfer in growth room and outside for hardening

From the previous regeneration experiment, BARI tomato19 and Binatomato-12 showed best performance. So, these two varieties were selected for transformation experiment.

Bacterial strain and plant expression vector construction

Agrobacterium tumefaciens strain GV3101 harboring Os*NHX1 and OsNHX2* genes were used for tomato transformation. The expression of the genes of interest was under the control of the double constitutive CaMV 35S promoter. The plant expression vector pB2WG7 incorporated the genes of interest Os*NHX1* and *OsNHX2* and *Bar* gene for selection. The engineering strain was grown in 50ml of YEM medium, containing 50mgl^{-1} streptomycin and 50mgl^{-1} rifampicin in a 28^{0}C shaker at 200rpm for 16h. The bacterial suspension was centrifuged and the bacteria was re-suspended in the MS medium to optical density (OD_{600}) of 0.6 to 1.0, and used for bacterial infection.

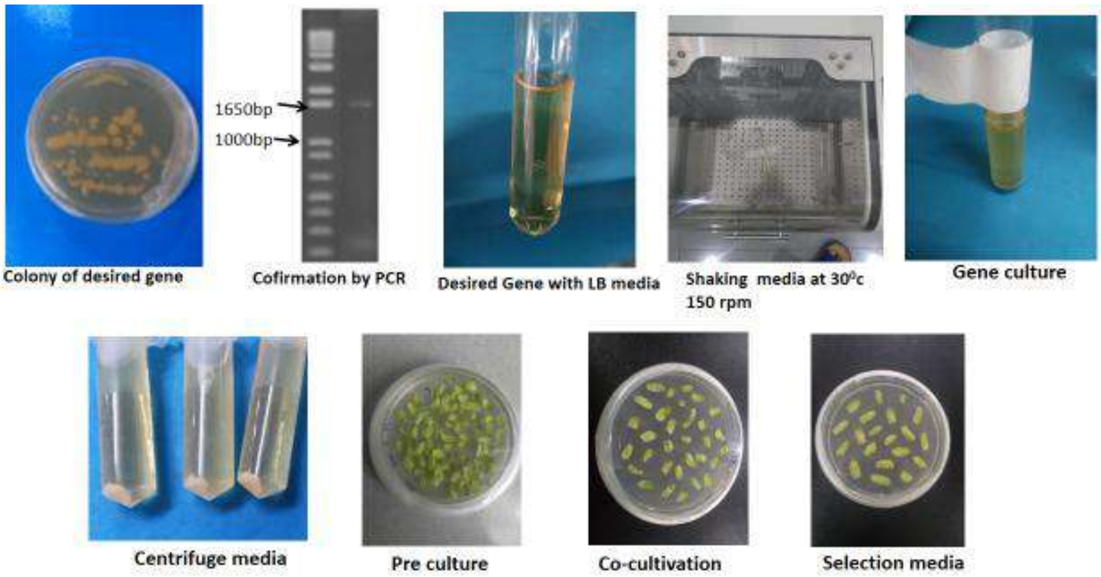


Fig 4. Steps for transformation in tomato

Plant transformation: Cotyledons from 10-day-old seedlings were cut at the tip and base. Middle pieces (~0.7cm × 1.0cm) were pre-cultured for 48h at 28°C on pre-culture medium with the adaxial surface in contact with the medium. Healthy explants that responded to pre-culture, as evident by swelling, were incubated in the bacterial suspension for 30 min and inverted every 10min during incubation. The explants were then blotted on sterile tissue paper and co-cultured on the same pre-culture medium for 72h at 28°C with 50–80 explants in each 9cm Petri plate. After exposure for different experimental durations, co-cultured explants were washed 4–5 times with washing medium, blotted on sterile tissue paper and transferred to a selection medium containing 2mg/l BAP and 0.5mg/l IAA for regeneration. Each Petri plate (9cm) had 20–25 explants for regeneration. Plates were cultured under a 16h light/8h dark cycle at 28°C. Explants that showed regeneration or callus formation were sub-cultured onto fresh selection medium every 15 days. Regenerated shoots were excised from the callus and transferred to a rooting medium. Shoots which did not produce roots after three weeks of their transfer to the rooting medium were discarded. Those plantlets which attained good shoot development (~8cm in height) and produced roots were transferred to pots containing autoclavable mixed soil (50% soil and 50% sand) for hardening. Pots were kept in a humidity chamber for 3–5 days in the culture room under a 16 h light/8 h dark cycle at 28°C and then in the greenhouse at 28 ± 2°C.

The transformation efficiency was calculated as the per cent co-cultivated explants producing independent transformation events, leading to regeneration of a complete plant on the selection medium. Multiple shoots generated from a single callus were treated as a single transformation event. Callus and shoot produced after gene *OsNHX$_2$* insertion in cotyledonary explant of

Binatomato-12 and BARI Tomato19. During the reporting period, rooted plantlet was found in BARI Tomato19 but not found in Binatomato-12. Leaf samples of BARI Tomato19 has been collected and stored at -20^{0}C for molecular analysis to confirm the transformants.

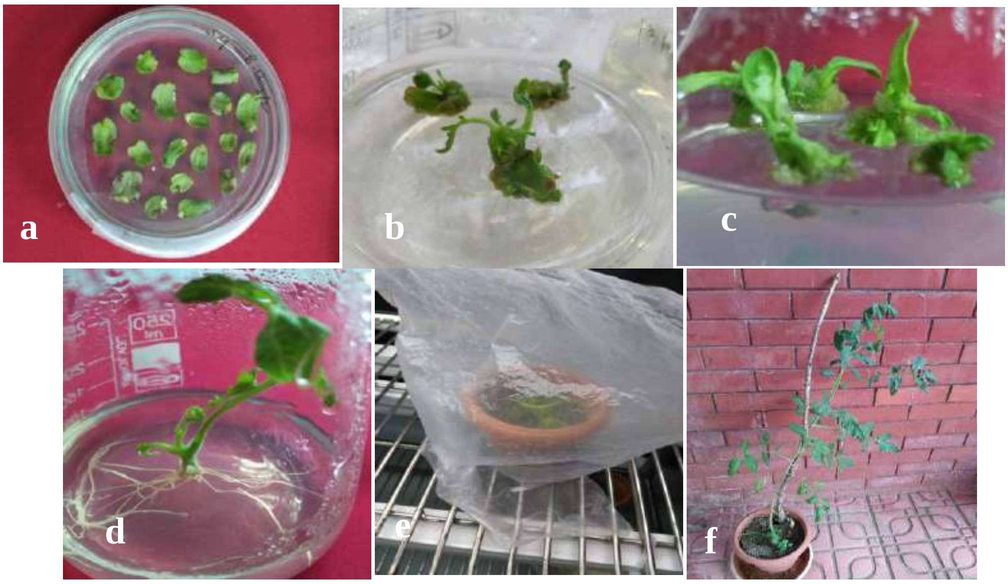


Fig 5. Callus induction (a); Shoot initiation (b); Shoot elongation (C); Regenerated plantlet (d) Hardening of rooted plantlet (e) and Complete plant of BARI tomato19 (f)

Programme Area II: Marker Assisted Selection/Marker Assisted Backcrossing

Project 2. Development of high yield stress tolerant (biotic and abiotic) rice varieties through MAS techniques

Improvement of tidal submergence tolerant rice varieties through marker assisted backcrossing

In T. Aman 2019, a total of 53 F_2 plants were grown for selecting the better plants. But during the season suddenly a windy storm damaged experiment and couldn’t select the desired plants. So, that collected samples were bulked and the next season further growing.

On the other hand, a total of 300 F_1 seeds were sown in a plastic tray and out of these about 210 F_1 plants was survived and rest of the seedlings damaged due to various disturbances. DNA extraction and PCR were done for primers survey. During the reporting period, a total of 108 SSR primers were surveyed and 42 primers were showed polymorphism (Fig 6). These polymorphic primer will be used for F_1 confirmation.

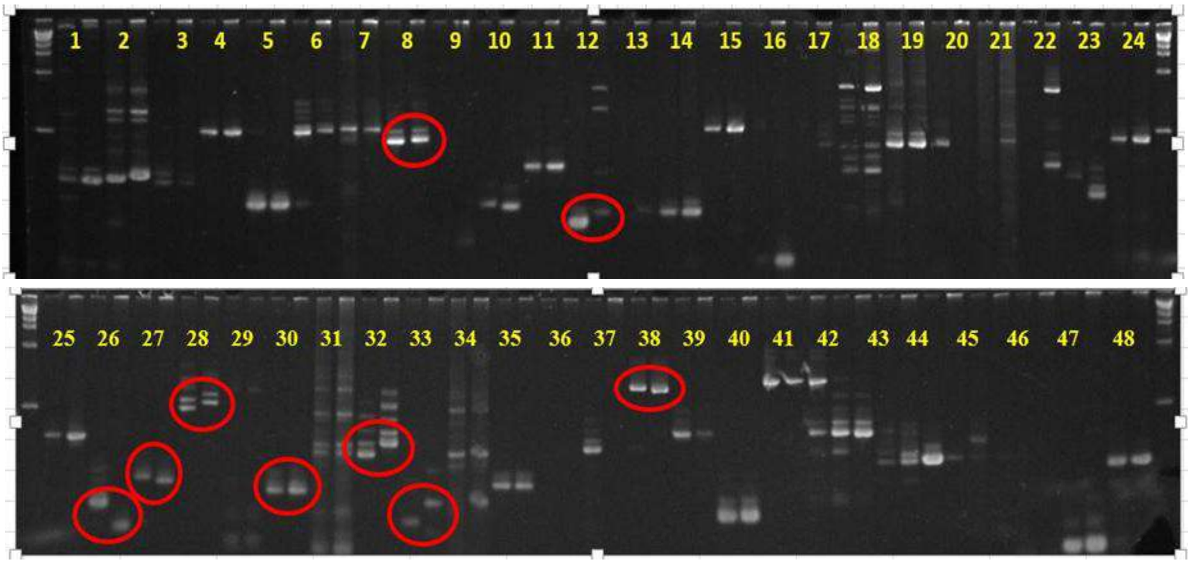
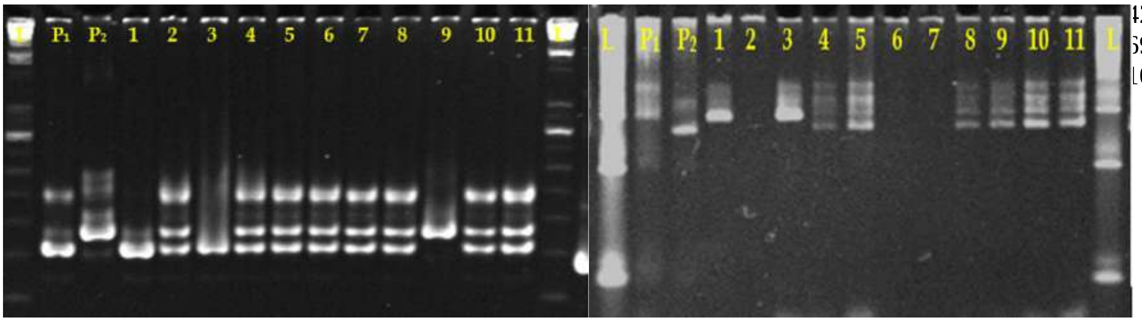


Fig 6. Primer survey for F_1 conformation of Moulata and BRRIdhan52 genotypes.

Legend: 1= RM118, 2= RM119, 3= RM120, 4= RM121, 5= RM315, 6= RM431, 7= RM124, 8= RM122, 9= RM289, 10= RM21, 11= RM129, 12= RM111, 13= RM141, 14= RM135, 15= RM121, 16= RM134, 42, 59, 10,



(a) (b)

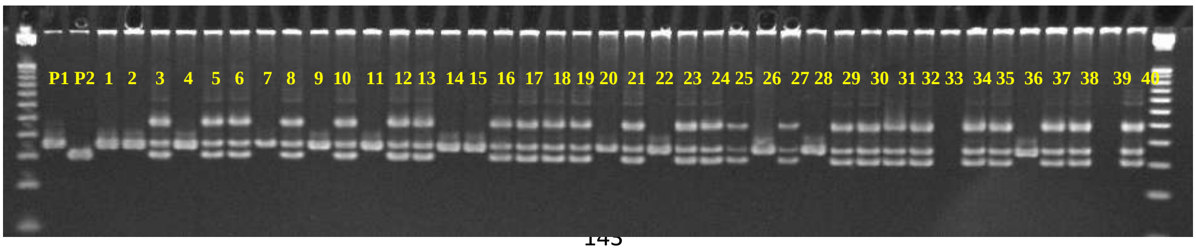
Fig 7. F_1 confirmation using RM519 (a) and RM140 (b) markers for Dudkolam x BRRIdhan46 crossing generation.

After primer survey, highly polymorphic primers were used to identify true F_1 plants. During the periods a total of 62 F_1 plant were selected and harvested the sample for further generation advanced.

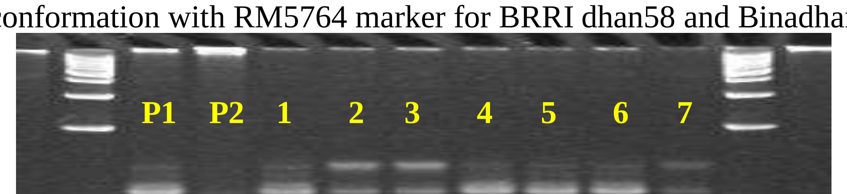
Development of salt tolerant rice varieties through marker assisted back crossing

In Boro 2019-20, for salt tolerance rice variety development, a total of 167 selected F_2 lines (from 4 different generations) were grown at BINA research field, Mymensingh. Out of these from the segregated F_2 lines, about 96 F_3 lines were selected on the basis of better plant type.

On the other hand, about 144 BC_1F_1 (from 4 different generations) seeds were grown during the season to develop BC_2F_1, but unfortunately it was not possible due to COVID-19 pandemic. In this situation, BC_1F_2 samples were harvested for further generation advanced.



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



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

We know BRRI and BINA has already developed a number of high yielding rice varieties. Those varieties gave maximum yield (in T. Aman 5.0 t/ha and Boro 6.5 t/ha) when follwed good agronomic management. But the yield potential has been reached in ceiling. So, we need to break the yield ceiling in the existing high yield rice varieties. A few literature states that some wild rice (*Oryza rufipogon*) contain high yield QTL and they used this QTL for break down the yield ceiling of high yielding varieties. In this purpose, a crossing program was made among the two high yield varieties viz. Binadhan-7 and Binadhan-16 and *Oryza rufipogon*. Firstly a crossing program was made by Binadhan-16 and *Oryza rufipogon* in the previous year. In T. Aman 2019, a total of 18 F_4 and 33 BC_2F_3 plants were transplanted in research field from that generation (Binadhan-16 x *Oryza rufipogon*). Out of these, only 11 F_4 and 26 BC_2F_3 plants were selected on the basis of better plant type with other good agronomic characteristics. On the other hand, a crossing program was made by Binadhan-7 and *Oryza rufipogon* in the previous year. In T. Aman 2019, a total of 33 F_2 plants were transplanted from that generation (Binadhan-7 x *Oryza rufipogon*). Out of these, only 18 F_3 plants were selected on the basis of better plant type and desirable agronomic characters.

Fig 9. BC_2F_3 generation of Binadhan-7 and *Oryza rufipogon*

Development of cold tolerant rice lines through Marker-assisted backcrossing (BC_1F_2)

In Boro 2019-20, about 33 plants of BC_1F_2 seeds and 105 lines (F_3 and F_4 generations) of different combinations (Table 5) were grown in a try and field. At 20 DAT, leaves were collected from every plants of BC_1F_1 and F_3 plant was confirmed through primer. Out of these, BC_1F_1 and F_3 plants were selected for BC_1F_2 and F_3 generations go to F_4 generation. Fertilizer application, weeding and other intercultural operation were done as per BINA recommended rice production practices. Usual methods of emasculation and pollination were followed. At maturity stage, about seeds of BC_1F_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	BC_1F_1 and F_4 generations
1	BRRI dhan28 × BRRI dhan36	20 plants BC_1F_1 and F_4 generations
2	BRRI dhan29 × BRRI dhan36	13 plants BC_1F_1 and F_3 generations
3	Iratom-24 × BRRI dhan36	F_4 generations
4	Binadhan-17 × BRRI dhan36	F_4 generations
5	Binadhan-18 × BRRI dhan36	F_4 generations
6	Binadhan-5 × BRRI dhan36	F_4 generations
7	Binadhan-6 × BRRI dhan36	F_4 generations
8	BPR_3 × BRRI dhan36	F_4 generations
9	BPR_4 × BRRI dhan36	F_4 generations
10	Binadhan-8 × BRRI dhan36	F_4 generations

Development and selection of cold tolerant rice for cold prone environments

F_3 and F_4 populations of which derived by *qCT* lines from BRRI dhan36 and popular HYV Binadhan-17, BRRI dhan28. Cold screening was performed bellow 10^0c at BINA HQ, Mymensingh. $F_3$and F_4 populations were evaluated under artificial cold stress condition for seven days (Fig. 10). The seedlings were allowed to grow until 3-leaf stages, and then, the pots were placed in the cold stress at below 10^0C for cold screening. Survivability was recorded at 7 days of recovery period after withdrawal of cold treatment as the percentage of green plants to the total plants tested per family**.**

Fig 10. Screening of F_3 populations of *qCT* lines using bellow 10^0C after 30 days at seedling stage.

Growing of M_2 /M_3 generation of submergence/cold tolerance rice

Growing of dry seeds for M_2 /M_3 population of different doses with gamma rays (200, 250, 300 and 350 (Gy). of BRRI dhan36, BRRI dhan51, BRRI dhan52, BRRI dhan79, Binadhan-11, BRRI dhan36, BPR1, BPR3, BPR4 and BPR7 mutant lines during Boro season 2020 at BINA

HQ, at Mymensingh. Total 150 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 15cm × 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.

Introgression of *SUB1* QTL into HYV rice varieties for submergence tolerant genotypes

In Aman and Boro'2019-20 about 38 plants from BC_1F_1 seeds and 50 line of F_3 generation from different combinations (Table 6) were grown in a try and field. When the seedling aged 20 days that times leaves were collected from every plants and BC_1F_1 plant were confirmed through *sub1* primers. Out of these, F_3 generation plants were selected for F_4 generations. Fertilizers application, weeding and other intercultural operation were done as appropriate time. Usual methods of emasculation and pollination were followed. At maturity stages, seeds were collected from F_3 generations and stored in paper bags with proper labeling.

Table 6. Grouping of 10 cross combinations

Sl. No.	Cross Combinations	BC_1F_1 and F_3 generations
1	Guti Swarna × BRRI dhan52	16 plants BC_1F_1 and F_3 generations
2	Mamun Swarna × BRRI dhan52	F_3 generations
3	Panpata Swarna × BRRI dhan52	F_3 generations
4	Bilati Swarna × BRRI dhan52	F_3 generations
5	Binadhan-17 × BRRI dhan52	12 plants BC_1F_1 and F_3 generations
6	Binadhan-7 × BRRI dhan52	10 plants BC_1F_1 and F_3 generations
7	BRRI dhan 49 × FR13A	F_3 generations

Genetic development and selection of submergence tolerance genotypes (*Oryza sativa L.)*

Different local varieties such as Guti Swarna , Mamun Swarna, Nepali Swarna, Bilati Swarna Ranjit Swarna were performed in the submergence tank for screening. F_3 populations derived with the crosses by submergence tolerance variety BRRI dhan52, Binadhan-11 and popular HYV Binadhan-17, Binadhan-7. Submergence screenings were performed in the submergence tank at BINA HQ, Mymensingh. Seeds from different F_2 were germinated in rows in 20 cm × 15 cm × 10 cm tray for selection. Thirty day-old seedlings were submerged for 21 days. The survival percentage and elongation ratio of plants has been taken 21 days after desubmergence. Submergence tolerance score given after desubmergence and 7 days after recovery for confirmation of the presence of the *Sub1* locus (Fig11)

Fig11: Screening of different local cultivars and F_3 populations of *Sub1* lines using artificial tank after 21 days at seedling stage.

DNA fingerprinting and confirmation of varieties/ F_1 using submergence/cold tolerant primers.

Genomic DNA Extraction

The CTAB mini-prep methods were followed for extract DNA from the leaves at Biotechnology Lab of BINA, Mymensingh. The simplified mini scale method for DNA isolation in PCR analysis was used. 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.

SSR markers and detection of their polymorphisms

Amplification of PCR amplification of simple sequence repeats (SSR) was performed with 1.5 µl 10X buffer, 0.75µl dNTPs, 1.0µl primer forward, 1.0µl primer reverse, 0.5µl Taq polymerase and 8.25µl ddH_2O using DNA thermal cycler. The PCR reactions were: initial denaturation at 94°C for 5 minutes, then final denaturation at 94°C for 1 minute and annealing at 55°C for one minute. Polymerization was carried out at 72°C for 2 minutes to complete a cycle and cycle was repeated for 34 times. The final extension was at 72°C for 7 minutes. After PCR, 6µl of 10X gel loading dye was added. Polymorphisms in the PCR products were detected by ethidium bromide staining after electrophoresis on 1.5% agarose gel using UV transilluminator. Primer survey for primer selection with submergence/cold tolerant germplasms was carried out using fifty five microsatellite markers. Selection of cold tolerance lines using ***qCT*** SSR primers.

Evaluation of germplasms using SSR markers

Polymorphism survey of FR13A, BRRI dhan52 and Binadhan-17 germplasms was carried out using thirty two microsatellite markers. Submergence tolerant genotypes was analyzed using a highly repeatable PCR based fingerprinting assay known as Simple Sequence Repeat (SSRs) or microsatellites markers. The microsatellite DNA markers produce a higher level of DNA polymorphism in rice. The microsatellite enriched libraries were constructed using the standard procedure with some modifications. The quality of extracted genomic DNA was also checked by Polyacrylamide gel electrophoresis (PAGE). Furthermore, to check the suitability of the extracted DNA, DNA was amplified with SSRs markers such as RM3843, RM5806, RM27877, RM28102, RM28502, RM180, RM206, RM209, RM217, RM219, RM228, RM231, RM234, RM241, RM247, RM24330, RM25022, RM25181, RM25519, RM26063, RM26416, RM26652, RM27694, RM208, RM211, RM35, RM51, RM80, RM127, RM134, RM138, RM140, RM149, RM164, RM169, RM249, RM276, RM296, RM300, RM314, RM336, RM337, RM400, RM407, RM443, RM493, RM494, RM508, RM515, RM520, RM153, RM23770, RM23668, RM5799, RM319, SSR1, RM217, RM219, RM228, RM231, RM234, RM241, RM247, RM24330, RM25022, RM25181. Amplified microsatellite loci were analyzed for polymorphism using Polyacrylamide gel electrophoresis (PAGE) and the result revealed that all the primers detected clear band show such as this primers RM556, RM562, RM594, RM296, RM23678, RM1115, RM495, RM153, RM23770. Out of thirty two SSR primers, nine primers were selected to evaluate the submergence tolerant genotypes for clear polymorphism and these primers were used for tagging the genes controlling *Sub1* QTL.

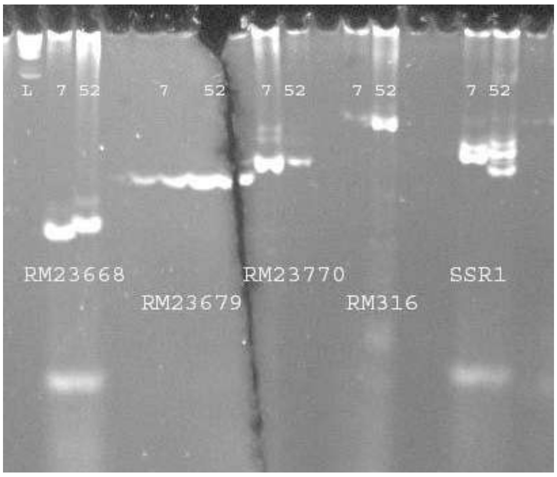


Fig 12. Banding pattern of BRRI dhan52 and Binadhan-7 germplasm using RM234, RM241, RM247, RM24330, RM25022, RM25181, RM1178, RM126, RM268, RM296, RM23678, RM1115, RM495, RM153, RM23770, RM23668, RM5799, RM319, SSR1, RM217, RM219, RM228, RM231, RM234, RM241, RM247, RM24330, RM25022, RM25181, and Molecular weight marker (100bp DNA ladder).

Field evaluation of rice mutants for growth duration, yield and yield contributing characters

Rice growth duration is a primary determinant of crop rotation in a rice-based cropping system and shortening the growth period is conducive to increasing cropping intensity. Several mutants were developed from different China rice varieties using different dose of gamma irradiations. Selected five rice mutants of M_4 generation were tested in Boro season 2019-20 at BINA Headquarters farm for growth duration and, yield and yield contributing characters.

Table 7. Preliminary yield trial of rice mutant lines for earliness and higher grain yield

Mutant lines	Days to maturity (Days)	No. of Effective tiller/hill (No.)	Plant height (cm)	Panicle length (cm)	Flag leaf length/breadth ratio	Filled grain/panicle	Grain length/breadth ratio	100 seed weight (gm)	Yield (t/ha)
RM-Ch-tez-250 (AC)-1	133 d	14.5 b	70 e	19.93 b	28.33 b	129.53 c	3.52 ab	2.42 c	6.80 b
RM-Ch-tez-250 (AC)-2	139 c	13.9 bc	80 bc	20.06 b	27.33 bc	135.47 b	3.47 ab	2.64 a	6.46 cd
RM-Ch-zao-300 (LD)-1	139 c	20.6 a	77 cd	21.40 b	24.73 d	145.43 a	3.52 ab	2.52 b	8.43 a
RM-Ch-zao-300 (LD)-2	151 b	13.9 bc	85 b	20.46 b	25.00 cd	135.43 b	3.27 c	2.36 d	6.72 bc
RM-Ch-zao-300 (LD)-5	140 c	13.4 c	72 de	20.06 b	26.06 bcd	129.60 c	3.35 bc	2.56 b	5.70 e
FTN-1	180 a	9.4 d	97 a	26.76 a	38.56 a	134.80 b	3.62 a	2.69 a	6.30 d

N.B.: Columns having common letters do not differ significantly at 0.05% level of significance

Seeds were sown on 9 November 2019 and transplanted to the field on 18 December, 2019. The experiment was laid out in RCBD with three replications. Unit plot size was 2m × 2m and spacing between hills 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 operations were followed as and when necessitated. Data on days to 50% flowering, days to maturity, plant height, total tillers plant^{-1} , effective tillers hill^{-1} , panicle length (cm) and yield (t/ha) were recorded from five randomly selected plants from each plot. Plot yield was converted into t/ha.

Among six lines, maturity period was the highest in FTN-1(160 days) and the lowest in RM-Ch-tez-250 (AC)-1. Tallest plant was found in FTN-1. Effective tiller plant^{-1} (21) was highest in RM-Ch-zao-300 (LD)-1 and the lowest was found in FTN (9). Filled grain was highest in RM-Ch-zao-300 (LD)-1 (145) and lowest (129) in RM-Ch-tez-250 (AC)-1. The highest grain yield (8.43 t/ha)) was found in RM-Ch-zao-300 (LD)-1 and lowest (5.70 t/ha) in RM-Ch-zao-300 (LD)-5 (Table 7). Based on early maturity and higher seed yield potential and morphology one line was selected and will be evaluated as multi location yield trial in next growing season.

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

More-efficient use of natural resources and plant nutrient are help to satisfy demand for food for ever increasing population. *Rhizobium* is basic component of bio-fertilizers, which has emerged as a promising alternative to nitrogenous fertilizers. Rhizobial strains isolated and characterized from Bangladesh, Germany, Turkey and Syria showed very good results at laboratory and glasshouse conditions for three different pulse legumes. Few strains showed promising results on growth and yield of lentil, pea and grass pea at glasshouse and pot experiment. Subsequently, we prepared bio-fertilizers from promising strains and evaluated their performance by field experiment on same crops. Our objectives were to develop common and effective bio-fertilizers for lentil, pea and grass pea for increasing their yield and to save nitrogenous fertilizers. Experiment was conducted at BINA substation farm Magura. There were five treatments, four from rhizobial strains and one absolutes 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, in most cases treatments four (mixed culture of BL129, BL153, BL460) had significant and positive effects 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 mixed culture treatment but statistically similar result also produced by the strains BL153 and BL460 at flowering stage (Table 8). At harvest, the highest number of pod/plant, seeds per pod and 100 seed weight were observed in the T_2 (Table 8). The highest yield was observed in the T_4 which was statistically similar with the T_2 and T_3.

Table 8. Effect of bio-fertilizers on growth and yield of pea

Treatments	At flowering stage		At harvest			
	Plant dry wt.(gm)	Nodule dry wt. (mg)	No. of pods/ plant	No of Seeds/pod	100 seed wt. (gm)	Yield/10 plant (gm)
T_1 (*R. bangladesense* BL129)	12.677 b	4.7833 c	37.967 b	4.4667 d	7.4733 A	128.74 b
T_2 ()	14.017 ab	4.7667 c	39.867 a	5.6333 a	7.4367 a	132.31 ab
T_3 (*R. lentis* BL460)	12.742 ab	6.2667 b	38.200 b	5.1500 b	7.3200 a	132.15 ab
T_4 (BL129; BL153; BL460)	14.143 a	8.5000 a	38.533 b	5.7500 a	7.8133 a	134.50 a
T_5 (control	10.958 c	3.8667 c	34.333 c	4.7833 c	6.6067 b	117.34 c

N.B.:Columns having common letters do not differ significantly at 0.05% level of significance

In case of grass 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, BL460 at flowering stage (Table 9). Similar result was also observed at harvest stage. The highest number of pods/plant, 100-seed weight and seed yield were observed in the T_2 and T_4 (Table 9).

Table 9. Effect of bio-fertilizers on growth and yield of grass pea

Treatments	At flowering stage		At harvest stage			
	Plant dry wt.(gm)	Nodule dry wt. (mg)	No. of pods/ plant	No of Seeds/pod	100 seed wt. (gm)	Yield/10 plant (gm)
T_1 (*R. bangladesense* BL129)	7.7467 b	6.6333 a	74.267 a	3.8333 c	5.450 b	96.20 b
T_2 (*R. bangladesense* BL153)	9.0500 a	7.6000 a	75.767 a	4.2167 ab	5.896 a	100.20 a
T_3 (*R. lentis* BL460)	5.5483 c	4.5667 b	64.767 b	4.2667 ab	5.496 b	86.31 c
T_4 (BL129; BL153; BL460)	9.0417 a	7.5000 a	78.300 a	4.3000 a	5.513 b	100.63 a
T_5 (control	5.3550 c	4.4000 b	64.000 b	4.0667 b	4.740 c	84.16 d

N.B.: Columns having common letters do not differ significantly at 0.05% level of significance

In case of lentil (*Lens culinaris l.*), maximum dry weight was produced by the mixed culture of rhizobium at flowering stage (Table 10). At harvest stage, the highest number of pod/plant, 100 seed weight and seed yield were observed in the T_4 (Table-13) and statistically similar result also observed for the T_2 and T_3.

Table 10. Effect of bio-fertilizers on growth and yield of lentil

Treatments	At flowering stage		At harvest stage			
	Plant dry wt.(gm)	Nodule dry wt. (mg)	No. of pods/ plant	No of Seeds/pod	100 seed wt. (gm)	Yield/10 plant (gm)
T_1 (*R. bangladesense* BL129)	5.4517 b	2.6667 a	133.97 b	1.8500 a	2.2233 c	46.197 a
T_2 (*R. bangladesense* BL153)	5.3367 bc	2.5333 a	146.47 a	1.8167 a	2.3133 ab	47.520 a
T_3 (*R. lentis* BL460)	5.3317 bc	2.6000 a	145.67 a	1.8833 a	2.3067 ab	46.957 a
T_4 (BL129; BL153; BL460)	7.4467 a	2.7000 a	149.63 a	1.8667 a	2.3533 a	47.637 a
T_5 (control	4.7733 c	1.7667 b	123.80 c	1.8000 a	2.2533 bc	41.313 b

N.B.: Columns having common letters do not differ significantly at 0.05% level of significance

Evaluation of probiotic bacterial strains against wheat blast at field conditions

A pot experiment was conducted at field conditions by artificial inoculation of wheat using fungal pathogen *Magnaporthe oryzae Triticum* and selected bacterial strains were used as bio-control agents along with chemical fungicide (Nativo). Inoculation experiment revealed that the strains B22 and GO1 showed the highest bio-control potential against blast of wheat caused by *Magnaporthe oryzae Triticum.* They showed lower disease incidence (0-52 %) and higher seed yield (52-55 g/pot) while control treatment had the maximum disease incidence (61-70%). The lowest seed yield (37g/pot) was observed in the reference *Bacillus* strain (Tables 11 and 12).

Table 11. Disease incidence at booting stage after first inoculation

Treatment	Lesion size (mm)	Length of spike (cm)	Length of infection in spike (cm)	% Disease Incidence
T_1 (Bacillus sp)	5.53 ab	13.33 a	19.00 a	59.33 a
T_2 (*B. subtilies* Ma11)	4.60 ab	13.66 a	8.00 a	60.33 a
T_3 (*B. megaterium* FR17)	4.60 ab	14.00 a	6.33 b	46.66 b
T_4 (*B. subtilies* J16)	5.73 a	13.00 a	8.00 a	58.33 a
T_5 (*B. subtilies* B22)	4.93 ab	12.00 ab	0.00 c	0.00 c
T_6 (*B. thuringiensis* GO1)	5.66a	0.00 c	0.00 c	0.00 c
T_7 (fungicide, Nativo)	5.13 ab	9.00 b	7.66 ab	63.33 a
T_8 (Control)	4.33 b	13.66 a	8.33 a	61.66 a

N.B.: Columns having common letters do not differ significantly at 0.05% level of significance

Table 12. Disease incidence at harvest after 2nd inoculation

Treatment	Length of infected spike (cm)	Length of infection in spike (cm)	% Disease Incidence	Yield (g/pot)
T_1 (Bacillus sp)	10.30 cd	6.96 bc	67.33 a	37.56 f
T_2 (*B. subtilies* Ma11)	10.93 bcd	6.10 de	57.33 b	42.67 e
T_3 (*B. megaterium* FR17)	12.36 a	7.10 ab	57.00 b	50.29 c
T_4 (*B. subtilies* J16)	10.69 bcd	7.53 a	70.00 a	47.30 d
T_5 (*B. subtilies* B22)	11.03bc	5.73 e	51.33 b	55.77 a
T_6 (*B. thuringiensis* GO1)	12.26 a	6.46 cd	52.33 b	53.67 ab
T_7 (fungicide, Nativo)	11.66 ab	6.50 cd	55.66 b	52.89 bc
T_8 (Control)	9.90 d	6.93 bc	70.00 a	46.05 d

N.B.: Columns having common letters do not differ significantly at .05% level of significance

Identification and evaluation of arsenic tolerant bacteria for arsenic mitigation in contaminated soil

A total of seventy two bacterial strains were isolated from different areas of Bangladesh to find and evaluate Arsenic (As) tolerant bacteria for mitigation of arsenic contamination and other biotechnological application. Strains colonies were circular, groove and flat in shapes and size ranged from 0.3mm to 5.8mm with white, off white, orange, yellow color. Among the strains, strain TAN-8 was able to grow in high concentrations (28mM) of arsenic. The highest arsenic tolerant strain TAN-8 showed maximum growth at 37°C and at pH-7 after 34h of inoculation. The strain TAN-8 was arsenic metabolizing bacteria since it produced violet color in silver nitrate test and suggesting that this strain uses arsenic for its own growth and development. The ERIC-PCR fingerprinting of arsenic tolerant TAN-8 strain showed seven different DNA bands. Sequencing and phylogenetic analysis of 16S rRNA gene confirmed that the strain TAN-8 was *Klebsiella pneumoniae* (100%). The strain TAN-8 was capable of effective metabolize of arsenic and survive in high arsenic condition along with high temperature and pH. Thus, strain TAN-8 could be used for mitigation of arsenic contaminated environment and to reduce arsenic uptake by field crops from As contaminated soil. Different characteristics of arsenic tolerant TAN-8 bacterial strain are shown in Figure 12.

Gene sequence

The following 16S rRNA gene sequence was obtained from arsenic tolerant TAN-8 bacterial strain. Obtained 16S-rRNA gene sequence was submitted to GeneBank NCBI and GeneBank accession number is MT663267.

AGTCGAGCGGTAGCACAGAGAGCTTGCTCTCGGGTGACGAGCGGCGGACGGGTGAGTAATG
TCTGGGAAACTGCCTGATGGAGGGGGATAACTACTGGAAACGGTAGCTAATACCGCATAAC
GTCGCAAGACCAAAGTGGGGGACCTTCGGGCCTCATGCCATCAGATGTGCCCAGATGGGAT
TAGCTAGTAGGTGGGGTAACGGCTCACCTAGGCGACGATCCCTAGCTGGTCTGAGAGGATG
ACCAGCCACACTGGAACTGAGACACGGTCCAGACTCCTACGGGAGGCAGCAGTGGGGAATA
TTGCACAATGGGCGCAAGCCTGATGCAGCCATGCCGCGTGTGTGAAGAAGGCCTTCGGGTT
GTAAAGCACTTTCAGCGGGGAGGAAGGCGATGAGGTTAATAACCTTGTCGATTGACGTTAC
CCGCAGAAGAAGCACCGGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGAGGGTGCAAGC
GTTAATCGGAATTACTGGGCGTAAAGCGCACGCAGGCGGTCTGTCAAGTCGGATGTGAAAT
CCCCGGGCTCAACCTGGGAACTGCATTCGAAACTGGCAGGCTAGAGTCTTGTAGAGGGGGG
TAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGGTGGCGAAGGC
GGCCCCCTGGACAAAGACTGACGCTCAGGTGCGAAAGCGTGGGGAGCAAACAGGATTAGA
TACCCTGGTAGTCCACGCCGTAAACGATGTCGATTTGGAGGTTGTGCCCTTGAGGCGTGGCT
TCCGGAGCTAACGCGTTAAATCGACCGCCTGGGGAGTACGGCCGCAAGGTTAAAACTCAAA
TGAATTGACGGGGGCCCGCACAAGCGGTGGAGCATGTGGTTTAATTCGATGCAACGCGAAG
AACCTTACCTGGTCTTGACATCCACAGAACTTTCCAGAGATGGATTGGTGCCTTCGGGAACT
GTGAGACAGGTGCTGCATGGCTGTCGTCAGCTCGTGTTGTGAAATGTTGGGTTAAGTCCCGC
AACGAGCGCAACCCTTATCCTTTGTTGCCAGCGGTTCGGCCGGGAACTCAAAGGAGACTGC
CAGTGATAAACTGGAGGAAGGTGGGGATGACGTCAAGTCATCATGGCCCTTACGACCAGGG
CTACACACGTGCTACAATGGCATATACAAAGAGAAGCGACCTCGCGAGAGCAAGCGGACCT
CATAAAGTATGTCGTAGTCCGGATTGGAGTCTGCAACTCGACTCCATGAAGTCGGAATCGCT
AGTAATCGTAGATCAGAATGCTACGGTGAATACGTTCCCGGGCCTTGTACACACCGCCCGTC
ACACCATGGGAGTGGGTTGCAAAAGAAGTAGGTAGCTTAACCTTCGGGAGG

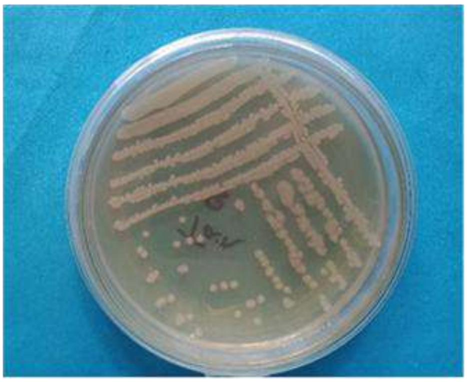


Fig. Growth of As tolerant bacteria (TAN-8)

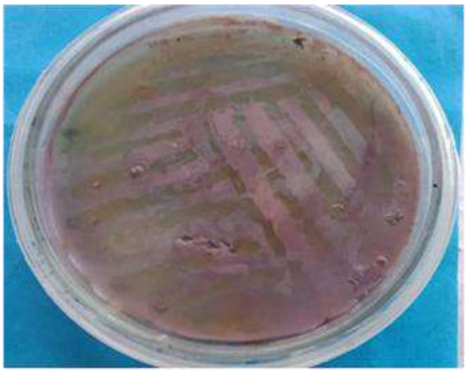
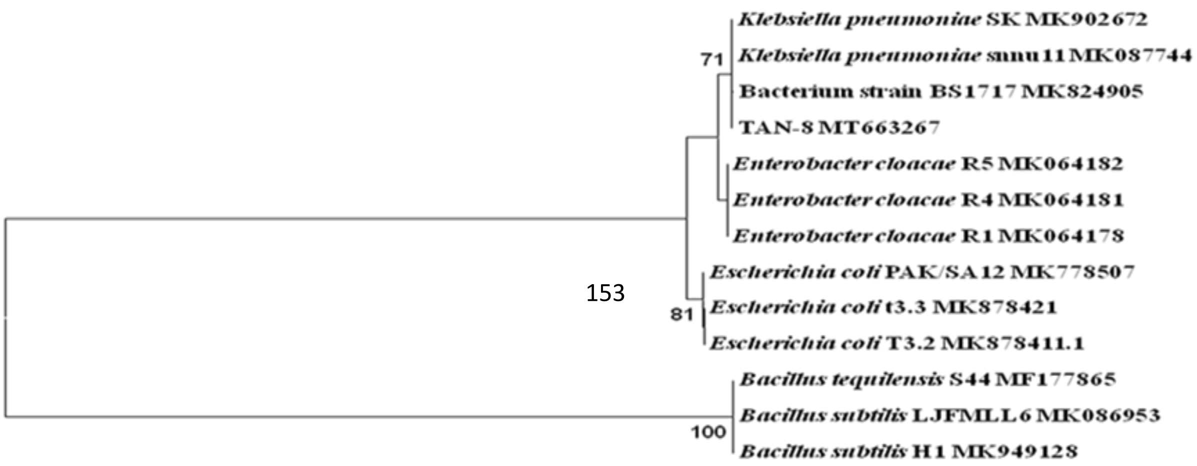


Fig. Growth of arsenic metabolizing bacteria on AgNO3

Fig. DNA fingerprint



Horticulture Division

Research Highlights of 2019-20

Lemon

A high yielding advanced lemon genotype CL-1 has been registered as **Binalebu-2** in 2019-20 which showed better fruiting and yield performances considering total yield (35-45 t ha^{-1}) and other important characters viz. most of the fruits are seedless, year round production, scented, attractive shape, size and color, thinner bark (0.35-0.45 cm), vitamin C content (30 mg/100 g fruit fresh weight), better juice content (31-35%), comparatively higher number of annual fruit bearing (130-170) and tolerance to different citrus diseases.

Chili

A high yielding chili advanced line Indo-CF-25 has been registered as **Binamorich-2** in 2019-20 which showed better field performances as well as better pungency level and higher yield (30-33 t ha^{-1}) at farmer's fields and different AEZs of the country. It also showed better performance in terms of other important agronomic characters viz. plant height, number of fruits, fruit size, individual fruit weight, dry matter content and tolerance to pests and diseases. Besides this, two exotic germplasm of chili were tested at BINA sub-station, Cumilla to see the performances for desirable characteristics.

Bottle gourd

Three M_6 mutants of bottle gourd have been selected having higher number of fruits, lower disease and insect susceptibility, bold leaves as well as good cooking quality from different advanced yield trials.

Brinjal

Two high yielding M_6 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 develop mutant tolerant to waterlogging condition, seeds of some local genotypes of brinjal were irradiated with different doses of gamma rays and the seeds were sown at BINA HQ farm, mymensingh in kharif season.

Carrot

Six M_5 mutants were evaluated in respect of seed yield and other yield attributing characters.
In case of *Brasilia agroflora* variety the highest seed yield (1119.56 kg ha^{-1}) was recorded from $V_1D_{75}P_2$ mutant line. In case of *Prima agroflora* variety, the highest seed yield (1107.54 kg ha^{-1}) was recorded from $V_2D_{75}P_3$ mutant line.

Garlic

Nine M_5 mutants obtained from irradiating the seeds of four BAU varieties and Binarashun-1 have been selected based on higher yield potentiality with bold clove size as well as better storage quality. These mutants will be further evaluated in preliminary yield trial in the next growing season.

Onion

Evaluation of M_5 mutants of which were developed from four local cultivars and one Indian cultivar through different doses gamma irradiation were successfully done at BINA HQ farm, Mymensingh where three mutants would be more promising with high seed yield and bulb yield potentials than the other irradiated mutants. Moreover, these mutants also possess desirable shape, size and good storage quality. Further evaluation procedure will be continued in next onion growing season in farmer's field.

To create genetic variability, seedlings of Taherpuri onion were pre-treated with different concentration of EMS solution before transplanting and harvested for next year screening in M_2.

Ginger

Five M_4 mutants having high yield potential and lower susceptibility to rhizome rot of zinger have been selected after stagnant waterlogging about 21days. These lines need to be further evaluated at different ginger growing areas. In addition, to develop mutants tolerant to rhizome rot of ginger, two cultivars were irradiated at different doses of gamma irradiation which are now in the experimental field.

Black Cumin

Seeds of fourteen M_3 populations derived from irradiated seeds of four local germplasms of black cumin have been preserved to screen high yield potential with better quality pod. Sixteen germplasm here given from the Ministry of Agriculture (MoA) which were grown at BINA, HQ farm in Rabi season.

Cumin

One genotype collected from Khagrachari is expecting to be promising to complete life cycle in our climatic condition.

Sweet pepper

Thirty two M_1 populations were developed and harvested the seeds for next season screening by irradiating an exotic genotype of Sweet pepper.

Okra

With the objectives of creating variability for soft fiber and good test seeds of three desirable lines of okra BARI Okra-1, BARI okra-2 and Khagrachari local were irradiated with 300, 450 and 600 Gy doses of gamma irradiation. Seeds of the survived M_1 plants were harvested dose wise for growing next generation.

Tomato

Two tomato lines are expected to be promising in winter season with higher number of fruits (78) and yield (108 t ha^{-1}). Moreover, another genotype of cherry tomato was found to be promising with high yield, taste and nutritional quality.

Sweet orange

The experiment was conducted with 16 M_1 plants of sweet orange at BINA farm, Mymensingh to create genetic variability. The irradiated plants ($WNMD_{40}P_2$) produced higher number of fruits (148) and higher TSS (14.8 %) compared to non-irradiated plants (TMD_0P_1).

Lime

The experiment was carried out with M_1 plants of lime at BINA HQs farm, Mymensingh. The irradiated plant ($LBD_{40}P_1$) produced the higher number of fruits (295 plant^{-1}) followed by irradiated plant $LBD_{20}P_1$ (280 plant^{-1}) compared to non irradiated plants (195-231 plant^{-1}).

Pomegranate

The experiment was conducted with seven pomegranate genotypes at BINA HQ farm. The tallest plant (315 cm) was recorded in P_2 genotype followed by P_1 genotype (310 cm) and P_3 genotype (275 cm), whereas the shortest plant was recorded in B_1 genotype (193 cm).

The cultivar P_2 produced the maximum number of fruits (95 plant^{-1}) along with length of fruit (5.6 cm) and breadth of fruit (5.5 cm), whereas the minimum number of fruits (78 plant^{-1}), length of fruit (4.7 cm), breadth of fruit (4.5 cm) and weight of individual fruit (203 g) were recorded in A_1. P_3 genotype accumulated the highest TSS (17.836 %), where the lowest (16.7 %) was recorded in B_1. The maximum weight of individual fruit (272 g) was obtained in P_3 genotype.

Ber

Thirteen germplasm of indigenous ber were collected from different parts of the country which were characterized in accordance with morphological variances and yield attributing characteristics. The early fruit bearing germplasm was found in GM-2, GM-4, GM-7 and GM-13. The genotype GM-4 showed double fruit bearing habit in a year. The highest amount of fruit (3.0 kg plant^{-1}) was found from GM-13 germplasm followed by followed by GM-4 (3.5 kg plant^{-1}) and GM- 7 (0.7 kg plant^{-1}).

Gladiolus

To create variability, the gladiolus corms were irradiated with 0, 10, 20, 30, 40 50 and 60 Gy doses of gamma rays and a large number of M_2 variants were harvested and will be grown in the next year for further screening.

Seed production of released varieties

Total production of seeds of Binatomato-10, Binatomato-11, Binatomato-12, Binamorich-1, Binarashun-1 and Binahalud-1 were 800 g, 500 g, 550 g, 2 kg, 40 kg and 500 kg, respectively during rabi season 2019-20. Besides these, there are five thousands saplings of Binalebu-1 were produced through cutting, air layering and grafting which were distributed among the farmers', home gardens, roof gardens, extension workers and Horticulture centre across the country for vast area coverage.

Germplasm collection

Furthermore, four hundred germplasm of different vegetables, fruits, spices and flowers were collected from home and abroad and conserved as future breeding materials to see their inherent characteristics for further irradiation process.

Yield trials of lemon genotypes at different location during 2019-20

Two germplasm of lemon viz. CL-1 and CL-2 were evaluated at BINA HQ farm and at farmer's field at Madhupur along with Binalebu-1. The experiment was laid out Complete Randomized Design with five replications. Plants were spaced at 3 m within rows of 3 m apart. Fertilizers were applied at the rate of Cowdung 20 kg, Urea 300 g, TSP 250 g, MoP 300 g, MOC 100 g, Bone meal 200 g, ash 2 kg per pit during pit preparation. Moreover, cultural and intercultural operations were followed as and when required. Data on various characters like plant height, number of fruits per plant, individual fruit weight, fruit length, fruit breadth, juice content, vitamin C content, number of seeds per fruit, rind characters and yield were recorded from randomly selected five plants. Fruit juice was extracted to determine the juice content per fruit vitamin C was assessed according to the method of Ranganna (1979).

BINA HQ farm, Mymensingh

The tallest plant height (265.23 cm) was found in CL-1 (Proposed Binalebu-2) genotype while the shortest plant (229.25 cm) was recorded in CL-2 (Table 1). Maximum number of fruits plant^{-1} (281.77) was obtained from CL-1 followed by Binalebu-1 (245.39) and CL-2 (224.23). In case of fruit yield and vitamin C content, the highest yield (40.36 kg/tree) and vitamin C content (29.65 mg/100ml) were obtained from CL-1 and the second highest fruit yield (32.14 kg plant^{-1}) and vitamin C content (24.891 mg/100ml) were found in Binalebu-1 (Table 2). The lowest fruit yield (24.77 kg plant^{-1}) and vitamin C content (20.56 mg/100ml) were recorded in CL-2.

Table 1. Yield and yield attributes of the tested lemon genotypes at Mymensingh during 2019-20

Genotypes	Plant height (cm)	Fruit number/ plant	Fruit length (cm)	Fruit breadth (cm)	Individual fruit weight (g)	Yield (kg/tree)
CL-1	265.23a	281.77a	7.50b	6.10a	143.22b	40.36a
CL-2	229.25b	224.23b	5.52c	4.30b	110.5c	24.77b
Binalebu-1	241.55c	245.399	5.98a	5.16a	131.0a	32.14b

Table 2. Fruit quality parameters of the tested genotypes at Mymensingh during 2019-20

Genotypes	No. of seed/ fruits	Rind thickness (mm)	Juice/ fruit (ml)	Wt. of rind (g)	Wt. of carpel (g)	Vit. C (mg/100g)
CL-1	4.14b	3.85b	54.31a	40.65a	48.32b	29.65a
CL-2	12.11a	5.42a	19.44a	37.12	53.15	20.56
Binalebu-1	6b	4.01a	24.02b	47.99	58.33	24.89

Madhupur, Tangail

At Madhupur, Tangail three genotypes showed the same trend in plant height, fruit weight and vitamin C content as described in the result of Mymensingh during 2019-2020 (Table 3 and table 4). Three parameters were the highest in the genotype CL-1 followed by Binalebu-1 and CL-2 genotype obtained the lowest result in case of yield and yield attributing characteristics.

Table 3. Yield and yield attributes of the tested lemon genotypes at Madhupur, Tangail during 2019-20

Genotypes	Plant height (cm)	Fruit number/ plant	Fruit length (cm)	Fruit breadth (cm)	Individual fruit weight (g)	Yield (kg $plant^{-1}$)
CL-1	260.54a	260.6a	7.48b	6.10a	135.9c	35.41a
CL-2	202.6b	217.3c	5.12c	4.32b	112b	24.30b
Binalebu-1	230.89b	225.3b	6.12a	5.24a	125a	28.12b

Table 4. Fruit quality parameters of the tested genotypes at Madhupur, Tangail during 2019-20

Genotypes	No. of seed/fruits	Rind thickness (mm)	Juice/ fruit (ml)	Wt. of rind (g)	Wt. of carpel (g)	Vit. C (mg/100g)
CL-1	5b	35.41a	53.28a	38.65a	45.47b	30.15a
CL-2	15a	24.30b	24.19b	35.89	52.15	21.00
Binalebu-1	6b	28.12b	26.74b	44.91	54.11	25.10

The advanced line CL-1 was released as **BinaLebu-2** by the National Seed Board (NSB) of Bangladesh.

On-farm trials of promising genotypes of chili during the winter season of 2019-20

The genotype IndoCF-25-1 (proposed Binamorich-2) along with two check varieties Binamorich-1 and BARI Morich-1 were put into on-farm trials in the winter season of 2019-20. These trials were carried out in farmers' field at Mymensingh Sadar, Gouripur, Sherpur and Jamalpur. Experiment was laid out in RCBD with three replications. Unit plot size was 12 m^2 (4.0 m × 3.0 m) with 50 cm spacing between two rows and plant to plant distance was 50 cm. Recommended management packages were followed for proper growth and development of chili. Data on various characters such as plant height, number of fruits/plant, fruit length and breadth (cm), yield/plant, average weight of fresh individual chili, total yield and pungency were recorded from 10 (ten) randomly selected plants in each plot. Fresh chili yield of each plot was recorded till harvest and averaged and then converted into t ha^{-1}. Appropriate statistical analysis was performed and the mean values of each character were compared.

Farmer's field, Boyra, Mymensingh

Significant difference was recorded in plant height among the chili genotypes/varieties (Table 5). The tallest plant height (76.20 cm) was found in the advance line IndoCF-25-1 (proposed Binamorich-2) genotype followed by Binamorich-1 (54.01 cm) (Table 5). The shortest plant height was recorded in BARI Morich-1 (37.10 cm). The maximum number of fruits per plant (108.5) was obtained from BARI Morich-1 followed by IndoCF-25-1 genotype (78.2) and the minimum from Binamorich-1 (65.4). The longest fruit (15.68) was found in Binamorich-1 followed by IndoCF-25-1 genotype (13.95). On the contrary, the shortest fruit length was recorded in BARI Morich-1 (6.18) (Table 5). Highest yield per plant (848.50 g) was recorded in Binamorich-1 which was statistically similar with IndoCF-25-1 (784.85 g). On the other hand lowest yield per plant was in BARI Morich-1 (174.50 g). In case of total fresh yield of chili, the highest yield (34.46 t ha^{-1}) was obtained in Binamorich-1. Statistically similar result was found in IndoCF-25-1 genotype (31.58 t ha^{-1}). BARI Morich-1 produced the lowest yield (11.75 t ha^{-1}) among the test genotypes (Table 5). Though, IndoCF-25-1 produced lower number of fruits per plant but it gave the higher yield compared to BARI Morich-1 which was attributed to its fruit length, fruit diameter, average individual fruit weight and yield per plant as well. This genotype also gave lower yield compared to Binamorich-1 but its pungency is stronger.

Table 5. Yield performances of chili genotypes at Mymensingh during Rabi, 2019-20 at Boyra, Mymensingh

Genotype/ Variety	Plant height (cm)	No. of fruits plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Yield (g plant^{-1})	Yield (t ha^{-1})	Average wt. (g fruit^{-1})	Taste/ Pungency
IndoCF-25-1	76.2	78.2	13.95	5.25	784.85	31.58	11.38	High
Binamorich-1	54.1	65.4	15.68	5.77	848.50	34.46	13.02	Medium
BARI Morich-1	37.3	108.5	6.18	2.69	174.50	11.75	1.72	High
Mean	55.86	84.03	11.94	4.57	602.62	25.93	8.71	
SD	19.51	22.13	5.06	1.65	372.12	12.36	6.11	

Farmers field, Gouripur, Mymensingh

The tallest plant (68.90 cm) was found in the advanced line IndoCF-25-1 followed by Binamorich-1 (40.2 cm) (Table 6). The shortest plant height was recorded in BARI Morich-1 (35.9 cm). The longest fruit (14.05) was found in Binamorich-1 followed by IndoCF-25-1 (11.83). On the contrary the shortest length of fruit was found in BARI Morich-1 (5.98). Highest yield per plant (818.50 g) was recorded in Binamorich-1 followed by IndoCF-25-1 (755.50 g). On the other hand, the lowest yield per plant was in BARI Morich-1 (152.50 g). In case of total fresh yield of chili, the highest yield (32.18 t ha^{-1}) was found in Binamorich-1. Statistically similar result was obtained in IndoCF-25-1 (30.25 t ha^{-1}) while BARI Morich-1 produced the lowest yield (10.92 t ha^{-1}) among the test genotypes (Table 6).

Table 6. Yield and yield contributing characters of chili genotypes during Rabi, 2019-20 at Gouripur, Mymensingh

Genotype/ variety	Plant height (cm)	No. of fruits plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Yield (g plant^{-1})	Yield (t ha^{-1})	Average wt. (g fruit^{-1})	Taste/ pungency
IndoCF-25-1	68.9	73.4	11.83	4.90	755.50	30.25	10.65	High
Binamorich-1	40.2	60.4	14.05	5.22	818.50	32.18	12.20	Medium
BARI Morich-1	35.9	98.5	5.98	2.60	152.50	10.92	1.54	High
Mean	48.33	77.43	10.62	4.24	575.50	24.45	8.13	
SD	17.94	19.37	4.17	1.43	367.68	11.76	5.76	

Farmers field, Sherpur

Among these genotypes, IndoCF-25-1 produced tallest plant (76.1 cm) and also gave higher yield than the check varieties (Table 7). Yield ranged from 143.50 g plant^{-1} to 738.15 g plant^{-1}.

The highest yield per plant (738.15 g plant^{-1}) was found in Binamorich-1 followed by the genotype IndoCF-25-1 (738.15 g plant^{-1}) while the lowest yield per plant (143.50 g plant^{-1}) was recorded in BARI Morich-1. Highest numbers of fruits (90.5) was found in BARI Morich-1 followed by IndoCF-25-1 (65.5) and the lowest number of fruits was found in Binamorich-1 (52.8). The highest yield was produced by the variety Binamorich-1 (31.80 t ha^{-1}) followed by genotype IndoCF-25-1 (29.05 t ha^{-1}) while the lowest was produced by BARI Morich-1 (Table 7).

Table 7. Yield and yield contributing characters of chili during Rabi, 2019-20 at Sherpur

Genotype/variety	Plant height (cm)	No. of fruits plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Yield (g plant^{-1})	Yield (t ha^{-1})	Average wt. (g fruit^{-1})	Taste/ pungency
IndoCF-25-1	76.1	65.5	11.50	4.72	738.15	29.05	10.50	High
Binamorich-1	46.5	52.8	13.75	5.10	795.10	31.80	12.25	Medium
BARI Morich-1	38.2	90.5	5.60	2.48	143.50	10.75	1.58	High
Mean	53.6	69.60	10.28	4.10	558.92	23.87	8.11	
SD	19.92	19.18	4.21	1.42	360.89	11.44	5.72	

Farmers field, Jamalpur

The tallest plant height (78.8 cm) was found in the advanced line IndoCF-25-1 followed by Binamorich-1 (Table 8). The shortest plant height was recorded in BARI Morich-1 (39.5 cm). The longest fruit (16.15) was found in Binamorich-1 followed by IndoCF-25-1 genotype (14.50). On the contrary, the shortest length of fruit was found in BARI Morich-1 (6.20). Highest yield per plant (855.50 g) was recorded in Binamorich-1. Statistically similar result was found in IndoCF-25-1 (784.10). On the other hand, the lowest yield per plant was recorded in BARI Morich-1 (172.40 g). In case of total fresh yield of chili, the highest yield (33.12 t ha^{-1}) was obtained in Binamorich-1 followed by IndoCF-25-1 genotype (31.80 t ha^{-1}) which was statistically similar with Binamorich-1 while BARI Morich-1 produced the lowest yield (Table 8).

Table 8. Yield and yield contributing characters of chili during Rabi, 2019-20

Genotype/ variety	Plant height (cm)	No. of fruits plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Yield (g plant^{-1})	Yield (t ha^{-1})	Average wt. (g fruit^{-1})	Taste/ pungency
IndoCF-25-1	78.8	80.5	14.50	5.32	784.10	31.80	11.28	High
Binamorich-1	45.6	67.8	16.15	5.78	855.50	33.12	12.44	Medium
BARI Morich-1	39.5	110.5	6.20	2.75	172.40	11.92	1.78	High
Mean	54.63	86.27	12.28	4.62	604.00	25.61	8.50	
SD	21.12	21.93	5.33	1.63	375.48	11.88	5.85	

Considering stronger pungency and at per yield and other yield attributes, the genotype IndoCF-25-1 was registered as BinaMorich-2 in 2020.

Bottle gourd

Evaluation of promising mutants of bottle gourd

The experiment was conducted at Kashiar Char, Sutiakhali, Mymensingh and BINA substation Khagrachari during rabi season 2019-2020 to evaluate the performance of promising M_6 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 as fruit length, fruit diameter, number of fruit/plant, fruit yield and average fruit weight were taken from each mutant. The data were subjected to proper statistical analyses and are shown in Table 9, Table 10, respectively.

BINA, HQ Mymensingh

Results showed that BL-4$M_6D_{300}P_{4-2}$ produced the highest number of fruits (22.67 plant^{-1}) in all the mutant population (Table 9). Rest of the mutants showed 15.33-19.33 fruits plant^{-1}. The control plant produced 15.33 fruits plant^{-1}.

Table 9. Yield attributes of elite M_6 mutants of bottle gourd at Mymensingh

Mutant/Variety	No. of fruits plant^{-1}	Length of fruit (cm)	Diameter of fruit (cm)	Color
BL-4 (control)	15.33	42.3	35.24	Dark green with whitish spot
BL-4$M_6D_{300}P_{4-2}$	22.67	48.25	36.24	Light green
BL-4$M_6D_{300}P_{5-2}$	18.67	43.16	37.81	Light green
BL-4$M_6D_{300}P_{6-3}$	19.33	42.15	34.51	Light green with whitish spot
BL-4$M_6D_{150}P_{3-2}$	17.67	46.32	37.46	Dark green
BL-4$M_6D_{150}P_{3-3}$	19.33	51.39	38.25	Dark green
SD(±)	2.40	3.74	1.50	-

Khagrachari sub-station

Results showed that BL-4$M_6D_{300}P_{4-2}$ produced the highest number of fruits (23.33 plant^{-1}) in all the mutant population (Table 10). Rest of the mutants showed 14.67-20.67 fruits/plant. The control plant produced 14.67 fruits/plant.

Table 10. Yield attributes of elite M_6 mutants of bottle gourd at Khagrachari

Mutant/ Variety	No. of fruits plant^{-1}	Length of fruit (cm)	Diameter of fruit (cm)	Color
BL-4 (control)	14.67	42.26	36.32	Dark green with whitish spot
BL-4$M_6D_{300}P_{4-2}$	23.33	49.62	35.78	Light green
BL-4$M_6D_{300}P_{6-2}$	18.33	42.27	35.15	Light green with whitish spot
BL-4$M_6D_{300}P_{6-3}$	19.67	42.5	35.21	Light green with whitish spot
BL-4$M_6D_{150}P_{3-2}$	17.00	46.32	34.25	Dark green
BL-4$M_6D_{150}P_{3-3}$	20.67	51.99	38.28	Dark green
SD(±)	3.01	4.22	1.38	-

Brinjal

Performances of promising mutants of brinjal

Farmers' field, Mymensingh

The experiment was conducted with seven M_6 mutants and their parents at BINA HQ farm, Mymensingh and BINA sub-station farm at Cumilla and Ishwardi to observe the performances. Seeds were sown on 19th October 2019 and transplanted on 17th November 2019. The experiment was laid out in row planting using suggested 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, number of fruit/plant, fruit yield and average fruit weight were recorded from ten randomly selected competitive plants of each mutant. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 11,12 and 13. Results showed that the mutants differed for yield and yield attributes (Table 11). The mutant line Ind$M_5D_{75}P_{29}$ showed the highest fruit yield (7.2 kg plant^{-1}) which was statistically similar to Ind$M_5D_{75}P_{38}$ (6.8 kg plant^{-1}). The rest mutants showed the fruit yield ranged from 6.51 to 3.7 kg plant^{-1}. It could be concluded that the mutants Ind$M_5D_{75}P_{29}$ contributed the highest yield (97.82 t ha^{-1}) followed by Ind$M_5D_{75}P_{38}$ (95.83 t ha^{-1}).

Table 11. Yield attributes of M_6 mutants of brinjal at BINA HQ farm, Mymensingh

Mutant/ Variety	Plant height (cm)	Branch plant^{-1} (no.)	Fruit plant^{-1} (no.)	Total fruit wt. plant^{-1} (kg)	Yield (t ha^{-1})
Ind$M_6D_{75}P_{29}$	102.35	9.5	31.24	7.2	97.82
Ind$M_6D_{75}P_{38}$	95.6	9.3	28.56	6.8	95.83
Ind$M_6D_{75}P_{42}$	78.25	8.5	23.23	4.5	67.39
Ind$M_6D_{75}P_{43}$	88.64	8.6	27.56	6.51	97.48
Ind$M_6D_{75}P_{45}$	87.25	9.1	18.74	4.2	62.89
Ind$M_6D_{75}P_{49}$	76.28	8.2	17.59	4.1	61.40
Control (Parent)	89.25	8.6	16.4	3.7	55.41
S D (±)	9.11	0.48	5.91	1.48	22.19

Cumilla sub-station

The mutant line Ind$M_5D_{75}P_{29}$ showed the highest fruit yield (7.5 kg plant^{-1}) which was statistically similar to Ind$M_5D_{75}P_{38}$ (7.2 kg plant^{-1}) (Table 12). The rest mutants showed the fruit yield ranged from 3.5-4.5 kg plant^{-1}. It could be concluded that the mutant Ind$M_5D_{75}P_{29}$ contributed the highest fruit yield (95.31 t ha^{-1}) followed by Ind$M_5D_{75}P_{38}$ (94.82 t ha^{-1}).

Table 12. Yield attributes of M_6 mutants of brinjal at Ishwardi sub-station 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$M_6D_{75}P_{29}$	92.50	10.3	28.5	7.5	95.31
Ind$M_6D_{75}P_{38}$	85.32	9.99	24.5	7.2	94.82
Ind$M_6D_{75}P_{42}$	78.98	9.40	18.6	4.5	67.39
Ind$M_6D_{75}P_{43}$	90.88	8.25	18.3	4.2	62.89
Ind$M_6D_{75}P_{45}$	92.25	8.46	18.7	4.3	64.39
Ind$M_6D_{75}P_{49}$	82.63	8.24	16.5	4.1	61.40
Control (Parent)	87.56	9.20	11.25	3.5	52.41
SD (±)	5.15	0.84	5.57	1.61	24.08

Ishurdi sub-station

The mutant line Ind$M_5D_{75}P_{29}$ showed the highest fruit yield (7.2 kg $plant^{-1}$) which was statistically similar to Ind$M_5D_{75}P_{38}$ (7.12 kg $plant^{-1}$) (Table 13). The rest mutants showed the fruit yield ranged from 3.42-4.8 kg $plant^{-1}$. It could be concluded that the mutant Ind$M_5D_{75}P_{29}$ contributed the highest fruit yield (98.82 t ha^{-1}) followed by Ind$M_5D_{75}P_{38}$.

Table 13. Yield attributes of M_6 mutants of brinjal at Ishwardi sub-station 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$M_6D_{75}P_{29}$	91.23	10.24	26.12	7.2	98.82
Ind$M_6D_{75}P_{38}$	84.25	9.55	22.23	7.12	96.62
Ind$M_6D_{75}P_{42}$	77.95	9.21	19.25	4.25	63.64
Ind$M_6D_{75}P_{43}$	88.77	8.25	17.5	4.26	63.79
Ind$M_6D_{75}P_{45}$	87.56	8.67	17.56	4.8	71.88
Ind$M_6D_{75}P_{49}$	81.23	8.29	15.32	3.5	52.41
Control (Parent)	89.32	9	14.25	3.42	51.21
SD (±)	4.81	0.71	4.11	1.59	23.84

Carrot

Evaluation of M_5 mutants of carrot (Seed to seed method)

The experiment was conducted with 20 M_5 mutants and two check varieties (*Brasilias agroflora* and *Prima agroflora*). It was laid out in Randomized Complete Block Design with three replications. The size of a unit plot was 2.0 m × 1.0 m accommodating thirty six plants per plot with a spacing of 25 cm × 25 cm. Plot to plot distance was provided 50 cm while the block to block distance 1.0 m. All the parameters on plant growth, yield components and quality seed of carrot were significantly influenced by the mutants (Table 14 and 15). The mutants $V_1D_{75}P_2$ produced the tallest plant (177.48 cm), higher number of primary umbel/plant (12.12), number of secondary umbel/plant (14.99), higher seed yield per plant (7.78 g) and seed yield per plot (217.77 g) than parents. The non irradiated plants took the minimum time to 50% flowering, days required from flower to fruit set whereas irradiated plants took the longer period in both of *Brasilia agroflora* (Table 14) and *Prima agroflora* varieties (Table 15). The highest seed yield (1119.56 kg ha^{-1}) was recorded from $V_1D_{75}P_2$ populations (Table 14) while the lowest yield (712.00 kg ha^{-1}) was recorded from $V_1D_oP_1$ populations (Table 15).

Table 14. Seed yield and related traits of M_5 mutants of carrot (Var. *Brasilia agroflora*)

Mutants	**Plant height (cm)**	**Days to 50% flowering**	**Days required from flower to fruit set**	**No. of primary umbels/plant**	**No. of secondary umbels/plant**	**Seed yield/ plant (g)**	**Seed yield/ plot (g)**	**Yield (Kg/ha)**
$V_1D_oP_1$	155.11	54.22	9.10	8.41	11.11	5.77	150.21	712.00
$V_1D_oP_2$	153.23	52.12	9.83	8.56	11.32	5.80	163.64	811.99
$V_1D_oP_3$	150.42	53.57	10.91	8.43	12.90	6.25	164.20	799.22
$V_1D_{50}P_1$	162.72	54.30	11.77	8.21	13.55	6.20	158.46	782.88
$V_1D_{50}P_2$	164.25	55.28	11.54	10.66	13.65	5.68	155.71	773.86
$V_1D_{50}P_3$	162.12	55.30	12.64	10.47	13.70	6.47	167.89	839.52
$V_1D_{75}P_1$	170.12	55.33	12.78	11.32	13.20	6.99	201.36	1099.21
$V_1D_{75}P_2$	**177.48**	**56.00**	**12.82**	**12.12**	**14.99**	**7.78**	**218.77**	**1119.56**
$V_1D_{75}P_3$	173.47	53.42	10.10	11.13	14.14	6.12	188.00	938.54
$V_1D_{75}P_4$	168.42	55.12	12.12	10.12	15.63	6.87	184.66	824.80
$V_1D_{100}P_1$	159.10	67.23	12.75	10.80	13.49	6.89	189.97	852.80
$V_1D_{100}P_2$	151.33	57.34	12.68	10.33	14.69	6.89	188.79	923.50
$V_1D_{100}P_3$	159.99	62.32	11.00	10.42	12.28	6.76	183.83	898.44

Table 15. Seed yield and related traits of M_5 mutants of carrot (Var. *Prima agroflora*)

Mutants	Plant height	Days to 50% flowering	Days required to fruit set	No. of primary umbels/plant	No. of secondary umbels/plant	Seed yield/ plant (g)	Seed yield/ plot (g)	Yield(t ha^{-1})
$V_2D_oP_1$	112.12	54.10	12.52	10.12	11.82	5.36	155.56	801.11
$V_2D_oP_2$	105.31	53.27	12.50	10.25	11.91	5.68	169.76	977.30
$V_2D_{50}P_1$	107.88	56.78	13.59	10.90	13.72	5.88	154.72	984.45
$V_2D_{50}P_2$	134.78	55.19	13.40	10.92	13.11	5.78	162.48	802.58
$V_2D_{50}P_3$	142.21	60.98	14.31	11.20	13.12	5.84	161.84	802.47
$V_2D_{75}P_1$	145.32	58.45	14.20	12.23	14.13	6.78	198.45	977.54
$V_2D_{75}P_2$	138.41	58.68	14.42	10.15	12.99	6.64	194.74	967.33
$V_2D_{75}P_3$	137.45	58.57	14.60	11.62	13.66	7.99	218.41	1107.54
$V_2D_{100}P_1$	141.54	55.74	14.55	11.10	11.50	6.99	210.76	1064.80
$V_2D_{100}P_2$	146.74	56.12	14.31	10.11	11.00	6.87	203.76	1002.80
$V_2D_{100}P_3$	142.10	54.47	14.40	10.14	12.25	6.69	203.76	987.80
$V_2D_{100}P_4$	139.00	55.55	15.24	11.47	10.74	7.84	200.00	977.00

Legend: V_1-Carrot variety (*Brasilias agroflora*), V_2-Carrot variety (*Prima agroflora)*

Garlic

Evaluation of M_5 mutants of garlic

The experiment was conducted to observe the performance of nine M_5 mutants developed from Garlic BAU Rasun-1, BAU Rasun-2, BAU Rasun-3, BAU Rasun-4 and AC-5. Seeds (Cloves) of the garlic were planted during 2nd week of November, 2019. 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 each mutant.

Results showed that the M_5 mutants differed with the check (Mother) variety for yield and yield attributes (Table 16-20).

In case of BAU Rasun-1, yield of the M_5 mutants were observed ranged from 5.15 to 8.75 t ha^{-1} whereas the highest yield (8.75 t ha^{-1}) was produced by the $B_1M_5D_{1.5}P_2$ mutant plants. The lowest yield was produced by $B_1M_5D_{2.0}P_1$ (5.15 t ha^{-1}) (Table 16).

In case of BAU Rasun-2, yield of M_5 mutants were ranged from 5.90 to 9.98 t ha^{-1}. The $B_2M_5D_{1.5}P_3$ produced the highest yield (9.98 t ha^{-1}). The lowest yield was produced by $B_2M_5D_{2.0}P_4$ (Table 17).

In case of BAU Rasun-3, yield of M_5 mutants were observed ranged from 6.44 to 9.93 t ha^{-1}. The $B_3M_5D_{0.75}P_1$ mutant plant produced the highest yield (9.93 t ha^{-1}) and the lowest yield was produced by $B_3M_5D_{1.5}P_5$ (6.44 t ha^{-1}) (Table 18).

In case of BAU Rasun-4, yield of M_5 mutants were observed ranged from 5.19 to 9.32 t ha^{-1}. The $B_4M_5D_{1.5}P_2$ plant produced the highest yield (9.32 t ha^{-1}) and the lowest yield was produced by B_5D_0 (5.00 t ha^{-1}) (Table 19).

The genotype AC-5 (Binarasun-1) of garlic responded well to the gamma irradiation. In case of AC-5 population, yield of M_5 mutants were observed ranged from 5.18 to 9.96 t ha^{-1}. The AC-$5M_5D_{0.75}P_1$ plant produced the highest yield (9.96 t ha^{-1}) which was followed by AC-$5M_5D_{0.75}P_9$ (9.82 t ha^{-1}). The lowest yield was produced by AC-$5M_5$D.0.75P_{10} (5.18 t ha^{-1}) and the non irradiated mother (5.37 t ha^{-1}) (Table 20).

Table 16. Agronomic performance of M_5 mutants derived from irradiated BAU Rasun-1

Mutants/ Mother	Plant height (cm)	Leaf $plant^{-1}$ (no.)	Fresh wt. of bulb $plant^{-1}$ (g)	Clove $bulb^{-1}$ (no.)	Bulb yield $plot^{-1}$ (kg)	Bulb yield (t ha^{-1})
$B_1M_5D_{1.0}P_1$	55.77	7.67	20.73	28.80	0.88	5.21
$B_1M_5D_{1.0}P_3$	55.96	6.65	17.67	30.43	0.94	7.94
$B_1M_5D_{1.0}P_5$	51.87	5.42	20.83	25.57	0.79	8.22
$B_1M_5D_{1.0}P_6$	47.12	5.68	20.02	26.38	0.81	7.49
$B_1M_5D_{1.5}P_1$	56.81	6.75	19.71	27.19	0.83	8.75
$B_1M_5D_{1.5}P_2$	56.28	5.63	19.00	31.94	0.99	8.27
$B_1M_5D_{2.0}P_1$	47.41	4.30	19.20	24.57	0.77	5.15
$B_1M_5D_{2.0}P_4$	48.93	6.34	17.87	25.37	0.79	6.33
$B_1M_5D_{2.0}P_5$	63.65	11.14	20.12	26.71	0.79	8.31
B_1D_0 (Mother)	46.93	5.93	21.24	25.88	0.82	7.69
SD (±)	5.36	1.89	1.34	2.26	0.09	0.83

Table 17. Agronomic performance of M_5 mutants derived from irradiated BAU Rasun-2

Mutants/ Mother	Plant height (cm)	Leaf plant^{-1} (no.)	Fresh wt. of bulb plant^{-1} (g)	Clove bulb^{-1} (no.)	Bulb yield plot^{-1} (kg)	Bulb yield (t ha^{-1})
$B_2M_5D_{0.75}P_3$	60.56	11.52	16.77	26.15	0.60	7.85
$B_2M_5D_{1.0}P_3$	53.00	7.61	17.77	25.07	0.63	7.63
$B_2M_5D_{1.0}P_5$	50.98	10.25	23.45	28.41	0.83	8.79
$B_2M_5D_{1.0}P_7$	48.96	10.54	15.57	29.98	0.55	9.08
$B_2M_5D_{1.5}P_1$	47.04	10.25	23.66	24.09	0.83	6.32
$B_2M_5D_{1.5}P_3$	47.04	9.56	24.36	23.20	0.86	9.98
$B_2M_5D_{2.0}P_1$	48.96	11.32	23.55	23.49	0.82	7.38
$B_2M_5D_{2.0}P_3$	44.82	11.22	21.46	25.36	0.75	8.71
$B_2M_5D_{2.0}P_4$	46.94	9.27	21.66	23.20	0.76	5.90
B_2D_0 (Mother)	40.92	8.29	15.87	25.07	0.56	6.88
SD (±)	6.15	1.11	20.54	2.32	0.13	9.29

Table 18. Agronomic performance of M_5 mutants derived from irradiated BAU Rasun-3

Mutants/ Mother	Plant height (cm)	Leaf plant^{-1} (no.)	Fresh wt. of bulb plant^{-1} (g)	Clove bulb^{-1} (no.)	Bulb yield plot^{-1} (kg)	Bulb yield (t ha^{-1})
$B_3M_5D_{0.75}P_1$	66.00	8.77	22.36	28.82	0.99	9.93
$B_3M_5D_{0.75}P_2$	68.28	7.81	20.97	25.84	0.72	7.18
$B_3M_5D_{0.75}P_3$	60.61	8.29	19.38	19.08	0.67	6.65
$B_3M_5D_{0.75}P_4$	58.92	7.34	21.96	20.37	0.75	7.51
$B_3M_5D_{1.0}P_3$	57.30	8.01	20.07	23.65	0.68	6.88
$B_3M_5D_{1.5}P_2$	45.68	6.58	20.57	23.45	0.68	6.84
$B_3M_5D_{1.5}P_3$	48.41	7.43	21.96	25.34	0.75	7.52
$B_3M_5D_{1.5}P_5$	46.52	7.52	20.86	26.53	0.73	6.44
B_3D_0(Mother)	60.89	8.39	13.11	23.25	0.55	7.54
SD (±)	7.62	0.69	46.22	3.56	0.10	0.97

Table 19. Agronomic performance of M_5 mutants derived from irradiated BAU Rasun-4

Mutants/ Mother	Plant height (cm)	Leaf plant^{-1} (no.)	Fresh wt. of bulb plant^{-1} (g)	Clove bulb^{-1} (no.)	Bulb yield plot^{-1} (kg)	Bulb yield (t ha^{-1})
$B_4M_5D_{0.75}P_1$	83.72	8.22	24.06	26.10	0.85	8.24
$B_4M_5D_{0.75}P_3$	81.65	8.32	24.95	21.47	0.88	6.54
$B_4M_5D_{0.75}P_6$	82.63	13.49	24.25	27.44	0.85	8.31
$B_4M_5D_{0.75}P_7$	80.67	12.58	26.04	19.74	0.92	8.92
$B_4M_5D_{0.75}P_8$	78.39	13.49	26.24	20.51	0.93	6.36
$B_4M_5D_{0.75}P_{10}$	77.31	12.79	26.84	20.61	0.95	5.19
$B_4M_5D_{0.75}P_{12}$	78.39	11.98	26.34	24.65	0.96	9.02
$B_4M_5D_{1.0}P_1$	76.23	9.13	25.25	22.73	0.89	6.68
$B_4M_5D_{1.5}P_2$	66.67	8.02	18.69	25.61	0.66	9.32
B_4D_0(Mother)	93.60	5.70	13.50	19.46	0.56	5.00
SD (±)	5.93	2.33	3.59	2.73	0.11	0.79

Table 20. Agronomic performance of M_5 mutants derived from irradiated AC-5 (Binarasun-1)

Mutants/ Mother	Plant height (cm)	Leaf plant^{-1} (no.)	Fresh wt. of bulb plant^{-1} (g)	Clove bulb^{-1} (no.)	Bulb yield plot^{-1} (kg)	Bulb yield (t ha^{-1})
AC-5$M_5D_{0.75}P_1$	82.41	10.90	27.29	25.00	0.99	9.96
AC-5$M_5D_{0.75}P_2$	77.39	11.09	24.14	23.28	0.87	8.72
AC-5$M_5D_{0.75}P_4$	76.04	11.96	25.19	23.56	0.91	6.10
AC-5$M_5D_{0.75}P_7$	76.90	10.03	24.43	19.46	0.86	8.65
AC-5$M_5D_{0.75}P_9$	77.87	10.03	26.42	21.46	0.95	9.82
AC-5$M_5D_{0.75}P_{10}$	72.75	10.90	25.47	21.37	0.71	5.18
AC-5$M_5D_{0.75}P_{12}$	75.94	11.87	24.61	21.37	0.88	8.88
AC-5$M_5D_{0.75}P_{13}$	77.20	10.42	25.37	19.17	0.91	9.16
AC-5$M_5D_{1.0}P_1$	70.82	9.55	25.57	24.04	0.80	5.37
AC-5$M_5D_{1.0}P_5$	69.85	6.36	25.67	21.46	0.92	6.47
AC-5D_0(Mother)	85.22	9.55	21.56	18.99	0.78	5.29
SD (±)	4.39	1.47	1.40	1.94	0.08	0.55

Onion

Evaluation of M_5 mutants of onion

The experiment was conducted to evaluate the performances of the M_5 mutants which were derived from five onion accessions (Taherpuri, Faridpuri, Onion-3, Spring and Indian onion). The experiment was laid out in plant progeny row method using spacing 30 cm × 15 cm. Fertilizers were applied at the rate of Urea 200 kg, TSP 175 kg, MoP 150 kg and gypsum 110 kg ha^{-1} apart from recommended cultural and intercultural operations. Onion bulb was harvested when at maturity (20th march, 2020). The harvested bulbs were kept in storage after optimum drying under sunlight. On the other hand, in case of pure seed production of the nine mutants previous year fresh bulbs were sown on November, BINA HQ farm. Recommended production packages were followed to ensure normal plant growth and development. After maturity, seeds were harvested and preserved for next year seedling production. Data on various characters were taken from each mutant line.

Results showed that the mutants differed for yield and yield attributes from their parents (Table. 21). In case of five genotypes of onion, plant height was ranged from 46.0 cm to 55.2 cm. Highest number leaves was found in $SD_{100}P_{13}$ (10.66) which was followed by $ID_{75}P_4$ (10.33) compared to their parent TD_0P_1 (7.33). The mutants $TD_{50}P_1$, $TD_{75}P_1$, $FD_{50}P_3$, $FD_{75}P_5$, $O_3D_{75}P_{10}$, $O_3D_{100}P_{11}$, $ID_{50}P_2$ and $ID_{75}P_4$ were produced highest seed yield plant^{-1} and highest bulb yield ($TD_{50}P_1$ = 3.72 g and 18.02 t ha^{-1}, $TD_{75}P_1$ = 3.75 g and 17.97 t ha^{-1}, $FD_{50}P_3$ = 3.90 g and 18.67 t ha^{-1}, $FD_{50}P_3$ = 3.85 g and 18.34 t ha^{-1}, $O_3D_{75}P_{10}$ = 3.90 g and 16.78 t ha^{-1}, $O_3D_{100}P_{11}$=3.86 g and 16.52 t ha^{-1}, $ID_{50}P_2$ = 3.96 g and 20.73 t ha^{-1} and $ID_{75}P_4$ = 3.88 g and 19.84 t ha^{-1}, respectively compared to their parents (Table 21).

Table 21. Agronomic performances of M_5 mutants of five onion genotypes

Treatment	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 (t ha^{-1})
TD_0P_1	50.2	7.33	2.10	43.2	3.32	89.3	0.80	2.80	13.38
$TD_{50}P_1$	53.1	9.75	3.25	50.4	3.95	102.8	0.93	3.72	18.02
$TD_{75}P_1$	54.0	9.10	3.66	49.5	3.69	103.5	0.95	3.75	17.97
FD_0P_1	47.2	7.10	2.40	44.5	2.32	75.2	1.06	2.78	12.23
$FD_{50}P_3$	51.7	9.95	3.60	48.8	3.86	88.4	0.82	3.90	18.67
$FD_{75}P_5$	51.5	10.02	3.87	49.4	3.66	86.0	0.72	3.85	18.34
$O_3D_0P_3$	46.2	7.95	2.17	42.0	2.75	72.5	0.73	3.02	10.54
$O_3D_{75}P_{10}$	55.0	9.88	3.56	48.6	3.58	90.8	0.86	3.90	16.78
$O_3D_{100}P_{11}$	53.6	9.92	3.82	48.1	3.72	92.0	0.84	3.86	16.52
SD_0P_1	46.0	7.20	2.80	43.5	2.94	68.2	0.55	2.82	10.04
$SD_{100}P_{13}$	50.5	10.66	3.66	47.2	3.60	91.8	0.49	3.91	15.05
ID_0P_1	48.3	7.33	2.77	44.0	2.04	65.2	0.66	2.77	13.54
$ID_{50}P_2$	53.5	10.10	3.10	48.5	3.10	98.8	0.67	3.96	20.73
$ID_{75}P_4$	55.2	10.33	3.05	47.0	2.86	97.6	0.61	3.88	19.84
SD (±)	2.65	1.43	0.98	3.05	0.48	8.98	0.18	0.94	2.14

Note: T-Taherpuri, F-Faridpuri, O_3-Onion-3, S-Spring and I-Indian onion

Ginger

Evaluation of M_4 mutants of ginger

The experiment was conducted to observe the performances of the M_4 mutants derived from six ginger accessions viz. Rangpur local (Taragonj), Thanchy local, Shilkhali local, Bandarban local (Whykong, Lama), Dinajpur local (Aamgonj, Khanshama), Bandorban local (Ruma). Six mutants including parents were planted during 3rd week of April, 2018. The experiment was laid out in 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 each mutant.

Results showed that the mutants differed for yield and yield attributes. In case of six genotypes of ginger, the M_4 mutants produced higher yield at 2Gy compare to their parents (Table 22). These mutants were also flooded for 21 days in continuous rainfall and flooded condition. But mutants were fully survived after the flooding condition and there was no rhizome rot occurred. The mutants under 2Gy irradiation would be further evaluated through preliminary yield trial at different locations for rhizome yield and other yield attributing characteristics as well as rhizome rot tolerance level in the next year.

Table 22. Agronomic performances of M_4 mutants of ginger develop from different irradiated genotypes

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 (t ha^{-1})
Taragonj, Rangpur (2 Gy)	42.45	33.33	16.47	15.30	135.78	340.20	511.83	35.65
Taragonj,Rangpur (0 Gy)	34.74	28.42	13.80	10.54	105.50	326.34	313.64	18.01
Thanchy (2 Gy)	46.85	35.25	16.61	14.11	146.92	476.32	517.22	36.42
Thanchy (0 Gy)	38.42	27.23	13.11	12.18	95.20	350.98	337.54	20.20
Shilkhali (2 Gy)	45.95	39.00	15.86	16.09	151.42	477.02	627.90	39.42
Shilkhali (0 Gy)	40.10	29.54	11.27	11.11	82.67	275.73	329.62	22.60
Whykong, Lama, Bandarban (2 Gy)	46.98	34.86	18.07	14.53	148.42	437.01	603.70	37.96
Whykong, Lama, Bandarban (0 Gy)	31.92	27.74	9.80	8.14	108.35	320.62	321.19	21.88
Aamgonj, Dinajpur (2 Gy)	45.55	39.29	15.86	14.09	151.94	519.02	512.60	34.27
Aamgonj, Dinajpur (0 Gy)	35.10	29.54	11.27	11.11	82.62	357.32	321.00	21.11
Ruma, Bandarban (2 Gy)	44.80	32.93	15.51	17.17	156.82	423.23	611.16	38.10
Ruma, Bandarban (0 Gy)	32.22	26.11	9.88	12.06	105.82	320.26	319.02	22.28
SD (±)	5.72	4.24	4.10	1.45	72.80	124.86	176.45	9.54

Black cumin

Screening of M_3 generation of black cumin

The experiment was conducted at Kashiarchar experimental field near about BINA HQ with 11 M_3 populations derived from irradiated seeds of three local germplasm of black cumin at different doses to screen high yield potential with better quality pod. Seeds were grown on 16th November, 2019 at 30 cm apart from row to row following non replicated plant rows. The parent germplasm also included in the experiment as control. Recommended doses of fertilizers were applied with recommended cultural and intercultural practices. Data on plant height, no. of branches plant^{-1}, no. of pods plant^{-1}, 1000 seed weight (g), seed wt. plant^{-1} (g) and seed yield (kg ha^{-1}) were recorded.

Results showed that, yield of the M_3 mutants were observed ranged from 547.33 to 796.67 kg ha^{-1} whereas the highest yield (796.67 kg ha^{-1}) was produced by the $BC_2M_3D_{50}$ mutant plants. The lowest yield was produced by parents (475.33 kg ha^{-1}) (Table 23).

Highest numbers of pods plant-^{1}(58.28) was produced by the $BC_2M_3D_{50}$ mutant plants. The lowest numbers of pods plant-^{1} was found in $BC_2M_3D_{250}$ (34.29) (Table 23).

Maximum weight of thousand seeds were found in both $BC_2M_3D_{50}$ and $BC_2M_3D_{10}$ (2.61g) mutants where as the minimum weight of thousand seeds was found in $BC_4M_3D_{20}$ (2.33g) (Table 23).

Table 23. Screening of M_3 generation of black cumin

M_3 Population	Plant height	No. of branches plant^{-1}	No. of pods plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (gm)	Seed yield (kg ha^{-1})
$BC_2M_3D_0$	41.21	12.00	49.43	2.51	17.34	475.33
$BC_2M_3D_{10}$	49.15	16.67	54.70	2.61	19.42	749.67
$BC_2M_3D_{50}$	**49.75**	**18.00**	**58.28**	**2.61**	**20.17**	**796.67**
$BC_2M_3D_{150}$	46.23	10.33	43.20	2.46	15.20	547.33
$BC_2M_3D_{250}$	46.60	9.33	34.29	2.56	12.52	620.33
$BC_3M_3D_0$	44.54	8.33	49.15	2.52	16.25	546.00
$BC_3M_3D_{20}$	37.31	9.67	56.22	2.56	18.52	627.67
$BC_3M_3D_{50}$	34.16	14.33	43.49	2.48	16.39	594.67
$BC_3M_3D_{150}$	41.48	7.67	44.43	2.53	14.81	613.00
$BC_4M_3D_0$	42.22	12.67	40.02	2.52	15.02	543.00
$BC_4M_3 D_{10}$	42.09	11.00	36.32	2.38	13.52	648.00
$BC_4M_3D_{20}$	43.47	11.33	42.15	2.33	15.15	595.67
$BC_4M_3D_{50}$	48.42	13.33	43.08	2.60	16.04	623.00
$BC_4M_3D_{100}$	41.46	11.00	38.85	2.34	14.18	697.33
SD (±)	5.33	1.78	5.90	0.09	2.20	84.92

Evaluation of some exotic black cumin germplasm

In case of exotic germplasms, yield was observed ranged from 563.33 to 801.67 kg ha^{-1} whereas the highest yield (801.67 kg ha^{-1}) was produced by the BC-11211 germplasm. The lowest yield was produced by (563.33 kg ha^{-1}) in BC-10861 (Table 24).

Highest numbers of pods plant-^{1}(58.43) was produced by the BC-11211 germplasm. The lowest numbers of pods plant-^{1} was found in BC-10864 germplasm (41.21) (Table 24).

Maximum weight of thousand seeds were found in BC-11211 germplasm (2.62g) mutants where as the minimum weight of thousand seeds was found in BC-10864 germplasm (2.22g) (Table 24).

Table 24. Evaluation of some exotic black cumin germplasm

Germplasm	Plant height	No. of branches plant^{-1}	No. of pods plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})
BC-10863	38.88	15.67	44.15	2.28	16.87	628.33
BC-10861	41.90	13.67	47.46	2.53	17.28	563.33
BC-10320	41.89	11.67	43.51	2.49	15.66	567.33
BC-11211	48.70	18.00	58.43	2.62	20.70	801.67
BC-10864	39.63	15.67	41.21	2.22	16.06	632.67
BC-11212	47.39	12.67	49.81	2.61	17.66	630.33
SD (±)	5.36	1.42	4.95	0.17	1.79	86.64

Cumin

Screening of cumin genotypes

To evaluate and identify the suitability of cumin germplasm in our climatic condition, five cumin germplasm were collected from home and abroad. The experiment was conducted at BINA HQs farm, Mymensingh to observe the performance of all the genotypes. The experiment was laid out in row planting method with standard spacing. Data on various characters such as plant height, number of branches plant^{-1}, days to 1st flowering, days to 1st fruiting, no. of pod plant^{-1} were recorded from randomly selected plant. Fruit yield of each plant was recorded after harvest. Some genotypes were burned at flowering stage. Considering better field performance including the completeness of its life cycle one genotype will be further evaluated in next season.

Sweet pepper

Growing of M_1 generation of sweet pepper

With view to develop high yielding and nutritionally improved sweet pepper mutants, dry seeds of an exotic genotype were irradiated with 100,150, 200 & 250 Gy doses of gamma rays to create genetic variability in winter season. One hundred seeds per dose were sown on 10 October, 2019 in seedbed. The germinated seedlings were transplanted in the main field on 15 November, 2019 at BINA HQ farm, Mymensingh in separate plots dose wise along with a plot for un-irradiated control. Finally, M_2 seeds were harvested from the survived plants and kept separately dose and variety wise to screen in the M_2 generation in next season.

Okra

Growing of M_1 generation of okra

Dry seeds of BARI okra-1, BARI okra-2 and Khagrachari local okra were irradiated with 300, 450 and 600 Gy doses of gamma rays using the ^{60}Co source to create genetic variability for high yield potential with soft fiber and good test. One hundred fifty seeds per dose were sown on 25 March, 2020 at BINA HQ farm, Mymensingh. The experiment was laid out in row planting method using spacing 30 cm × 30 cm. Recommended production packages were followed to ensure normal plant growth and development. 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.

Tomato

Screening of winter and summer tomato/cherry tomato genotypes

Seven tomato genotypes were collected from home and abroad which were grown in both winter and summer season. The experiment was conducted at BINA HQs farm, Mymensingh to observe their performances. The experiment was laid out in row planting method with standard spacing. Recommended production packages were followed to ensure normal plant growth and development. 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. Two tomato lines would be promising in winter season with higher number of fruits (78) and yield (108 t ha^{-1}). Moreover, there are some exotic cherry tomato genotypes were evaluated for the suitability in our country. The experiment was conducted at BINA HQs farm, Mymensingh to observe their performances. The experiment was laid out in row planting method with standard spacing. Data on various characters such as plant height, number of fruits $plant^{-1}$, fruit weight $plant^{-1}$ and average fruit weight were recorded from 10 randomly selected plants. Fruit yield of each plant was recorded after harvest. Considering better field performance including fruit yield $plant^{-1}$ and other important agronomic characters one genotype will be further evaluated at different locations in next season.

Growing of M_1 population of sweet orange and lime

Sweet orange

The experiment was conducted with 16 M_1 populations of sweet orange and five check varieties at the BINA farm, Mymensingh to create genetic variability. The experiment was laid out in row planting. The $WNMD_{40}P_2$ population showed the tallest plant (275 cm) along with maximum number of fruits (148) per plant, accumulated higher TSS (14.20 %) and minimum number of seed $fruit^{-1}$ (5) whereas the shortest plant (235 cm) ,the minimum number of fruits (92) $plant^{-1}$, length of fruit (5.0 cm), breadth of fruit (5.2 cm) and maximum number of seed $fruit^{-1}$ (11) were recorded in TMD_0P_1 (Table 25). The maximum length of fruit (6.8 cm), breadth of fruit (6.9 cm) and weight of individual fruit (294 g) were found in MMD_{40} population.

Lime

The experiment was carried out with M_1 population 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 (295 $plant^{-1}$) and individual fruit weight (141 g) whereas the lowest number of fruit yield (195 $plant^{-1}$) and individual fruit weight (128 g) was found in LBD_0P_1 population.

Table 25. M_1 population of Sweet orange and Lime

Species	Sl. No.	Crop species	Planting date	Plant height (cm)	No. of fruits plant^{-1}	Weight of individual fruit (g)	Length of fruit (cm)	Breadth of fruit (cm)	No. of seed fruit^{-1}	% TSS
Sweet orange	1.	TMD_0P_1	08.05.16	235	92	154	5.00	5.20	11	11.7
	2.	$TMD_{20}P_2$	08.05.16	237	118	194	5.60	5.60	8	11.6
	3.	$TMD_{40}P_1$	08.05.16	245	113	199	5.30	5.40	7	11.2
	4.	$TMD_{40}P_2$	08.05.16	240	117	198	5.00	5.50	7	11.5
	5.	$TMD_{40}P_3$	08.05.16	247	115	188	4.80	5.80	8	11.6
	6.	$WNMD_0$ P_1	08.05.16	208	121	197	6.80	5.60	9	13.4
	7.	$WNMD_{20}P_1$	08.05.16	261	131	192	6.50	6.90	10	13.4
	8.	$WNMD_{40}P_1$	08.05.16	241	142	211	6.40	6.80	10	13.5
	9.	**$WNMD_{40}P_2$**	**08.05.16**	**275**	**148**	**257**	**6.70**	**6.60**	**5**	**14.89**
	10.	$WNMD_{60}P_1$	08.05.16	255	125	207	6.40	6.50	8	13.5
	11.	MMD_0 P_1	08.05.16	245	125	193	5.70	5.00	6	13.8
	12.	MMD_{20} P_1	08.05.16	255	142	188	5.60	5.20	5	13.7
	13.	**MMD_{40}**	**08.05.16**	**266**	**128**	**294**	**6.80**	**6.90**	**5**	**14.2**
	14.	BARI malta-1	08.05.16	251	128	185	5.70	5.90	9	13.8
	15.	BARI malta-1	08.05.16	244	132	195	5.60	5.80	7	13.7
	16.	NMD_{20}	08.05.16	295	183	194	5.40	5.40	7	13.2
Lime	22.	LBD_0P_1	08.05.16	225	195	128	4.80	4.50	5	8.3
	23.	LBD_0P_2	08.05.16	235	231	132	5.60	5.10	2	8.5
	24.	$LBD_{20}P_1$	08.05.16	217	280	138	5.70	5.20	9	8.5
	25.	$LBD_{20}P_2$	08.05.16	257	275	139	5.75	5.50	8	8.7
	26.	$LBD_{40}P_1$	08.05.16	**317**	**295**	**141**	**5.75**	**5.60**	**1**	**8.8**

Screening of Pomegranate germplasm on growth, yield and quality attributes

The experiment was conducted with seven pomegranate genotypes at BINA head quarters farm, Mymensingh. The tallest plant (315 cm) was recorded in P_2 followed by P_1 (310 cm) and P_3 (275 cm) whereas the shortest plant was recorded in B_1 (193 cm) (Table 26).

The cultivar P_2 showed the maximum number of fruits (95 plant^{-1}), length and breadth of fruit were 5.8 and 5.6 cm whereas the minimum number of fruits (38 plant^{-1}), length of fruit and breadth (4.7 and 4.5) of fruit were recorded in A_1. P_2 genotype accumulated the highest TSS (17.88 %) and maximum weight of fruit plant^{-1} (272 g) where as the lowest TSS (16.11 %) and minimum weight of fruit plant^{-1} (203 g) was recorded in B_1 (Table 26).

Table 26. Performance of Pomegranate on growth, yield and quality

Sl No.	Genotypes 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) P_1	28.11.16	310	66	205	5.6	5.5	16.20
2.	Pomegranate (India) P_2	09.10.16	315	95	272	5.8	5.6	17.88
3.	Pomegranate (India) P_3	09.10.16	275	79	258	5.5	4.6	16.80
4.	Anar (India) A_1	28.11.16	265	38	215	4.7	4.5	16.24
5.	Anar (India) A_2	28.11.16	259	49	242	5.0	5.5	17.47
6.	Bedana (India) B_1	28.11.16	193	39	203	4.8	5.3	16.11
7.	Bedana (India) B_2	28.11.16	246	42	238	4.8	5.5	17.36

Ber

Collection, evaluation and improvement of indigenous Ber (Zyzyphus mauritiana) germplasm

A field experiment was conducted in June 2018 at the Field Laboratory of the BINA Sub-Station, Nalitabari, Sherpur to select germplasm with desirable traits like high yield, short duration, early fruit bearing, higher edible portion, best pickling quality and longer shelf life of indigenous ber. Thirteen germplasm were collected from Kushtia, Pabna, Natore, Mymensingh and Sherpur districts of Bangladesh. The experiment was laid out in randomized complete block design (RCBD) with three replications. The sources and short description of the germplasm are shown in Table 27.

Table 27. Short description of collected Ber germplasm

SL. No.	Germ-plasm name	Source of collection	Average plant height (m)	Average no. main branch plant^{-1}	Time of 1st flowering	Fruit wt plant^{-1} (kg)
1.	GM-1	Mymensingh sadar	2.30	2.67	-	-
2.	GM-2	Ishwardi, Pabna	2.23	3.33	October, 2019	0.50
3.	GM-3	Trishal, Mymensingh	3.30	6.67	-	-

4.	GM-4	Doulatpur-1, Kushtia	3.93	6.67	October, 2019 July, 2020	2.0 (Rab) 1.5 (Kharif-2)
5.	GM-5	Bhaluka, Mymensingh	2.00	2.00	-	-
6.	GM-6	Horticulure centre 1, Mymensingh	2.73	3.67	-	-
7.	GM-7	Lalpur, Natore	2.08	3.33	October, 2019	0.70
8.	GM-8	Horticulure centre - 2 , Mymensingh	2.83	6.00	-	-
9.	GM-9	Kushtia sadar	2.62	2.67	-	-
10.	GM-10	Jhenaigati, sherpur	2.93	3.00	-	-
11.	GM-11	Germplasm-1, BAU, Mymensingh	2.85	3.33	-	-
12.	GM-12	Germplasm-1, BAU, Mymensingh	2.70	3.33	-	-
13.	GM-13	Doulatpur-2, Kushtia	4.73	6.67	October, 2019	4.0

Result showed that the tallest plant was found GM-13 (4.73 m) followed by GM-4 (3.93 m) and GM-3 (3.30 m) and shortest plant was GM-5 (2.00 m). In case of branches, the maximum numbers of main branches (6.67) were found GM-3, GM-4 and GM-13 and minimum number of main branches was GM-5 (2.00). The early fruit bearing was found in GM-2, GM-4, GM-7 and GM-13. The genotype GM-4 also showed twice fruit bearing habit in a year. The highest fruit (4.0 kg plant^{-1}) was found GM-13 germplasm followed by followed by GM-4 (3.5 kg plant^{-1}: mean of two season) and GM- 7 (0.7 kg plant^{-1}) (Table 27).

Gladiolus

Growing of M_1 generation of gladiolus

To create variability, the gladiolus corms (average weightt; 16.0 gm and diameter; 3.5 cm, color ; white, pink and yellow color flowers) were irradiated with 0, 10, 20, 30, 40 50 and 60 Gy doses of gamma rays and the irradiated corms were planted in 20 November 2019 at BINA sub-station Nalitabari farm.

The plant height (60.20 cm), leaf length (43.00 cm), no. of leaves plant^{-1} (12.40), spike length (95.20 cm) and no. of florets plants^{-1} (13.50) were found to be the highest in the white colour gladiolus at 50 Gy and the lowest plant height (50.54 cm), leaf length (33.50 cm), number of leaf plant^{-1} (10.45), spike length (60.25 cm) and number of florets plant^{-1} (8.50) were observed in case of yellow color gladiolus which irradiated at 20 Gy. Germination percentage was almost similar in respect of doses of radiation. Finally, the M_1 corms from the survived plants were bulked dose and floret color wise and kept refrigerator for growing of M_2 generation in the next growing season.

Seed production of released varieties

The seed production experiments of Binatomato-10, Binatomato-11, Binatomato-12, Binamorich-1, Binarasun-1 and Binahalud-1 were conducted at BINA HQ farm during 2019-20. Seed production of these released varieties is necessary for being extension in the farmer's field across the country. Recommended production packages were followed to ensure normal plant growth and development. Data on seed yield were recorded at the final harvest. Total seed production of Binatomato-10, Binatomato-11, Binatomato-12, Binarashun-1 and

Binamorich-1 were 800g, 500g, 550g, 2kg, 40 kg and 500 kg, respectively (Table 28). The production of seeds in case of tomato was low due to unfavorable environmental conditions such as early blight of tomato.

Table 28. Seed production of released varieties during 2019-20

Variety	Seed yield
Binatomato-10	800 g
Binatomato-11	500 g
Binatomato-12	550 g
Binamorich-1	2 kg
Binarashun-1	40 kg
Binahalud-1	500 kg

Besides these, five thousand saplings of Binalebu-1 were produced through cutting, air layering and grafting which were distributed among the farmer's, home gardeners, roof gardeners, extension workers etc across the country for vast area coverage.

Crop Physiology Division

Research Highlights

- Five rice genotypes (Dhanigold, BRRI hybrid-6, Binadhan-7, Agrodhan-12 and Arize-7006) were evaluated under three soil moisture regimes (Control, 60 and 40% FC) for growth, yield attributes and yield. Arize-7006 and Dhanigold reduced less yield and total dry matter under water stress treatments and showed some tolerance to water stress. Arize-7006 and Agrodhan-12 showed better yield performance in natural field condition in another experiment.

- Study of flowering pattern of five lentil mutants showed that the mutants produced higher reproductive efficiency, yield contributing characters and yield compared to Binamasur-8. Effects of chitosan on growth and yield of tomato and mungbean was investigated in pot and field conditions, the highest yield of tomato and mungbean was found when chitosan was applied 75 ppm and 50 ppm, respectively.

- Five mutants of lentil were evaluated at BINA sub-station Magura and Ishurdi substations and farmer's fields and three mutants (LMI-3, LMM-7 and LMM-9) showed higher yield than Binamasur-8. Six mutants of mungbean were also evaluated at BINA sub-station Magura and Ishurdi substations and farmer's fields and three mutants (MM-1, MM-5 and LMI-12) produced higher yield than Binamoog-8. An experiment was conducted with nine mutants of sesame and five mutants were selected for further study.

- Twenty rice genotypes were selected to know their grain shape, size, nutritional properties and cooking qualities. The results revealed that grain size of all the genotypes was similar except a land race Jirakalani. Shape of grains was short in all the genotypes. Amylose content was higher in Basiraj followed by BRRI dhan66, BRRI dhan71 and BRRI dhan57. Binadhan-10 showed highest Zn content and BRRI dhan73 had the highest Fe content. Protein content ranged from 4.86-7.2% in the studied rice genotypes.

Temperature tolerance of rice varieties at reproductive stage

An experiment was conducted with eight rice varieties *viz*. Binasail, Iratom-24, Binadhan-18, Binadhan-5, Binadhan-6, Binadhan-14, Binadhan-10 and Binadhan-17 at pot yard and in plant growth chamber of Bangladesh Institute of Nuclear Agriculture (BINA) during December 2019 to May, 2020 to assess the effect of high temperature (36 ^{0}C) at two growth stages *viz*. flowering stage and grain filling growth stage on morpho-physiological parameters and yield. The 36 ^{0}C temperature was imposed for 7 days in plant growth chamber. The experiment was laid out in a completely randomized design with three replications. Yield and yield attributes were recorded at maturity. Data were analyzed statistically.

Results indicated that high temperature imposed both at flowering stage and grain filling stage had significant negative influence on plant parameters (Table 1). Number of effective tillers plant^{-1}, number of grains panicle^{-1}, 1000-grain wt. and yield plant^{-1} were decreased due to high temperature. But plant height and length of panicle was not affected. Amongst the varieties, Binadhan-5 and Binadhan-6 produced higher number of effective tillers plant^{-1}, Binasail, Iratom-24, Binadhan-18 and Binadhan-10 produced higher number of grains panicle^{-1} (Table 1). Binadhan-5 showed the highest yield followed by Binadhan-18 and Binadhan-10. High temperature imposed at flowering or grain filling drastically reduced yield and yield contributing parameters of all the varieties (Table 2). Yield reduction was less in Binadhan-5, Binadhan-6, Binadhan-10 and Binadhan-18 and showed some tolerance to high temperature (Table 3).

Table 1. Temperature effect at different growth stages on yield and yield attributes in rice

Treatment	Plant height (cm)	No. of effective tillers plant^{-1}	Length of panicle (cm)	No. of grains panicle^{-1}	1000-grain wt. (g)	Yield plant^{-1} (g)
Ambient	102.9a	25.83a	25.95a	108.6a	23.58a	18.11a
36^{o}C at flowering	101.7a	21.21b	26.06a	82.55b	22.49b	12.66b
36^{o}C at grain filling	101.4a	20.63b	26.12a	80.57b	22.57b	12.51b
Variety						
Binasail	133.0a	21.22c	29.97a	101.1a	15.24e	11.30f
Iratom-24	83.67f	24.67b	28.53b	99.29a	23.75b	14.70d
Binadhan-18	96.89d	17.44e	27.91b	99.82a	27.96a	16.41b
Binadhan-5	107.2c	29.56a	25.89c	92.67b	21.51d	17.99a
Binadhan-6	110.0b	29.44a	25.02d	76.78d	23.13c	15.69c
Binadhan-14	89.81e	18.33de	25.67c	83.22c	21.67d	10.78f
Binadhan-10	112.1b	20.56cd	25.67c	95.89ab	27.92a	15.58c
Binadhan-17	83.33f	19.22cde	24.19e	75.90d	21.85d	12.94e

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

Table 2. Interaction effect between variety and growth stage on yield and yield attributes of rice under temperature treatments

Interaction	Plant height (cm)	Effective tiller plant^{-1}	Length of panicle (cm)	Grains panicle^{-1}	1000-grain wt. (g)	Yield plant^{-1} (g)
V1T1	131.7a	23.67cd	30.40a	116.1ab	16.53k	14.13d-g
V1T2	135.0a	19.67d-h	29.93ab	102.1c	14.48l	9.683j
V1T3	132.3a	20.33d-g	29.57ab	85.07d	14.71l	10.07j
V2T1	84.67ghi	30.33ab	29.07bc	115.9ab	24.36d	17.94c
V2T2	83.67ghi	21.67c-f	28.13cd	91.80d	23.38ef	13.34fgh
V2T3	82.67hi	22.00cde	28.40cd	90.20d	23.51ef	12.83ghi
V3T1	99.67e	21.00d-g	27.40de	121.3a	28.59a	20.33b
V3T2	93.00f	14.67h	28.13cd	92.13d	27.53c	14.67def
V3T3	98.00e	16.67fgh	28.20cd	86.00d	27.78bc	14.23d-g
V4T1	109.3bc	34.00a	25.20f-i	110.7bc	22.11hi	24.40a
V4T2	107.7cd	33.33a	26.40ef	84.00d	21.40ij	14.77def
V4T3	104.7d	21.33c-f	26.07fg	83.33d	21.02j	14.80de
V5T1	113.7b	33.67a	24.47hij	102.3c	24.07de	20.70b
V5T2	104.3d	26.33bc	24.93g-j	61.73f	22.90fg	13.37e-h
V5T3	112.0bc	28.33b	25.67fgh	66.33ef	22.42gh	13.00gh
V6T1	88.33g	20.00d-g	21.67k	103.0c	22.13hi	13.83d-g
V6T2	93.67f	16.00gh	20.87k	73.33e	21.32j	9.233j
V6T3	87.43gh	19.00d-h	20.93k	73.33e	21.56ij	9.267j
V7T1	112.3bc	22.67cde	25.47fgh	109.7bc	28.31ab	18.50c
V7T2	111.7bc	20.33d-g	25.53fgh	85.33d	27.47c	14.00d-g
V7T3	112.3bc	18.67d-h	26.00fg	92.67d	27.98abc	14.23d-g
V8T1	83.67ghi	21.33c-f	23.90j	90.04d	22.52gh	15.00d
V8T2	84.33ghi	17.67e-h	24.53hij	70.00ef	21.44ij	12.23hi
V8T3	82.00i	18.67d-h	24.13ij	67.67ef	21.58ij	11.60i

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

Where, V1=Binasail, V2=Iratom-24, V3=Binadhan-18, V4=Binadhan-5, V5=Binadhan-6, V6=Binadhan-14, V7=Binadhan-10 and V8=Binadhan-17, T1= Ambient temperature, T2= 36 ^{0}C at flowering stage and T3= 36 ^{0}C at grain filling stage.

Growth and yield of rice genotypes under water stress

A pot experiment was carried out to assess the effects of water stress on growth and yield of some rice genotypes. Control (100% FC) and two water stresses such as 60 and 40% FC were imposed at booting stage and continued until final harvest on five rice genotypes *viz*. Dhanigold, BRRI hybrid-6, Binadhan-7, Agrodhan-12 and Arize-7006. The experiment was laid out in a Complete Randomized Design with three replications. Thirty day old seedlings were transplanted in plastic pots containing 8 kg soils pot^{-1} on August 12, 2019. Recommended doses of fertilizers were applied and cultural practices were done whenever required. Data on plant height, number total tillers, effective tillers plant^{-1}, filled grains and unfilled grains panicle, 1000-grain wt., yield, total dry matter plant^{-1} and harvest index were recorded.

Results showed that plant height, number of total tillers, effective tillers plant^{-1}, filled grains panicle^{-1}, 1000-grain weight, yield and total dry matter plant^{-1} decreased but unfilled grains panicle^{-1} increased with water stress (Table-3). Harvest index was not affected with water stress treatments. Among the genotypes, Arize-7006 produced higher yield followed by Dhanigold. These two genotypes also showed higher total dry matter. Other three genotypes showed similar yield and total dry matter under water stress treatments. Yield and total dry matter drastically reduced in all the varieties due to water stress (Table-4). However, Arize-7006 and Dhanigold reduced less yield and total dry matter under water stress treatments and showed some tolerance to water stress.

Table 3. Effect of water stress on growth and yield of rice genotypes

Treatment	Plant height (cm)	Total tiller plant^{-1}	Effective tiller plant^{-1}	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	1000-grain wt. (g)	Yield plant^{-1} (g)	TDM plant^{-1} (g)	HI
Control	107.7a	33.53a	30.33a	126.4a	21.92b	24.52a	31.47a	95.63a	0.31
60% FC	82.20b	29.27ab	20.47b	88.32b	40.69a	23.86b	23.53b	66.69b	0.39
40% FC	71.07c	26.33b	14.20c	70.52b	47.05a	23.70b	20.53b	67.91b	0.31
Variety									
Dhanigold	101.7a	37.44a	24.67a	115.1a	45.62a	25.11b	29.00ab	101.9a	0.28
BRRI hybrid-6	89.67ab	30.33b	22.89b	88.18a	40.73ab	23.04c	22.56bc	59.93b	0.41
Binadhan-7	65.56c	29.33b	19.22b	51.02b	33.31b	22.23d	17.76c	51.73b	0.33
Agrodhan-12	80.56b	24.44b	18.33a	107.2a	39.91ab	26.76a	21.78bc	65.82b	0.34
Arize-7006	97.56a	27.00b	23.22a	113.9a	23.20c	23.01c	34.78a	104.3a	0.31

In a column, figure(s) with same letter or without letter do not differ significantly at $P \leq 0.05$ by DMRT.

Table 4. Interaction between variety and water stress on growth and yield of rice genotypes

Interaction	Plant height (cm)	Total tiller plant^{-1}	Effective tiller plant^{-1}	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	1000-grain wt. (g)	Yield plant^{-1} (g)	TDM plant^{-1}	HI
V1T1	113.07ab	44.00a	34.67a	139.2a	19.86de	25.60c	38.67b	128.9a	0.29
V1T2	100.3abc	37.33ab	19.67efg	108.2ab	54.93ab	24.87d	26.67bcd	83.27bcd	0.32
V1T3	91.0abc	31.0abcd	19.67efg	97.80abc	62.07a	24.86d	21.67cde	93.60b	0.23
V2T1	103.3abc	3.33abcd	27.33bcd	126.2ab	21.53de	23.53e	26.67bcd	68.80bcdf	0.38
V2T2	85.67c	34.67abc	25.33de	84.0abcd	36.33cd	22.94f	21.67cde	59.53defg	0.47
V2T3	80.00cd	26.0bcd	16.00fgh	54.33bcd	64.33a	22.64fgh	19.33cde	51.47efg	0.37
V3T1	97.33abc	38.67ab	31.67abc	100abc	31.33cde	22.90ghi	26.67bcd	76.50bcde	0.34
V3T2	42.67e	28.67bcd	15.67gh	30.07cd	32.67cde	22.09i	15.0de	43.47fg	0.34
V3T3	56.67de	20.67cd	10.33hi	23.00d	35.93cd	22.20hi	11.67e	35.23g	0.32
V4T1	107.3abc	28.33bcd	26.00cd	133.80a	19.27de	27.50a	13.67de	66.17bcdef	0.16
V4T2	86.67bc	25.33bcd	19.67efg	101.90abc	44.47bc	26.57b	30.0bc	62.27cdefg	0.55
V4T3	47.67e	19.67d	9.33i	85.93abcd	56.00ab	26.22b	21.67cde	69.03bcdef	0.28abc
V5T1	117.0a	26.33bcd	32.00ab	132.80a	17.60e	23.59e	51.67a	137.8a	0.31abc
V5T2	95.67abc	20.33cd	22.00def	117.5ab	35.07cd	22.84fg	24.33bcde	84.93bcd	0.36abc
V5T3	80.00cd	34.33abc	15.67gh	91.53abcd	16.93e	22.59fgh	28.33bcd	90.23bc	0.25bc

In a column, figure(s) with same letter or without letter do not differ significantly at $P \leq 0.05$ by DMRT.

Where, V1=Dhanigold, V2=BRRI hybrid-6, V3=Binadhan-7, V4=Agrodhan-12, V5=Arize-7006, T1=Control, T2=60% FC and T3=40% FC.

Yield performance of some rice genotypes

A field experiment was carried out with four hybrid rice along with Binadhan-7 during T. aman season 2019 at BINA farm, Mymensingh. The objective of the study was to compare yield performance of the hybrids. The experiments were laid out following a randomized complete block design with three replications having a unit plot size of 4 m × 5 m. Row to row and plant to plant distances were 20 cm and 15 cm, respectively. Recommended doses of fertilizers were applied and cultural practices were done whenever required. Data on morphological, yield and yield attributes were recorded at harvest from 10 randomly selected plants of each plot and grain yield was taken from the whole plot and converted into ton ha^{-1}. Results showed that Agrodhan and Dhanigold produced longer plants. Arize-7006, Agrodhan and Dhanigold produced higher number of total tillers and effective tillers $hill^{-1}$ (Table-5). Arize-7006 and Agrodhan-12 showed higher yield and harvest index.

Table 5. Growth and yield of some rice genotypes

Variety	Plant height (cm)	No. of total tiller $hill^{-1}$	No. of effective tiller $hill^{-1}$	No. of grain $panicle^{-1}$	Length of panicle (cm)	1000-grain wt. (g)	Yield (tha^{-1})	HI
Dhanigold	111.3 ab	9.53a	9.06a	120.0b	27.93a	25.42b	5.16b	0.44b
BRRI hybrid-6	113.1c	8.26c	7.93b	123.7b	28.73a	23.32c	5.00b	0.44b
Binadhan-7	90.7c	8.66bc	7.73b	93.0d	24.47b	22.72c	4.00c	0.38c
Agrodhan-12	116.2a	9.2ab	8.80a	104.7c	28.40a	27.39a	6.00a	0.47a
Arize-7006	107.4b	9.53a	9.26a	154.0a	25.60b	23.35c	6.33a	0.45ab

In a column, figure(s) with same letter or without letter do not differ significantly at $P \leq 0.05$ by DMRT.

Study of flowering pattern in lentil genotypes

A pot experiment was carried out at BINA pot yard, Mymensingh during November 2019 to February 2020 to assess the flowering pattern and its relationship with seed yield of lentil genotypes. 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. Per cent pod set to opened flowers (reproductive efficiency, RE) was then estimated as: % pod set = (Number of pod $plant^{-1}$ ÷ Number of opened flowers $plant^{-1}$) × 100. At harvest, seed yield and yield attributes were recorded. The collected data were analyzed statistically.

Daily flowering converted to 3-day interval had shown differential peak period (Table 6). The flowering duration range from 22 to 24 days after flowering started. $LMMI_3$ showed greater number of flowers followed by LMM-6 and LMM-9. On the other hand, LMM-4 produced the lowest number of flowers. All the mutants showed higher reproductive efficiency, yield contributing characters and yield compared to Binamasur-8 (Table 7). The mutants also showed 5- 8 days earlier crop duration than Binamasur-8 with better harvest index.

Table 6. Flowering pattern at three-day interval of lentil genotypes

Genotypes	Days to flowering	No 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	
LMM-4	49b	25cde	94a	151cd	99f	82c	78c	31cd	15b	557e
LMM-6	50b	29b	84c	161a	112d	71d	81b	42b	21a	595b
LMM-9	52b	24cdef	82cd	153c	137b	85b	90a	31cd	11c	599b
LMM-7	51b	27c	79e	141e	121c	97a	77c	32c	9d	585c
$LMMI_3$	50b	26cd	86b	160ab	153a	87b	82b	21e	3e	605a
Binamasur-8	54a	34a	84c	150cd	110de	71d	75d	47a	4e	572cd

Same letter(s) in a column do not differ significantly at $P \leq 0.05$ by DMRT.

Table 7. Variation in reproductive efficiency, days to maturity, biological yield, yield attributes and seed yield of lentil genotypes

Varieties	Reproductive efficiency (%)	Days to maturity	Biological yield plant^{-1} (g)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed wt. (g)	Seed wt. plant^{-1} (g)	Harvest index (%)
LMM-4	39.32d	94.10e	17.23de	252de	1.94de	2.01c	6.98bc	40.51b
LMM-6	42.54a	95.21bcd	19.21a	259bc	2.05bc	2.32bc	6.89bc	35.86de
LMM-9	41.20b	95.10bcd	17.31de	263b	1.97d	1.98cd	6.87bcd	38.70cd
LMM-7	40.02bc	97.23b	18.32bc	271a	2.13ab	2.58b	7.32a	39.95c
LMM-I_3	38.54de	96.10bc	17.43d	256bcd	2.16a	2.68a	7.34a	42.11a
Binamosur-8	33.2f	102.21a	18.45b	235f	1.79ef	1.99cd	6.21e	33.65f

Same letter(s) in a column do not differ significantly at $P \leq 0.05$ by DMRT.

Effect of chitosan on growth and yield of winter tomato in field condition

A field experiment was conducted to investigate the effect of foliar application of chitosan at different levels of concentration on growth, yield and yield attributes of tomato variety Binatomato-7 (Table 8). The experiment was conducted at BINA farm, Mymensingh during winter season, 2019-20. Unit plot size was 4m x 5m. Row to row and plant to plant distance was 50 cm. Recommended doses of fertilizers were applied and cultural practices were done whenever required. The experiment was laid out in RCBD with three replications. Plant height, number of branch, single fruit weight increased both at 75 and 100 ppm. The highest fruit yield was recorded at 75 ppm followed by 100 ppm. The highest fruit yield in 75 ppm due to production of higher number of fruits plant^{-1} and higher single fruit weight.

Table 8. Effect of different concentrations of chitosan on growth and yield of winter tomato

Concentration of Chitosan (ppm)	Plant height (cm)	No. of branch plant^{-1}	No. of fruit plant^{-1}	Single fruit wt. (g)	Fruit wt. plant^{-1} (kg)	Fruit yield (t ha^{-1})
0	105.3b	5.2b	31.3b	39.2b	1.4c	51.2d
50	105.4b	5.1b	33.1b	40.5b	1.48b	54.3c
75	110.3a	6.2a	39.4a	42.4a	1.79a	61.3a
100	109.2a	6.1a	34.4b	41.2a	1.58b	60.2b

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

Effect of chitosan on yield and yield attributes of summer tomato grown in pots

A pot experiment was conducted to see the effect of chitosan application at different concentrations on yield and yield attributes of tomato variety Binatomato-7 (Table 2). The experiment was conducted during February to May 2020. Each pot contained 12 kg soil. Recommended doses of fertilizers were applied and cultural practices were done whenever required. The experiment was laid out in CRD with three replications. Results revealed that number of flowers and fruits plant^{-1}, reproductive efficiency (RE) and fruit yield plant^{-1} were increased by applying chitosan compared to control (Table 9). Number of flowers increased at 75 ppm, number of fruits increased at 50, 75 and 100 ppm, single fruit increased at 75 ppm and reproductive efficiency at 50 ppm. The highest fruit yield was found at 75 ppm followed by 50 ppm. The highest fruit yield in 75 ppm due to production of higher number of fruits plant^{-1} and higher single fruit weight.

Table 9. Effect of different concentrations of chitosan on yield attributes and yield of summer tomato

Concentration of chitosan (ppm)	No. of flowers plant^{-1}	No. of fruits plant^{-1}	Single fruit wt. (g)	Reproductive efficiency (%)	Fruit yield plant^{-1} (g)
0	22.8b	9.1c	40.1b	39.1bc	385.3e
25	23.9b	10.8bc	39.1.c	45.1bc	402.5d
50	27.4b	14.3b	42.3b	52.2a	541.2ab
75	30.7a	16.2a	44.6a	54.2b	654.3a
100	24.3b	11.1b	43.1b	35.7b	532.3bc

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

Effect of chitosan on yield and yield attributes of summer mungbean grown in pots

A pot experiment was conducted to see the effect of chitosan application at different concentrations on yield and yield attributes of two tomato varieties Binamoog-7 (Table 10). The experiment was conducted during March to May 2020. Each pot contained 12 kg soil. Recommended doses of fertilizers were applied and cultural practices were done whenever required. The experiment was laid out in CRD with three replications. The results showed that application of chitosan increased plant height, number of pods and yield plant^{-1}. The highest yield was recorded at 50 ppm.

Table 10. Effect of foliar application of chitosan on yield attributes and seed yield of summer mungbean

Treatments	Plant height (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000-seed weight (g)	Seed yield plant^{-1} (g)
Variety					
Binamoog-7	31.5b	34.5a	10.6b	34.51b	7.6b
Binamoog-8	35.6a	27.6b	12.5a	41.32a	8.1a
Concentration (ppm) of chitosan					
0	31.5cd	20.6c	10.3b	38.32	7.2b
25	34.7b	21.7c	10.4b	37.23	7.6b
50	36.9a	25.7a	11.1a	37.34	8.8a
75	35.4b	22.3b	10.3b	36.25	7.8b
100	33.2c	22.8b	10.3b	36.30	7.6b
Interaction of variety and concentration					
Binamoog-7 × 0 ppm	29.2f	25.4d	10.2cd	31.2a	7.1b
Binamoog-7 × 25 ppm	30.1de	27.5c	10.5c	29.1bc	8.2a
Binamoog-7 × 50 ppm	32.6d	32.3a	11.1b	29.4bc	7.4b
Binamoog-7 × 75 ppm	30.2de	30.2b	10.6c	30.5b	8.3a
Binamoog-7 × 100 ppm	27.4g	30.0b	10.2cd	28.2d	7.4b
Binamoog-8 × 0 ppm	34.2bc	23.4f	11.3b	24.1ef	6.4c
Binamoog-8 × 25 ppm	35.1b	23.8f	11.7b	24.7ef	7.1b
Binamoog-8 × 50 ppm	39.4a	29.7bc	12.2a	26.2e	8.1a
Binamoog-8 × 75 ppm	33.2c	26.2cd	10.6c	26.6e	8.0a
Binamoog-8 × 100 ppm	33.0c	24.0e	11.1b	24.1ef	7.1b

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

Effect of chitosan on yield and yield attributes of summer mungbean in field condition

A field experiment was conducted to investigate the effect of foliar application of chitosan at different levels of concentration on yield and yield attributes of summer mungbean varieties Binamoog-7 and Binamoog-8 (Table 11). The experiment was conducted at BINA farm, Mymensingh during March to May, 2020. Unit plot size was 4m x 5m. Recommended doses of fertilizers were applied and cultural practices were done whenever required. The experiment was laid out in RCBD with three replications. The results revealed that chitosan had positive influence on yield attributes of mungbean varieties. The highest yield was recorded at 50 ppm followed by 75 ppm and 25 ppm.

Table 11. Effect of foliar application of chitosan on yield and yield attributes of mungbean

Concentration of chitosan (ppm)	Plant height (cm	Branches plant-[1] (no.)	Pods plant^{-1} (no)	Pod length (cm)	1000-seed wt. (g)	Seeds pod^{-1} (no.)	Seed wt. plant^{-1} (g)	Straw wt. plant^{-1} (g)	Seed weight (kg ha^{-1})
Variety									
Binamoog-7	37.5b	3.50ab	36.5a	7.1b	39.51b	9.6b	5.2b	7.23a	1588b
Binamoog-8	39.6a	4.41a	41.9b	7.8a	45.32a	11.5a	5.9a	7.34a	1670a
Concentration of chitosan									
0	60.6b	3.70cd	14.4e	7.3a	39.2	10.2b	3.75b	6.90c	1305d
25	62.2c	4.11b	19.4b	7.1ab	41.3	12.4a	3.83b	7.23ab	1567b
50	66.4a	4.41b	21.4a	7.0ab	36.4	10.1b	4.65a	7.45a	1677a
75	61.4cd	4.00a	18.2bc	7.3a	39.2	10.3b	4.21a	7.34ab	1588b
100	60.2e	3.32c	15.4d	7.1ab	34.2	10.1b	3.94b	6.35cd	1503c
Interaction									
Binamoog-7 × 0 ppm	60.2d	3.2bb	13.8d	6.3b	39.2bc	9.2bcd	3.7bc	6.2bcd	1365bc
Binamoog-7 × 25 ppm	62.4bc	3.0bc	14.1cd	6.5b	39.7bc	9.7bc	3.8bc	6.5bcd	1386bc
Binamoog-7 × 50 ppm	64.2b	4.1a	17.8b	7.1a	41.4b	10.4b	4.1b	7.6ab	1573a
Binamoog-7 × 75 ppm	62.2bc	4.2a	16.1c	7.1a	41.2b	10.0b	4.0ab	7.1ab	1543a
Binamoog-7 × 100 ppm	60.1d	3.0bc	14.0	6.3b	38.2bc	9.1bcd	3.7bc	6.9ab	1344bc
Binamoog-8 × 0 ppm	60.1	3.7b	13.6d	7.1a	40.2b	10.2b	4.2b	7.1ab	1275cd
Binamoog-8 × 25 ppm	64.5b	3.5b	17.4b	7.4a	42.3b	10.7b	4.7a	7.3ab	1484b
Binamoog-8 × 50 ppm	66.7a	4.4a	20.7a	7.5a	44.6a	11.4a	4.5a	7.8a	1595a
Binamoog-8 × 75 ppm	62.1bc	4.2a	17.3b	7.1a	39.3bc	10.3b	3.9bc	7.0ab	1586a
Binamoog-8 × 100 ppm	60.0d	3.1bc	16.3c	6.9b	39.1bc	9.5bc	3.8bc	6.9ab	1435b

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

Screening of lentil mutants in respect of morphological attributes and yield

The experiment was conducted during winter season of 2019-20 at four locations *viz.,* BINA sub-station and farmers field in Magura, Ishurdi sub-station and farmers filed with five lentil mutants along with a check Binamosur-8. The experiment was laid out following a randomized complete block design with three replications having a unit plot size of 3 m × 4 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 mutants and check variety Binamusur-8 showed almost similar plant height with some variations in different locations (Tables 12-15). There was no much more variation among the mutants in respect of no. of branch plant^{-1} and seed pod^{-1} among the locations. Maximun mutants had bolder seed than check variety. Maximum mutants found higher seed wt. plant^{-1} and seed weight m^{-2} than check in Magura where LMM-7 and LMM-9 produced the highest seed weight m^{-2} in Magura on-station and farmers field due to higher no. of branch plant^{-1}, higher no. of pod plant^{-1}, higher no. of seed pod^{-1} and larger seed size. Similar result was found in respect of Ishurdi location both at sub-station and farmers field. Here LMI-3 also produced the highest seed weight m^{-2} at Ishuirdi sub-station. Maximum mutants produced higher straw weight than check variety in both the locations. Considering locations, results indicated that most of the mutants specially LMM-7, LMM-9 and LMI-3 performed better than check variety in case of growth, yield attributes and yield at Magura and Ishurdi.

Table 12. Yield and yield components of lentil mutants at Magura on-station in 2019-20

Mutants	Plant height (cm)	No. of branch plant^{-1}	No. of pod plant^{-1}	No. of seed pod^{-1}	Straw wt. plant^{-1} (g)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Seed wt. m^{-2} (g)
LMI-3	43.9a	6.0	231a	1.77	4.48	21.0a	6.61a	341ab
LMM-4	41.0b	5.5	229a	1.73	4.43	21.5a	6.69a	339ab
LMM-6	43.6a	6.1	209b	1.73	3.81	21.4a	5.20b	226d
LMM-7	38.9c	6.9	233a	1.8	4.45	21.5a	6.75a	359a
LMM-9	39.8c	5.7	210b	1.77	3.75	20.8a	4.98b	324b
Binamasur-8	44.5a	5.3	187c	1.73	3.84	19.7b	4.97b	275c

In a column, the figure(s) with similar/without letter(s) do not differ significantly by DMRT at $P \leq 0.05$.

Table 13. Yield and yield components of lentil mutants at Magura farmers field in 2019-20

Mutants	Plant height (cm)	No. of branch plant^{-1}	No. of pod plant^{-1}	No. of seed pod^{-1}	Straw wt. plant^{-1} (g)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Seed wt. m^{-2} (g)
LMI-3	39.7a	5.53bc	219b	1.73a	4.08bc	20.2b	7.06a	341b
LMM-4	33.0c	5.20bc	208b	1.70a	4.08bc	20.7a	6.32a	327bc
LMM-6	31.0d	5.13bc	208b	1.67a	3.87c	20.1b	6.60a	335bc
LMM-7	38.3b	5.60b	208b	1.73a	4.25b	20.6a	6.18a	320c
LMM-9	38.6b	6.13a	234a	1.73a	4.81a	20.5a	7.13a	366a
Binamasur-8	31.0d	5.00c	166c	1.57b	4.08bc	19.2c	4.77b	273d

In a column, the figure(s) with similar/without letter(s) do not differ significantly by DMRT at $P \leq 0.05$.

Table 14. Yield and yield components of lentil mutants at Ishurdi on-station in 2019-20

Mutants	Plant height (cm)	No. of branch plant^{-1}	No. of pod plant^{-1}	No. of seed pod^{-1}	Straw wt. plant^{-1} (g)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Seed wt. m^{-2} (g)
LMI-3	40.7b	6.5b	265a	1.83	4.2bc	21.1b	8.5a	346a
LMM-4	39.4c	6.2bc	250b	1.77	4.5b	21.9a	7.5c	248d
LMM-6	36.3d	7.0a	236c	1.77	5.5a	21.6a	7.1d	306b
LMM-7	42.7a	7.2a	266a	1.77	4.4bc	21.5ab	8.0b	311b
LMM-9	41.3b	6.2bc	219d	1.83	4.4bc	21.1b	6.5e	326ab
Binamasur-8	41.5ab	5.9c	201e	1.73	4.1c	20.0c	6.2f	273c

In a column, the figure(s) with similar/without letter(s) do not differ significantly by DMRT at $P \leq 0.05$.

Table 15. Yield and yield components of lentil mutants at Ishurdi farmers field in 2019-20

Mutants	Plant height (cm)	No. of branch plant^{-1}	No. of pod plant^{-1}	No. of seed pod^{-1}	Straw wt. plant^{-1} (g)	1000-seed wt. (g)	Seed wt. plant^{-1} (g)	Seed wt. m^{-2} (g)
LMI-3	39.4cd	6.6abc	270c	1.57b	4.4cd	19.89	8.0a	327b
LMM-4	39.0d	6.2c	252d	1.63ab	5.0b	19.66	7.9a	298c
LMM-6	49.6a	6.5bc	294b	1.73a	6.0a	19.79	7.9a	335b
LMM-7	40.9bc	7.3a	345a	1.62b	4.0d	19.96	8.0a	348a
LMM-9	40.1cd	7.2ab	235e	1.57b	4.4c	20.03	7.8a	322b
Binamasur-8	41.8b	6.6abc	209f	1.73a	4.6c	19.30	5.6b	290c

In a column, the figure(s) with similar/without letter(s) do not differ significantly by DMRT at $P \leq 0.05$.

Screening of mungbean mutants in respect of morphological attributes and yield

The experiments was conducted during Kharif-I season of 2020 at four locations *viz.*, BINA sub-stations, Magura, farmers field and Ishurdi sub-station and farmers field with six mungbean mutants along with a check variety Binamoog-8 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 × 4 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^{-1}, respectively at the time of final land preparation. Proper cultural practices were followed as and when necessary. Data on morphological and yield attributes were recorded at harvest from 10 randomly selected plants in each plot and seed yield was taken from the whole plot and converted into gm^{-2}.

Data of different parameters showed significant differences among the genotypes in all locations at P≤ 0.05 (Tables 16-19). The Highest pods $plant^{-1}$ was found in genotypes MM-8 and MM-1 (23.8 and 21.6) which was followed by other mutants and the lowest was found in check variety Binamoog-8 (17.6) at Ishurdi on-station. All the mutants produced higher pod length and seed weight per m^{-2} than Binamoog-8 where the highest seed weight were observed in MM-1, MM-5 and MM-11.Similar results was observed in farmers field in Ishurdi. In case of Magura locations, MM-1, MM-8 and MI-12 produced higher seed wt. m^{-2}, Branch number $plant^{-1}$, Pod number $plant^{-1}$where the lowest seed yield was found in MM-2 and Binamoog-8. Considering all the locations, results indicated that mutants MM-1 showed the best performance which was followed by MM-5 and MM-11 in Ishurdi and MM-8 and MI-12 in Magura. Among the mutants MM-1, MM-5 and LMI-12 showed 5 days early than check variety.

Table 16. Yield and yield components of mungbean mutants at Ishurdi on-station in 2019-20

Mutants	Plant height (cm)	No of branch $plant^{-1}$	No. of pod $plant^{-1}$	Pod length (cm)	No. of seed pod^{-1}	Seed wt. m^{-2} (g)
MM-1	48.1bc	1.33b	21.6b	8.7a	11.0bc	256a
MM-2	46.8c	1.78a	21.1b	7.4b	10.9c	218c
MM-5	47.0c	1.03c	15.2d	8.4a	11.1abc	257a
MM-8	51.9a	1.95a	23.8a	6.7bc	11.9a	194d
MM-11	44.0d	1.05c	17.8c	8.7a	11.8ab	254a
MI-12	52.2a	1.18bc	17.3c	8.3a	11.4abc	243b
Binamoog-8	49.6b	1.25bc	17.6c	6.4c	10.5c	219c

In a column, the figure(s) with similar/without letter(s) do not differ significantly by DMRT at P ≤ 0.05.

Table 17. Yield and yield components of mungbean mutants at Ishurdi farmers field in 2019-20

Mutants	Plant height (cm)	No of branch $plant^{-1}$	No. of pod $plant^{-1}$	Pod length (cm)	No. of seed pod^{-1}	Seed wt. m^{-2} (g)
MM-1	45.5c	1.43a	12.6bc	7.6ab	10.7c	242a
MM-2	43.0d	1.08bc	11.5cd	7.6ab	11.1bc	206c
MM-5	44.9cd	0.68d	12.5bc	7.7ab	11.2bc	248a
MM-8	56.5a	0.75d	10.9d	7.7a	10.9bc	190d
MM-11	48.6b	0.68d	10.7d	7.5bc	10.8bc	245a
MI-12	45.6c	0.95c	14.8a	7.4c	12.0a	228b
Binamoog-8	55.9a	1.20b	12.9b	7.4c	11.5ab	200c

In a column, the figure(s) with similar/without letter(s) do not differ significantly by DMRT at P ≤ 0.05.

Table 18. Yield and yield components of mungbean mutants at Magura on-station in 2019-20.

Mutants	Plant height (cm)	No of branch $plant^{-1}$	No. of pod $plant^{-1}$	Pod length (cm)	No. of seed pod^{-1}	Seed wt. m^{-2} (g)
MM-1	56.2b	2.30a	24.73a	8.3bc	11.73	251a
MM-2	46.7cd	2.07a	26.4a	8.0c	13.07	180d
MM-5	44.1d	1.37c	12.47b	8.8b	12.60	202c
MM-8	70.9a	1.73b	29.13a	6.8d	11.93	218b
MM-11	49.0c	1.00d	16.93b	10.0a	12.07	170e
MI-12	60.3b	2.20a	25.27a	8.5bc	11.87	225b
Binamoog-8	70.9a	2.13a	27.93a	7.9c	12.47	200c

In a column, the figure(s) with similar/without letter(s) do not differ significantly by DMRT at P ≤ 0.05.

Table 19. Yield and yield components of mungbean mutants at Magura farmers field in 2019-20

Mutants	Plant height (cm)	No of branch plant^{-1}	No. of pod plant^{-1}	Pod length (cm)	No. of seed pod^{-1}	Seed wt. m^{-2} (g)
MM-1	50.3c	2.17b	20.7b	8.5a	11.8a	238ab
MM-2	50.8c	2.50a	22.3a	7.4b	11.1bc	175d
MM-5	50.5c	2.20b	19.9b	8.5a	12.0a	224bc
MM-8	63.1b	2.53a	22.6a	7.6b	12.1a	253a
MM-11	48.9c	2.13b	17.5c	8.2a	11.4ab	233bc
MI-12	68.7a	2.53a	16.4c	8.4a	11.7ab	239ab
Binamoog-8	62.7b	2.17b	20.8b	6.8c	10.6c	218c

In a column, the figure(s) with similar/without letter(s) do not differ significantly by DMRT at P ≤ 0.05.

Screening of sesame mutants in respect of morphological attributes and yield

The experiment was conducted during Kharif-I season of 2020 at BINA sub-station, Magura with ten Sesame mutants along with a check variety Binatil-2 to evaluate the performance of genotypes through yield and yield attributes. The experiment was laid out following a randomized complete block design with three replications having a unit plot size of 3 m × 3 m. Row to row and plant to plant distances were 30 cm and 8 cm, respectively. Urea, triple superphosphate and muriate of potash were applied at the rate of 160, 150 and 70 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 gm^{-2}.

Data of different parameters showed significant differences among the genotypes in all locations at P≤ 0.05. Data revealed that the highest plant height was found in SM-3 followed by Binatil-2. SM-10 produced more no. of branches followed by SM-5. The lowest number of branch was found in SM-9 (Table 20). Maximum capsule plant^{-1} was found in mutant SM-4 following SM-10, SM-2. The lowest number of capsule plant^{-1} was found in SM-6. SM-5 showed longer capsule size followed by SM-2. SM-1 produced the highest no. of seed capsule^{-1} followed by SM-7 and SM-2. Seed yield m^{-2} was higher in SM-9, SM-7 and SM-5 than Binatil-2. SM-1, SM-4, SM-5, SM-7 and SM-9 were selected for further investigation.

Table 20. Yield and yield components of sesame mutants at Magura sub-station in 2019-20

Mutants	Plant height (cm)	No. of branch plant^{-1}	No. of capsule plant^{-1}	Capsule length (cm)	No. of Seed capsule^{-1}	Seed yield. m^{-2} (g)
SM-1	134cde	3.30cd	44.0def	2.29cd	87.5a	56.6d
SM-2	129e	3.50bc	53.3ab	2.54ab	76.6b	43.3g
SM-3	145a	3.50bc	42.8ef	2.36c	60.8cd	32.0h
SM-4	132de	3.07ef	57.4a	2.33cd	66.3c	48.5f
SM-5	135cd	3.60ab	44.6def	2.57a	66.3c	63.0b
SM-6	138bc	2.50g	35.7g	2.41bc	63.3c	48.9f
SM-7	135cd	3.23de	50.5bc	2.04e	80.3b	63.4b
SM-8	136cd	3.17def	48.4cd	2.19de	57.1d	52.8e
SM-9	132de	3.00f	46.9cde	2.37c	62.7cd	66.7a
SM-10	132de	3.77a	54.5ab	2.33cd	61.5cd	48.9f
Binatil-2	142ab	3.20def	42.3f	2.31cd	62.9c	60.0c

In a column, the figure(s) with similar letter(s) do not differ significantly by DMRT at P ≤ 0.05.

Grain shape, nutritional characters and cooking qualities of rice genotypes

Twenty rice genotypes were selected to know their grain shape, size, nutritional properties and cooking qualities. The rice grains were classified by standard evaluation system (SES) for rice (IRRI, 1996). The concentrations of Fe and Zn ions in the extracts were analyzed by atomic absorption spectrophotometer (AAS) (Model: SHIMADZU AA-7000) at the wavelengths of 248.3 and 213.9 nm, respectively as described by APHA 2012. Amylose was determined following the method of Robyt and Whelan (1968). The results revealed that grain shape of all the genotypes was short (Table 21). All the genotypes had similar grain size except a land race Jirakalani. Amylose content was higher in Basiraj followed by BRRI dhan66, BRRI dhan71 and BRRI dhan57. Binadhan-10 showed highest Zn content and BRRI dhan73 had the highest Fe content. Protein content ranged from 4.86-7.2%.

Table 1. Grain shape and grain size of rice genotypes

Variety	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	1000- grain weight (g)
Binadh 8	5.18gh	1.82ef	2.84d-h	21.82a
Binadh 10	5.61efg	1.81ef	3.07b-ef	22.32a
BRRIdh 67	6.34abc	1.90def	3.34abc	22.07a
BRRIdh73	6.06b-f	1.78f	3.40ab	22.63a
BRRIdh53	6.26bc	1.78f	3.58a	21.54a
BRRIdh54	6.07b-f	1.89def	3.21a-d	23.02a
BRRIdh47	5.52fg	2.03bcd	2.72e-h	23.03a
Binadh7	5.52fg	2.16ab	2.54gh	24.30a
Iratom24	5.80c-f	1.97cde	2.94c-g	21.99a
BRRIdh56	6.23bcd	1.98cde	3.14b-e	21.97a
BRRIdh57	6.44ab	1.90def	3.38abc	23.32a
BRRIdh66	6.18b-e	2.13abc	2.89d-h	24.23a
BRRIdh71	5.63d-g	2.10abc	2.68fgh	23.86a
Basiraj	6.87a	2.25a	2.90d-h	20.32a
Pazam	5.98b-f	2.13abc	2.80d-h	20.67a
Nazirshaildh	6.36abc	1.86def	3.41ab	21.37a
Gahinda	4.67h	1.86def	2.49h	19.97a
Jirakalani	5.63d-g	1.90def	2.95c-g	14.95b
Ranisalut	5.55fg	1.81ef	3.07b-f	22.58a
Dulai	4.85h	1.76f	2.76e-h	21.01a

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

Table 22. Nutritional properties and cooking qualities of rice genotypes

Genotype	Amylose (%)	Amylopectin (%)	Zn content (ppm)	Fe content (ppm)	Protein %	Volume expansion ratio	Kernel elongation ratio
Binadhan- 8	23.99cde	76.00c-g	23.18bc	6.31ef	5.287de	2.84a	1.33a-d
Binadhan- 10	21.67f	78.33bc	25.8a	5.53f	7.20a	1.85ef	1.25a-e
BRRI dhan 67	22.17ef	77.83bcd	14.70hi	11.64b	6.30a-d	2.37a-d	1.23a-e
BRRI dhan73	22.97def	77.03b-f	21.66cde	14.42a	7.03ab	2.51ab	1.35a-d
BRRI dhan53	22.57def	77.43bcd	13.80i	12.36b	7.27a	2.45abc	1.15b-e
BRRI dhan54	23.53c-f	76.47c-f	14.95hi	8.32cd	6.02a-e	1.98c-f	1.33a-d
BRRI dhan47	23.57c-f	76.47c-f	18.96f	5.98ef	6.07a-e	1.73ef	1.20a-e
Binahan7	22.75def	77.25b-e	14.32hi	7.21de	5.26de	1.83ef	1.09de
Iratom24	22.70def	77.30b-e	14.92hi	9.35c	5.18de	1.89def	1.11cde
BRRI dhan56	22.86def	79.01b	16.01gh	12.17b	5.93b-e	1.51f	1.21a-e
BRRI dhan57	25.27abc	74.73fgh	18.79f	6.94def	6.29a-d	1.84ef	1.21a-e
BRRI dhan66	26.31ab	73.69gh	21.20de	8.09cd	5.59cde	1.70ef	1.16a-e
BRRI dhan71	26.10ab	73.90gh	22.02bcd	8.83c	4.86e	1.86ef	1.22a-e
Basiraj	27.10a	72.90h	21.44de	12.49b	5.65cde	1.96def	1.43a
Pazam	24.53bcd	75.47d-g	16.63g	6.21ef	6.61abc	1.85ef	1.38abc
Nazirshail	25.17bc	74.83e-h	13.56i	5.72ef	5.28de	2.14b-e	1.41ab
Gahinda	22.87def	77.13b-f	22.62bcd	8.76c	6.31a-d	1.74ef	1.22a-e
Jirakalani	22.15ef	77.85bcd	23.58b	6.91def	6.34a-d	1.75ef	1.26a-e
Ranisalut	18.26 g	81.77a	13.31i	9.60c	5.17de	1.60f	1.04e
Dulai	24.13cde	75.87c-g	20.17ef	5.53f	5.10de	1.56f	1.11cde

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

Soil Science Division

Determination of critical limit of nutrients for soils and crops

Pot trials were conducted on mustard and maize during Rabi season 2019-20. Pot trials on maize was also repeated in Khari-1 season 2020. For pot trials, bulk soils were collected from the surface layer (0-15 cm) from the selected locations as mentioned in Tables 1 and 2. The soils were processed (ground? and sieved). Pot trials on response of mustard and maize to each of P and Mg were conducted in completely randomized design (CRD) with two treatments (with and without P and Mg) and three replications. For mustard trial 5 kg soils were used per pot; while 10 kg soils were used per pot for maize trial for both the nutrients. On the basis of soil analysis, nutrients were used at the rate of $N_{150}P_{35}K_{90}S_{25}Mg_6Zn_2B_1$ kg/ha for mustard and $N_{250}P_{60}K_{120}S_{45}Mg_{10}Zn_3B_2$ kg/ha for maize. The processed soils were weighed for individual pot and mixed with all the nutrients (except N and the nutrient in study) thoroughly and poured into the pot. Phosphorus and magnesium were mixed with the soil along with other nutrients during pot preparation as per treatment. Reagent grade chemicals (TSP for P and MgO for Mg) were used as the sources of nutrients. Nitrogen was applied in two equal splits at 15 and 30 days after emergence in maize and at 11 and 25 days after emergence in mustard.

For P and Mg response trials for mustard, seeds were sown on 4 December 2019 and for maize trials the seeds were sown on 11December 2019, respectively. Ten (10) sprouted seeds of mustard (Binasharisha 9) and 6 sprouted seeds of maize (BARI hybrid maize 7) were sown per pot. Distilled water was added to the soil for 'Zou' condition after sowing. Seedlings were thinned to desired population (5 plants/pot for mustard and 3 plants/pot for maize) within 15 and 25 days after emergence, respectively. Intercultural operations like irrigation, weeding etc. were maintained for proper plant growth. Mustard plants for P and Mg response trials were harvested on 15 January 2020 (six weeks after sowing). Fresh and dry weights of mustard plants were recorded, which are being processed for chemical analysis. The maize plants of both P and Mg response trials were harvested on 14 February 2020 (nine weeks after sowing). Pot trials on maize with P and Mg in Kharif-1 season was sown on 2 March 2020 and harvested on 20April 2020 (seven weeks after sowing).

Relative yield and Critical Limit of P for mustard

Table 3 demonstrates that in low P soil the dry matter yield of mustard ranges from 2.02-3.06 g/pot without P and 2.52-3.83 g/pot with P application and the percent relative yield ranges from 74-92. In medium P soil, the dry matter yields ranges from 4.05-4.81 g/pot without P and 4.25-5.40 g/pot with P application. The percent relative yield ranges from 82-95. In high P soil, the dry matter yields ranges from 4.48-5.67 g/pot without P and 4.80-6.95 g/pot with P application. The percent relative yield ranges from 82-95. Overall, the dry matter yield of mustard ranges from 2.02-5.67 g/pot without P and 2.52-6.95 g/pot with P application. The percent relative yield ranges from 74-95 with a mean value of 84.1. The estimated critical level of P for mustard crop was found 14.8 ppm (Fig. 1) compare to the value of 10 ppm mentioned in FRG-2018.

Table 3. Relative yield of mustard and Rabi maize with and without P at HQ, BINA during 2019-20

Soil sample No.	Sample name	Avail P (ppm)	Mustard			Maize		
			Dry matter yield (g/pot)		Relative yield (%)	Dry matter yield (g/pot)		Relative yield (%)
			With P	Without P		With P	Without P	
Low P								
1.	BAU-92	11.51	3.00	2.25	75	5.49	4.43	81
2.	BAU-98	8.40	2.65	2.06	78	4.70	3.53	75
3.	BAU-101	8.40	2.55	2.10	82	5.70	4.43	78
4.	BAU-103	12.90	3.03	2.40	79	5.29	4.61	87
5.	BINA-3	13.33	3.25	2.70	83	5.57	4.76	85
6.	BINA-18	7.75	3.10	2.61	84	3.55	3.33	94
7.	BINA-21	12.84	3.26	2.82	87	5.88	4.93	84
8.	BINA-29	12.47	3.70	3.06	83	7.19	5.87	82
9.	BAU-152	14.13	3.83	2.82	74	6.28	4.72	75
10.	BINA-86	14.56	3.16	2.92	92	6.50	5.95	92
11.	BINA-74	12.04	3.32	2.52	76	6.03	4.75	79
12.	BINA-148	10.75	2.52	2.02	80	4.98	3.68	74
Medium P								
13.	BINA-80	16.80	5.18	4.81	93	7.10	6.21	87
14.	BINA-124	16.50	5.40	4.49	83	7.88	6.10	77
15.	BAU-136	19.67	4.25	4.05	95	7.51	6.83	91
16.	BINA-146	18.06	5.23	4.31	82	7.50	6.82	91
High P								
17.	BAU-123	31.40	5.70	5.23	92	9.64	8.75	91
18.	BINA-81	42.57	6.95	5.67	82	9.52	8.26	87
19.	BAU-154	39.99	4.80	4.55	95	8.64	8.08	94
20.	BINA-101	33.60	5.28	4.48	85	8.89	7.24	81

Relative yield and Critical Limit of P for maize (Rabi and Kharif-1)

Rabi season:

Table 3 shows that in low P soil, the dry matter yield ranges from 3.33-5.87 g/pot without P and 3.55-7.19 g/pot with P application. The percent relative yield ranges from 74-94. In medium P soil, the dry matter yield ranges from 6.10-6.83 g/pot without P and 7.10-7.88 g/pot with P application. The percent relative yield ranges from 77-91. In high P soil, the dry matter yields ranges from 7.24-8.75 g/pot without P and 8.64-9.64 g/pot with P application. The percent relative yield ranges from 81-94. Overall, the dry matter yield of maize ranges from 3.33-8.75 g/pot without P and 3.55-9.64 g/pot with P application. The percent relative yield ranges from 74-94 with a mean value of 84.3 in case of maize. The estimated critical level of P for maize crop was found as 16.1 ppm (Fig. 2) compare to the value of 10 ppm mentioned in FRG-2018.

Kharif-I season:

It is revealed from Table 4 reveals that in low P soil, the dry matter yield ranges from 93.92-125.88 g/pot without P and 115.95-148.84 g/pot with P application. The percent relative yield ranges from 72-88. In medium P soil, the dry matter yield ranges from 124.07-132.99 g/pot without P and 131.82-144.52 g/pot with P application. The percent relative yield ranges from 89-94. In high P soil, the dry matter yields ranges from 136.36-167.32 g/pot without P and

145.27-185.91 g/pot with P application. The percent relative yield ranges from 84-95. Overall, the dry matter yields of maize ranges from 93.92-167.32 g/pot without P and 115.95-185.91 g/pot with P application. The percent relative yield ranges from 72-95 with a mean value of 85.5 in case of maize. The estimated critical level of P for maize crop was found 14.5 ppm (Fig. 3) compare to the value of 10 ppm mentioned in FRG-2018.

Table 4. Dry matter yield (g/pot), percent relative as affected by phosphorus (P) and magnesium (Mg) application in maize at SSD, BINA, Mymensingh during Kharif-I season 2020.

Soil sample No.	Sample name	Avail. P (ppm)	Dry matter yield (g/pot)		% RY	Sample name	Excha. Mg (meq%)	Dry matter yield (g/pot)		% RY
			Without P	With P				With-out Mg	With Mg	
Low P						**Low Mg**				
1.	BAU-92	11.51	98.56	115.95	85	BINA-105	0.58	116.48	156.11	75
2.	BAU-98	8.40	106.89	133.61	80	BINA-107	0.58	104.44	124.71	84
3.	BAU-101	8.40	93.92	130.44	72	BINA-121	0.57	93.96	121.65	77
4.	BAU-103	12.90	107.97	143.96	75	BINA-127	0.55	109.29	124.45	88
5.	BINA-3	13.33	95.02	122.32	78	BINA-130	0.36	87.46	122.43	71
6.	BINA-18	7.75	125.34	142.43	88	BINA-150	0.32	104.14	130.84	80
7.	BINA-21	12.84	103.16	135.74	76	BAU-111	0.17	95.62	116.60	82
8.	BINA-29	12.47	109.97	129.53	85	BAU-112	0.17	96.44	128.72	75
9.	BAU-152	14.13	116.25	135.00	86	BAU-138	0.29	83.81	116.94	72
10.	BINA-86	14.56	125.05	148.84	84	BAU-139	0.29	88.04	117.55	75
11.	BINA-74	12.04	125.88	143.19	88	BAU-158	0.28	106.60	122.82	87
12.	BINA-148	10.75	120.29	136.69	88	BAU-167	0.28	120.12	137.05	88
Medium P						**Medium Mg**				
13.	BINA-80	16.80	132.99	144.52	92	BINA-13	0.79	141.15	156.53	90
14.	BINA-124	16.50	126.34	142.40	89	BINA-15	0.92	127.08	151.29	84
15.	BAU-136	19.67	127.32	135.88	94	BINA-103	0.79	140.62	149.60	94
16.	BINA-146	18.06	124.07	131.82	94	BINA-112	0.79	142.10	148.02	96
High P						**High Mg**				
17.	BAU-123	31.40	136.36	162.56	84	BINA-4	1.67	133.14	150.00	89
18.	BINA-81	42.57	150.28	172.74	87	BINA-20	1.67	157.96	168.19	94
19.	BAU-154	39.99	138.40	145.27	95	BINA-79	1.67	137.10	166.51	82
20.	BINA-101	33.60	167.32	185.91	90	BINA-87	1.35	143.59	159.88	90

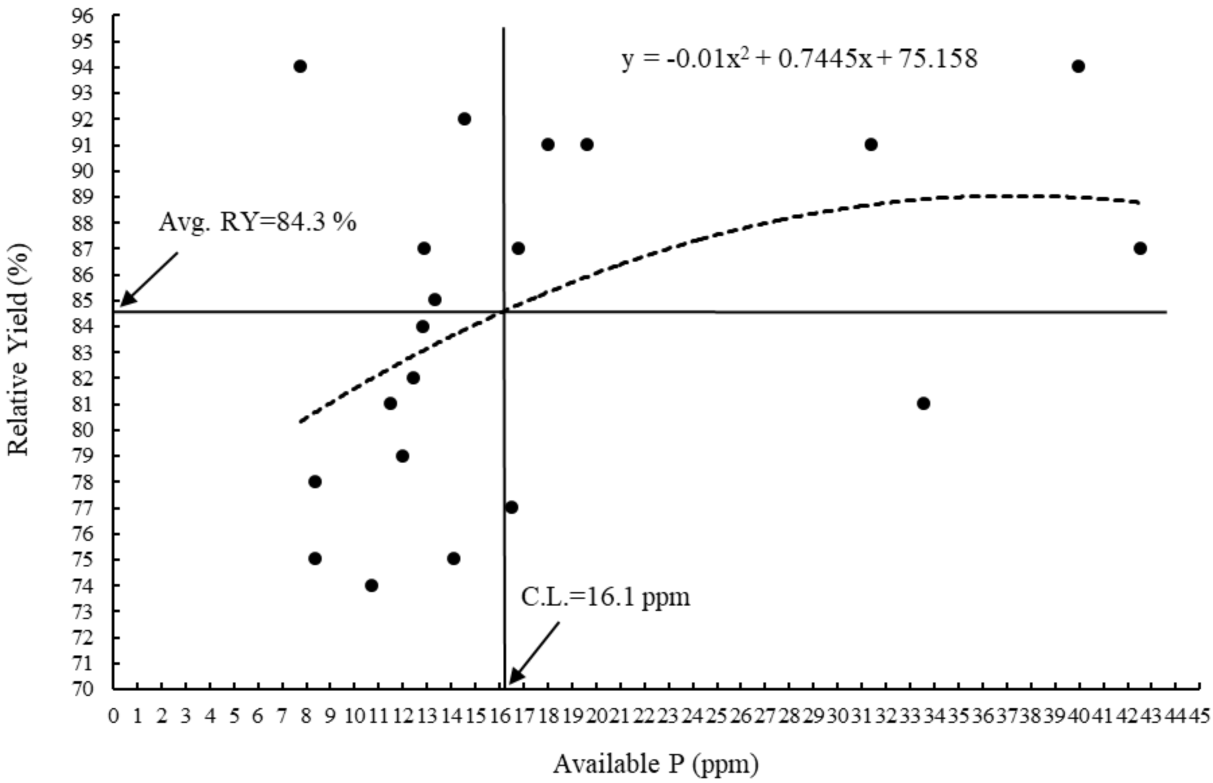


Fig 2. Critical limit of P for Rabi maize in Bangladesh, SSD, BINA, 2019-20

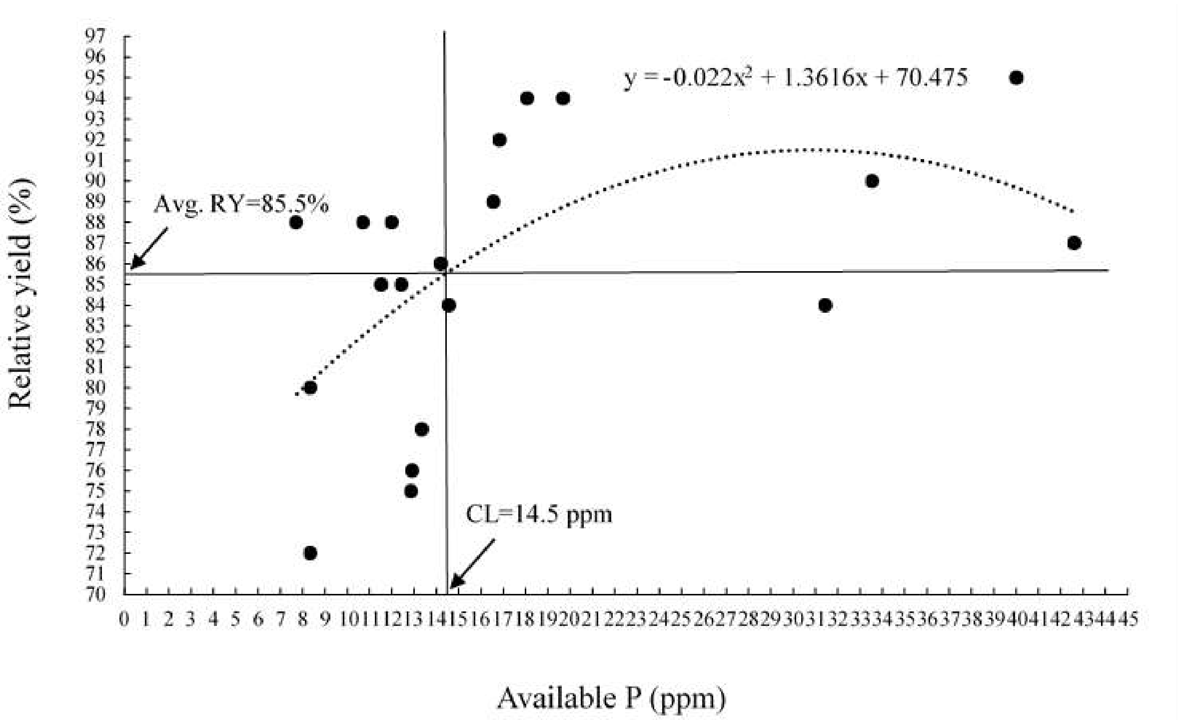


Fig 3. Critical limit of P for Kharif maize in Bangladesh, SSD, BINA, 2019-20

Relative yield and Critical Limit of Mg for mustard

It was observed that in low Mg soil, the dry matter yield ranges from 1.32-1.86 g/pot without Mg and 1.48-2.47 g/pot with Mg application (Table 5). The percent relative yield ranges from 73-97. In medium Mg soil, the dry matter yield ranges from 5.08-5.79 g/pot without Mg and 5.48-6.68 g/pot with Mg application. The percent relative yield ranges from 87-93. In high Mg soil, the dry matter yields range from 6.02-7.10 g/pot without Mg and 6.52-7.78 g/pot with Mg application. The percent relative yield ranges from 88-95. Overall, the dry matter yield of mustard ranges from 1.32-7.10 g/pot without Mg and 1.48-7.78 g/pot with Mg application. The percent relative yield ranges from 73-97 with a mean value of 84.6 in case of mustard. The estimated critical limit of Mg for mustard crop was found 0.59 meq% (Fig. 4) compare to the value of 0.50 meq% mentioned in FRG-2018.

Table 5. Relative yield of mustard and Rabi maize with and without Mg at SSD, BINA during 2019-20

Soil sample No.	Sample name	Excha. Mg (meq%)	Mustard Dry matter yield (g/pot)		Relative yield (%)	Maize Dry matter yield (g/pot)		Relative yield (%)
			With Mg	Without Mg		With Mg	Without Mg	
Low Mg								
1.	BINA-105	0.58	1.77	1.57	89	8.82	7.26	82
2.	BINA-107	0.58	1.89	1.83	97	8.42	6.34	75
3.	BINA-121	0.57	1.48	1.32	89	8.08	7.09	88
4.	BINA-127	0.55	1.90	1.33	70	8.01	6.76	84
5.	BINA-130	0.36	2.00	1.45	73	8.00	5.96	75
6.	BINA-150	0.32	2.12	1.63	77	7.00	5.43	78
7.	BAU-111	0.17	2.00	1.62	81	8.90	7.52	85
8.	BAU-112	0.17	2.10	1.73	82	10.50	7.68	73
9.	BAU-138	0.29	2.32	2.12	91	6.80	5.88	86
10.	BAU-139	0.29	2.47	1.86	75	6.65	5.83	88
11.	BAU-158	0.28	2.23	1.62	73	7.19	5.56	77
12.	BAU-167	0.28	1.76	1.37	78	6.65	4.71	71
Medium Mg								
13.	BINA-13	0.79	6.68	5.79	87	10.08	8.34	83
14.	BINA-15	0.92	6.65	5.34	80	10.65	9.06	85
15.	BINA-103	0.79	6.27	5.66	90	9.20	7.53	82
16.	BINA-112	0.79	5.48	5.08	93	9.25	7.64	83
High Mg								
17.	BINA-4	1.67	7.10	6.72	95	11.31	10.41	92
18.	BINA-20	1.67	7.32	6.46	88	11.77	10.02	85
19.	BINA-79	1.67	7.78	7.10	91	12.90	10.47	81
20.	BINA-87	1.35	6.52	6.02	92	10.98	10.56	96

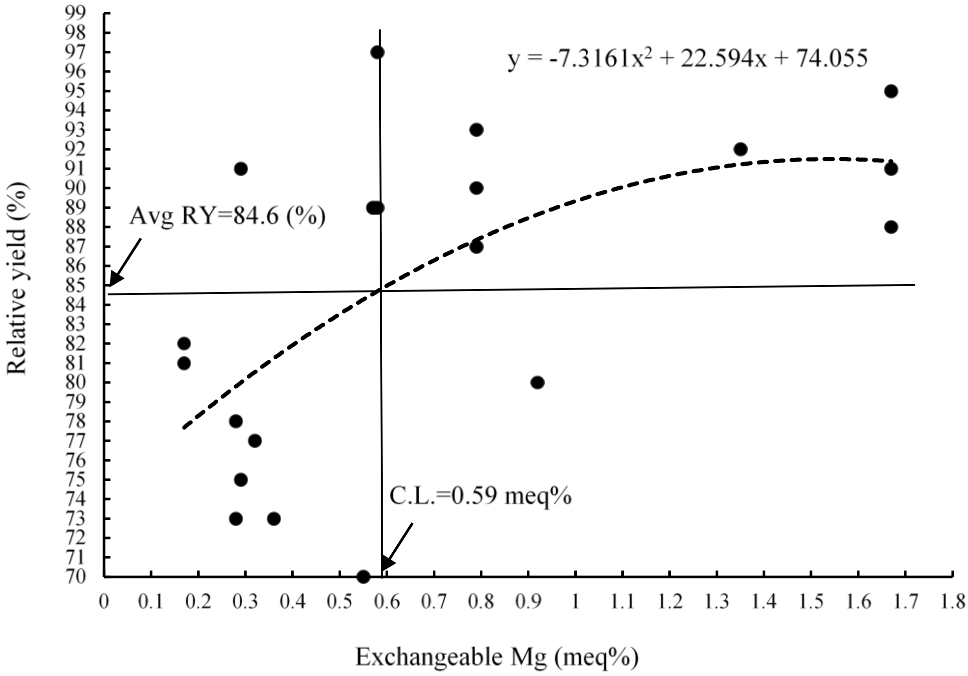


Fig 4. Critical limit of Mg for mustard in Bangladesh, SSD, BINA, 2019-20

Relative yield and Critical Limit of Mg for maize (Rabi and Kharif-1)

Rabi season:

It was observed that in low Mg soil, the dry matter yield of maize range from 4.71-7.68 g/pot without Mg and 6.65-10.50 g/pot with Mg application (Table 5). The percent relative yield ranges from 71-88. In medium Mg soil, the dry matter yields range from 7.73-9.06 g/pot without Mg and 9.20-10.65 g/pot with Mg application. The percent relative yield ranges from 82-85. In high Mg soil, the dry matter yields range from 10.02-10.56 g/pot without Mg and 10.98-12.90 g/pot with Mg application. The percent relative yield ranges from 81-96. Overall, the dry matter yields of maize ranges from 4.71-10.56 g/pot without Mg and 6.65-12.90 g/pot with Mg application. The percent relative yield range from 71-96 with a mean value of 82.5 in case of maize. The estimated critical level of Mg for maize crop was found 0.60 meq% (Fig. 5) compare to the value of 0.50 meq% mentioned in FRG-2018.

Kharif-I season:

Table 4 shows that in low Mg soil, the dry matter yields range from 87.46-120.12 g/pot without Mg and 116.60-156.11 g/pot with Mg application. The percent relative yield ranges from 71-88. In medium Mg soil, the dry matter yields range from 127.08-142.10 g/pot without Mg and 148.02-156.53 g/pot with Mg application. The percent relative yield ranges from 84-96. In high Mg soil, the dry matter yields range from 133.14-157.96 g/pot without Mg and 150.00-168.19 g/pot with Mg application. The percent relative yield ranges from 82-94. The overall, the dry matter yields of maize ranges from 87.46-157.96 g/pot without Mg and 116.60-168.19 g/pot with Mg application. The percent relative yield ranges from 71-96 with a mean value of 83.8 in case of maize. The estimated critical level of Mg for maize crop was found 0.52 meq%(Fig. 6) compared with the value of 0.50 meq% mentioned in FRG-2018.

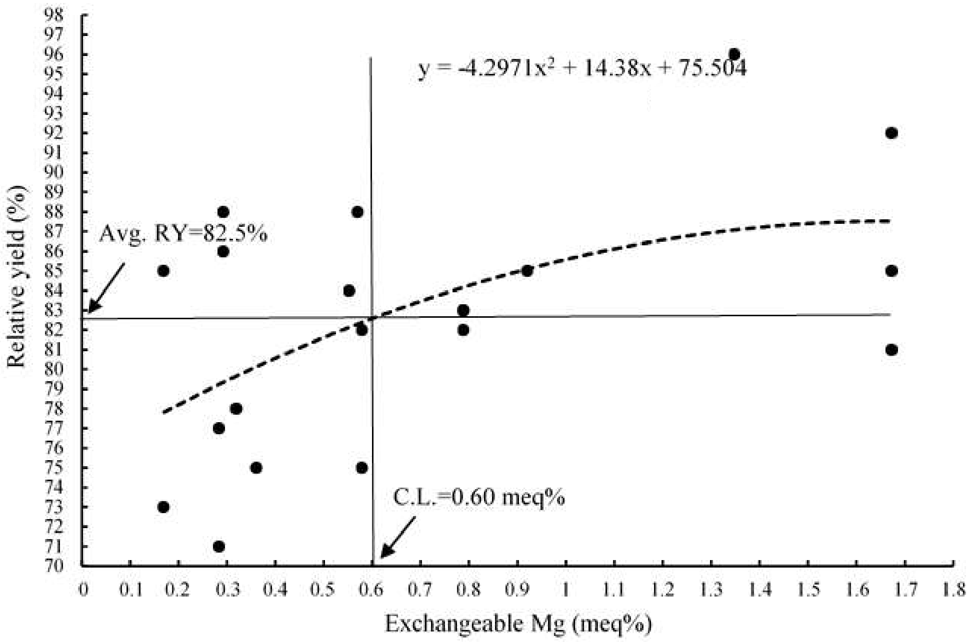


Fig 5. Critical limit of Mg for Rabi maize in Bangladesh, SSD, BINA, 2019-20

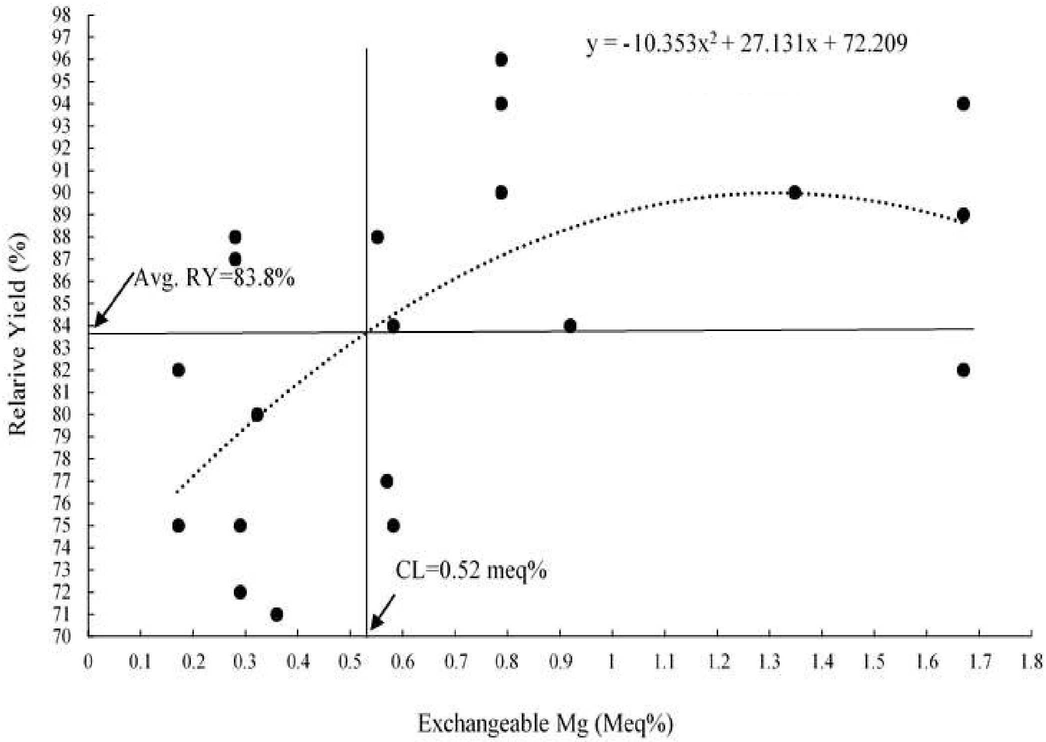


Fig 6. Critical limit of Mg for Kharif maize in Bangladesh, SSD, BINA, 2019-20

Benchmark survey to characterize bio-physicochemical properties of soil in the selected study areas

Objective:

Thirty soil samples were collected from the drought prone areas (Nachole of ChapaiNawabganj) at 0-15cm depth to characterize the biological and chemical properties of soil. All the samples analyzed for soil microbial biomass carbon and total nitrogen content.

Results:

The results obtained from the soil analysis are presented in Figure 1 and 2 where L-1, L-2, L-3, ... L-30 denotes location of the samples. Microbial biomass carbon of the tested soils varied from 35-827 kg-C/ha where the highest microbial biomass content was recorded in soil no. L-3 (Fig. 1). The lowest microbial biomass content (35 kg-C/ha) was found in soil no. L-25. The second highest microbial biomass carbon was found in L-23 soil sample. Most of the soil samples were in 127 to 453 kg-C/ha. Less amount of microbial biomass carbon was obtained from L-4, L-8, L-12, L-15, L-19, L-21, L-22, L-25 and L-30 soil samples.

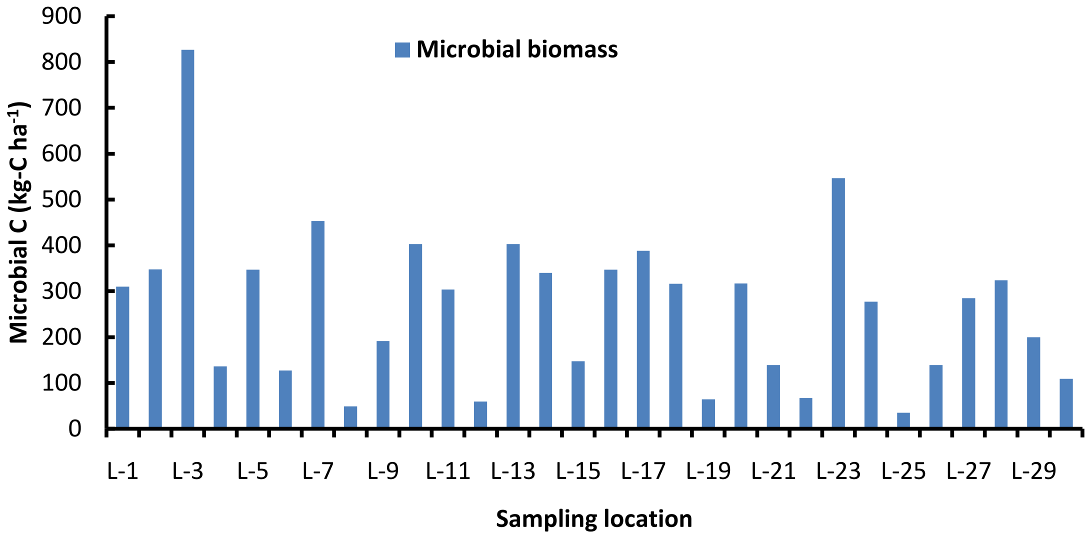


Fig. 1.Microbial biomass content in different samples of Nacholupazilla at ChapaiNawabganj.

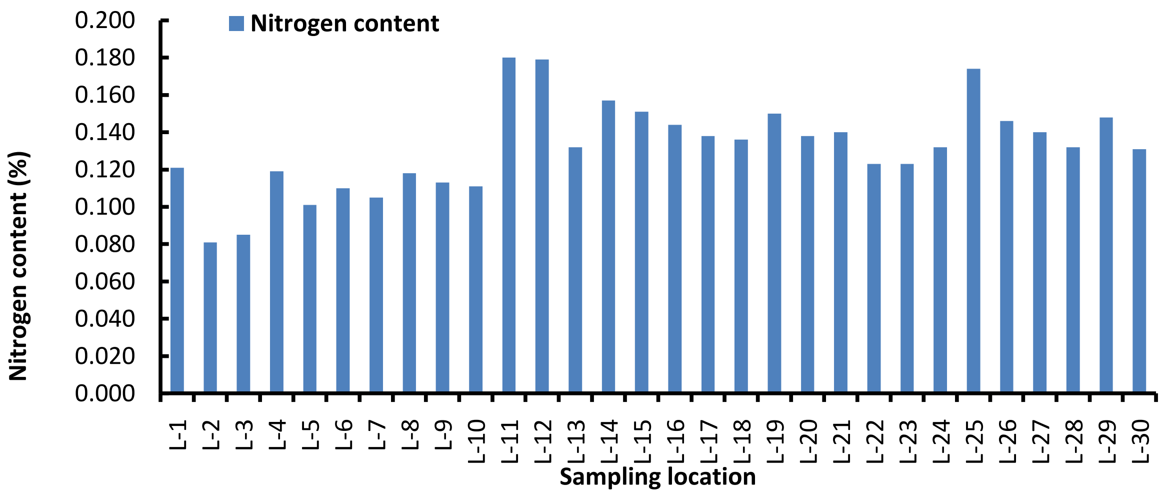


Fig. 2.Nitrogen status in different locations of Nacholupazilla at ChapaiNawabganj.

Nitrogen status in soil is an important trait for grain production and is thereby an important aspect of rice growth improvement. Nitrogen content differed significantly due to different location of studied areas (Fig. 2). Maximum nitrogen content was obtained from locations L-11, L-12 and L-25 and the minimum nitrogen content was found in L-2 location.Most of the soil samples were fall in 1.31 to 1.46 per cent nitrogen.

Improvement of soil health in unfavorable eco-systems with organic amendments for sustainable crop production

First field experiment was carried out to evaluate the effect of different organic amendments on soil and crops in drought prone areas of Bangladesh. Treatments composition were T_0= control, T_1= 100% recommended fertilizer (RF), T_2= 100% RF + 2.0 biochar (rice husk), T_3=RF (IPNS) + 3.0 t ha^{-1} poultry manure, T_4=RF (IPNS) + 3.0 t ha^{-1}vermicompost and T_5= RF(IPNS) + 3.0 t ha^{-1} standard organic fertilizer.

Table 1. Effect of chemical and its combination with organic fertilizers on yield and yield attributing characters of rice in Aman 2019

Treatment	Plant height (cm)	Panicle length (cm)	Root weight (gm)	Total tiller (no.)	Non-effective tiller (no.)	Filled grain(no)	Unfilled grain(no)	1000 seed weight (g)	Grain weight (t/ha)	Straw weight (t/ha)
T_0	96.80c	20.60b	2.69	10.93	0.80	97.13	8.27	21.40	5.92	6.70
T_1	101.13ab	21.27ab	2.76	12.53	1.00	115.53	15.00	21.27	6.00	7.41
T_2	100.67ab	21.47ab	2.86	13.00	0.93	123.20	10.60	21.00	6.26	7.34
T_3	103.13a	21.67ab	2.56	11.87	0.80	127.53	10.87	14.80	6.05	7.12
T_4	98.20bc	21.33ab	2.10	12.07	0.87	104.53	11.27	21.13	6.03	6.84
T_5	99.60bc	22.20a	2.42	12.73	0.78	118.93	10.27	21.47	6.53	7.56
Sig. Level	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)	1.82	3.71	18.79	11.10	35.68	25.77	34.22	8.11	12.04	11.18
LSD>0.05	3.30	1.45	0.88	2.46	0.56	53.66	6.88	22.12	1.34	1.46

Table 2. Effect of chemical and its combination with organic fertilizers on yield and yield attributing characters of mustard in Aman2020

Treatment	Plant height (cm)	Panicle length (cm)	Total tiller (no.)	Non-effective tiller (no.)	Grain (no)	1000 seed weight (g)	Grain weight (t/ha)	Straw weight (t/ha)
T_0	74.93b	12.13b	33.93c	6.67b	20.93	3.34	0.75b	1.12
T_1	95.67a	13.00ab	46.53abc	7.93a	25.40	3.06	1.52a	2.07
T_2	97.13a	13.10ab	42.40abc	8.10a	23.53	2.94	1.55a	2.31
T_3	96.53a	14.07a	54.13a	7.85a	24.13	3.30	1.77a	2.97
T_4	96.40a	14.00a	47.67ab	7.13ab	24.67	3.27	1.77a	2.79
T_5	94.27a	13.60ab	40.00bc	7.93a	24.07	3.40	1.67a	2.75
Sig. Level	**	*	*	**	NS	NS	**	NS
CV(%)	3.46	7.25	8.43	17.29	10.80	12.02	17.29	10.80
LSD>0.05	5.82	1.76	12.85	1.17	4.67	0.70	0.47	0.98

Yield and yield attributing characters results significantly did not perform except plant height in different treatments (Table 1). Rice yield was or lowest only in control plots whereas positive yield trend was maintained in all the organic amendment treatments. Maximum panicle length (22.20 cm), total tiller (12.73) and thousand seed weight (21.47 g) were observed in recommended fertilizer using IPNS + 3.0 t ha^{-1} organic fertilizer treated plot. On the other hand, the lowest non-effective tiller per plant was obtained from the same treatment. Maximum root weight (2.86 g) per plant was found in recommended fertilizer using IPNS + 3.0 t ha^{-1} poultry manure. As a result, highest grain and straw yields were found in recommended fertilizer using 3.0 t ha^{-1} organic fertilizer. The second highest grain and straw yields were found in recommended fertilizer using IPNS + 3.0 t ha^{-1} poultry manure. Effects of chemical fertilizer and IPNS based (chemical and organic amendments) fertilizer treatments on yield and yield components of Rabi crops results are presented in Table 2. Maximum seed and straw yields of mustard were observed in recommended fertilizer + 3.0 t ha^{-1} poultry manure due to higher panicle length, total tiller per plant and thousand seed weight. All the treatments produced significantly higher yield and yield attributes compare to control treatment.

Second field experiment was carried out to evaluate the effect of integragrated plant nutrient system of poultry manure and chemical fertilizer and sole use of chemical fertilizers on soil and crops in drought prone areas of Bangladesh. Two treatment such as T_1= 100% recommended fertilizer (RF) and T_2=RF (IPNS) + 3.0 t ha^{-1} poultry manure using T. aman-Boro- (wheat/mustard/lentil/chickpea) cropping systems. Experimental design followed randomized complete design with three replications at Nacholeupazilla, ChapaiNawabganj.

Recommended dose of chemical fertilizers along with 3.0 t/ha treatments showed significant variation on yield and yield attributing characters of rice (Table 3). Maximum yield attributing characters such as plant height, panicle length, effective tiller, non-effective tiller, root weight, 1000 seed weight were found in recommended doses of chemical fertilizers in combination with 3.0 t/ha poultry manure treatment.

Table 3. Effect of chemical and organic fertilizers on yield and yield attributing characters of Aman rice 2019

Treatment	Plant height (cm)	Panicle length (cm)	Total tiller (no.)	Non-effective tiller (no.)	Root weight (gm)	Filled grain (no)	Unfilled grain (no)	1000 seed weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
T_1	85.13	22.93	11.03	1.00	6.55	156.37	24.43	21.00	6.54	6.94
T_2	84.43	23.33	10.70	1.00	6.61	152.83	20.13	21.40	6.42	6.98
Sig. Level	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)	1.49	2.05	7.30	23.66	12.16	9.48	33.94	2.60	12.16	7.21

Table 4. Effect of chemical and organic fertilizers on yield and yield attributing characters of mustard 2020

Treatment	Plant height (cm)	Root weight (gm)	Total tiller (no.)	Pod length (cm)	Seed per pod (no)	1000 seed weight (g)	Grain weight (t/ha)	Straw weight (t/ha)
T_1	97.73	11.87	56.60	7.67	28.40	2.63	0.97	4.67
T_2	93.80	14.20	57.53	8.00	25.00	2.81	0.61	3.08
Sig. Level	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)	1.55	7.70	25.95	4.54	5.05	13.35	14.62	12.09

Table 5. Effect of chemical and organic fertilizers on yield and yield attributing characters of lentil 2020

Treatment	Plant height (cm)	Root weight (gm)	Total tiller (no.)	100 seed weight (g)	Seed yield (t/ha)	Hay yield (t/ha)
T_1	31.20a	5.40	77.40	1.77	2.59	2.52
T_2	28.20b	4.40	70.70	1.29	2.51	2.14
Sig. Level	*	NS	NS	NS	NS	NS
CV(%)	1.43	14.42	16.24	16.18	1.61	6.53

Table 6. Effect of chemical and organic fertilizers on yield and yield attributing characters of wheat 2020

Treatment	Plant height (cm)	Root weight (gm)	Total tiller (no.)	Spike length (cm)	100 seed weight (g)	Grain weight (t/ha)	Straw weight (t/ha)
T_1	91.60	7.80	5.47	9.16	4.72	3.83	7.24
T_2	88.87	8.00	6.80	9.27	5.28	3.89	6.36
Sig. Level	NS	NS	NS	NS	NS	NS	NS
CV(%)	3.44	12.53	17.91	3.52	17.49	17.83	15.52

The highest grain and straw yield were obtained from recommended doses of chemical fertilizers with 3.0 t/ha poultry manure treatment. In mustard and lentil experiments, maximum seed and hay yield were observed in recommended fertilizer using IPNS + 3.0 t ha^{-1} poultry manure (Table 4 -6).Maximum seed and straw yields (1.77 and 2.97 t ha^{-1}) of mustard were found in recommended fertilizer using IPNS + 3.0 t ha^{-1} poultry manure. Recommended fertilizer using IPNS + 3.0 t ha^{-1} poultry manure produced higher grain and straw yields of lentil due to higher yield contributing characters except wheat yield. On the other hand, chemical fertilizer produced the higher grain and straw yield of wheat over recommended fertilizer using IPNS + 3.0 t ha^{-1} poultry manure.

Development Of Phospho- Vermicompost Using Different Combination Of Organic Residues With Rock Phosphate

Objective

A glass house experiment was conducted to develop Phospho-vermicompost using different combination of organic residues with rock phosphate and earthworms during 2019-2020.

Method

The experiment was conducted in a Completely Randomized Design with eight treatments and three replications for each treatment. The treatments were as follow as:

T_1: 50% Cowdung (CD)+ 50% Mustard straw (MST)
T_2:50% CD +50% Water hyacinth (WH)
T_3:50% CD+ 50% Rice straw (RST)
T_4: 50% CD +25% WH + 25% RST
T_5:50% CD+50% MST+ 4% Rock phosphate (RP)
T_6:50%CD +50% WH+ 4% RP
T_7: 50% CD+ 50% RST+ 4% RP
T_8: 50% CD +25% WH + 25%RST + 4% RP

Initial nutrients status of different residues has been given in the table 1. Rrock phoshate (@ 4%) was mixed well with the mixtures of organic residues as treatments plan into the plastic pots and all the pots were pre-incubated for three weeks. After softening and partial decomposed of residues then 150 earth worms (*Eisenia foetida* or Red wiggler earthworms) were released into all the plastic pots. All the pots were covered with gunny bag to make dark condition. Small amount of water was sprayed if necessary to avoid the dryness of the residues. After 90 days of incubation, the residues were completely decomposed and no bad odor was observed. So vermicompost was ready for collection. Then the samples were collected from each pot for chemical analysis. The collected vermicompost were dried and grinded and kept in plastic bottle. The prepared samples were analyzed for pH, organic carbon, total N, P, K and S.

Result

The nutrient contents of vermicompost with or without rock phosphate amended are presented in the Tabe 2. The pH was almost similar in all the treatment combinations but with rockphosphate amended vermicompost showed greater pH than without rock phosphate amended treatments. It may be happened be due to addition of rock phosphate with organic residues. Adding of rock phosphate, all the combinations of organic residues showed lower C:N ratio after vermicomposting and also increased nutrient contents including P . Among the treatments, the treatments T_8 gave the highest N (1.42%), P (1.45%), K (1.52%) and S (0.35%) contents and lower C:N ratio (10.7) than that of all other treatments which indicated the better quality of phospho-vermicompost. Therefore, 50% cowdung +25% water hyacinth +25% rice straw with 4% rock phosphate powder and red wiggler earthworms could be used for the production of phosphate rich vermicompost i. e. Phospho-vermicompost. The developed phospho-vermicompost could be used in the cultivation of different crops for full supplement of phosphatic fertilizers and parttial supplement other chmemical fertilizers (N, P and S)

Table 1. Nutrient contents in different organic materials used in the experiment

Organic residues	Org C(%)	%N	%P	%K	%S
Water hyacinth	45	0.65	0.35	1.8	0.23
Cowdung	38	0.65	0.3	0.46	0.23
Rice straw	48	0.67	0.17	1.4	0.13
Mustard straw	46	0.57	0.13	1.3	0.20

Table 2. pH, Organic carbon (O.C) and total N, P, K and S contents in with or without rock phosphate amended vermicompost

Treatments	pH	%OC	%N	%P	%K	%S	C:N ratio
T_1	7.73	16.2	1.1	0.45	1.4	0.28	14.72
T_2	7.95	16.4	1.23	0.45	1.80	0.30	13.3
T_3	7.82	17.3	1.17	0.52	1.70	0.34	14.78
T_4	7.9	16.8	1.2	0.50	1.75	0.34	14.0
T_5	8.05	15.5	1.23	1.2	1.35	0.32	12.60
T_6	8.13	15.1	1.35	1.37	1.4	0.30	11.18
T_7	8.10	15.9	1.37	1.38	1.45	0.33	11.6
T_8	8.15	15.2	1.42	1.45	1.52	0.35	10.7

Note: T_1: 50% Cowdung (CD)+ 50% Mustard straw (MST), T_2:50% CD +50% Water hyacinth (WH), T_3:50% CD+ 50% Rice straw (RST), T_4: 50% CD +25% WH + 25% RST, T_5:50% CD+50% MST+ 4% Rock phosphate (RP), T_6:50%CD +50% WH+ 4% RP,T_7: 50% CD+ 50% RST+ 4% RP and T_8: 50% CD +25% WH + 25%RST + 4% RP

Reduction Of Chemical Fertilizer In Crop Production Using Different Vermicompost

Field experiments were conducted to reduce the chemical fertilizer with the integrated use of different kinds of vermicompost and chemical fertilizers in T. aman-Boro rice cropping pattern at the BINA farm, Mymensingh during 2019-20. The experiment is being conducted in long term experimental field with different kinds of organic manures. 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% N from Chemical Fertilizer (CF), T_3:70%N from CF, T_4: 30% N from vermicompost-3 + 70% N from CF and T_5:30% N from vermicompost-4 + 70% N from CF and T_6: 100% PKS only. The treatments of Boro rice (var. Binadhan -10) were: T_1: Native soil fertility, T_2: 100% NPKS from chemical fertilizer (CF), T_3:75% NKS from CF (Non IPNS) with 1 t ha^{-1} Phospho-vermicompost (P-Vermicom), T_4: 100% NKS (IPNS) with 2 t ha^{-1}P-Vermicom, T_5: 100% NKS from CF (Non IPNS) with 2 t ha^{-1} P-Vermicom and T_6: 100% NKS. The experiments were conducted in a Randomized Complete Block Design with three replications for each treatment. The properties of initial soil have been given in the Table 1. T. Aman rice (var. Binadhan-17) was transplanted in August 2019 and harvested in the first week of Nov. 2019 where as Boro rice (Binadhan-10) was transplanted in the first week of Feb. 2020 and harvested on second week of May 2020. Fertilizer rates 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 in respective cases. Therefore, N, P, K and S were also reduced from CF treatments in T. aman or in Boro rice, respectively. Nutrient contents of different vermicompost have been given in the Table 2. Vermicompost and all chemical 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 the Table 3 and Table 4 for T. aman and Boro rice, respectively. Partial cost-benefit analysis was done only in case of Boro rice only.

Table 1. 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 2. Nutrient contents in different manures applied in T. aman and Boro rice during 2019-20

Name of manures	%N	%P	%K	%S
T. aman rice				
Vermicompost-3	1.2	0.5	1.8	0.45
Vermicompost-4	1.1	0.45	1.4	0.5
Boro rice				
Phospho -vermicompost	1.42	1.45	1.52	0.35

Table 3. Full rates (100%) of fertilizers and 30% N equivalent manures for T. aman rice

Crops	Nutrients (kg ha^{-1})				Manures (t ha^{-1})*	
	N	P	K	S	30% N equivalent Vermicompost-3	30% N equivalent Vermicompost-4
T. aman rice	77.1	8.4	61.7	9.3	1.9	2.1

*dry weight basis

Table 4. Amount of fertilizers and Phospho-vermicompost applied in Boro rice as treatment plan

Treatments	Chemical Fertilizer (CF) (kg ha^{-1})				Phospho-vermicompost (t ha^{-1})
	N	P	K	S	
T_1: Native soil fertility	-	-	-	-	-
T_2:100% NPKS from chemical fertilizer (CF)	134	14	68	13	-
T_3:75% NKS from CF (Non IPNS) + 1 t ha^{-1} Phospho-vermicompost (P-Vermicom),	100.5	-	51	9.75	1.0
T_4: 100% NKS (IPNS) + 2 t ha^{-1}P-Vermicom,	105.5	-	37.8	6.0	2.0
T_5: 100% NKS from CF (Non IPNS) + 2 t ha^{-1} P-Vermicom	134	-	68	13	2.0
T_6: 100% NKS.	134	-	68	13	-

Yields and yield contributing characters of T. Aman rice were significantly influenced with the different treatments in 2019 (Table 5). The treatment T_5 gave maximum grain yield (5.5 t ha^{-1}) followed by the treatment T_4 (5.4 t ha^{-1}). But the treatmentsT_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 vermicompost-3 or vermicompost-4 gave comparable yield to the sole application of 100% N from chemical fertilizer alone. But the vermicompost -3 gave greater grain yield than vermicompost-4. Therefore, 30% N, P, K and S fertilizer could be saved with the integrated (IPNS) use of vermicompost-3 or vermicompost-4 in the cultivation of T. aman rice.

Table 5. Yield and yield contributing characters of T. Aman rice (Binadhan-17) as affected by different treatments during 2019-20

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	2.7c	3.0b	89.6b	20.8b	5.9c	132.2c	35.7ab
T_2	5.1a	5.2a	101.9a	23.4a	9.3ab	185.0ab	44.7a
T_3	4.0b	4.8a	100.3a	23.3a	8.2b	171.7b	44.3a
T_4	5.4a	5.2a	101.3a	23.6a	9.8a	191.7ab	36.7ab
T_5	5.5a	5.3a	100.8a	23.7a	9.9a	198.0a	31.7b
T_6	3.1c	3.8b	97.7b	22.5ab	6.7c	144.0c	43.3a
lsd	**0.73**	**0.88**	**7.68**	**2.27**	**1.23**	**24.1**	**10.09**
SE(±)	**0.234**	**0.279**	**0.722**	**0.722**	**0.390**	**7.648**	**3.203**
CV(%)	**9.47**	**10.69**	**5.28**	**5.47**	**8.19**	**7.77**	**14.09**

In a column, figures having common letter(s) do not differ significantly at 5% level of probability.

Application of Phospho-vermicompost significantly influenced the yields and yield contributing characters of Boro rice (Binadhan-10) during 2019-20 (Table 6). The treatment T_4 (7.23.0 t ha^{-1}) gave maximum grain yield of Boro rice followed by the treatments T_2 and T_5. But the treatments T_2 and T_5 produced statistically similar grain yields. The treatment T_1 (native soil fertility) gave the lowest yield (2.69 t ha^{-1}) of Boro rice. The treatment T_3 (5.26 t ha^{-1}) gave the fourth highest grain yield where applied non IPNS chemical fertilizer (NKS) with one t ha^{-1} Phospho-vermicompost. The results from the treatment T_4 (100% NKS (IPNS) with 2 t ha^{-1}P-Vermicom) indicated that full demand of P could be met up from 2 t ha^{-1} Phospho-vermicompost with IPNS chemical fertilizer (NKS) which was sufficient for attained the highest grain yield of Boro rice than that of the treatment T_2 (100% NPKS from CF) and the treatmentT_5 (100% NKS from CF (Non IPNS) + 2 t ha^{-1} Phospho-vermicompost). Similar trends were also observed in case of straw yields. Hence, the results revealed that 100% P and substantial amount of N (21%), K (44.6%) and S (53.7%) fertilizers could be saved with the integrated use of Phospho-vermicompost in the cultivation boro rice. Partial cost benefit analysis (Table 6) showed that the application of Phospho-vermicompost (@2 tha^{--1}) with IPNS chemical fertilizer (NKS) gave higher return about of Tk.18,213 / - than that of only 100% chemical fertilizer treatment. Therefore, use of Phospho-vermicompost was beneficial for the cultivation of Boro rice in combination of suitable dose of chemical fertilizers.

Table 6. Yield and yield contributing characters of Boro rice (Binadhan-10) as affected by Phospho-vermicompost during 2019-20

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	2.69e	2.21d	76.1c	17.4b	5.5d	91.8d	5.7c
T_2	6.32b	5.87ab	96.8b	23.4a	12.2a	145.8b	14.4b
T_3	5.26c	5.72bc	98.5ab	22.7a	9.7bc	135.3b	16.4b
T_4	7.23a	6.62a	100.5a	23.9a	12.5a	161.4a	9.7c
T_5	6.24b	6.22ab	98.9ab	23.3a	12.0ab	143.5b	21.5a
T_6	4.54d	4.95c	98.7ab	22.4a	7.4cd	107.6c	22.1a
lsd	**0.4**	**0.8**	**3.0**	**1.9**	**2.1**	**12.3**	**4.5**
SE(±)	**0.16**	**0.25**	**0.98**	**0.60**	**0.77**	**1.46**	**3.92**
CV(%)	**5.05**	**8.38**	**5.78**	**4.71**	**13.54**	**5.18**	**16.87**

In a column, figures having common letter(s) do not differ significantly at 5% level of probability.

Table 7. Partial Cost-Benefit analysis from the integrated use of phospho-vermicompost with chemical fertiizers in the cultivation of Boro rice (Binadhan-10)

Treatments	Total return (Tk.)	Input cost(Tk.)	Net return(Tk.)	Marginal (Tk.) return
T_1	80360.0	-	80360.0	-
T_2	185033.3	10036	174997.3	-
T_3	162366.7	12388	149978.7	-25018.6
T_4	210833.3	17623	193210.3	18213.0
T_5	187066.7	20496	166570.7	-8426.6
T_6	140366.7	8496	131870.7	-43126.6

Urea=16/-Tk.kg^{-1}, MOP=22/-Tk. kg^{-1}, Gypsum=25/- Tk.kg^{-1}, Phospho-vermicompost=6/-Tk.kg^{-1}

Rice=20 Tk. kg^{-1} and Rice straw=10 Tk. kg^{-1}.

Effects of various fertilizer doses on mustard under zero tillage system after harvesting of T.aman rice

In Bangladesh, after harvesting of T. aman rice, farmer's used to keep fallow land in short period of time before the cultivation of Boro rice. But now a days, many short durable mustard varieties (Like Binasharisha-9, Binasharisha-10 etc) are available which could be cultivated between T. aman and Boro rice/Aus rice which may increase the production of oil seeds as well as cropping intensity. This additional oil seed can meet up the demand of edible oil in the country and can create the scope for saving the foreign currency through avoiding the import of edible oil. Generally farmer's cultivated the mustard in between of T. aman and Boro/Aus rice with conventional tillage system. Sowing time of mustard is critical and short, due to the preceding of T. aman rice in the same field. Sometimes, T. aman rice also harvested in late or sometimes heavy shower occurred in the last week of October or the first week of November in changing climatic condition which arise the causes for late sowing of mustard. In this situation, cultivation of mustard are hampered with conventional land preparation, because of conventional land preparation takes time than zero tillage systems. Information on optimum fertilizer requirement of mustard cultivation under zero/minimum tillage systems and late sowing condition is scanty. In zero/minimum tillage system, investigation is needed to find out the requirement of fertilizer for mustard cultivation in the different agro-ecological zones (AEZs) of Bangladesh. Therefore, a research has been under taken to see the effect of various fertilizer doses on mustard under zero tillage system after harvesting of T.aman rice as well as whole cropping pattern.

A field experiment conducted at the BINA substation farm, Ishwardi, Pabna during 2018-19 to 2018-20 to see the effects of various fertilizer doses on mustard under zero tillage system after harvested of T.aman rice in the Mustard-T.Aus-T.aman cropping pattern. The reported data of mustard is only for during 2019-20. Nine treatments combination were used in the experiment. The treatments were T_1: Native soil fertility only (no fertilizer), T_2: 50% recommended N, T_3: 100% recommended N, T_4: 100% recommended NPKS, T_5:125% recommended N, T_6:125% recommended NPKS, T_7: 50% recommended NPKS, T_8: 50% recommended PKS+100%N, T_9: 50% recommended PKS+125%N. The experiment was carried out in a RCB design with three replications. Initial nutrient status and interpretation of soil test value have been given in the Table 1. At sowing time soil moisture was 45%. So the condition of germination for seed of mustard was well in zero tillage condition. Seeds of mustard (Binashrisha-9) were sown in zero tillage system on 30 Nov. 2019. The fertilizers were applied on the basis of AEZ (FRG, BARC-2018) and rates of fertilizer have been given in the Table 2. TSP, MoP, gypsum, zinc and boron were applied before the sowing of seeds. Urea was top dressed in two equal splits i.e. 14 days after sowing (DAS) and 40 DAS. Weeding, irrigation and other intercultural operation were done as and when necessary. The mustard crop was harvested on the 3rd week of Feb. 2020. Yield and yield contributing characters were recorded.

Table 1.Physico-chemical properties of initial soil

Soil analysis interpretation	Texture	pH	O.C (%)	Total N (%)	P ($\mu g g^{-1}$)	K (meq%)	S ($\mu g g^{-1}$)
	Silt loam	7.1	0.87	0.11	17.0	0.13	14.0
		Alkaline	Low	Low	medium	Low	Low

Table 2. Rates of fertilizer applied in the experiment

Level of rates	Rates of fertilizer (kg ha^{-1})						Comments
	N	**P**	**K**	**S**	**Zn**	**B**	Zinc and Boron applied as basal in all the plots
100%	90	27	32	15	1.0	1.0	
50%	45	13.5	16	7.5	-	-	
125%	113	34	40	19	-	-	

Seed and straw yields of mustard (Binashrisha-9) were significantly influenced with the different treatments (Table 3). Maximum seed yield (1183.3 kg ha^{-1}) was obtained in the treatment T_4 (100% recommended NPKS) followed by the treatment T_6 -125% recommended NPKS (1116.7 kg ha^{-1}). But the treatments T_4, T_6 and T_9 gave the statistically identical results in respect of seed yield of mustard. The result indicated that application of all kinds of fertilizer together with increasing rates have tremendous influence on seed yield of mustard in zero tillage system. The lowest seed yield was recorded in the treatment T_1 where no fertilizer was applied (Table 3). Similar trends were observed in case of straw yields. Yield contributing characters of mustard were also significantly influenced with the fertilizer application. The treatments T_4 and T_6 gave almost similar results regarding yield contributing characters of mustard but both the treatments gave the highest plant height, number of pods $plant^{-1}$ and number of seeds pod^{-1} among all the treatments (Table 3). The results revealed that 100% recommended NPKS or 125% NPKS enhanced more crop growth which influenced the seed yield of mustard in late sowing condition under zero tillage systems.

Table 3. Effect of various fertilizer doses on yields and yield cntributing characters of mustard under zero tillage during 2019-20 after harvested of T. aman rice

Treatments	**Seed yield (kgha^{-1})**	**Straw yield (kgha^{-1})**	**Plant height (cm)**	**No. of pod $plant^{-1}$**	**No. of seed pod^{-1}**
T_1: Native soil fertility only	150.0d	733.3d	49.3e	11.7e	9.3e
T_2: 50% recommended N	183.3d	1566.7cd	67.0d	19.0e	17.7d
T_3: 100% recommended N	450.0c	2123.3bc	71.3cd	29.7cd	21.0bcd
T_4: 100% recommended NPKS	1183.3a	3750.0a	97.3ab	88.0a	25.7a
T_5:125% recommended N	640.0c	1733.3cd	66.0d	23.0cde	20.7cd
T_6:125% recommended NPKS	1116.7a	3900.0a	105.3a	97.0a	25.0a
T_7: 50% recommended NPKS	616.7c	2576.7abc	84.3bc	35.3c	23.7abc
T_8: 50% recommended PKS+100%N	900.0b	3293.3ab	97.0ab	60.0b	24.0abc
T_9: 50% recommended PKS+125%N	1016.7ab	3866.7a	95.7ab	86.7a	24.7ab
CV(%)	**16.19**	**17.5**	**10.95**	**15.82**	**10.1**

Delineation of nutrients status in the Tista Meander Floodplain soils

Soil fertility in Bangladesh has declined over time. As a result, deficiency of nutrient has arisen which is likely to produce negative impact on crop yield. Soil test is an indicator of fertility status of an area. With this perspective, a soil survey was done to determinate macronutrients status across the Tista Meander Floodplains (AEZ 3). Fifty soil samples at 0-15 cm depth were collected from 50 sites across the AEZ 3.

Every soil sample was spread on a brown paper in the laboratory for air-drying and some unwanted materials viz. stones, pebbles, gravels, plant roots etc. were removed prior to air-drying. The air-dry soil was ground by mortar & pestle and sieved through a 2-mm (10-mesh) sieve. The samples were kept into plastic bottles for physical and chemical analysis. All analysis was done following standard methods.

A summary statistics of soil data with the information of maximum, minimum, mean and standard deviation for different nutrients plus pH & organic matter and macronutrient (N, P, K, S, Ca & Mg) status of 50 soil samples are shown in Table.

Results and discussion

Soil pH and organic matter

The mean value of pH of studied soils was as high as 5.60 (Sample id 14) and was low as 4.39 (Sample id 46). The mean value of soil pH was 5.05 over all studied samples.

Concerning organic matter content of soil, it varied from 0.38 %(Sample id 16) to 3.51 %(Sample id 31). When these values are compared with earlier organic matter data generated by SRDI, it appears that organic matter content of soil has considerably increased. The increased organic matter content indicates a good soil management with addition of organic matter from some sources. However, the soil test value that soil organic matter has increased in AEZ 3 can not be generalized. The general consensus is that soil organic matter has declined over time particularly in high land and medium high land, with intensive cropping.

Macronutrients status

Total N content of soils varied from 0.02 (Sample id 16) to 0.18 %(Sample id 31), available P from 5.00 (Sample id 27) to 165.70 (Sample id 6) mg kg^{-1} and available S from 46.50 mg kg^{-1} (Sample id 33) to 138.20 mg kg^{-1} (Sample id 24), with the corresponding mean values of 0.11%, 30.94 mg kg^{-1} and 65.64 mg kg^{-1}. Exchangeable K content of soils ranged from 0.07 (Sample id 47) - 0.35 (Sample id 6) cmol kg^{-1}, Ca content from 1.78 (Sample id 37) - 7.78 (Sample id 1) cmol kg^{-1} and Mg content from 0.26 (Sample id 40) -1.54 (Sample id 24) cmol kg^{-1}; their average values being 0.14 cmol kg^{-1}, 3.67 cmol kg^{-1} and 0.66 cmol kg^{-1}, respectively. Concerning the soil analysis results, the N content remains almost unchanged, the available P level increased in most cases and the available S status increased. The exchangeable K status has generally declined, the Ca level has always increased and the Mg level increased in all samples except 5, 6, 7, 9, 10, 41, 43, 17, 21, 36 and 39 where it rather decreased.

Conclusion

Although not significant, soil pH has decreased based on the earlier information (SRDI, 1998). The mean value of pH of studied soils was as high as 5.50 and was low as 4.69. Looking at the data generated by SRDI (1998), the soil pH varied from 5.00 to 5.82 over the all studied series.

Concerning organic matter content of soil, it varied from 1.99% to 3.51%. When these values are compared with earlier organic matter data generated by SRDI, it appears that organic matter content of soil all over series has considerably increased. The increased organic matter content indicates a good soil management with addition of organic matter from some sources. However, the soil test value that soil organic matter has increased in AEZ 3 can not be generalized. The general consensus is that soil organic matter has declined over time particularly in high land and medium high land, with intensive cropping.

Total N content of soils varied from 0.02-0.18%, available P from 5.00-165.70 mg kg^{-1} and available S from 46.50-138.20 mg kg^{-1}, with the corresponding mean values of 0.11%, 30.94 mg kg^{-1} and 65.64 mg kg^{-1}. Exchangeable K content of soils ranged from 0.07-0.35 cmol kg^{-1}, Ca content from 1.78-7.78 cmol kg^{-1} and Mg content from 0.26-1.54 cmol kg^{-1}; their average values being 0.14 cmol kg^{-1}, 3.67 cmol kg^{-1} and 0.66 cmol kg^{-1}, respectively. Concerning the soil analysis results, the N content remains almost unchanged, the available P level increased in most cases and the available S status increased. The exchangeable K status has generally declined, the Ca level has always increased and the Mg level increased in all samples except 5, 6, 7, 9, 10, 41, 43, 17, 21, 36 and 39 where it rather decreased.

Table: Top soil characteristics of Tista Meander Floodplain

Sample ID	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S
			(cmol kg^{-1})				mg kg^{-1}	
1	5.10	2.41	7.78	1.36	0.11	0.12	5.30	56.30
2	5.55	3.06	6.13	1.09	0.09	0.15	5.16	56.30
3	5.46	2.51	5.64	0.85	0.13	0.13	9.72	73.00
4	5.08	2.41	3.66	0.75	0.10	0.12	6.45	55.50
8	5.26	2.58	3.89	0.61	0.13	0.13	7.10	62.40
11	5.07	2.51	4.90	0.91	0.17	0.13	34.63	66.10
12	4.85	2.37	3.31	0.48	0.10	0.12	32.27	61.60
14	5.60	1.96	3.75	0.49	0.10	0.10	10.97	82.60
19	5.43	2.99	7.37	1.22	0.12	0.15	11.49	81.50
20	5.08	2.10	3.27	0.62	0.17	0.11	14.60	58.60
22	4.99	1.72	3.84	0.53	0.19	0.09	15.53	63.70
29	5.41	2.72	4.62	1.06	0.15	0.14	11.43	59.40
32	5.36	2.24	2.48	0.37	0.14	0.11	22.51	53.30
33	5.15	2.85	3.13	0.42	0.11	0.14	13.16	46.50
35	5.20	2.37	1.96	0.30	0.15	0.12	69.65	50.60
44	4.46	2.27	2.61	0.31	0.11	0.11	75.12	64.00
45	5.01	1.82	3.16	0.58	0.09	0.09	22.45	69.90
46	4.39	1.93	3.00	0.37	0.09	0.10	37.46	46.60
48	4.97	2.13	3.41	0.60	0.18	0.11	44.51	47.30
49	4.90	1.89	3.30	0.37	0.09	0.10	28.93	71.70
50	4.99	2.24	2.90	0.46	0.08	0.11	15.37	49.10
5	4.80	1.10	1.92	0.36	0.13	0.06	145.30	51.10
6	5.40	1.38	3.91	1.19	0.35	0.07	165.70	60.30
7	4.45	1.96	2.04	0.45	0.20	0.10	15.89	48.90
9	4.80	2.03	3.07	0.57	0.12	0.10	8.05	52.30
10	5.00	2.61	3.75	0.74	0.12	0.13	12.36	51.00
41	4.83	1.51	3.33	0.46	0.15	0.08	26.99	68.70

43	4.94	1.72	3.64	0.51	0.12	0.09	53.18	71.40
17	5.11	1.00	2.89	0.44	0.16	0.05	68.18	56.90
21	4.90	1.79	3.10	0.50	0.16	0.09	9.11	60.00
36	4.73	1.62	1.98	0.31	0.12	0.08	55.73	69.10
13	5.10	1.75	3.14	0.52	0.12	0.09	15.29	73.00
15	5.32	3.20	4.57	0.70	0.15	0.16	10.75	60.80
16	4.98	0.38	3.77	0.61	0.13	0.02	11.07	54.20
18	5.29	2.41	4.38	0.74	0.16	0.12	8.18	62.70
23	5.24	2.51	4.15	1.17	0.17	0.13	20.64	93.10
24	5.50	2.65	5.78	1.54	0.14	0.13	6.07	138.20
25	5.41	2.27	3.87	0.92	0.15	0.11	7.20	84.00
30	5.33	2.89	3.18	0.59	0.16	0.15	12.81	65.60
31	5.21	3.51	4.16	0.76	0.15	0.18	11.16	54.90
34	5.35	2.34	3.39	0.53	0.15	0.12	30.34	64.00
42	4.84	2.68	3.93	0.50	0.12	0.13	6.95	67.60
47	4.70	2.54	3.20	0.33	0.07	0.13	32.32	48.50
27	5.15	1.96	3.09	0.68	0.10	0.10	5.00	80.40
28	5.23	2.41	4.08	1.33	0.15	0.12	7.42	97.80
37	4.78	1.58	1.78	0.28	0.21	0.08	85.18	60.80
38	4.73	1.13	2.47	0.40	0.16	0.06	33.95	64.00
40	4.55	0.79	2.39	0.26	0.14	0.04	46.21	52.60
26	4.85	3.03	3.52	0.88	0.14	0.15	6.86	79.70
39	4.85	1.99	2.59	0.38	0.12	0.10	26.43	60.90
Maximum	5.60	3.51	7.78	1.54	0.35	0.18	165.70	138.20
Minimum	4.39	0.38	1.78	0.26	0.07	0.02	5.00	46.50
Mean (n=50)	5.05	2.15	3.67	0.66	0.14	0.11	30.94	65.64
sd	0.29	0.63	1.25	0.32	0.04	0.03	32.96	15.93

Effects of rhizobia inoculation nitrogen and molybdenum on growth, nodulation and yield of soybean and lentil

Field experiments of soybean and lentil were conducted in 2019-2020 to see the effect of rhizobia inoculant strains, nitrogen and molybdenum on growth, nodulation and yield at BINA Head Quarter's farm. There were six treatments viz. uninoculated (control), inoculant strain-1, inoculant strains-2, mixed inoculatnt, nitrogen @ 45 kgha^{-1} for soybean and 30 kgha^{-1} for lentil were applied and molytenum @ 2.0 kgha^{-1}. Design was followed completely randomized block (RCB) with three replications. Data on growth and nodulation were recovered at 50% flowering stage. Yield and attributes were recorded after ripening. Results summarized (Table 1-4) showed that inoculation of rhizobia strains recorded higher plant height, root length, nodule number, nodule dry weight, grain weight per plant, number of pod plant, grain yield and strain yield of both soybean and lentil.

In soybean experiment (Table 1-2) plant height ranged from 40.87 to 43.42 cm and nodule number ranged from 3.01 to 20.07 per plant. The treatment with molybdenum recorded the highest nodule number among the treatments. Nodule dry weight recorded also highest in molybdenum treated inoculated plots (125 mg/plant). Pod number per plant showed highest with molybdenum treatment. Grain yield of soybean showed the highest in mixed inoculation with molybdenum applied plots (1589 kgha^{-1}). Mixed inoculation showed higher grain yield over single inoculation. Stover yield also showed highest with mixed inoculation and molybdenum application @ 2.0 kg per hectare. The 100 seed weight recorded significantly higher in inoculation over uninoculated treatment.

In case of lentil the highest nodulation was observed with mixed inoculation and molybdenum application. (Table 3). Nodule dry weight was found highest with mixed inoculation and molybdenum treatment. Grain and Stover yield showed highest in inoculation with mixed strain and molybdenum application (Table 4).

Table 1. Effect of Rhizobia inoculation, nitrogen and molybdenum on growth and nodulation of soybean

Treatment	Plant height (cm)	Root length (cm)	Nodule plant^{-1} (no.)	Nodule dry weight (mg plant^{-1})
Uninoculated	31.75 b	9.43	3.01 b	7.11 c
R-strain-1	40.87 a	12.58 a	16.78 a	106.0 ab
R-strain-2	41.33 a	12.90 a	15.82 a	100.0 ab
R-strain-m	42. 92 a	13.27 a	17.88 a	109 ab
N30	42.48 a	12.85 a	3.06 b	8.18 c
R-strain-m-Mo_2	43.24 a	13.20 a	20.07 a	125 a
Sig. level	**	**	**	**
CV(%)	3.82	4.82	12.70	9.37

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

Table 2. Effect of Rhizobia inoculation and Molybdenum on yield and yield attributes of soybean

Treatment	Pod plant^{-1} (no.)	Seed wt. plant^{-1} (g)	100 seed wt. (g)	Grain Yield (kgha^{-1})	Stover yield (kgha^{-1})
Uninoculated	20.64 c	5.83 b	10.01 b	1052 b	1409 b
R-strain-1	28.11 ab	7.99 a	10.89 a	1497 a	2024 a
R-strain-2	26.66 b	8.21 a	10.96 a	1481 a	2002 a
R-strain-m	28.63 ab	8.08 a	10.85 a	1538 a	2074 a
N30	29.34 ab	8.62 a	10.92 a	1517 a	2053 a
R-strain-m-Mo_2	32.73 a	8.80 a	11.27 a	1589 a	2150 a
Sig. level	*	**	**	**	**
CV(%)	10.55	8.12	1.96	5.81	5.84

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

Table 3. Effect of Rhizobia inoculation, nitrogen and molybdenum on growth, nodulation and nodulation of lentil

Treatment	Plant height (cm)	Root length (cm)	Nodule plant^{-1} (no.)	Nodule dry weight (mgplant^{-1})
Uninoculated	26.84 b	6.50 b	1.82 d	6.95 c
R-strain-1	32.97 a	7.91 a	11.57 c	66.30 b
R-strain-2	33.63 a	7.82 a	12.37 bc	67.93 b
R-strain-m	34.10 a	8.14 a	13.30 ab	68.65 b
N30	33.97 a	8.17 a	2.43 d	7.46 c
R-strain-m-Mo_2	34.68 a	8.30 a	14.83 a	77.61 a
Sig. level	**	*	**	**
CV(%)	3.48	7.40	6.37	6.06

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

Table 4. Effect of rhizobia inoculation, nitrogen and molybdenum on yield and yield attributes of lentil

Treatment	Podplant-1 (no.)	Seed wt.plant^{-1} (g)	Grain Yield (kgha^{-1})	Stover yield (kgha^{-1})
Uninoc	18.69 b	1.32 b	933 b	1141 b
R-stain-1	26.08 a	1.62 a	1158 a	1442 a
R-stain-2	25.88 a	1.65 a	1166 a	1451 a
R-stain-m	26.43 a	1.66 a	1174 a	1472 a
N30	26.02 a	1.67 a	1182 a	1482 a
R-stain-m-Mo_2	27.97 a	1.72 a	1233 a	1542 a
Sig. level	**	**	*	*
CV(%)	3.63	3.48	7.67	7.52

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

Biofertilizer production and distribution at BINA in 2019-2020

An amount of 1487 kg biofertilizers were produced at BINA and distributed to farmers and other users of country (Table 5). The highest amount was for soybean (636 kg) followed by mungbean and the lowest amount was for lentil production (110 kg).

Table 5. Biofertilizer production and distribution at BINA in 2019-2020

Sl. No	Crop	Production & distribution (kg)
1	Lentil	110
2	Soybean	636
3	Mungbean	604
4	Groundnut	137
	Total	**1487**

Plant Pathology Division

Research Highlights

- Twenty four mutants/lines showed moderately resistant and other seven showed moderately susceptible reaction to bacterial leaf blight in aman season. Four mutants/lines showed moderately resistant and other twenty one showed moderately susceptible reaction to sheath blight.

- Thirteen mutants/advanced lines were found to be moderately resistant and other two lines were found as moderately susceptible to bacterial blight in boro season. Among the mutants/lines, six were showed moderately resistant, nine moderately susceptible reaction to sheath blight. Three advanced lines were found as moderately resistant to leaf blast in natural conditions.

- Thirty three germplasms and mutants of wheat were assessed against blast. The lowest incidence (11.25%) and severity (5.12%) were found in the entry BWM-5 and BWM-2, respectively at Mymensingh. Disease incidence and severity were low in Meherpur.

- Twenty six selected mutants including susceptible check (BARI Gom-26) of wheat were assessed against blast and blight. The lowest incidence of blast and blight were found in the entries C-16-150 Gy at all the growing stage. The lowest severity of blast was found in entries C-16-150 Gy, C-16-300 Gy and C-33-300 Gy. Fifteen entries were found lower severity of blight.

- Twenty five treatments of different nutrients and their dilution were evaluated against blast incidence of wheat. The incidence and severity of blast at 80, 90 and 100 Days After Sowing were ranged from 6.56-62.39 %, 71.99-100%, and 100% and 36.8-72.76%, 60.7-100% and 100%, respectively. The mean incidence and severity showed lower in the treatment "Ash" compared to others.

- Five rapeseed mutants and a check variety, Binasarisha-9 were tested against alternaria blight at BINA farm, Mymensingh and BINA substation farm, Rangpur. All the mutants were found susceptible to the disease.

- Five mutants of groundnut showed moderately resistant reaction to foot and root rot and cercospora leaf spot diseases.

- 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 germination (%), moisture content (%) of jute (O-9897) and onion (BARI Piaj-1). The germination rate was better for seeds in tin containers (87% in jute seed and 85% in onion seeds) followed by plastic containers (85% in jute seed and 83% in onion seeds) compared to cloth bags (74% in jute seed and 71% in onion seeds).

- An experiment was conducted in the laboratory of Plant Pathology Division, BINA, Mymensingh to know the association of different fungi with mungbean (Binamoog 5, Binamoog 7, Binamoog 8 and Binamoog 9) and mustard (Binasarisha 4, Binasarisha 7, Binasarisha 8 and Binasarisha 9) seeds. In mungbean the seed associated fungi were *Fusarium* sp., *Cuvularia* sp. and *Aspergillus* sp. whereas in mustard seeds the associated fungi were *Fusarium* sp., *Alternaria* sp., *Cuvularia* sp. and *Aspergillus* sp. The total incidence (%) of fungi ranged from 18.4-20.0% in mungbean seeds and 19.1-20.0% in mustard seeds.

- Four advanced mutants of lentil were found susceptible to root rot while highly susceptible to moderately susceptible against stemphylium blight.

- Application of vermicompost as soil amendment + Seed treatment with BINA-LT-17$_{+}$ Soil amendment with *Trichoderma* (50g/m^2) gave the lowest root rot diseases severity in lentil over the control.

- Soil amendment with vermicompost (1.75 ton/ha), Seed treatment with BINA-CP-2 (*Rhizobium*), Seed treatment with formulated *Trichoderma* , Soil amendment with *Trichoderma* (50g/m^2) and their integration showed no effects on root rot incidence of chickpea.

- In field evaluation of soybean mutants, two mutants (SBM-02 and SBM-07) showed moderately resistant and tolerant reaction to collar rot and in case of cercospora leaf spot SBM 02, SBM 07 showed moderately resistant and rest of mutant and checks showed tolerant reaction in Mymensingh

- Tomato varieties (Binatomato-11 and Binatomato-12) which was completely covered by a net from seed sowing to transplanting and all growth stages found free from leaf curl virus.

Rice

Evaluation of mutants/advanced lines of rice for sheath blight and bacterial blight during aman season

Twelve mutants, 19 advanced lines of rice along with seven 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. Twenty eight days old seedlings were transplanted in the field on 8 August 2019. The fertilizers were applied as per recommendations. Ten hills in each plot were inoculated at the booting stage with *X. oryzae* 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 were ranged from 1.2-6.9 (Table 1). Among the mutants/lines, twenty for showed moderately resistant and seven showed moderately susceptible reaction to bacterial leaf blight. Mean severity of ShB were ranged from 1.9-8.2 (Table 1). Four mutants/lines showed moderately resistant, twenty one showed moderately susceptible and 6 showed susceptible reaction to sheath blight. Moderately resistant mutants/lines will be tested in inoculation condition in next year.

Table 1. Mean incidence and severity of bacterial leaf blight and sheath blight in some advanced mutants/lines of rice during aman season of 2019 at Mymensingh

Mutant/variety	Bacterial leaf blight			Sheath blight		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
BR11-300----1	43.3	1.5	MR	100.0	3.7	MS
BR11-300----2	50.0	1.6	MR	100.0	2.1	MR
BR11-300----3	20.0	1.3	MR	83.3	1.9	MR
BR11-300----4	100.0	2.7	MR	100.0	4.7	MS
BR11-300----5	26.7	1.2	MR	80.0	2.3	MR
RLM-19	66.7	1.8	MR	86.7	3.6	MS
RLM-20	100.0	3.1	MR	100.0	4.0	MS
RLM-49	70.0	1.7	MR	100.0	2.0	MR
RLM-81	83.3	2.4	MR	100.0	4.6	MS
N_1/300/P-5(2)	70.0	2.3	MR	100.0	4.7	MS
Magic-10	100.0	1.8	MR	100.0	5.7	S
Magic-12	93.3	1.9	MR	100.0	4.3	MS
Magic-27	100.0	2.2	MR	100.0	6.3	S
Magic-35	53.3	2.0	MR	100.0	4.7	MS
Magic-37	100.0	3.9	MS	100.0	5.2	MS
Magic-45	93.3	1.6	MR	93.3	5.2	MS
Magic-58	66.7	1.9	MR	100.0	4.5	MS
Magic-62	100.0	4.3	MS	100.0	6.3	S
MFG-69	53.3	2.1	MR	100.0	4.7	MS
MFG-72	83.3	4.1	MS	100.0	5.7	MS
MFG-75	100.0	3.0	MR	100.0	5.7	MS
MFG-76	100.0	2.4	MR	100.0	6.2	S
MFG-78	100.0	3.0	MR	100.0	5.1	MS
MFG-82	83.3	4.4	MS	100.0	4.2	MS
MFG-86	93.3	1.9	MR	100.0	4.3	MS
SH-1	100.0	4.1	MS	100.0	6.8	S
SSB-3	66.7	1.8	MR	100.0	3.7	MS
SSB-4	100.0	2.7	MR	100.0	5.1	MS
MV-10	86.6	3.8	MS	86.6	4.7	MS
MV-40	100.0	3.9	MS	100.0	5.9	S
IRBB-60	100.0	2.0	MR	100.0	4.0	MS
Binadhan-7	100.0	2.7	MR	100.0	6.1	S
Binadhan-16	93.3	2.3	MR	100.0	5.6	S
Binadhan-17	83.3	1.7	MR	100.0	3.0	MR
Binadhan-22	100.0	4.1	MS	100.0	4.9	MS
BR11	56.7	2.1	MR	100.0	2.9	MR
BRRI dhan49	33.3	1.4	MR	100.0	3.3	MR
BRRI dhan56	83.3	1.9	MR	100.0	4.1	MS
TN-1	100.0	6.9	S	100.0	8.2	HS

MR = Moterately resistant, MS= Moderately susceptible, S= Susceptible, HS= Highly susceptible

Evaluation of bacterial leaf blight nursery rice lines

Five bacterial leaf blight nursery rice lines along with 2 varieties were assessed against bacterial leaf blight during aman season of 2019 under inoculated field conditions. The experiment was conducted in a randomized complete block design with three replications at BINA farm, Mymensingh. The unit plot size was 2 m x 1 m and spacing between rows and hills were maintained 20 cm and 15 cm, respectively. Twenty five days old seedlings were transplanted on 25 August 2018. The fertilizers were applied as per recommendation.

Mean incidences and severity of BLB were ranged from 80.0-100% and 1.6-8.5, respectively (Table 2). All the advanced lines except IRBBN-9 were found to be moderately resistant to bacterial blight.

Table 2. Mean incidence and severity of bacterial leaf blight0 0o0f0 0s0o0m0e0 0a0d0v0a0n0c0e0d0 0l0i0n0e0s0 0o0f0 0r0i0c0e0 0d0u0r0i0n0g0 0a0m0a0n0 0s0e0a0s0o0n0 0o0f0 020001090 0a0t0 0M0y0m0e0n0s0i0n0g0h0

Lines/variety	Incidence (%)	Severity (0-9)	Disease reaction
IRBBN-6	80.0	2.6	MR
IRBBN-9	100.0	4.2	MS
IRBBN-17	86.7	3.2	MR
IRBBN-18	93.3	2.1	MR
IRBBN-31	100.0	2.7	MR
Binadhan-7	100.0	3.8	MS
Binadhan-17	66.7	1.6	MR
TN-1	100.0	8.5	HS

MR= Moderately resistant, MS= Moderately susceptible, HS= Highly susceptible

Evaluation of some promising mutants and advanced lines of rice for bacterial blight and sheath blight during boro season

Two promising mutants and 13 advanced lines along with 5 varieties and 1 susceptible variety were assessed against bacterial leaf blight and sheath blight during boro season of 2019-20 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 on 2 February 2020. 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 36.7-100% and 1.7-4.7, respectively (Table 3). All the mutants and advanced lines except SL-10 and SL-44 were found to be moderately resistant to bacterial blight. Mean severity of ShB were ranged from 2.5-7.1 (Table 3). Among the mutants/lines, six were showed moderately resistant and nine were moderately susceptible to sheath blight. Moderately resistant mutants/lines will be tested in inoculation condition in next year. Among the evaluated materials only three lines showed moderately resistant and other two lines and Binadhan-18 showed moderately susceptible reaction to sheath blight disease in natural conditions.

Table 3. Mean incidence and severity of bacterial blight and sheath blight of some mutants/ lines of rice during boro season of 2019-20 at Mymensingh

Mutant/lines/variety	Bacterial leaf blight			Sheath blight		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
RM-16(N)-8	86.7	2.6	MR	100.0	4.0	MS
RM-16(N)-10	36.7	1.7	MR	83.3	2.8	MR
Magic-10	43.3	1.7	MR	66.7	2.7	MR
Magic-12	60.0	2.1	MR	73.3	3.9	MS
Magic-19	50.0	2.1	MR	66.7	3.8	MS
Magic-23	93.3	2.2	MR	70.0	3.5	MS
Magic-27	43.3	1.8	MR	63.3	3.3	MR
Magic-45	46.7	1.7	MR	83.3	3.8	MS
Magic-52	63.3	2.0	MR	100.0	5.0	MS
Magic-76	100.0	1.9	MR	90.0	3.1	MR
SL-10	100.0	3.6	MS	83.3	4.3	MS
SL-44	100.0	4.9	MS	83.3	3.0	MR
SL-56	93.3	3.0	MR	73.3	4.9	MS
SL-58	76.7	2.3	MR	66.7	2.8	MR
SH-1	83.3	2.4	MR	100.0	5.2	MS
Binadhan-10	76.7	2.7	MR	60.0	2.5	MR
Binadhan-18	76.7	3.9	MS	83.3	3.6	MS
Binadhan-24	40.0	2.0	MR	90.0	4.6	MS
BRRI dhan28	80.0	2.5	MR	83.3	3.1	MR
BRRI dhan29	36.7	2.6	MR	60.0	4.0	MS
TN-1	100.0	4.7	MS	100.0	7.1	HS

MR= Moderately resistant, MS= Moderately susceptible, S= Susceptible

Table 4. Mean incidence and severity of leaf blast of some advanced lines of rice during boro season of 2019-20 at Mymensingh

Lines/variety	Leaf blast		
	Incidence (%)	Severity (0-9)	Disease reaction
Magic-12	2.3	3.2	MR
Magic-27	2.3	2.1	MR
Magic-45	46.7	5.2	MS
Magic-76	50.0	4.8	MS
SL-44	2.7	1.7	MR
Binadhan-18	21.7	4.6	MS
TN-1	86.7	6.9	S

MR= Moderately resistant, MS= Moderately susceptible, S= Susceptible

Wheat

Evaluation of wheat mutants and germplasms against blast at Meherpur and Mymensingh during 2019-2020

Thirty three germplasms and mutants of wheat including susceptible check varieties were assessed against blast in winter season of 2019-20 under inoculated field condition at Mymensingh. To maintain temperature and moisture, the whole experimental field was covered by polythene sheet. The experiment was conducted in a randomized block design (RCBD) with three replications. Line to line distance was 20 cm and block to block 1m. The fertilizers were applied as recommended dose. Inoculum was sprayed at booting stage with conidia suspension of *Magnaporthe oryzae* Triticum inocula were 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.

Mean incidence and severity of blast at BINA farm were ranged from 11.25 -100% and 5.0-100%, respectively. The lowest incidence (11.25%) and severity (5.12%) were found in the entry BWM-5 and BWM-2, respectively (Table 5).

At Meherpur, mean incidence and severity of blast were ranged from 1.05-58.81% and 1.1-71.7%, respectively. Disease incidence and severity both were low in Meherpur under natural condition, (Table 6).

Table 5: Incidence and severity of blast in some entries of wheat inoculated with spores of *Magnaporthe oryzae* Triticum at pre-heading stage in BINA farm, Mymensingh

Entries	Disease Incidence (%)	Disease Severity (%)
BARRI Gom 26	100	100
BWM 1	35.65	13.04
BWM 2	14.77	5.12
BWM 3	27.54	18.12
BWM 4	78.41	96.11
BWM 5	11.25	21.12
BWM 6	13.15	15.12
BWM 7	32.717	17.14
BWM 8	89.32	89.33
BWM 9	68.42	18.10
BWM 10	81.65	75.76
BWM 11	95.14	84.32
BWM 12	65.14	54.46
BWM 13	67.73	79.76
BWM 14	89.41	27.24
BWM 15	67.35	25.48
BWM 16	78.24	40.21
BWM 17	57.21	24.12
BWM 18	87.45	54.78
BWM 19	58.75	22.64
BWM 20	47.32	19.24
BWM 21	27.32	18.44
BWM 22	47.33	14.22

BWM 23	54.25	37.25
BWM-250-21	99.4	88.0
BWM-200-25	97.6	86.5
BWM-200-29	100	100
BWM-200-30	100	100
BWM 40	100	97.45
BWM 41	100	98.54
BWM 42	100	98.45
BWM 43	100	91.47
BWM 44	100	97.45
LSD (0.05)	**15.5**	**7.4**

Table 6: Incidence and severity of blast in some entries of wheat inoculated with spores of *Magnaporthe oryzae* Triticum at pre-heading stage in Meherpur

Entries	Disease Incidence (%)	Disease Severity (%)
BARRI Gom 26	21.24	47.88
BWM 1	7.14	2.10
BWM 2	4.01	1.40
BWM 3	1.05	4.20
BWM 4	6.74	3.10
BWM 5	2.07	1.40
BWM 6	3.04	4.10
BWM 7	2.10	9.20
BWM 8	21.21	4.13
BWM 9	7.54	7.70
BWM 10	24.54	5.40
BWM 11	38.70	4.17
BWM 12	2.42	1.10
BWM 13	8.25	2.60
BWM 14	17.51	8.83
BWM 15	24.15	5.40
BWM 16	2.54	3.10
BWM 17	7.54	8.60
BWM 18	11.17	6.10
BWM 19	22.42	5.40
BWM 20	15.71	11.10
BWM 21	7.45	15.90
BWM 22	5.18	1.40
BWM 23	7.48	2150
BWM-150-21	57.15	2.17
BWM-150-25	27.15	6.13
BWM-250-29	16.12	1.17
BWM-150-30	27.17	1.43
BWM 40	24.51	0.17
BWM 41	44.42	54.63
BWM 42	58.81	71.70
BWM 43	42.85	4.87
BWM 44	28.51	7.93
LSD (0.05)	**7.4**	**12.8**

Evaluation of some selected wheat mutants (M_3) and germplasms against blast and blight

Twenty six selected mutants including susceptible check (BARI Gom-26) of wheat were assessed against blast and blight in winter season of 2019-20 under inoculated field condition. To maintain 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. Line to line distance was 20 cm and block to block 1 m. The fertilizers were applied as per recommendation. Inocula 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 and blight were ranged from 5-80% and 5-75%, respectively. The lowest incidence of blast and blight were found in the entities C-16-150 Gy at all the growing stages.

Mean severity of blast and blight were ranged from10-80 and 10-35, respectively. The lowest severity of blast was found in entries C-16-150 Gy, C-16-300 Gy and C-33-300 Gy at all the growth stages. Fifteen entries were found lower severity of blight (Table 7).

Table 7. Incidence and severity of blast and blight of wheat mutants at BINA farm, Mymensingh

Treatments	Blast		Blight	
	Diseases Incidence (%)	Diseases Severity (%)	Diseases Incidence (%)	Diseases Severity (%)
BARI Gom-26	60	40	60	20
C-2-150Gy	70	30	50	25
C-2-200Gy	50	50	40	15
C-2-250Gy	40	30	30	10
C-2-300Gy	40	30	35	15
CYMMIT-2	60	25	60	30
C-8-150Gy	55	25	45	15
C-8-200Gy	55	40	45	20
C-8-250Gy	80	70	60	35
C-8-300Gy	70	80	75	25
CYMMIT-8	60	70	55	25
C-14-150Gy	25	20	30	10
C-14-200Gy	35	40	25	10
C-14-250Gy	40	50	45	10
C-14-300Gy	40	30	30	10
CYMMIT-14	45	40	30	10
C-16-150Gy	5	10	5	10
C-16-200Gy	15	50	20	10
C-16-250Gy	20	30	20	20
C-16-300Gy	10	10	10	10
CYMMIT-16	30	20	25	10
BG-33-150Gy	50	40	30	10

BG-33-200Gy	50	40	30	10
BG-33-250Gy	30	40	20	10
BG-33-300Gy	10	10	10	10
BARI Gom-33	15	20	15	10
LSD (0.05)	15	11	7	5

Evaluation of some nutrients on development of wheat blast

An experiment was conducted to evaluate the effect of some nutrients against blast incidence of wheat following CRD with three replications. Nutrients were applied in pot soil individually by hand. Data on disease incidence and severity were taken after 80, 90 and 100 days after seed sowing (DAS).

The incidence and severity of blast at 80, 90 and 100 DAS were ranged from 6.56-62.39 %, 71.99-100%, and 100% and 36.8-72.76%, 60.7-100% and 100%, respectively. The mean incidence and severity showed lower in the treatment Ash compared to others (Table 9 &10).

Table 8. Name of the treatment and their application rate

Treatment	Name	Application rate (g/pot)	Treatment	Name	Application rate (g/pot)
Phosphorus	P_0	0.0	Silicon	Si_0	0.0
	P_1	1.6		Si_1	0.8
	P_2	2.4		Si_2	2.0
	P_3	4.0		Si_3	4.0
	P_4	5.6		Si_4	8.0
Potassium	K_0	0.0	Ash_0	Ash_0	0.0
	K_1	1.28		Ash_1	24
	K_2	1.92		Ash_2	48
	K_3	2.56		Ash_3	72
	K_4	3.2		Ash_4	96
Magnesium	Mg_0	0.0			
	Mg_1	1.28			
	Mg_2	2.56			
	Mg_3	3.84			
	Mg_4	5.12			

Table 9. Nutrient effect on wheat blast incidence

Treatment	Disease Incidence (80 DAS)	Mean Incidence	Disease Incidence (90 DAS)	Mean Incidence	Disease Incidence (100 DAS)	Mean Incidence
Control	32.55		72.94		100	
P_0	11.85		93.65		100	
P_1	20.67	18.69	98.99	95.28	100	
P_2	25.53		97.40		100	100
P_3	25.86		94.04		100	
P_4	9.54		92.30		100	
K_0	26.37		95.94		100	
K_1	18.84	19.17	96.81	97.11	100	
K_2	17.65		96.38		100	100
K_3	11.22		98.53		100	
K_4	21.75		97.91		100	
Mg_0	62.39		98.18		100	
Mg_1	60.82		100.00	98.77	100	
Mg_2	25.82	41.85	100.00		100	100
Mg_3	33.58		100.00		100	
Mg_4	26.66		95.68		100	
Si_0	6.56		89.97		100	
Si_1	19.24	21.14	96.51	95.34	100	
Si_2	21.98		95.31		100	100
Si_3	30.36		99.35		100	
Si_4	27.54		95.55		100	
Ash_0	18.03		85.82		100	
Ash_1	8.70		80.13		100	
Ash_2	11.26	13.03	82.23	79.62	100	100
Ash_3	13.31		71.99		100	
Ash_4	13.86		77.92		100	
LSD (0.05)	18.71		15.72		-	

DAS Days After Sowing

Table 10. Nutrient effect on wheat blast severity

Treatment	Disease Incidence (80 DAS)	Mean Incidence	Disease Incidence (90 DAS)	Mean Incidence	Disease Incidence (100 DAS)	Mean Incidence
P_0	44.52		79.64		100	
P_1	38.01	42.75	89.18	83.20	100	
P_2	46.68		87.45		100	100
P_3	47.77		85.84		100	
P_4	36.80		73.88		100	
K_0	56.38		100.00		100	
K_1	47.78		100.00	100.00	100	100
K_2	48.00	49.74	100.00		100	
K_3	51.06		100.00		100	
K_4	45.49		100.00		100	
Mg_0	51.82	54.91	85.15	83.45	100	100

Mg_1	58.50		85.48		100	
Mg_2	48.25		79.47		100	
Mg_3	54.91		84.09		100	
Mg_4	61.05		78.07		100	
Si_0	47.06		100.00		100	
Si_1	58.55		100.00		100	
Si_2	64.62	57.76	95.45	99.09	100	100
Si_3	72.76		100.00		100	
Si_4	45.80		100.00		100	
Ash_0	44.52		79.64		100	
Ash_1	38.01		80.18		100	
Ash_2	40.68	41.55	87.45	81.40	100	100
Ash_3	47.77		85.84		100	
Ash_4	36.80		73.88		100	

DAS Days After Sowing

Mustard/rapeseed

Field evaluation of rapeseed mutants/lines against Alternaria blight

Five rapeseed mutants and a check variety Binasarisha-9 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 2019-20. 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 11. Response of mutants/lines/varieties of rapeseed to alternaria blight at Mymensingh during winter season of 2019-20

Mutants/variety	Leaf area diseased (%)	Disease severity (0-5)	Disease reaction
RM -005	36.8	4	S
RM -07	34.2	4	S
RM-10	36.2	4	S
RM-18	36.0	4	S
RM-20	37.4	4	S
Binasarisha-9	39.3	4	S

S= Susceptible

Table 12. Response of mutants/lines/varieties of rapeseed to Alternaria blight at Rangpur during winter season of 2019-20

Mutants/variety	Leaf area diseased (%)	Disease severity (0-5)	Disease reaction
RM -005	33.0	4	S
RM -07	32.3	4	S
RM-10	35.8	4	S
RM-18	36.5	4	S
RM-20	34.0	4	S
Binasarisha-9	38.1	4	S

S= Susceptible

The disease incidence of Alternaria blight ranged from 34.2-39.3% and 32.3-38.1% at Mymensingh and Rangpur, respectively. All the mutants of rapeseed and the check variety Binasarisha-9 were found susceptible to alternaria blight (Table 11 and 12). At both location.

Groundnut

Field evaluation of advanced mutants of groundnut against foot and root rot and cercospora leaf spot

Five mutants along with one variety (Binachinabadam-4) of groundnut were evaluated for their resistance to foot and root rot (*Sclerotium rolfsii*) and cercospora leaf spot (*Cercospora achidicola*) diseases under field condition at Mymensingh in 2020. The experiments 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 15 cm, respectively. Seeds were sown on 2 January 2020. The disease severity was assessed following the scale 0-5 for cercospora leaf spot.

Mean root rot incidences ranged from 1.45 to 8.53 (Table 13). All the mutants along with the check variety were moderately resistant to the disease. Mean cercospora leaf spot incidence and severity ranged from 86.7 to 100% and 2.2 to 2.9. All the mutants and varieties 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 2020

Mutants/varieties	Root rot		Cercospora leaf spot		
	Incidence (%)	Disease reaction	Incidence (%)	Severity (1-9)	Disease reaction
RG-kha-19/1	5.26	MR	90.0	2.3	MR
B_6/282/62	2.53	MR	100	2.9	MR
B_6/282/63	8.53	MR	96.7	2.5	MR
B_6/282/64	4.79	MR	86.7	2.2	MR
B_6/282/80	1.45	MR	86.7	2.3	MR
Binachinabadam-4	3.12	MR	100	2.8	MR

MR= Moderately resistant

Jute and onion

Effect of different storage containers on seed quality 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 germination (%), moisture content (%) 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 germination (%), moisture content (%) at every 15 days during the experimental period.

Moisture content was determined by using high constant temperature oven method following International Rules for Seed Testing and the moisture content of seeds was measured by the following formula (ISTA, 1999).

Moisture content (%) = $[(M_2-M_3) \times 100] / (M_2-M_1)$

M_1= weight of container + cover
M_2= weight of container + cover + seeds before drying
M_3= weight of container + cover + seeds after drying
Germination test was done in Petridis with moistened blotter paper taking 400 seeds from each storage container with four replications. Germination percentage was calculated using the formula: Germination (%) = (Number of seed germinated x100)/ Number of seeds tested

Table 14. Moisture content (%) of jute seeds stored in different containers during the storage period

Containers	Moisture content (%)					
	Before storage	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
Tin container	12.3	12.5	13.0	13.4	13.7	14.2
Plastic container	12.3	12.7	13.1	13.5	13.9	14.2
Polythene bag	12.3	12.9	13.3	13.9	14.3	14.6
Cloth bag	12.3	13.6	15.7	16.4	16.9	18.0
LSD ($P \geq 0.05$)	--	NS	0.53	0.67	0.69	0.52

DAS= Days after storage

Table 15. Moisture content (%) of onion seeds stored in different containers during the storage period

Containers	**Moisture content (%)**					
	Before storage	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**
Tin container	10.1	10.3	10.6	10.9	11.1	11.7
Plastic container	10.1	10.2	10.5	10.9	11.0	11.6
Polythene bag	10.1	10.3	10.6	10.8	11.3	11.8
Cloth bag	10.1	10.6	11.9	12.6	14.7	15.9
LSD ($P \geq 0.05$)	--	NS	0.33	0.24	0.46	0.32

DAS= Days after storage

Table 16. Germination (%) of jute seeds stored in different containers during the storage period

Containers	**Germination (%)**					
	Before storage	**15 DAS**	**30 DAS**	**45 DAS**	**605 DAS**	**75 DAS**
Tin container	91	90	89	88	88	87
Plastic container	91	88	86	86	85	84
Polythene bag	91	86	85	82	81	81
Cloth bag	91	82	80	77	75	74
LSD ($P \geq 0.05$)	--	2.13	2.50	2.08	3.10	2.92

DAS= Days after storage

Table 17. Germination (%) of onion seeds stored in different containers during the storage period

Containers	Germination (%)					
	Before storage	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**
Tin container	88	87	87	86	86	85
Plastic container	88	85	85	84	84	83
Polythene bag	88	85	83	83	80	80
Cloth bag	88	78	76	74	73	71
LSD ($P \geq 0.05$)	--	2.00	1.98	1.82	1.05	1.80

DAS= Days after storage

The moisture of jute and onion seeds increased with increasing of storage time (Table 14 and 15). After 75 days, the amount of moisture content was higher in cloth bag (18.0% in jute seeds and 15.9% in onion seeds) and was lower in tin container (14.2% in jute seeds and 11.6% in onion seeds) and plastic container (14.2% in jute seeds and 11.9% in onion seeds) followed by polythene bag (14.6% in jute seeds and 11.8% in onion seeds). The initial rate of germination was similar for all containers and it decreased with increase of storage period (Table 16 and 17). After 75 days, the germination rate was better for seeds in tin containers (87% in jute seed and 85% in onion seeds) followed by plastic containers (84% in jute seed and 83% in onion seeds) compared to cloth bags (74% in jute seed and 71% in onion seeds).

Management of damping off disease of onion seedlings

An Experiment was conducted to control damping off disease (*Rhizoctonia* sp., *Fusarium* sp., *Sclerotium rolfsii*) of onion seedlings at BINA farm, Mymensingh during kharif season of 2019-20. The treatments were: T_1 = Seed treated with Vitavax, T_2 = Soil treated with biofungicide T_3 = Soil treated with Dithane M-45, T_4 = Soil solarization and T_5 = Control. The biofungicide was Trichoderma based which was prepared at the laboratory of Plant Pathology Division of BINA. The biofungicide was applied in the soil two days before sowing seeds. For soil solarization the plot soil was covered with black polythene for 7 days. The Experiment was done in randomized complete block design with three replications. The unit plot size was 2m × 1.5m. The line to line spacing was 30 cm. The recommended doses of fertilizer was: Urea: 260, TSP: 200, MP: 150, Gypsum: 110 kg/ha, cowdung 10 ton/ha. Intercultural operation and irrigation were applied when necessary. Data was taken on germination (%) and disease severity following 0-5 scale (Khangura et. al. 1999). The germination (%) rate at different treatments varied from 69-80% (Table 18). The seedlings in all treatments were highly susceptible to damping off disease. The result of the experiment indicates that no treatment was effective to control damping off of onion seedlings. However, the experiment will be repeated in the next season.

Table 18. Effect of different treatments on damping off disease of onion seedlings

Treatments	Germination (%)	Disease reaction (0-5)
T_1 = Seed treatment with Vitavax	78	S
T_2 = Soil treatment with biofungicide	76	S
T_3 = Soil treatment with Dithane M-45	75	S
T_4 = Soil solarization	80	S
T_5 = Control	69	S

Mungbean and mustard

Assessment of seed-borne mycoflora in different varieties of mungbean and mustard

An experiment was conducted in the laboratory of Plant Pathology Division, BINA, Mymensingh to know the association of different fungi with mungbean and mustard seeds. Four varieties of mungbean (Binamoog 5, Binamoog 7, Binamoog 8 and Binamoog 9) and four varieties of mustard (Binasarisha 4, Binasarisha 7, Binasarisha 8 and Binasarisha 9) were taken for the investigation. To detect seed borne fungi associated with seeds in samples, four hundred seeds of each sample were assayed following standard blotter method (ISTA, 1996). In this method three layers of moistened filter paper (Whatman No. 1) were placed in Petri dishes. The seeds in Petri dishes (placed on three layers of moistened filter paper, Whatman No. 1) were incubated at 22 ± 2^0C for seven days. The seeds were examined under microscope at 25x magnification to observe the presence of seed borne fungi and the associated fungi were identified by observing the growth characters on the incubated seeds on blotting paper.

Table 19. Incidence of seed-borne fungi (%) in different varieties of mungbean

Varieties	Incidence of fungi (%)			Total incidence (%)
	***Fusarium* sp.**	***Cuvularia* sp.**	***Aspergillus* sp.**	
Binamoog 5	5.7	4.2	10.1	20.0
Binamoog 7	6.3	4.4	9.4	20.1
Binamoog 8	5.5	4.0	8.9	18.4
Binamoog 9	5.0	5.1	9.5	19.6
LSD ($P\geq0.05$)	0.47	0.50	0.45	0.71

Table 20. Incidence of seed-borne fungi (%) in different varieties of mustard

Varieties	Incidence of fungi (%)				Total incidence (%)
	***Fusarium* sp.**	***Alternaria* sp.**	***Cuvularia* sp.**	***Aspergillus* sp.**	
Binasarisha 4	3.6	5.2	2.9	8.1	19.1
Binasarisha 7	4.2	4.5	3.6	7.5	19.8
Binasarisha 8	4.0	4.8	3.3	7.9	20.0
Binasarisha 9	4.2	5.4	3.1	7.2	19.9
LSD ($P\geq0.05$)	0.52	0.44	0.40	0.56	0.61

In mungbean seeds the associated fungi were *Fusarium* sp., *Cuvularia* sp. and *Aspergillus* sp. whereas in mustard seeds the associated fungi were *Fusarium* sp., *Alternaria* sp., *Cuvularia* sp. and *Aspergillus* sp. (Table 19 and 20). The total incidence (%) of fungi ranged from 18.4-

20.0% in mungbean seeds and 19.1-20.0% in mustard seeds. The incidence of *Aspergillus* sp. was higher than other fungi in both mungbean and mustard seeds.

Lentil

Evaluation of lentil mutants against root rot and stemphylium blight

Four advanced mutants along with two check varieties of lentil were evaluated against root rot (*Sclerotium rolfsii*) and Stemphylium blight (*Stemphylium sarciniformis*) at Magura and Ishurdi during the winter season of 2019-20. The experiments were conducted in randomized complete block design with three replications. The seeds were sown in rows on 2nd week of December 2019 in both locations. Distance between rows and seeds were 30 cm and 5 cm, respectively.

The mean incidence of root rot and stemphylium blight ranged from 86.33 to 99.10% and 61.67 to 93.33% in Ishuardi respectively. In Ishwardi all the mutants were susceptible to root rot. The mean severity of stemphylium blight ranged from 4-5 and all the mutants were found highly susceptible to susceptible to stemphylium blight (Table 21).

Table 21. Disease reaction of root rot and stemphylium blight on lentil mutants at Ishwardi

Mutants/ varieties	Root rot		Stemphylium blight		
	Disease Incidence (%)	Disease reaction	Disease Incidence (%)	Disease severity (0-5)	Disease reaction
LM-118-9	93.17	S	80.00	5	HS
LM- 138-3	91.43		81.67	5	HS
LM-206-5	86.33		61.67	5	HS
LM-185-2	96.33		71.67	5	HS
Utfala	99.10		93.33	5	HS
Binamasur-8	93.82		65.00	4	S

S = Susceptible, HS = Highly Susceptible

But in Magura the mean incidence of root rot was found 100%. All the mutants were susceptible to root rot. In case of stemphylium blight the mean severity ranged from 3-4 and all the mutants were found moderately susceptible to susceptible (Table 22).

Table 22. Disease reaction of root rot and stemphylium blight on lentil mutants at Magura

Mutants/ varieties	Root rot		Stemphylium blight		
	Disease Incidence (%)	Disease reaction	Disease Incidence (%)	Disease severity (0-5)	Disease reaction
LM-118-9	100	S	82.00	4	S
LM- 138-3	100		87.67	4	S
LM-206-5	100		55.67	4	S
LM-185-2	100		70.67	3	MS
Utfala	100		95.33	4	S
Binamasur-8	100		60.00	3	MS

MS = Moderately Susceptible, S = Susceptible

Comparison of vermicompost, biofertilizer, biopesticides and their integration against root rot of Lentil

An experiment was conducted to evaluate the effectiveness of vermicompost, biofertilizer, biopesticides and their integration against root rot of Lentil at Ishurdi during the winter season of 2019-20. The experiments were conducted in randomized complete block design with three replications. The susceptible lentil variety was used Binamasur-6. The seeds were sown in rows on 2nd week of November 2019. Size of the plots was 2.0 m × 1.5 m and plant spacing was 30 cm with continuous sowing. The fertilizers were applied as per recommendations and normal cultural practices were followed. Eight treatments were T_1= Soil amendment with vermicompost (1.75 ton/ha), T_2= Seed treatment with BINA-LT-17 (*Rhizobium*), T_3= Seed treatment with formulated *Trichoderma* ,T_4= Soil amendment with *Trichoderma* (50g/m^2), T_5= Soil amendment with vermicompost (1.75 ton/ha) + Seed treatment with BINA-LT-17 (*Rhizobium*), T_6= Soil amendment with vermicompost (1.75 ton/ha) + Seed treatment with formulated *Trichoderma*, T_7= Soil amendment with vermicompost (1.75 ton/ha) + Seed treatment with BINA-LT-17 (*Rhizobium*) + Soil amendment with *Trichoderma* (50g/m^2) and T_8= Control (no treatment). During the growing period the plots were inspected regularly to record the incidence of root rot disease from seedling to maturity stage of the crop.

Root rot incidence was significantly influenced by the treatments (Table 23). The lowest root rot (76.43%) was obtained from Soil amendment with vermicompost + Seed treatment with BINA-LT-17 + Soil amendment with *Trichoderma* (50g/m^2) which was followed by Soil amendment with vermicompost and Seed treatment with BINA-LT-17 (*Rhizobium*) by 80.02% and the highest incidence (98.15%) was obtained from untreated control.

Number of pod/plant, plant height and yield of lentil under different treatments varied significantly from one to another. The highest number of pod/plant (214.55) was recorded in Seed treatment with BINA-LT-17 (*Rhizobium*) and the lowest (176.22) of this parameters were obtained from untreated control. The highest plant height (42.89 cm) and yield/ plot (435.00 g /m^2) were recorded in Soil amendment with vermicompost + Seed treatment with BINA-LT-17 (*Rhizobium*) and the lowest of these parameters were obtained from untreated control.

Table 23: Effect of vermicompost, biofertilizer, biopesticides and their integration on root rot and yield contributing characters of lentil

Treatments	Root rot (%)	Plant height (cm)	No. of Pods / Plant	Yield /plot (g/m^2)
Soil amendment with vermicompost	85.03	40.33	194.22	329.65
Seed treatment with BINA-LT-17	93.33	39.78	214.55	372.47
Seed treatment with *Trichoderma*	87.52	40.00	188.56	361.54
Soil amendment with *Trichoderma*	88.03	38.57	179.66	316.55
Soil amendment with vermicompost + Seed treatment with BINA-LT-17	80.02	42.89	178.67	435.00
Soil amendment with vermicompost + Seed treatment with *Trichoderma*	97.92	41.56	187.67	396.00
Soil amendment with vermicompost + Seed treatment with BINA-LT-17 + Soil amendment with *Trichoderma* (50g/m^2)	76.43	40.00	200.89	378.43
Control (no treatment)	98.15	37.34	176.22	316.54

Chickpea

Comparison of vermicompost, biofertilizer, biopesticides and their integration against root rot of chickpea

An experiment was conducted to evaluate the effectiveness of vermicompost, biofertilizer, biopesticides and their integration against root rot of chickpea at Magura during the winter season of 2019-20. The experiments were conducted in randomized complete block design with three replications. The susceptible chickpea variety was used Binachola-3. The seeds were sown in rows on 2nd week of December 2019. Size of the plots was 2.0 m × 1.5 m and plant to plant distance was 10 cm. Row to row distance was 40cm. The fertilizers were applied as per recommendations and normal cultural practices were followed.

The treatments were T_1= Soil amendment with vermicompost (1.75 ton/ha), T_2= Seed treatment with BINA-CP-2 (*Rhizobium*), T_3= Seed treatment with formulated *Trichoderma* , T_4= Soil amendment with *Trichoderma* (50g/m^2), T_5= Soil amendment with vermicompost (1.75 ton/ha) + Seed treatment with BINA-CP-2 (*Rhizobium*), T_6= Soil amendment with vermicompost (1.75 ton/ha) + Seed treatment with formulated *Trichoderma*, T_7= Soil amendment with vermicompost (1.75 ton/ha) + Seed treatment with BINA-CP-2 (*Rhizobium*) + Soil amendment with *Trichoderma* (50g/m^2) and T_8= Control (no treatment). During the growing period the plots were inspected regularly to record the incidence of root rot disease from seedling to maturity stage of the crop. Dead plants were removed from the field after counting. Treatments showed no effects on root rot incidence (Table 24).

Number of pod/plant, plant height and yield of chickpea under different treatments varied significantly from one to another (Table 24). The highest number of pod/plant (80.00) was recorded in Soil amendment with vermicompost + Seed treatment with BINA-CP-2 + Soil amendment with *Trichoderma* (50g/m^2) and the lowest of this parameters was obtained from untreated control (51.27). The highest plant height (42.07cm) and yield/ plot (280.95g /m^2) were recorded in Soil amendment with *Trichoderma* and the lowest of these parameters were obtained from untreated control.

Table 24: Effect of vermicompost, biofertilizer, biopesticides and their integration on root rot and yield contributing characters of chickpea

Treatments	**Root rot (%)**	**Plant height (cm)**	**No. of Pods / Plant**	**Yield /plot (g/m^2)**
Soil amendment with vermicompost	100	38.73	73.6	188.41
Seed treatment with BINA-CP-2 (*Rhizobium*)	100	38.13	59.73	157.10
Seed treatment with formulated *Trichoderma*	100	38.80	64.96	158.10
Soil amendment with *Trichoderma*	100	42.07	77.27	280.95
Soil amendment with vermicompost + Seed treatment with BINA-CP-2 (*Rhizobium*)	100	38.87	65.40	194.01
Soil amendment with vermicompost + Seed treatment with formulated *Trichoderma*	100	39.87	72.73	227.76
Soil amendment with vermicompost + Seed treatment with BINA-CP-2 + Soil amendment with *Trichoderma* ($50g/m^2$)	100	39.40	80.00	221.08
Control (no treatment)	100	37.4	51.27	107.21

Soybean

Evaluation of soybean mutants against collar rot and cercospora leaf spot disease

Three mutants (SBM 02, SBM 05 and SBM 07) along with two check varieties Binasoybean-4 and Binasoybean-6 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 was 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. Seeds were sown on 02 January 2019 at BINA farm, Mymensingh, maintaining row to row distance 75 cm and plot to plot distance 30 cm. The fertilizer was applied at 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 at pod ripening stage following (0-9) scale.

The incidence of collar rot ranged from 6.66-26.66% and cercospora leaf spot 10-14% at BINA farm, Mymensingh (Table 25). The mutants SBM 02, SBM 07 were showed moderately resistant and tolerant reaction and SBM-05 showed moderately susceptible to collar rot disease. In case of cercospora leaf spot SBM 02, SBM 07 showed moderately resistant and rest of mutant and checks showed tolerant reaction.

Table 25. Disease reaction of three mutants and varieties of soybean against collar rot and Cercospora leaf spot at Mymensingh 2020

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	6.66	2	MR	10	1	MR
SBM-05	26.66	6	MS	14	3	T
SBM-07	16.66	4	T	11	1	MR
Binasoybean-4	13.33	4	T	10	3	T
Binasoybean-6	10	3	MR	12.33	3	T

MR= Moderately Resistant, MS= Moderately Susceptible, T= Tolerant

Tomato

Study on seed borne status of leaf curl virus of tomato

An investigation was carried out at BINA farm, Mymensingh during rabi season of 2019-20 to check the seed borne status of leaf curl virus of tomato. Two varieties (Binatomato-11 and Binatomato-12), two tomato mutants (TM-4 and TM-8) and one line (Cherolla) were used in this experiment. Tomato seedlings were raised in seedbed which was completely covered by a net from seed sowing to transplanting to prevent infestation by insect vector. The experiments were conducted in a randomized complete block design with three replications. The unit plot size was 3m × 2m. Thirty days old seedlings were transplanted in the field where three replicates of Binatomato-11 and Binatomato-12 were covered by net during transplanting and another three replicates remained uncovered from transplanting. The fertilizers were applied as per recommendations and normal cultural practices were followed. TYLCV symptoms were diagnosed according to the description of "Leaf curl and yellowing viruses of pepper and tomato: an overview" by Green and Kalloo (1994). When the seedling was established, the soil around the base of each seedling was pulverized. Staking was done to each growing plant by bamboo stick to keep them erect. Weeding, pruning and watering were done in the plots as and when necessary. No insecticide was applied to any of these plots under this experiment to give maximum opportunity for the increase of the whitefly population and also the disease incidence.

The experimental plots were inspected to look for the appearance of leaf curl disease symptom at 15 days interval. Data on TYLCV incidence (%) was recorded at 15 days interval commencing from 30 days after planting (DAP) up to 75 DAP. TYLCV incidence (%) and gradation were done where HR (Highly Resistant) = no leaf curl symptom, R (Resistant) = 1-25% plants infected, MR (Moderately Resistant) = 26-50% plants infected, MS (Moderately Susceptible) = 51-75% plants infected, S (Susceptible) = 76-100% plants infected (Begum and Khan, 1996).

The percentage of TYLCV incidence is presented in Table 26. The mean incidence ranged from 0.00 to 8.33. There was no disease incidence found inside the net. Seeds were collected from virus infected plants for sowing in next year.

Table 26. Mean incidence and severity of tomato yellow leaf curl virus at Mymensingh 2020

Mutants/lines/ varieties	Tomato yellow leaf curl		
	Disease incidence (%)	Disease severity (%)	Disease reaction
Binatomato-11(inside net)	0	0	HR
Binatomato-12(inside net)	0	0	HR
Binatomato-11(without net)	8.33	40	R
Binatomato-12(without net)	3.03	20	R
TM-4	5.67	80	R
TM-8	8.33	48.33	R
Cherolla	9.6	32.92	R

HR = Highly Resistant, R= Resistant

Entomology Division

Research Highlights

- The management approaches with pheromone traps (YSB lure) was effective against stem borer of rice.
- IPM components with cartap insecticide (Santap 50 SP) was effective against leaf roller of rice.
- The management approaches with pheromone trap (Helico lure) and spraying of HNPV was effective against pod borer of chickpea.
- IPM components with light trap + hand picking of 1st instar larvae was effective against hairy caterpillar of Mungbean.
- The management approaches with virtako 40WG was effective against leaf roller of Soybean.
- IPM components with Biotrine (Bio-insecticide) was effective against jassid of Okra.
- The management approaches with pheromone trap (Fall armyworm lure) and spraying of FNPV was effective against fall armyworm of miaze.
- The management approaches with Biotrine (Bio-insecticide) was effective against thrips of garlic.
- IPM components with K-mites (Bio-insecticide) was effective against red mites of chilli.
- Two advanced lines of rice were found moderately resistant (MR) and rest three were moderately susceptible (MS) to brown plant hopper (BPH).

Effectiveness of different management approaches against stem borer of rice

The experiment was conducted in a randomized complete black design with three replications during boro season of 2019-20 at BINA Farm, Mymensingh. There were four treatments. The treatment were: T_1 = Pheromone trap (YSB-lure), T_2 = Collection of egg mass + Virtako 40WG, T_3 = Pheromone trap + Cartap insecticide, T_4 = Granular insecticide (Diazon 10G) and T_5 = Control. The tested variety was Binadhan-17. Data were recorded during maximum tillering and heading stage and presented in the Table 1.

Different management approaches with Pheromone trap + Cartap insecticide was the most effective against stem borer of rice. The lowest white head infestation was found in the management approaches (0.9%) and the highest was found in the control (2.5%).

Table 1: Effect of different treatments on rice yellow stem bore infestation

Treatments	White heat (%)
T_1: Pheromone trap (YSB-lure)	1.25
T_2: Collection of egg mass + Virtako 40WG	1.51
T_3: Pheromone trap + Cartap insecticide	0.9
T_4: Granular insecticide (Diazon 10G)	1.22
T_5: Control	2.5

Effectiveness of different management approaches against leaf roller (*cnaphalocrosismedinalis*) of rice

The experiment was conducted in a randomized complete black design with three replications during aman season of 2019-20 at BINA Farm, Mymensingh. There were five treatments. The treatment were: T_1 = Use light trap + Use perching, T_2 = Collection of rolled leaves + Virtako 40 WG, T_3 = Cartap insecticide (Santap 50SP), T_4 = Granular insecticides (Marshal 6G) and T_5 = Control. The tested variety was Binadhan-20. Data were recorded during maximum tillering and heading stage and presented in the Table 2.

Different management approaches with Cartap insecticide (Santap 50SP) was the most effective against leaf roller of rice. The lowest leaf roller infestation was found in the management approaches (0.15%) and the highest was found in the control (5.53%).

Table 2: Effect of different treatments against rice leaf roller infestation

Treatments	Rolled leaves (%)
T_1:Use light trap + Use perching	3.05
T_2: Collection of rolled leaves + Virtako 40 WG	1.01
T_3:Cartap insecticide (Santap 50SP)	0.15
T_4: Granular insecticides (Marshal 6G)	1.45
T_5:Control	5.53

Effectiveness of different management approaches against pod borer of chickpea

The experiment was conducted in a randomized complete black design with three replications during rabi season of 2019-20 at Magura. There were four treatments. The treatment were: T_1 = Pheromone trap (Helico lure), T_2 = Pheromone trap (Helico lure) + Spraying of HNPV, T_3 = Vitako 40WG and T_4 = Control. The variety was Binasola-8. Data were recorded during fruiting stage and presented in the Table 3.

Different management approaches with Pheromone trap (Helico lure) + Spraying of HNPV was the most effective against pod borer of chickpea. The lowest pod borer infestation was found in the management approaches (1.11%) and the highest was found in the control (4.19%).

Table 3: Effect of different treatments against pod borer of chickpea

Treatments	% Pod borer
T_1: Pheromone trap (Helico lure)	2.24
T_2: Pheromone trap (Helico lure) + Spraying of HNPV	1.11
T_3:Vitako 40WG	1.42
T_4: Control	4.19

Development of management approaches against hairy caterpillar of summer mungbean

The experiment was conducted in a randomized complete black design with three replications during kharif season of 2019-20 at BINA Farm, Mymensingh. There were four treatments. The treatment were: T_1 = Use light trap + Hand picking of 1st instar larvae, T_2 = Lamdacyhalothrin, T_3 = Vitako 40WG and T_3 = Control. The variety was Binamoog-7. Data were recorded during fruiting stage and presented in the Table 4.

Different management approaches with Use light trap + Hand picking of 1st instar larvae was the most effective against hairy caterpillar of mungbean. The lowest hairy caterpillar infestation was found in the management approaches (1.12%) and the highest was found in the control (5.58%).

Table 4: Effect of different treatments on hairy caterpillar of summer mungbean

Treatments	% Infested leaves
T_1: Use light trap + Hand picking of 1st instar larvae	1.12
T_2:Lamdacyhalothrin	1.35
T_3:Control	5.58

Comparative evaluation of different IPM treatments against leaf roller of soybean

The experiment was conducted in a randomized complete black design with three replications during kharif season of 2019-20 at BINA Farm, Mymensingh. There were four treatments. The treatment were: T_1 = Hand picking of rolled leaves, T_2 = Virtako 40WG, T_3 = Altima plus and T_4 = Control. The variety was Binasoybean-5. Data were recorded during maximum vegetative stage and presented in the Table 5.

Different management approaches with virtako 40WG was the most effective against leaf roller of soybean. The lowest leaf roller infestation was found in the management approaches (1.54%) and the highest was found in the control (6.43%).

Table 5: Effect of different treatments on leaf roller of soybean

Treatments	Rolled leaves (%)
T_1: Hand picking of rolled leaves	2.47
T_2:Virtako 40WG	1.54
T_3:Altima plus	1.61
T_4: Control	6.43

Development of integrated management approaches for the control of jassid of okra

The experiment was conducted in a randomized complete black design with three replications during kharif season of 2019-20 at BINA Farm, Mymensingh. There were four treatments. The treatment were: T_1 = Spray with soap water + Neem seed extract, T_2 = Tobacco solution + Chilli solution, T_3 = Biotrin (Bio insecticide) and T_4 =Control. Data were recorded during maximum vegetative stage and presented in the Table 6.

Different management approaches with Biotrin (Bio insecticide) was the most effective against jassid of okra. The lowest jassid infestation was found in the management approaches (1.56%) and the highest was found in the control (5.11%).

Table 6: Effect of different on jassid of okra

Treatments	% infested leaves
T_1:Spray with soap water + Neem seed extract	2.51
T_2: Tobacco solution + Chilli solution	3.72
T_3:Biotrin (Bio insecticide)	1.56
T_4: Control	5.11

Development of integrated management approaches for the control of thrips of garlic

The experiment was conducted in a randomized complete black design with three replications during rabi season of 2019-20 at BINA Farm, Mymensingh. There were four treatments. The treatment were: T_1 = White sticky trap + yellow sticky trap, T_2 = Tobacco solution, T_3 = Biotrin (Bio insecticide) and T_4 =Control. The variety was Binarasun-1. Data were recorded during maximum vegetative stage and presented in the Table 7.
Different management approaches with Biotrin (Bio insecticide) was the most effective against thrips of garlic. The lowest thrips infestation was found in the management approaches (1.24%) and the highest was found in the control (4.52%).

Table 7: Effect of different treatments on garlic thrips

Treatments	% Infestation
T_1:White sticky trap + yellow sticky trap	3.22
T_2: Tobacco solution	3.51
T_3:Biotrin (Bio insecticide)	1.24
T_4: Control	4.52

Development of management approaches against red mites of chilli

The experiment was conducted in a randomized complete black design with three replications during rabi season of 2019-20 at BINA Farm, Mymensingh. There were four treatments. The treatment were: T_1 = Ecomce 1.8 EC, T_2 = Acamites 1.8 EC, T_3 = K-mites (Bio-insecticide) and T_4 =Control. The variety was Binarasun-1. Data were recorded during maximum vegetative stage and presented in the Table 8.

Different management approaches with K-mites (Bio-insecticide) was the most effective against red mites of chilli. The lowest mites infestation was found in the management approaches (1.42%) and the highest was found in the control (7.51%).

Table 8: Effect of different treatments on chilli mites

Treatments	% Infestation
T_1 :Ecomce 1.8 EC	4.60
T_2 :Acamites 1.8 EC	1.51
T_3 :K-mites (Bio-insecticide)	1.42
T_4 :Control	7.51

Development of management approaches against fall armyworm (*Spodopterafrugiperda*) of maize

The experiment was conducted in a randomized complete black design with three replications during kharif season of 2019-20 at BINA Farm, Mymensingh. There were four treatments. The treatment were: T_1 = Pheromone trap (Fall armyworm lure), T_2 = Spraying of FNPV + Pheromone trap, T_3 =Virtako 40WGand T_4 =Control. Data were recorded during maximum vegetative stage and presented in the Table 9.

Different management approaches with Pheromone trap (Fall armyworm lure) + Spraying of FNPV trap was the most effective against fall armyworm of maize. The lowest fall armyworm infestation was found in the management approaches (1.52%) and the highest was found in the control (8.73%).

Table 9: Effect of different treatments on fail armyworm of mize

Treatments	% Infestation
T_1:Pheromone trap (Fall armyworm lure)	3.44
T_2: Spraying of FNPV + Pheromone trap	1.52
T_3:Virtako 40WG	6.56
T_4: Control	8.73

Screening of cold tolerant and other advanced rice lines against brown plant hopper under artificial infested condition

Five advanced mutants of rice, Jumlimashi, BPH-P-033, BPH-P-034, BPH-P-026and BPH-P-019were evaluated along with one resistant check T27A and a susceptible check TN1 against brown plant hopper under artificial infested condition. The experiment was conducted in a completely randomized design with three replications. Data were recorded during seedling stage, and presented in the Table 10.

Two advanced lines of rice were found moderately resistant (MR) and remaining three were moderately susceptible (MS) to brown plant hopper under artificial infested condition.

Table 10: Mean infestation of cold tolerant and other advanced rice lines against brown plant hopper

Mutants/lines	Damage scale (0-9)	Level of resistance
Jumlimashi	1	MR
BPH-P-033	3	MS
BPH-P-034	3	MS
BPH-P-026	1	MS
BPH-P-019	3	MR
TN1 (Susceptible check)	7	S
T27A (Resistant check)	1	R

MR = Moderately Resistant, S = Susceptible, R = Resistant, MS = Moderately Susceptible

Agronomy Division

Research Highlights

- During Aman season, out of two varieties (Binadhan-17 and Binadhan-22), Binadhan-22 produced the maximum seed yield (5.34 t ha^{-1}) and among three different dates of transplanting, July 15 produced the highest seed yield (5.82 t ha^{-1}) whereas Aug 15 was lowest (5.49 t ha^{-1}) in Mymensingh.

- In Aman season, the effect of combined application of different levels of silicon and plant growth retardants showed that the cultivar Chinishail produced the maximum seed yield (3.49 t ha^{-1}) at silicon @10 kg ha^{-1} and plant growth retardants, Sodium prohexadion calcium (80% 600 ppm).

- The mutant rice line, RM-40(c) -4-2-8 produced the highest grain yield (5.82 t ha^{-1}) when transplanted on January 15 and February 15 transplanting produced the lowest grain yield (5.49 t ha^{-1}) during boro season.

- In Boro season, among different tillage operations, plough land at 20 cm depth with 60 cm disc by 5 times and application of FYM (5 t ha^{-1}) produced the maximum grain yield (6.84 t ha^{-1}) in saline prone area at Jadobpur, Shyamnagar, Satkhira.

- Among different established methods of transplanting, the application of Penoxulum (herbicide) in transplanting method produced the maximum seed yield (5.53 t ha^{-1}) during aus season in Mymensingh location.

- Weed management among eighteen selected commercial grade herbicides, the Bensulfuron methyl + Bispyriback sodium (T_{14}) showed the highest seed yield (7.21 t ha^{-1}) followed by Pyrazosulfuran ethyl + Pretilachlor (T_{16}) (7.16 t ha^{-1}) treated plot during boro season.

- Study on determination of optimum seed rate for better growth and yield of lentil lines/variety showed that the mutant line, LM-118 produced the highest yield (2.18 t ha^{-1}) at Ishurdi followed by LM-99 (2.10 t ha^{-1}) at Chapainawabgonj at 30 kg ha^{-1} seed rate .

- The optimum spacing 25cm row spacing for better growth and yield of mungbean lines/variety, showed that mutant MBM-656-51-2 produced maximum seed yield (1456.2 kg ha^{-1}) followed by MBM-427-87-3 (1421.3 kg ha^{-1}).

- Among different row spacing, 50cm yielded the maximum seed by Binasola-8 (1234 kg ha^{-1}) followed by the mutant line, CPM-8-200 (1184 kg ha^{-1}) at Ishurdi location.

- The mustard mutant line, RM-005 produced the maximum seed yield (2.21 t ha^{-1}) at 25 cm row spacing at Rangpur location. The interaction effect of mutant/variety, line spacing and location showed that the released variety, Binasarisha-9 produced the highest seed yield (2.28 t ha^{-1}) at 35 cm row spacing at Rangpur location.

- The wheat mutant, M-W-M-1 showed the highest grain yield 3.89 t ha^{-1} at Bina Substation Chapainawabganj.

- Study on determination of growth and yield of groundnut mutant/variety showed that Binachinabadam-4 produced highest seed yield (2.41 t ha^{-1}) followed by mutant BM-11-1 (2.29 t ha^{-1}).

- Study on determination of late sowing potentialities (December 13) of mustard varieties in respect of yield at Mymensingh location showed that Binasharisha-9 produced highest seed yield (1.31 t ha^{-1}) followed by BARI Sharisha-14 (1.27 t ha^{-1}).

Effect of different dates of transplanting on yield and yield contributing characters of rice mutant/variety in T. Aman season

The experiment was conducted at BINA HQ farm Mymensingh during aman season 2019-20. Two released varieties (Binadhan-17 and Binadhan-22) were evaluated with three dates of transplanting (July 15, July 30, August 15) during Aman season at Mymensingh. The objective was to evaluate the yield performances of released varieties as affected by different dates of transplanting. The 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 15 produced the highest grain yield (5.82 t ha^{-1}) whereas Aug 15 transplanting produced the lowest grain yields (5.49 t ha^{-1}) (Table 1). Between two varieties, Binadhan-22 produced the highest grain yield (5.24 t ha^{-1}). The interaction effect of date and variety showed that Binadhan-22 produced the maximum grain yield (5.34 t ha^{-1}) when transplanted at July 30. The data recorded on crop duration from transplanting to maturity revealed that Binadhan-17 required the least average 116 days and the Binadhan-22 required maximum average 122 days (Table 1).

Table 1. Effect of different dates of transplanting on yield and yield contributing characters of 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})	Crop duration (days)
Dates of transplanting:										
July 15 (D_1)	107.4	10.2	9.4	26.2	106.1	26.7	21.2	5.82	6.77	
July 30 (D_2)	107.8	10.0	8.9	25.3	111.4	25.8	21.2	5.72	6.76	
Aug. 15 (D_3)	106.6	10.3	9.2	25.3	96.7	27.7	20.5	5.49	6.65	
$LSD_{0.05}$	2.5	1.1	1.2	0.9	8.1	3.6	0.7	0.17	0.15	
Varieties:										
Binadhan-17 (V_1)	102.4	10.4	9.5	23.3	100.2	23.1	22.19	5.07	6.70	116
Binadhan-22 (V_2)	91.1	10.1	9.4	25.3	104.7	21.8	23.46	5.24	6.54	122
T value	*	*	NS	NS	*	*	NS	NS	NS	
Dates × Variety:										
D_1V_1	104.7	11.6	10.5	23.3	99.2	22.9	22.03	4.85	6.55	
D_1V_2	92.9	10.1	9.3	25.5	104.0	21.3	23.13	5.16	6.66	
D_2V_1	102.2	9.5	8.3	23.1	105.3	20.5	22.63	5.05	6.75	
D_2V_2	88.2	10.2	9.6	24.9	103.3	20.4	23.43	5.22	6.87	
D_2V_1	100.1	10.3	9.6	23.6	96.3	26.0	21.89	5.32	6.79	
D_2V_2	92.1	10.0	9.1	25.5	106.7	23.6	23.80	5.34	6.09	
$LSD_{0.05}$	2.7	2.5	3.1	0.7	9.1	1.6	0.51	0.49	0.41	
CV%	1.4	10.3	8.5	1.7	4.5	3.7	1.78	5.75	3.10	

Effect of silicon and plant growth retardant on lodging resistance, growth and yield of selected local T. Aman aromatic rice cultivars

The experiment was conducted at BINA HQs farm Mymensingh during Aman season 2019. Two local cultivars Tulsimala and Chinishail were evaluated with four 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. Between two varieties Chinishail produced the maximum yield 3.20 t ha^{-1}. The effect of combined application of silicon 10 kg ha^{-1}, plant growth retardants 800 ppm gives the maximum yield 3.26 t ha^{-1}. The interaction effect of cultivar with silicon and plant growth retardants the cultivar Chinishail produced the maximum yield (3.49 t ha^{-1}) silicon 10 kg ha^{-1}, plant growth retardants 800 ppm (Table 2).

Table 2. 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)	135.4	15.2	12.8	23.2	118.8	20.7	10.6	2.73	6.37
Chinishail(V_2)	116.4	16.7	14.4	23.5	124.5	17.7	12.3	3.20	6.31
T value	*	*	*	1.8	17.0	*	1.4	0.4	0.9
Silicon and plant growth retardant levels :									
Control (S_0P_O)	126.7	16.5	13.9	22.7	112.6	20.3	11.3	2.68	6.51
2.5 kg ha^{-1},200 ppm (S_1P_1)	124.8	16.4	14.1	23.5	135.9	16.7	11.4	2.81	6.34
5 kg ha^{-1},400 ppm (S_2P_2)	125.5	14.6	12.4	23.5	126.0	19.6	11.6	2.96	6.35
7.5 kg ha^{-1},600 ppm (S_3P_3)	125.3	16.4	13.9	23.1	115.8	18.9	11.4	3.12	6.20
10 kg ha^{-1},800 ppm (S_4P_4)	127.2	15.9	13.8	23.7	117.8	20.6	11.5	3.26	6.32
$LSD_{.05}$	5.8	2.2	2.3	1.5	10.0	3.2	0.2	0.07	0.13
Variety × Silicon and plant growth retardant levels :									
$V_1S_0P_O$	136.3	16.3	13.4	22.0	103.1	19.3	10.4	2.52	6.60
$V_1S_1P_1$	134.0	16.0	13.3	23.2	136.8	18.0	10.5	2.54	6.40
$V_1S_2P_2$	135.0	14.1	12.1	23.5	122.9	23.2	10.8	2.68	6.33

$V_1S_3P_3$	133.7	14.7	12.2	23.5	124.8	18.5	10.8	2.89	6.20
$V_1S_4P_4$	138.0	15.0	13.1	23.5	106.4	24.7	10.6	3.03	6.35
$V_2S_0P_O$	117.0	16.7	14.4	23.5	122.1	21.3	12.1	2.84	6.43
$V_2S_1P_1$	115.7	16.9	14.9	23.8	135.1	15.4	12.3	3.07	6.27
$V_2S_2P_2$	116.0	15.1	12.7	23.5	129.2	15.9	12.5	3.23	6.37
$V_2S_3P_3$	117.0	18.1	15.5	22.7	106.9	19.2	12.1	3.35	6.20
$V_2S_4P_4$	116.3	16.7	14.5	23.9	129.2	16.5	12.4	3.49	6.30
$LSD_{.05}$	8.2	3.2	3.2	2.2	14.1	4.6	0.4	0.10	0.18
CV(%)	4.3	11.5	13.7	5.4	6.7	13.8	2.7	7.76	2.82

Effect of date of transplanting on the yield and yield contributing characters of rice mutant line RM-40(c)-4-2-8 in Boro season

The experiment was conducted at BINA HQs farm during Boro season 2018-19. The mutant line, RM-40(c)-4-2-8 was evaluated compared with one check variety Binadhan-10 with four dates of transplanting. The objective was to evaluate the yield performances of mutant line at optimum dates of transplanting. Three different dates of transplanting were January 15, February 1 and February 15 in Mymensingh. Thirty five day old seedlings were transplanted in a 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 are discussed below.

The effect of dates of transplanting on grain yield showed that of Jan. 15 transplanting produced the highest grain yield (5.82 t ha^{-1}) whereas Feb. 15 transplanting produced the lowest grain yield (5.49 t ha^{-1}). Among two varieties/mutant, Binadhan-10 produced the highest grain yield (5.67 t ha^{-1}). The interaction effect of date and variety showed that Binadhan-10 produced the maximum yield (6.39 t ha^{-1}) at January 15 transplanting followed by Feb. 1 (6.29 t ha^{-1}) (Table 3).

Table 3. Date of transplanting on the yield and yield contributing characters of Boro rice mutant/varieties at BINA HQs farm Mymensingh during 2019-20

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})	Crop duration (days)
Dates of transplanting :										
January 15 (D_1)	107.4	10.2	9.4	26.2	106.1	26.7	21.2	5.82	6.77	
February 01 (D_2)	107.8	10.0	8.9	25.3	111.4	25.8	21.2	5.72	6.76	
February 15 (D_3)	106.6	10.3	9.2	25.3	96.7	27.7	20.5	5.49	6.65	
$LSD_{0.05}$	2.5	1.1	1.2	0.9	8.1	3.6	0.7	0.17	0.15	
Mutant/Varieties :										

RM-40(c) - 4-2-8 (V_1)	99.9	10.6	9.7	24.3	81.3	21.9	23.0	5.12	6.18	142
Binadhan-10 (V_2)	114.7	9.7	8.6	27.0	128.2	31.6	19.0	6.23	7.28	145
T value	1.8	1.2	NS	0.4	8.0	NS	0.2	0.23	0.38	
Dates × Varieties :										
D_1V_1	100.5	10.8	10.0	25.4	81.1	19.5	23.1	5.25	6.30	
D_1V_2	114.4	9.5	8.7	27.0	131.2	33.9	19.2	6.39	7.25	
D_2V_1	100.3	10.1	8.8	23.6	91.2	20.6	23.5	5.15	6.13	
D_2V_2	115.3	9.9	8.9	27.0	131.7	30.9	19.0	6.29	7.39	
D_3V_1	98.9	11.0	10.3	23.8	71.7	25.6	22.3	4.98	6.11	
D_3V_2	114.3	9.5	8.1	26.9	121.6	29.9	18.7	6.00	7.20	
$LSD_{0.05}$	2.6	2.0	1.9	1.0	12.4	3.0	0.8	0.16	0.49	
CV(%)	2.9	7.0	8.1	2.2	5.9	8.5	2.2	1.91	3.62	

Improving the yield of Boro rice through tillage and farmyard manure under saline condition at Farmer's field of Jadobpur, Shyamnagar, Satkhira

The experiment was conducted at farmer's field of Jadabpur, Shyamnagar, Satkhira during boro season, 2019-20. 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 during boro season. 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 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 150 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 operation, 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 (6.65 t ha^{-1}). Application of FYM at 5 t ha^{-1} had significant effect on most of the plant parameters and produced the highest grain yield (6.21 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 (6.84 t ha^{-1}) (Table 4).

Table 4. Tillage and farmyard manure application on yield and yield contributing characters of boro rice under salinity condition at Farmer's field of Jadobpur, Shyamnagar, Satkhira

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})

					(no.)				
Tillage:									
Control (T_0)	98.1	11.4	8.4	23.7	105.3	10.8	23.68	5.26	6.37
Plough 3 times (T_1)	99.4	12.0	9.6	24.4	110.7	8.6	23.94	5.77	6.70
Plough 4 times (T_2)	99.3	12.8	10.1	24.9	115.5	7.6	23.64	6.19	7.13
Plough 5 times (T_3)	97.2	12.8	10.3	24.7	114.1	8.1	23.64	6.65	7.48
$LSD_{.05}$	2.5	1.8	0.7	0.4	3.3	1.2	0.42	0.57	0.69
Manure:									
Control (C_0)	97.2	11.5	9.0	24.1	109.3	7.8	23.83	5.64	6.69
FYM 2.5 t ha^{-1} (C_1)	97.9	11.8	9.4	24.6	110.8	8.6	23.83	5.83	6.82
FYM 3.75 t ha^{-1} (C_2)	97.7	12.4	9.7	24.4	112.4	9.2	23.70	5.96	6.89
FYM 5.0 t ha^{-1} (C_3)	98.7	12.3	9.8	24.3	110.3	9.2	23.81	6.21	6.97
FYM 6.25 t ha^{-1} (C_4)	99.8	12.6	9.8	24.6	113.0	9.0	23.71	6.05	7.04
FYM 7.5 t ha^{-1} (C_5)	99.8	12.9	10.1	24.5	112.8	8.8	23.48	6.09	7.12
$LSD_{.05}$	1.7	0.6	0.3	0.4	2.1	1.4	0.44	0.12	0.24
Tillage × Manure:									
T_0 C_0	96.2	10.6	7.5	23.7	104.0	8.0	23.55	5.06	6.29
T_0 C_1	99.9	10.8	7.9	24.4	106.0	9.8	23.81	5.22	6.42
T_0 C_2	96.9	11.3	8.5	24.0	105.7	11.7	23.42	5.24	6.33
T_0 C_3	100.0	12.0	8.8	23.2	104.0	12.7	23.98	5.40	6.24
T_0 C_4	97.3	11.7	8.8	23.7	106.0	11.5	23.87	5.26	6.42
T_0 C_5	98.3	12.2	8.8	23.5	106.3	11.0	23.47	5.36	6.54
T_1 C_0	97.5	11.5	8.9	24.3	110.7	8.5	24.18	5.44	6.46
T_1 C_1	98.6	11.9	9.7	24.2	109.1	8.8	23.80	5.69	6.55
T_1 C_2	98.8	11.9	9.6	24.2	111.5	9.4	24.22	5.85	6.69
T_1 C_3	99.9	12.2	9.7	24.7	110.0	6.9	24.09	5.72	6.83
T_1 C_4	101.6	12.3	9.5	24.5	113.2	8.7	23.82	5.80	6.79
T_1 C_5	100.1	12.4	9.3	24.5	110.0	9.1	23.54	6.11	6.85
T_2 C_0	97.8	12.0	9.8	24.7	112.3	7.7	24.25	5.76	6.68
T_2 C_1	97.2	12.3	9.9	25.1	114.1	7.5	23.59	6.00	6.95
T_2 C_2	98.8	13.0	9.1	24.9	115.7	7.1	23.58	6.06	7.14
T_2 C_3	97.7	12.7	9.1	24.8	116.3	7.3	23.37	6.11	7.30
T_2 C_4	102.5	13.2	9.3	25.1	116.4	8.1	23.67	6.24	7.32
T_2 C_5	101.7	13.4	10.5	24.5	118.3	8.0	23.41	6.28	7.40
T_3 C_0	97.3	9.9	8.7	23.8	104.2	6.9	23.35	5.64	7.34

T_3 C_1	95.8	10.3	9.0	24.6	113.9	8.2	24.12	6.23	7.35
T_3 C_2	96.2	12.5	10.5	24.5	116.7	8.5	23.59	6.31	7.39
T_3 C_3	97.2	13.4	12.1	24.5	117.9	7.1	23.81	6.84	7.52
T_3 C_4	97.9	13.1	10.5	24.9	116.2	7.7	23.47	6.27	7.63
T_3 C_5	98.9	13.5	10.8	25.6	116.7	7.1	23.49	6.10	7.67
$LSD_{0.05}$	3.3	1.2	0.6	0.9	4.0	2.9	0.88	0.24	0.29
CV(%)	3.7	5.9	8.3	2.9	6.0	8.8	2.10	5.92	12.00

Evaluation of the efficiency of herbicide on different establish methods of Aus rice (Binadhan-19)

A field experiment was conducted at the Agronomy field of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh under wet land condition during April to July in Aus season 2019. 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 = Bensulfuron + Acetachlor and H_2 =Penoxulum. 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 Complete Block Design. 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 (5.12 t ha^{-1}). The treatments among two selected commercial grade herbicides Penoxulum treated plot gives the highest yield (5.33 t ha^{-1}). The observation of weed competition in H_1 = Bensulfuron + Acetachlor and H_2 =Penoxulum treated plot was lower than control plots. The number of effective tillers, field grains $panicle^{-1}$ and grain yield was higher in compare with control plot. The interaction effect of establishment methods and herbicide showed that the combination of transplanting method with Penoxulum application gives the maximum yield 5.53 t ha^{-1} (Table 5).

Table 5. 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)	39.0	96.6	9.1	7.9	22.0	67.4	22.18	3.47	4.79	39.0
Line sowing (M_2)	39.7	96.4	9.7	8.2	21.7	68.0	22.14	3.66	5.06	39.7
Dibbling (M_3)	38.2	98.1	9.1	8.2	21.6	65.8	22.19	3.66	5.05	38.2
Transplanting(M_4)	33.0	96.7	9.7	8.2	22.5	67.2	22.12	3.71	5.12	33.0
$LSD_{.05}$	1.4	2.6	0.1	0.7	1.2	7.8	0.37	0.06	0.08	1.4
Herbicide										
Control (H_0)	37.8	97.3	9.3	8.0	22.2	68.4	22.16	3.36	4.63	37.8
Bensulfuran methyl + Acetachlor (H_1)	37.9	97.0	9.4	8.2	21.6	67.5	22.18	3.65	5.04	37.9
Penoxulum (H_2)	36.8	96.6	9.6	8.3	22.1	65.4	22.14	3.86	5.33	36.8
$LSD_{.05}$	1.3	1.4	0.1	0.3	0.4	4.8	0.16	0.08	0.11	1.3
Methods × Herbicide :										
M_1 H_0	39.3	96.8	8.4	7.4	21.9	65.6	22.10	3.10	4.28	39.3
M_1 H_1	40.3	96.9	9.6	8.4	22.1	69.1	22.20	3.52	4.86	40.3
M_1 H_2	37.3	96.3	9.4	7.9	22.1	67.5	22.23	3.78	5.22	37.3
M_2 H_0	39.0	97.5	9.6	8.0	22.1	72.2	21.93	3.43	4.73	39.0
M_2 H_1	40.3	96.3	9.8	8.1	21.1	65.7	22.20	3.69	5.09	40.3
M_2 H_2	39.7	95.5	9.8	8.5	22.0	65.9	22.30	3.87	5.35	39.7
M_3 H_0	39.7	98.3	9.4	8.2	21.7	68.1	22.42	3.42	4.72	39.7
M_3 H_1	38.0	98.3	8.8	8.0	21.5	66.5	22.07	3.76	5.19	38.0
M_3 H_2	37.0	97.8	9.2	8.5	21.8	62.7	22.10	3.79	5.23	37.0
M_4 H_0	33.0	96.7	9.6	8.3	22.9	67.5	22.20	3.48	4.80	33.0
M_4 H_1	33.0	96.5	9.4	8.2	21.9	68.7	22.23	3.64	5.02	33.0
M_4 H_2	33.0	97.0	10.0	8.2	22.7	65.4	21.93	4.01	5.53	33.0
$LSD_{.05}$	2.5	2.8	0.2	0.6	0.9	9.5	0.32	0.16	0.22	2.5
CV%	3.9	2.3	1.1	7.5	4.6	8.2	1.44	4.55	4.87	3.9

Effect of different herbicides on weed infestation and yield in boro rice (Binadhan-5)

A field experiment was conducted at the Agronomy field of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh under wet land condition during January to May 2019. Seventeen selected commercial grade herbicides were, Control (T_0), Two hand weeding (T_1), Bensulfuran methyl + Acetachlor (T_2), 2-4 diamine (T_3), Pretilachlor (T_4), Triafemon (T_5), Pyrazosulfuran ethyl (T_6), Trisulfuron (T_7), Pendimethyline (T_8), Metsulfuran methyl (T_9), Butachlor (T_{10}), Ethoxysulfuron (T_{11}), Carfentrazol ethyl (T_{12}), Fenoxpro-p-ethyl (T_{13}), Bensulfuron methyl + Bispyriback sodium (T_{14}), Penoxulum (T_{15}), Pyrazosulfuran ethyl + Pretilachlor (T_{16}). Bispyriback sodium (T_{17}), Paraquqte dichloride (T_{18}), Glyphosate (T_{19}). 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 3-4 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 eighteen selected commercial grade herbicides suppress different weed species. The highest weed species was found in control plots whereas less weed species were in T_{11} and T_{12} treatments (Table.6).

Table 6. Effect of herbicide to suppress weed species and their absolute density, relative density % at 45 DAT

Treatment	Local name	Scientific name	Absolute density (no./m^2)	Relative density (%)
T_0	Shama	Echinochloa colonum	1	5.56
	Gaicha	Paspalum distichum	1	5.56
	Khude shama	Echinochloa colona	3	16.68
	Arail	Leersia hexandra L.	2	11.11
	Chechra	Scirpus mucronatus L	1	5.56
	Sushnishak	Marsilea quadrifolia	1	5.56
	Holdemutha	Cyperus difformis	3	16.68
	Baro chuca	Cyperus iria	1	5.56
	Keshuti	Eclipta alba	1	5.56
	Panikachu	Monochoria vaginalis	2	11.11
	Zhilmorich	Sphenoclea zeylanica	2	11.11
			Total =18	100
T_1	Khude shama	Echinochloa colonum	1	16.67
	Arail	Leersia hexandra	2	33.33
	Holdemutha	Cyperus difformis	1	16.67
	Chechra	Scirpus mucronatus	2	33.33
			Total = 6	100
T_2	Shama	Echinochloa colonum	2	28.57
	Panikachu	Monochoria vaginalis	1	14.28
	Holdemutha	Cyperus difformis	4	57.14
			Total = 7	100
T_3	Shama	Echinochloa colonum	2	25
	Gaicha	Paspalum distichum	1	12.5

	Khude shama	Echinochloa colonum	3	37.5
	Arail	Leersia hexandra	2	25
			Total = 8	100
T_4	Holdemutha	Cyperus difformis	2	25
	Chechra	Scirpus mucronatus	2	25
	Shushnishak	Marsilea quadrifolia	3	37.5
	Arail	Leersia hexandra	1	12.5
			Total = 8	100
T_5	Baro chucha	Cyperus iria	4	66.67
	Gaicha	Paspalum distichum	2	33.33
			Total = 6	100
T_6	Keshuti	Eclipta alba	2	28.57
	Sushnishak	Marsilea quadrifolia	1	14.28
	Holdemutha	Cyperus difformis	3	42.85
	Chechra	Cyperus iria	1	28.57
			Total = 7	100
T_7	Panikachu	Monochoria vaginalis	2	66.67
	Zhilmorich	Sphenoclea zeylanica	1	33.33
			Total = 3	100
T_8	Panikachu	Monochoria vaginalis	1	12.5
	Arail	Leersia hexandra	2	25
	Holdemutha	Cyperus difformis	3	37.5
	Chechra	Scirpus mucronatus	2	25
			Total = 8	100
T_9	Khude shama	Echinochloa colona	2	22.22
	Arail	Leersia hexandra	2	22.22
	Panikachu	Monochoria vaginalis	1	11.11
	Holdemutha	Cyperus difformis	4	44.44
			Total = 9	100
T_{10}	Panikachu	Monochoria vaginalis	1	25
	Zhilmorich	Sphenoclea zeylanica	2	50
	Barochucha	Cyperus iria	1	25
			Total = 4	100
T_{11}	Arail	Leersia hexandra	5	100
			Total = 5	100
T_{12}	Khude shama	Echinochloa colona	4	100
			Total = 4	100
T_{13}	Shama	Echinochloa colonum	1	11.11
	Keshuti	Eclipta alba	2	22.22
	Panikachu	Monochoria vaginalis	2	11.11
	Holdemutha	Cyperus diformis	2	33.33
	Zhilmorich	Sphenoclea zeylanica	2	22.22
			Total=9	100
T_{14}	Panikachu	Monochoria vaginalis	2	66.67

	Zhilmorich	Sphenoclea zeylanica	1	33.33
	Baro chucha	Cyperusiria	1	100
			Total = 4	
T_{15}	Khude shama	Echinochloa colona	2	28.57
	Arail	Leersia hexandra L.	2	28.57
	Chechra	Scirpus mucronatus L	3	42.85
			Total = 7	100
T_{16}	Shama	Echinochloa colonum	2	22.22
	Keshuti	Eclipta alba	2	22.22
	Panikachu	Monochoria vaginalis	1	11.11
	Holdemutha	Cyperus diformis	4	11.11
			Total = 9	100
T_{17}	Shama	Echinochloa colonum	2	25
	Gaicha	Paspalum distichum	1	12.5
	Khude shama	Echinochloa colona	3	37.5
	Arail	Leersia hexandra	2	25
			Total = 8	100
T_{18}	Arail	Leersia hexandra	3	42.85
	Panikachu	Monochoria vaginalis	4	57.14
			Total =7	100
T_{19}	Chechra	Scirpus mucronatus	1	16.6
	Arail	Leersia hexandra	2	33.32
	Panikachu	Monochoria vaginalis	3	49.98
			Total = 6	100

In control treatment grain yield was significantly decreased due to weed infestation. In this experiment highest weed control efficiency was found 86.55 % at (Pyrazosulfuran ethyl 100 gm +Pretilachlor 100 gm, 20WP) which is followed by Bispyriback sodium 300 WP 82.35% and lowest 58.54 % at Fenoxpro-p-ethyl treated plot (Table 7).

Table 7. Effect of herbicide on weed species, weed density, fresh and dry weight and weed control efficiency % at 45 DAT

Treatments	Rate of application	Weed species (no. m^{-2})	Weed density (no. m^{-2})	Weed dry wt. (g m^{-2})	Weed control efficiency (%)
T_0	No weeding	11	18	35.7	-
T_1	2 times	4	6	6.52	81.73
T_2	180 g/ha	3	7	7.62	78.65
T_3	1.25 L/ha	4	8	6.8	80.90
T_4	1.0 L/ha	4	8	7.2	79.83
T_5	200 g/ha	2	6	6.3	82.35
T_6	125 g/ha	4	7	6.7	81.23
T_7	400 g/ha	2	3	7.8	77.9
T_8	1000ml/ha	4	8	13.3	62.74

T_9	50 g/ha	4	9	8.3	76.75
T_{10}	25 kg/ha	3	4	7.8	78.15
T_{11}	100 g/ha	1	1	6.7	81.23
T_{12}	104 ml/ha	1	1	8.2	77.03
T_{13}	650 g/ha	6	9	14.8	58.54
T_{14}	160 g/ha	3	3	6.8	80.95
T_{15}	150 ml/ha	3	3	7.5	78.99
T_{16}	87.5 ml/ha	4	4	7.2	79.83
T_{17}	200 g/ha	4	4	4.8	86.55
T_{18}	550 ml/ha	2	7	8.4	76.47
T_{19}	680ml/ha	3	6	9.3	73.94

Among eighteen selected commercial grade herbicides, the Bensulfuron methyl + Bispyriback sodium (T_{14}) showed the highest yield (7.21 t ha^{-1}) followed by Pyrazosulfuran ethyl + Pretilachlor (T_{16}) (7.16 t ha^{-1}). The number of effective tillers, field grains panicle^{-1} and grain yield was higher in Bensulfuron methyl + Bispyriback sodium (T_{14}) Pyrazosulfuran ethyl + Pretilachlor (T_{16}) were compared with other treatments (Table 8).

Table 8. 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 (T_0)	105.7	10.1	8.6	23.4	98.7	11.5	25.44	4.41	7.41
Two hand weeding (T_1)	106.7	11.5	9.9	23.6	112.4	11.5	25.64	5.49	7.49
Bensulfuran methyl + Acetachlor (T_2)	106.9	14.5	10.7	22.7	119.5	12.0	25.46	6.38	7.38
2-4 diamine (T_3)	106.3	11.9	11.4	21.5	123.3	14.6	25.38	6.39	7.39
Pretilachlor (T_4)	106.4	12.7	12.1	24.1	123.3	11.7	25.08	6.50	7.50
Triafemon (T_5)									
Pyrazosulfuran ethyl (T_6)	105.9	12.5	11.9	23.2	122.3	16.8	25.64	6.64	7.64
Trisulfuron (T_7)	106.6	12.5	11.2	23.3	120.3	9.5	25.34	6.18	8.18
Pendimethyline (T_8)	108.6	11.5	11.2	23.8	118.5	12.8	25.47	6.73	8.73
Metsulfuran methyl (T_9)	107.8	11.3	10.7	22.7	125.9	13.0	24.91	6.43	8.43
Butachlor (T_{10})	109.3	14.8	10.9	23.5	125.1	11.7	25.50	6.61	8.61
Ethoxysulfuron (T_{11})	110.6	12.3	11.8	22.5	127.1	11.1	25.04	6.65	8.65

Carfentrazol ethyl (T_{12})	107.2	11.4	10.2	22.9	128.5	12.5	25.55	6.22	8.22
Fenoxpro-p-ethyl (T_{13})	107.6	11.3	10.8	23.5	139.5	13.6	25.37	6.81	7.99
Bensulfuron methyl + Bispyriback sodium (T_{14})	107.5	13.3	12.2	22.0	146.6	6.7	25.45	7.21	8.34
Penoxulum (T_{15})	107.6	14.4	13.6	22.6	122.4	12.2	25.09	6.97	7.97
Pyrazosulfuran ethyl + Pretilachlor (T_{16})	106.4	12.8	12.2	23.3	124.9	16.1	24.87	7.16	8.16
Bispyriback sodium (T_{17})	106.4	12.2	11.6	23.9	127.9	13.1	25.12	6.27	8.27
Paraquate dichloride (T_{18})	106.1	12.9	12.2	23.6	125.4	15.7	24.69	6.42	8.42
Glyphosate (T_{19})	104.9	12.1	11.2	23.6	124.8	12.6	24.00	6.34	8.34
$LSD_{0.05}$	2.3	2.1	2.1	2.1	13.0	3.6	0.98	0.47	0.87
CV(%)	1.3	9.9	10.6	5.5	6.3	6.9	2.35	3.57	3.57

Determination of optimum seed rate for growth and yield of lentil mutant line/variety

The experiment was conducted at BINA substation, Ishurdi, Chapainawabganj and Magura during rabi season of 2019-20 to evaluate the effect of optimum seed rate on the growth and yield contributing characters of lentil mutant lines/variety. Treatments were four seed rate (25 kg ha^{-1}, 30 kg ha^{-1}, 35 kg ha^{-1} and 40 kg ha^{-1}) and viz. LM-99, LM-118, 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 locations Ishurdi produced the highest seed yield (2.09 t ha^{-1}).Among different advance lines/variety, LM-99 produced the highest seed yield (1.66 t ha^{-1}) followed by LM-118 (1.58 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, 35 kg ha^{-1} showed the highest seed yield (1.64 t ha^{-1}). The interaction results of mutant/variety and seed rate revealed that the yield of LM-118 was the highest (1.77 t ha^{-1}) at 30 kg ha^{-1}. The interaction effect of mutant/variety and location showed that Binamasur-8 produced maximum seed yield (2.20 t ha^{-1}) in Ishurdi followed by Chapainawabgang (2.10 t ha^{-}

[1]). The interaction effect of seed rate and location showed that seed rate at 30 kg ha^{-1} produced maximum seed yield (2.12 t ha^{-1}) followed by 25 kg ha^{-1} (2.01 t ha^{-1}) at same location Ishurdi. The interaction effect of seed rate, variety and location showed that at 30 kg ha^{-1}, LM-118 produced the highest yield (2.18 t ha^{-1}) at Ishurdi followed by at 30 kg ha^{-1}, LM-99 produced (2.10 t ha^{-1}) at Chapainawabgonj. The data recorded on crop duration revealed that the advanced mutant line LM-99 required the least average (120 days) and Binamasur-5 required maximum average (123 days) (Table 9).

Table 9. Determination of optimum seed rate for growth and yield of lentil lines during 2019-2020 at BINA substations, Ishurdi and Chapainawabganj Magura

Treatments	Populations m^{-2} (no.)	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000 seed wt.(g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Crop duration (days)
Location(s) :									
Ishurdi (L_1)	78.3	42.6	2.3	208.6	1.7	21.40	2.09	4.54	
Chapainawabgang (L_2)	69.4	28.8	7.6	106.4	1.7	19.83	1.24	4.90	
Magura (L_3)	60.7	35.7	4.7	121.2	1.6	22.03	1.44	4.54	
LSD $_{0.05}$	2.9	1.5	0.6	32.7	0.1	0.39	0.16	0.26	
Mutants/Variety :									
LM-99 (V_1)	69.9	35.8	4.8	150.6	1.6	21.36	1.66	4.56	120
LM-118 (V_2)	71.2	35.0	4.9	145.4	1.7	20.74	1.58	4.72	120
LM- 206-5 (V_3)	67.7	36.2	5.0	146.9	1.6	21.49	1.55	4.60	120
Binamasur-8 (V_4)	69.0	35.8	4.8	138.5	1.7	20.76	1.51	4.76	123
$LSD_{0.05}$	6.9	1.5	0.6	15.0	0.1	0.39	0.17	0.22	
Seed rate :									
25 kg ha^{-1} (S_1)	59.1	35.9	4.9	152.3	1.7	21.17	1.60	4.61	
30 kg ha^{-1} (S_2)	65.9	36.1	4.8	144.4	1.7	21.10	1.58	4.71	
35 kg ha^{-1} (S_3)	72.3	35.6	4.9	138.9	1.7	21.12	1.64	4.59	
40 kg ha^{-1} (S_4)	80.6	35.1	4.9	146.0	1.7	20.96	1.55	4.73	
$LSD_{0.05}$	3.3	1.1	0.4	10.3	0.1	0.20	0.07	0.16	
Location × Mutant/Variety:									
L_1V_1	72.6	43.1	2.3	209.6	1.7	21.86	2.09	4.45	
L_1V_2	85.0	40.8	2.3	219.5	1.7	20.80	1.81	4.60	
L_1V_3	75.9	44.6	2.5	213.0	1.7	21.67	1.97	4.47	
L_1V_4	79.7	41.9	2.2	192.2	1.7	21.28	2.20	4.64	
L_2V_1	74.0	29.1	7.4	110.4	1.7	20.26	1.43	4.76	
L_2V_2	65.2	28.4	7.6	102.5	1.7	19.36	1.36	4.96	
L_2V_3	66.6	28.3	7.6	105.3	1.7	20.79	1.16	4.86	
L_2V_4	71.9	29.5	7.8	107.4	1.7	18.93	1.02	5.01	
L_3V_1	63.2	35.1	4.7	132.0	1.6	21.96	1.45	4.45	
L_3V_2	63.6	35.8	4.8	114.3	1.6	22.06	1.49	4.60	
L_3V_3	60.6	35.8	4.9	122.3	1.6	22.02	1.53	4.47	
L_3V_4	55.3	36.0	4.4	116.1	1.7	22.06	1.31	4.64	
$LSD_{0.05}$	11.9	2.7	1.0	25.9	0.1	0.67	0.29	0.38	
Mutants/Variety × Seed rate :									
$V_1 S_1$	56.7	36.5	5.0	165.5	1.6	21.62	1.65	4.56	
$V_1 S_2$	66.4	35.7	4.8	154.3	1.7	21.54	1.64	4.47	
$V_1 S_3$	74.8	35.7	4.5	135.5	1.6	21.36	1.67	4.38	

V_1S_4	81.7	35.3	4.8	147.3	1.6	20.91	1.66	4.81	
V_2S_1	61.6	35.9	4.9	146.0	1.7	20.71	1.56	4.65	
V_2S_2	65.8	35.9	4.5	143.7	1.7	20.58	1.54	4.75	
V_2S_3	74.4	34.2	5.2	140.7	1.7	20.80	1.77	4.65	
V_2S_4	83.3	33.9	5.0	151.3	1.7	20.87	1.73	4.84	
V_3S_1	54.0	36.7	4.8	151.3	1.6	21.41	1.65	4.60	
V_3S_2	64.4	35.8	4.7	140.4	1.6	21.43	1.65	4.54	
V_3S_3	72.9	36.6	5.2	146.2	1.7	21.70	1.55	4.63	
V_3S_4	79.4	35.7	5.2	149.6	1.7	21.42	1.36	4.63	
V_4S_1	64.3	34.4	4.7	146.4	1.7	20.92	1.54	4.64	
V_4S_2	66.9	37.1	5.0	139.0	1.7	20.82	1.49	5.05	
V_4S_3	67.1	36.1	4.7	133.1	1.7	20.64	1.55	4.71	
V_4S_4	77.7	35.6	4.7	135.6	1.7	20.64	1.45	4.64	
$LSD_{0.05}$	6.6	2.3	0.7	20.6	0.1	0.40	0.14	0.32	
Seed rates × location :									
S_1L_1	62.5	43.2	2.3	224.0	1.7	21.40	2.12	4.55	
S_1L_2	71.7	43.7	2.4	199.9	1.7	21.47	1.81	4.58	
S_1L_3	82.5	42.8	2.4	194.3	1.8	21.49	1.97	4.46	
S_2L_1	96.6	40.7	2.2	216.0	1.6	21.24	2.01	4.58	
S_2L_2	57.4	28.5	7.5	106.8	1.7	19.88	1.19	4.75	
S_2L_3	62.8	29.1	7.2	107.8	1.7	19.91	1.22	4.96	
S_3L_1	74.6	28.6	7.8	104.5	1.7	19.92	1.41	4.86	
S_3L_2	82.9	29.2	8.0	106.4	1.7	19.63	1.16	5.02	
S_3L_3	57.6	36.0	4.8	126.1	1.6	22.22	1.46	4.55	
S_4L_1	63.1	35.6	4.8	125.4	1.6	21.91	1.40	4.58	
S_4L_2	59.8	35.5	4.6	117.7	1.6	21.96	1.44	4.46	
S_4L_3	62.2	35.5	4.6	115.5	1.7	22.01	1.48	4.58	
$LSD_{0.05}$	5.7	2.0	0.6	17.8	0.1	0.35	0.12	0.28	
Location× Mutants/Variety × Seed rates :									
$L_1V_1S_1$	61.9	44.7	2.3	256.3	1.7	21.84	1.91	4.51	
$L_2V_1S_1$	67.0	43.3	2.7	194.7	1.7	21.99	1.97	4.36	
$L_3V_1S_1$	75.0	43.0	2.4	175.7	1.8	21.94	1.87	4.29	
$L_1V_1S_2$	86.5	41.3	1.8	211.7	1.5	21.65	2.01	4.65	
$L_2V_1S_2$	67.3	43.3	2.6	213.3	1.6	20.66	2.10	4.57	
$L_3V_1S_2$	76.0	41.7	2.1	213.7	1.8	20.83	2.05	4.64	
$L_1V_1S_3$	91.3	39.7	2.5	210.0	1.8	21.23	2.01	4.51	
$L_2V_1S_3$	105.3	38.3	2.2	241.0	1.6	20.48	2.07	4.69	
$L_3V_1S_3$	57.7	46.0	2.1	217.0	1.6	21.70	2.05	4.55	
$L_1V_1S_4$	72.7	45.0	2.3	197.7	1.7	21.62	2.01	4.38	
$L_2V_1S_4$	80.3	45.3	2.7	208.3	1.7	21.76	1.73	4.47	
$L_3V_1S_4$	93.0	42.0	2.7	229.0	1.7	21.59	1.77	4.50	
$L_1V_2S_1$	63.0	38.7	2.1	209.3	1.7	21.40	2.02	4.54	
$L_2V_2S_1$	71.0	44.7	2.5	193.7	1.6	21.44	2.01	4.93	
$L_3V_2S_1$	83.3	43.3	1.9	183.3	1.7	21.04	2.07	4.58	
$L_1V_2S_2$	101.5	41.0	2.2	182.3	1.7	21.24	2.18	4.50	
$L_2V_2S_2$	48.7	29.5	7.7	110.0	1.7	20.98	1.39	4.65	
$L_3V_2S_2$	65.3	29.7	7.1	111.7	1.7	20.60	1.42	4.70	
$L_1V_2S_3$	87.3	28.7	6.7	112.0	1.6	20.29	1.44	4.57	
$L_2V_2S_3$	94.7	28.6	7.9	107.7	1.7	19.17	1.46	5.11	
$L_3V_2S_3$	57.3	28.3	7.5	103.7	1.8	19.03	1.17	4.82	
$L_1V_2S_4$	55.0	29.7	6.3	104.1	1.7	19.11	1.27	4.98	
$L_2V_2S_4$	68.7	26.6	8.4	100.3	1.7	19.27	1.51	4.92	
$L_3V_2S_4$	79.7	29.0	8.1	101.8	1.7	20.03	1.50	5.14	

$L_1V_3S_1$	52.3	27.5	7.6	104.9	1.7	20.70	1.27	4.71	
$L_2V_3S_1$	57.3	26.9	7.2	104.3	1.7	20.85	1.35	4.88	
$L_3V_3S_1$	76.0	29.6	7.7	105.3	1.7	21.19	1.40	4.95	
$L_1V_3S_2$	80.7	29.1	7.9	106.8	1.8	20.41	0.63	4.89	
$L_2V_3S_2$	71.3	28.5	7.1	108.5	1.7	18.80	0.94	4.82	
$L_3V_3S_2$	73.3	30.1	7.9	111.0	1.7	19.08	0.83	5.30	
$L_1V_3S_3$	66.3	29.3	8.3	100.5	1.7	18.94	1.27	4.98	
$L_2V_3S_3$	76.7	30.0	8.0	109.3	1.8	18.89	1.03	4.93	
$L_3V_3S_3$	59.6	35.3	5.1	130.1	1.4	22.04	1.41	4.51	
$L_1V_3S_4$	67.0	34.0	4.6	156.4	1.7	22.04	1.40	4.36	
$L_2V_3S_4$	62.1	35.4	4.5	118.8	1.5	21.85	1.46	4.29	
$L_3V_3S_3$	64.1	35.8	4.7	122.5	1.7	21.91	1.51	4.65	
$L_1V_4S_1$	60.0	36.2	4.7	121.1	1.7	22.45	1.43	4.57	
$L_2V_4S_1$	66.3	36.5	5.2	113.3	1.6	21.80	1.30	4.64	
$L_3V_4S_1$	63.1	36.3	4.7	111.7	1.6	21.90	1.62	4.51	
$L_1V_4S_2$	64.9	34.5	4.7	111.2	1.7	22.09	1.61	4.69	
$L_2V_4S_2$	52.1	36.6	4.6	131.9	1.7	21.83	1.43	4.55	
$L_3V_4S_2$	63.1	35.5	4.7	119.3	1.4	21.83	1.50	4.38	
$L_1V_4S_3$	62.5	35.0	5.2	124.9	1.6	22.16	1.53	4.47	
$L_2V_4S_3$	64.7	36.0	5.1	113.1	1.5	22.26	1.67	4.50	
$L_3V_4S_3$	58.6	36.1	4.9	121.3	1.6	22.57	1.55	4.54	
$L_1V_4S_4$	56.3	36.6	4.6	112.5	1.7	21.95	1.41	4.93	
$L_2V_4S_4$	51.5	35.6	3.9	115.5	1.8	21.93	1.13	4.58	
$L_3V_4S_4$	55.0	35.7	4.0	115.0	1.7	21.80	1.14	4.50	
$LSD_{0.05}$	5.7	4.0	1.3	35.7	0.2	0.70	0.25	0.55	
CV%	7.5	8.8	5.8	7.1	9.7	3.23	9.56	7.25	

Determination of optimum spacing on yield and yield contributing characters of mungbean mutants/variety

The experiment was conducted at BINA substation Ishurdi. 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 row spacing's. Three row spacings 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-plot over location) used for the experiment and the means were compared with LSD. The results are discussed below.

Among the mutant lines/varieties, MBM-656-51-2 produced the highest seed yield (1404 kg ha^{-1}) followed by MBM-427-87-3 (1377 kg ha^{-1}). The seed yield of 25 cm row spacing was the highest (1423 kg ha^{-1}) whereas 20 cm row spacing produced the lowest seed yield (1368 kg ha^{-1}). The interaction effect of variety and row spacing showed that mutant MBM-656-51-2 produced maximum seed yield (1456 kg ha^{-1}) at 25cm row spacing followed by MBM-427-87-3 (1421 kg ha^{-1}) at 25cm row spacing (Table 10). 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. 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 (kg ha^{-1})
Mutant/varieties :								
MBM-656-51-2 (V_1)	37.3	20.7	1.4	12.0	6.7	9.4	37.42	1404
MBM-427-87-3(V_2)	39.5	21.0	1.5	11.6	6.9	9.3	38.37	1377
BARI Mung-8(V_3)	37.9	20.9	1.4	11.8	7.0	9.4	38.29	1366
Binamung-8(V_4)	36.1	28.5	1.4	11.5	7.0	9.9	38.47	1358
$LSD_{0.05}$	3.3	12.6	0.1	2.1	0.7	1.5	1.19	107
Row spacing :								
20 cm (S_1)	39.1	21.0	1.4	12.0	6.8	9.8	38.36	1368
25 cm (S_2)	37.5	26.7	1.4	11.5	7.0	9.4	38.10	1423
30 cm (S_3)	36.5	20.6	1.4	11.7	6.9	9.4	37.95	1345
$LSD_{0.05}$	3.3	10.2	0.1	0.8	0.4	0.7	0.85	37
Mutant/variety × Row spacing :								
V_1S_1	37.5	20.7	1.4	12.0	6.8	9.6	37.97	1379
V_1S_2	34.5	20.7	1.3	12.0	6.8	9.0	37.17	1456
V_1S_3	39.9	20.8	1.5	12.0	6.7	9.5	37.13	1376
V_2S_1	40.0	21.1	1.5	12.3	6.8	9.7	38.53	1393
V_2S_2	41.2	20.8	1.3	10.9	6.9	9.3	38.53	1426
V_2S_3	37.2	21.1	1.5	11.7	6.9	9.0	38.03	1343
V_3S_1	41.3	21.3	1.4	11.8	7.0	9.5	38.67	1346
V_3S_2	37.8	19.9	1.3	11.3	7.0	9.7	38.27	1406
V_3S_3	34.7	21.6	1.4	12.3	7.0	9.0	37.93	1346
V_4S_1	37.5	20.9	1.4	12.0	6.7	10.1	38.27	1353
V_4S_2	36.3	45.4	1.5	11.6	7.1	9.7	38.43	1406
V_4S_3	34.4	19.1	1.2	10.9	7.1	10.0	38.70	1316
$LSD_{0.05}$	6.7	20.4	0.3	1.5	0.8	1.4	1.70	75.28
CV (%)	7.6	8.0	9.2	7.6	6.7	8.6	2.70	6.75

Determination of optimum row spacing on yield and yield contributing characters of chickpea mutants/variety

The experiment was conducted at BINA substation Ishurdi. Two advanced mutant lines were evaluated compared with one check variety with four different row spacing. The objective was to evaluate the yield performances of mutant lines as affected by different row spacing’s. Four row spacing were 30 cm, 40 cm, 50 cm and 60 cm. The advanced mutant lines were CPM-8-200, CPM-8-300 and one check variety was Binasola-8. Data on yield and yield components were recorded at harvest and analyzed statistically following the split-plot design used for the experiment and the means were compared with LSD. The results are discussed below separately. Among the mutant lines/varieties, Binasola-8 produced the highest seed yield (1196 kg ha^{-1}) followed by CPM-8-200 yielded (1139 kg ha^{-1}). The seed yield of 50 cm row spacing was the highest (1185 kg ha^{-1}) whereas 30 cm row spacing produced the lowest seed yield (1005 kg ha^{-1}). The interaction effect of variety and row spacing showed that mutant line produced maximum seed yield Binasola-8 (1234 kg ha^{-1}) at 50 cm row spacing followed by CPM-8-200 (1184 kg ha^{-1}) (Table 11). The data recorded on crop duration from sowing to maturity revealed that the advanced mutant line required the least average (128 days) and required maximum average (131 days).

Table 11. Effect of spacing on yield and yield contributing characters of chickpea mutants/variety at BINA Substations Chapainawabganj

Treatment	Populations m^{-2} (no.)	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	100 seed wt.(g)	Seed yield (kg ha^{-1})	Stover yield (t ha^{-1})
Mutant/varieties :							
CPM-8-200 (V_1)	27.2	56.6	4.4	57.0	22.3	1139	2537
CPM-8-300 (V_2)	28.3	53.0	4.5	60.6	23.1	1078	2691
Binasola-8 (V_3)	29.0	46.6	3.6	67.7	17.2	1196	2195
$LSD_{0.05}$	3.6	7.5	1.1	26.1	2.1	74	382
Row spacing :							
30 cm (S_1)	35.0	53.9	3.9	48.8	20.3	1005	2447
40 cm (S_2)	29.2	53.6	4.2	64.8	21.8	1078	2220
50 cm (S_3)	25.8	51.3	4.4	67.0	20.3	1185	2413
60 cm (S_3)	22.6	51.4	4.8	69.5	21.8	1040	2152
$LSD_{0.05}$	1.3	4.5	0.7	12.4	NS	130	271
Mutant/variety × Row spacing :							
V_1S_1	32.7	60.7	3.7	44.3	20.3	980	3241
V_1S_2	28.3	57.2	4.1	54.2	21.1	1069	2900
V_1S_3	25.7	55.9	5.1	57.0	21.3	1184	3034
V_1S_4	22.0	52.5	5.1	52.6	21.2	1095	2971
V_2S_1	35.3	52.0	4.5	44.1	23.3	931	2145
V_2S_2	29.3	57.8	4.9	62.7	22.4	983	2563
V_2S_3	25.3	51.0	5.6	73.0	21.3	1085	2656
V_2S_4	23.0	51.2	5.5	72.4	21.8	858	2400
V_3S_1	37.0	43.0	3.6	56.9	17.1	995	1954
V_3S_2	30.0	45.9	3.5	52.5	18.1	1087	2197
V_3S_3	26.3	46.9	3.8	64.9	17.9	1234	2547
V_3S_4	22.7	50.7	4.2	67.5	17.8	1008	2084
$LSD_{0.05}$	2.2	7.9	1.2	13.2	1.8	175	470
CV (%)	11.4	8.8	4.1	9.9	3.4	12	13

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 2019-20 to evaluate the effect of optimum line spacing on the growth and yield contributing characteristics of advance mustard lines/variety viz. RM-005, RM-07 RM-10, RM-18, RM-20 along with one check variety , Binasarisha-9. 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.

Between two locations Magura produced highest seed yield (1.97 t ha^{-1}). Among different advance lines/variety, RM-007 produced the highest seed yield (2.11 t ha^{-1}) followed by RM-18(2.03 t ha^{-1}) and Binasarisha-9 (2.02 t ha^{-1}). Among different line spacing, 20 cm showed highest seed yield (1.97 t ha^{-1}). The interaction of mutant/variety and location revealed that the yield of Binasarisha-9 was the highest (2.24 t ha^{-1}) at Magura. The interaction effect of line spacing and location showed that 30 cm line spacing produced the maximum seed yield (2.11 t ha^{-1}) in Rangpur. The interaction effect of mutant and line spacing showed that mutant line, RM-005 at 25 cm produced maximum seed yield (2.21 t ha^{-1}) line spacing in Rangpur. The interaction effect of mutant/variety, line spacing and location showed that Binasarisha-9 produced highest seed yield (2.28 t ha^{-1}) at 35 cm line spacing in Rangpur (Table 12).
The data recorded on crop duration revealed that the advanced mutant line RM-005, RM-07, RM-10, RM-18 and RM-20 required the least average 86 days and Binasarisha-9 required maximum average 86 days.

Table 12. Effect of different levels of line spacing on the yield and yield contributing characters of mustard mutant/variety at 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 t.(g.)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Location(s) :									
Rangpur (L_1)	54.11	99.76	2.30	39.61	26.21	4.72	3.24	1.76	3.59
Magura (L_2)	55.10	99.67	2.24	39.39	26.62	4.69	3.21	1.97	3.38
T value	NS	NS	*	*	*	NS	NS	*	NS
Mutant/Variety :									
RM-005 (V_1)	55.21	98.65	2.32	40.91	23.95	4.86	3.47	2.11	3.45
RM-07	53.50	90.52	2.95	42.42	20.76	4.42	3.11	1.65	3.19

(V_2)									
RM-10 (V_3)	51.79	87.87	3.57	38.74	20.92	4.48	3.36	1.60	3.25
RM-18 (V_4)	53.83	103.32	1.46	31.68	34.52	4.38	2.93	2.03	3.30
RM-20 (V_5)	57.75	103.82	1.36	35.43	33.79	4.34	3.40	1.84	3.21
Binasarisha-9 (V_6)	55.54	114.12	1.96	47.83	24.56	5.77	3.10	2.02	3.32
$LSD_{0.05}$	4.80	0.63	0.25	2.06	1.83	0.14	0.29	0.17	NS
Line spacing :									
20 cm (S_1)	63.42	101.77	2.60	45.84	24.16	4.97	3.24	1.97	3.32
25 cm (S_2)	57.67	97.44	2.12	35.57	25.23	4.45	3.21	1.86	3.19
30 cm (S_3)	52.94	96.93	1.52	32.91	28.78	4.69	3.23	1.80	2.88
35 cm (S_4)	44.39	102.72	2.83	43.68	27.48	4.71	3.23	1.76	2.95
$LSD_{0.05}$	1.48	0.59	0.33	2.36	1.04	0.11	0.04	0.10	0.15
Mutants/Variety × Location :									
V_1L_1	55.00	99.20	2.35	41.72	23.43	4.86	3.48	1.75	3.03
V_1L_2	54.08	89.93	2.98	41.70	20.34	4.46	3.11	1.68	3.17
V_2L_1	50.17	87.87	3.65	38.82	20.47	4.51	3.42	1.60	3.17
V_2L_2	52.25	103.68	1.50	31.83	34.50	4.37	2.94	1.87	2.99
V_3L_1	57.50	103.53	1.38	35.55	33.62	4.33	3.39	1.85	2.98
V_3L_2	55.67	114.36	1.93	48.02	24.91	5.80	3.13	1.80	3.20
V_4L_1	55.42	98.10	2.28	40.10	24.46	4.85	3.45	2.03	3.12
V_4L_2	52.92	91.10	2.92	43.13	21.18	4.38	3.11	1.61	3.02
V_5L_1	53.42	87.87	3.48	38.66	21.37	4.45	3.30	1.61	3.24
V_5L_2	55.42	102.95	1.42	31.53	34.53	4.38	2.92	2.19	3.11
V_6L_1	58.00	104.10	1.33	35.30	33.97	4.36	3.40	1.84	3.42
V_6L_2	55.42	113.88	1.98	47.63	24.21	5.73	3.07	2.24	3.25
$LSD_{0.05}$	6.79	0.89	0.35	2.91	2.59	0.20	0.41	0.07	NS
Line spacing × Location :									
S_1L_1	62.67	101.33	2.58	46.19	23.78	4.98	3.28	1.89	3.26
S_1L_2	57.28	97.67	2.19	34.68	24.84	4.46	3.23	1.76	3.23
S_2L_1	52.50	97.51	1.44	32.94	28.77	4.70	3.24	1.75	2.84
S_2L_2	44.00	102.54	2.99	44.61	27.44	4.75	3.22	1.64	3.02
S_3L_1	64.17	102.20	2.63	45.49	24.54	4.96	3.19	2.11	3.37
S_3L_2	58.06	97.22	2.06	36.46	25.62	4.44	3.18	2.03	3.16
S_4L_1	53.39	96.35	1.59	32.88	28.79	4.68	3.22	1.86	2.92
S_4L_2	44.78	102.90	2.67	42.75	27.52	4.68	3.23	1.88	2.87
$LSD_{0.05}$	2.09	0.84	0.47	3.34	1.48	0.15	0.06	0.01	0.21
Mutants/Variety × Line spacing :									
V_1S_1	65.67	94.40	3.23	45.40	19.35	4.79	3.45	2.15	3.33
V_1S_2	58.83	88.67	3.07	38.00	19.10	4.60	3.57	2.21	3.12
V_1S_3	52.00	98.00	0.90	23.47	33.90	4.32	3.40	1.93	2.81
V_1S_4	44.33	113.53	2.07	56.77	23.43	5.71	3.45	1.87	2.98

V_2S_1	59.00	94.40	3.23	45.40	19.35	4.79	3.25	1.80	3.50
V_2S_2	58.00	89.47	2.37	37.03	20.67	4.24	3.05	1.68	3.38
V_2S_3	53.17	88.87	2.30	43.57	22.43	4.19	3.10	1.63	2.86
V_2S_4	43.83	89.33	3.90	43.67	20.58	4.45	3.03	1.48	2.99
V_3S_1	58.17	84.33	3.28	39.23	21.97	4.53	3.32	1.71	3.14
V_3S_2	54.17	88.67	3.07	38.00	19.10	4.60	3.35	1.52	3.29
V_3S_3	50.83	85.83	3.28	40.53	22.33	4.32	3.28	1.73	2.93
V_3S_4	44.00	92.67	4.63	37.18	20.27	4.46	3.48	1.46	3.22
V_4S_1	63.67	104.80	1.13	32.73	34.20	4.50	2.90	2.18	3.29
V_4S_2	56.00	99.47	0.63	29.43	30.97	4.33	2.92	2.10	3.14
V_4S_3	52.17	98.00	0.90	23.47	33.90	4.32	2.98	1.84	2.93
V_4S_4	43.50	111.00	3.17	41.10	39.00	4.35	2.92	2.01	2.98
V_5S_1	67.17	113.53	2.07	56.77	23.43	5.71	3.35	2.00	3.11
V_5S_2	60.17	105.47	1.40	29.37	36.80	3.60	3.37	1.85	3.32
V_5S_3	56.50	100.00	0.83	28.97	36.77	4.47	3.43	1.80	3.34
V_5S_4	47.17	96.27	1.13	26.60	38.17	3.60	3.43	1.73	3.42
V_6S_1	66.83	119.13	2.67	55.50	26.67	5.50	3.15	2.15	3.21
V_6S_2	58.83	112.93	2.20	41.57	24.77	5.34	3.00	2.04	3.27
V_6S_3	53.00	110.87	0.90	37.47	23.37	6.52	3.18	1.90	3.42
V_6S_4	43.50	113.53	2.07	56.77	23.43	5.71	3.05	2.00	3.33
$LSD_{0.05}$	3.62	1.45	0.81	5.78	2.55	0.26	0.11	0.02	0.30
Location × Mutant/Variety × Line spacing :									
$L_1V_1S_1$	65.33	94.60	3.20	45.73	18.73	4.83	3.47	1.86	3.29
$L_2V_1S_1$	59.00	89.33	3.20	38.33	18.27	4.60	3.63	1.79	3.15
$L_1V_1S_2$	51.67	99.60	1.00	23.53	33.53	4.27	3.40	1.69	2.91
$L_2V_1S_2$	44.00	113.27	2.00	59.27	23.20	5.75	3.43	1.67	2.76
$L_1V_1S_3$	59.00	94.60	3.20	45.73	18.73	4.83	3.27	1.83	3.52
$L_2V_1S_3$	58.00	88.53	2.33	35.40	20.00	4.29	3.07	1.63	3.41
$L_1V_1S_4$	54.33	87.93	2.20	41.67	22.13	4.24	3.10	1.68	2.71
$L_2V_1S_4$	45.00	88.67	4.20	44.00	20.50	4.47	3.00	1.58	3.04
$L_1V_2S_1$	57.00	83.67	3.33	38.40	21.63	4.53	3.40	1.71	3.08
$L_2V_2S_1$	52.67	89.33	3.20	38.33	18.27	4.60	3.43	1.68	3.32
$L_1V_2S_2$	49.00	85.17	3.27	41.40	22.00	4.33	3.30	1.61	2.96
$L_2V_2S_2$	42.00	93.33	4.80	37.13	19.97	4.57	3.53	1.40	3.31
$L_1V_2S_3$	61.33	103.40	1.07	33.40	33.60	4.47	2.93	2.04	3.16
$L_2V_2S_3$	54.33	99.13	0.40	29.00	30.93	4.35	2.93	1.91	3.04
$L_1V_2S_4$	51.00	99.60	1.00	23.53	33.53	4.27	3.00	1.82	2.79
$L_2V_2S_4$	42.33	112.60	3.53	41.40	39.93	4.38	2.90	1.72	2.96
$L_1V_3S_1$	66.00	113.27	2.00	59.27	23.20	5.75	3.37	2.00	3.38
$L_2V_3S_1$	61.00	106.33	1.67	27.80	36.33	3.58	3.33	1.78	3.00
$L_1V_3S_2$	56.33	100.40	0.47	28.53	37.07	4.44	3.47	1.90	2.82
$L_2V_3S_2$	46.67	94.13	1.40	26.60	37.87	3.55	3.40	1.72	2.72
$L_1V_3S_3$	67.33	118.47	2.67	54.60	26.80	5.49	3.23	1.88	3.48
$L_2V_3S_3$	58.67	113.37	2.33	39.20	25.27	5.33	3.00	1.81	3.35
$L_1V_3S_4$	52.67	112.33	0.73	39.00	24.37	6.63	3.20	1.80	3.01

$L_2V_3S_4$	44.00	113.27	2.00	59.27	23.20	5.75	3.07	1.71	2.95
$L_1V_4S_1$	66.00	94.20	3.27	45.07	19.97	4.75	3.43	2.04	3.21
$L_2V_4S_1$	58.67	88.00	2.93	37.67	19.93	4.60	3.50	2.04	3.25
$L_1V_4S_2$	52.33	96.40	0.80	23.40	34.27	4.37	3.40	2.17	2.91
$L_2V_4S_2$	44.67	113.80	2.13	54.27	23.67	5.67	3.47	2.07	3.13
$L_1V_4S_3$	59.00	94.20	3.27	45.07	19.97	4.75	3.23	1.77	3.35
$L_2V_4S_3$	58.00	90.40	2.40	38.67	21.33	4.19	3.03	1.73	3.03
$L_1V_4S_4$	52.00	89.80	2.40	45.47	22.73	4.15	3.10	1.58	2.91
$L_2V_4S_4$	42.67	90.00	3.60	43.33	20.67	4.43	3.07	1.37	2.90
$L_1V_5S_1$	59.33	85.00	3.23	40.07	22.30	4.53	3.23	1.70	3.23
$L_2V_5S_1$	55.67	88.00	2.93	37.67	19.93	4.60	3.27	1.37	3.44
$L_1V_5S_2$	52.67	86.50	3.30	39.67	22.67	4.30	3.27	1.85	3.21
$L_2V_5S_2$	46.00	92.00	4.47	37.23	20.57	4.35	3.43	1.51	3.31
$L_1V_5S_3$	66.00	106.20	1.20	32.07	34.80	4.52	2.87	2.12	3.16
$L_2V_5S_3$	57.67	99.80	0.87	29.87	31.00	4.31	2.90	2.08	3.04
$L_1V_5S_4$	53.33	96.40	0.80	23.40	34.27	4.37	2.97	1.87	2.89
$L_2V_5S_4$	44.67	109.40	2.80	40.80	38.07	4.33	2.93	2.10	2.91
$L_1V_6S_1$	68.33	113.80	2.13	54.27	23.67	5.67	3.33	2.00	3.38
$L_2V_6S_1$	59.33	104.60	1.13	30.93	37.27	3.61	3.40	1.92	3.06
$L_1V_6S_2$	56.67	99.60	1.20	29.40	36.47	4.50	3.40	1.70	3.14
$L_2V_6S_2$	47.67	98.40	0.87	26.60	38.47	3.65	3.47	1.73	2.93
$L_1V_6S_3$	66.33	119.80	2.67	56.40	26.53	5.51	3.07	2.42	3.58
$L_2V_6S_3$	59.00	112.50	2.07	43.93	24.27	5.35	3.00	2.27	3.35
$L_1V_6S_4$	53.33	109.40	1.07	35.93	22.37	6.41	3.17	2.28	3.43
$L_2V_6S_4$	43.00	113.80	2.13	54.27	23.67	5.67	3.03	2.00	3.22
$LSD_{0.05}$	5.12	2.05	1.14	8.18	3.61	0.37	0.15	0.03	0.21
CV%	65.33	94.60	3.20	45.73	18.73	4.83	3.47	1.86	5.7

Evaluation of yield and yield contributing characters of wheat mutant/varieties during 2019-2020

The experiment was conducted at BINA Substation Rangpur, Chapainawabganj, farmer's field of Thakurgaon, Rajshahi and BINA Farm Mymensingh during rabi season 2019-20. One mutant line was evaluated compared with one check variety with 5 locations. The objective was to evaluate the yield performances of mutant line as affected by agro-climatic condition in Bangladesh. The mutant line was M-W-M-1, the check variety was, BARI Gom 28. The experiment was carried out in a 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.

Among different mutant line/variety, BARI Gom 28 produced highest seed yield (3.68 t ha^{-1}) followed by mutant line M-W-M-1 (3.55 t ha^{-1}). Among different location, the highest grain yield (3.85 t ha^{-1}) was found in farmer's field of Thakurgaon. The interaction results of variety and locations, revealed that the yield of the mutant M-W-M-1 was the highest (3.89 t ha^{-1}) at Bina substation farm, Chapainawabganj (Table 13). The mutant M-W-M-1 took the highest duration 129 days to maturity whereas BARI Gom 28 took the lowest duration of 123 days to maturity.

Table 13. Evaluation of yield and yield contributing characters of wheat mutant/varieties in different AEZs

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Spike length (cm)	Spikelet's spike^{-1} (no.)	1000 seed wt. (g)	Grain yield. t. ha^{-1}	Straw yield t. ha^{-1}	Maturity (days)
Location(s)									
Rangpur (L_1)	97.8	10.4	8.3	16	39.9	47.6	3.46	5.79	
Thakurgaon (L_2)	98.8	9.1	7.7	15.8	44.9	46.8	3.85	6.47	
Chapainawabganj (L_3)	90.5	9.1	5.5	15.8	46.5	46.2	3.46	5.79	
Rajshahi (L_4)	90.5	10.4	6.4	16	49.7	50.0	3.76	6.46	
Mymensingh (L_5)	94.3	11.7	8.7	16	49.7	47.6	3.46	6.20	
$LSD_{0.05}$	5.1	2.0	0.8	0.3	2.6	2.0	0.1	0.6	
Varieties:									
M-H-M-1 (V_1)	94.2	10.3	8.3	15.0	44.7	46.8	3.55	6.10	129
BARI Gom-28 (V_2)	94.5	10.0	7.5	15.9	47.6	48.5	3.68	6.19	123
T value	NS	NS	**	*	*	*	*	NS	
Variety × Location:									
V_1 L_1	100.1	10.7	8.5	16.4	40.2	43.6	3.34	5.60	
V_1 L_2	95.5	10.1	8.1	16.8	39.6	51.7	3.58	5.99	
V_1 L_3	98.9	12.8	10.8	15.6	40.8	46.4	3.89	6.57	
V_1 L_4	98.7	9.3	7.5	16.3	49.1	47.3	3.84	6.37	
V_1 L_5	88.4	9.3	5.5	16.9	46.4	45.8	3.34	5.60	
V_2 L_1	92.6	8.9	5.5	15.6	46.6	46.6	3.58	5.99	
V_2 L_2	88.4	10.7	5.9	16.1	48.2	54.7	3.87	6.54	
V_2 L_3	92.6	10.2	6.8	16.2	51.2	45.3	3.84	6.39	
V_2 L_4	95.3	12.0	8.6	16.5	48.2	43.6	3.34	6.22	
V_2 L_5	93.3	11.5	8.8	16.1	51.2	51.7	3.58	6.19	
$LSD_{0.05}$	5.2	1.8	1.2	2.2	3.3	0.7	0.14	0.58	
CV(%)	4.0	10.1	7.8	4.29	3.2	3.1	8.4	0.44	

Evaluation of yield and yield contributing characters of groundnut mutant line/variety during 2019-2020

The experiment was conducted at BINA Substation Rangpur during rabi season of 2019-20. One mutant line was evaluated compared with two check varieties. The objective was to evaluate the yield performances of mutant line as affected by agro-climatic condition in Bangladesh. The mutant line was BM-11-1 and the check varieties were, Binacinabadam-4 and Binacinabadam-8. The experiment was carried out 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 results are discussed below.

Among different mutant line/variety, Binachinabadam-4 produced highest seed yield (2.41 t ha^{-1}) followed by mutant BM-11-1 (2.29 t ha^{-1}). BM-11-1 took the highest duration 123 days to maturity Binachinabadam-4 took the lowest duration of 117 days to maturity (Table 14).

Table 14. Evaluation of yield and yield contributing characters of groundnut mutant line/variety at BINA Substation Rangpur

Treatment	Populations m^{-2} (no.)	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	100 seed wt.(g)	Seed yield (t ha^{-1})
Mutant/varieties :						
BM-11-1(V_1)	20.67	40.17	6.60	15.17	48.24	2.29
Binacinabadam-4 (V_2)	24.00	41.70	5.93	13.33	44.67	2.41
Binacinabadam-8 (V_3)	27.00	37.27	4.53	13.40	42.84	2.17
$LSD_{0.05}$	NS	4.45	1.28	10.22	1.15	0.14
CV%	2.60	4.95	14.30	2.14	4.54	7.80

Evaluation of late sowing potentials of mustard varieties on yield and yield contributing character at BINA farm, Mymensingh

The experiment was conducted at BINA farm, Mymensingh during rabi season of 2019-20. The objective was to evaluate the yield potentials of released mustard varieties in late sowing. Seeds of Tori-7, BARI Sharisha-14, Binasharisha-7, Binasharisha-9 were sown on 13 December 2019. 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.
Among different varieties, Binasarisha-9 produced highest seed yield (1.31 t ha^{-1}) followed by BARI Sharisha-14 (1.27 t ha^{-1}) (Table.15).

Table 15. Evaluation of late sowing potentialities of mustard varieties on yield and yield contributing character at BINA farm, Mymensingh during 2019-20.

Treatment	Plant height (cm)	Populations m^{-2} (no.)	Branches $plant^{-1}$ (no.)	Siliqua $plant^{-1}$ (no.)	Seeds $Siliqua^{-1}$ (no.)	Siliqua length (cm)	1000 seed wt.(g.)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Maturity (days)
Varieties:										
Tori-7	64.67	78.00	4.37	43.87	23.67	5.43	3.47	1.06	2.87	66
BARI Sharisha-14	60.00	72.70	3.00	31.47	34.15	5.03	3.47	1.27	3.11	74
Binasharish-7	55.00	114.47	2.73	39.00	26.00	4.77	3.30	1.00	2.93	78
Binasarisha-9	47.67	103.13	2.73	31.87	28.40	7.10	3.40	1.31	2.90	81
$LSD_{0.05}$	3.66	7.23	0.50	2.44	4.40	0.63	0.33	0.15	3.13	-
CV (%)	3.23	3.93	7.83	3.34	7.49	5.61	4.82	6.51	NS	-

Agricultural Engineering Division

Research Highlights

- Strip tillage and irrigation at early and flowering stages produced the highest yield of Mungbean.

- The highest yield was obtained in 100 cm wide beds accompanied by 30 cm drain between the beds, followed by 150 cm spacing accompanied by 30 cm drain between the beds.

- Application of Nitro benzene (at 44 DAT) and "α 1, Napthyl Acetic Acid (at 52 DAT) showed less seed dropping rate for Binadhan-14.

- Fifteen sesame mutants survived under natural rainfall. Ten mutants survived less than 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.

- Seed priming (12 hrs soaking in water, and then drying for 6 hrs) + 30% excess Gypsum at basal dose (in addition to recommended dose) + One irrigation at vegetative stage (45 DAS) + 30% excess Gypsum (in addition to recommended dose) produced the highest seed yield of soybean.

- From average grain yield of two locations, it is found that the treatment "Continuous ponding (3-5 cm) + 150 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering) + 10 kg/ha Si (basal)+ addition of PK (25%) at booting + No ridge (high density, 10×10 cm)+ Washout (change standing water) at 20 days interval" was the best among the treatments.

- Application of chemical amendment *or* combination of chemical and organic amendments minimized the detrimental effects of irrigation–water salinity and improved grain yield of Binadhan-10. Use of fresh water at critical growth stages and saline water at all other growth stages with effective amendment practice can maximize production of the Binadhan-10 up to 35%.

- Fineness Modulus of aquifer materials (depth wise) ranged from 2.43 to 2.93. Coefficient of Uniformity (C_u) is greater than 2 (110 ft to 160 ft), which indicated well graded materials. Arithmetic mean of hydraulic conductivity (K) and Transmissibility (T) of aquifer were found as 20 m/day and 498 m^2/day, respectively,. The Specific Yield (S_y) of the aquifer material ranged from 0.0004 to 0.03.

- The quality of groundwater (DTW) at Nachol and NiamatpurUpazila were found within permissible limit for drinking and irrigation purposes according to FAO, DPHE, GOB and WHO guidelines.

- The pattern "T.Aman-Mustard-T.Aus" yielded the 2nd highest REY (as well as net profit) with 39% irrigation water savings compare to P-4 (T. Aman-Mustard-Boro); but sacrificing 7% yield at Nachol. The pattern "T. Aman-Lentil-T.Aus" yielded the 2nd highest REY (as well as net profit) with 48% irrigation water savings compared to "T. Aman-Mustard-Boro" but sacrificing 9% yield at Niamatpur.

Drought screening and irrigation management for field crops

Studies on the effect of different tillage practices and irrigation management on Mungbean production under conservation agriculture practice

The objectives of the experiment were to study the effect of different tillage practices on water use in mungbean cultivation and to develop appropriate irrigation application rate for conservation and conventional tillage practices on mungbean production.

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 replications were used. The design was RCBD with split-plot.

The seeds were sown on 4th March 2020, and harvested on 15th May 2020. Agronomic data were collected throughout the whole period of the mungbean growing season. The statistical analysis was performed using statistical software Statistix10 (Version10.0). Rainfall distribution during the mungbean growing period is depicted in Figure 1.1.

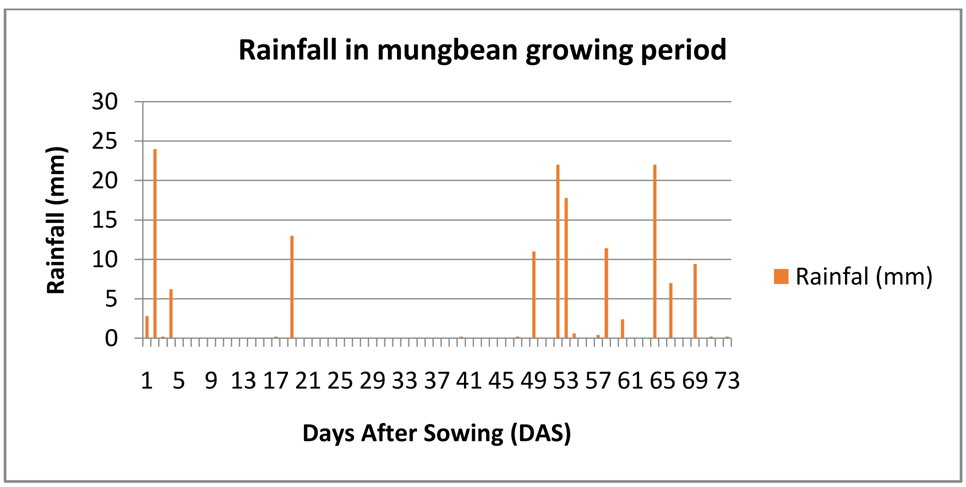


Figure 1.1.Rainfall during the mungbeangrowing period

There was rainfall at vegetative, pod formation and ripening stages of the crop which affected the treatment effect and crop yield. All yield attributing characters showed insignificant difference comparison with tillage systems except Pod/plant. Plant height showed significant difference within irrigation methods, and others yield attributing characters showed insignificant difference.

The mean effects of tillage and irrigation treatment on yield and yield attributing characters of mungbean cultivar are summarized in Table 1.1. The interaction effect between tillage and irrigation treatments showed significant difference in grain yield (Table 1.2).

Table 1.1. 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	plant population/ m^2	Yield (kg/ha)
T1	36.3	1.2	16.9 a	7.9	11.9	52.1	1572.2
T2	37.5	0.8	13 b	7.8	11.6	46.8	1511.1
T3	35.2	0.9	14.8 ab	7.8	11.9	41.9	1451.1
F-test (at 5%)	NS	NS	S	NS	NS	NS	NS
Irrigation							
I1	36.1 ab	0.9	13.9	7.8	11.8	49.9	1450.0
I2	33.9 b	0.9	15	7.9	11.6	45.6	1566.7
I3	38.9 a	1.1	15.9	7.7	12.1	45.3	1517.8
F-test (at 5%)	S	NS	NS	NS	NS	NS	NS

Note: Significantly different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 1.2.Interaction effect between tillage and irrigation

Tillage	Yield(kg/ha)		
	Irrigation I_1	Irrigation I_2	Irrigation I_3
T_1	1366.7	1650	1700
T_2	1583.3	1483.3	1466.7
T_3	1400	1566.7	1386.7

It was difficult to maintain treatments properly due to excess rainfall. There was rainfall at pod formation and ripening stages of the crop which affected the irrigation treatment effects and crop yield. However, from the results of harvest, thefarmer's practice /no irrigation and control /full tillage produced lowest seed yield (1366 kg/ha). It is also revealed that strip tillage (T_1) and irrigation at early stage and flowering stage (I_3) produced the highest seed yield (1700 kg/ha).

Response of sesame cultivars to different drainage provisions

The objective was to find out the effect of different drainage spacing's on sesame yield.

The experiment was carried out at BINA HQ, Mymensingh; BINA Sub-station, Magura; BINA Sub-station, Iswardi; and Farmer's field, Sathia, Pabna during the period from March 2020 to June 2020. The imposed drainage treatments were:T_1 = Control (normal flat land, no special drain); T_2= 200 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= 100 cm wide beds and 30 cm drain (10 cm depth) between the beds. The test varieties were:V_1 = Binatil-2, V_2 = Binatil-3 and V_3 = Binatil-4.The experimental design was RCBD, with 3 replications. The main plot size was 7 m $\times$ 5 m.The statistical analysis was performed using statistical software of IRRI, "STAR".The rainfall distribution during the experimental period (March to May 2020) is depictedin **Fig. 2.1**. A total of 457 mm rainfall was occurred specially at vegetative and flowering stages of sesame. In addition, a strong storm-hitduring the pod filling period.

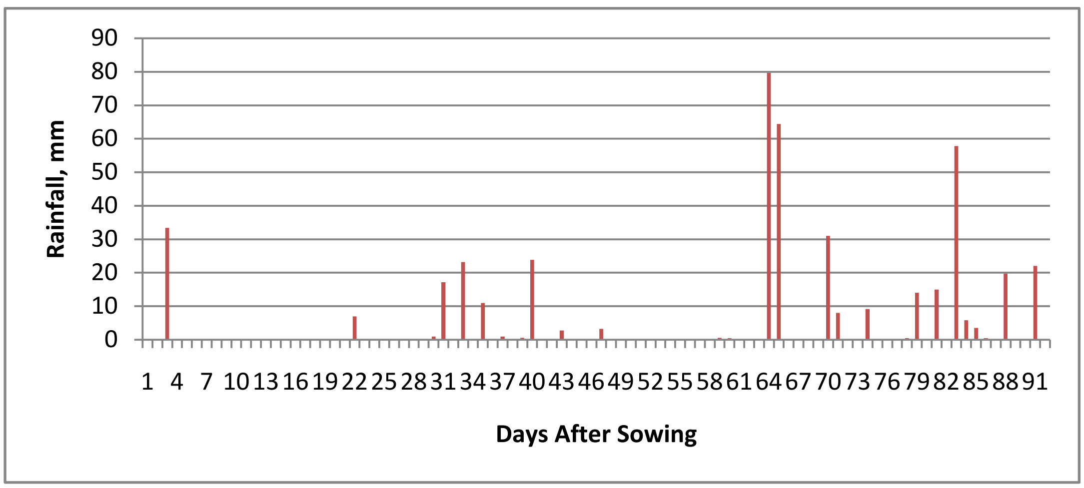


Fig. 2.1. Rainfall distribution during experiment period (March to May, 2020)

The mean effects of drainage treatments and cultivars on yield of sesame are summarized in Table 2.1. The drainage treatments demonstrated significant effect on seed yield. Among four locations, the highest average yield (1102kg/ha) was obtained in T_4 (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 (530kg/ha). The yield of treatment T4 and T3 are statistically similar except Magura.

The cultivars showed significant difference in seedyield at all locations except BINA Sub-station, Ishwardi. The cultivar V_3 (Binatil-4) produced the highest average yield (939kg/ha) followed by V_1 (Binatil-2) and V_2 (Binatil-3). Interaction effects of drainage treatments and cultivars on grain yield of sesame are shown in Table. 2.2. From interaction effects, V_1 (Binatil-2) produced the highest yield (573 kg/ha) followed byV_2 (Binatil-3). But in drainage treatment T_3 (150 cm bed) and T_4 (100 cm bed), Binatil-4 produced the height yield followed by Binatil-3 and Binatil-2.

Table 2.1. Mean effects of drainage treatments and cultivars on yield of sesame cultivars

Treatment	Grain yield (kg/ha)				
	Mymensingh	Magura	Iswardi	Sathia, Pabna	Average
T_1 (Flat land)	489 b	490 c	585 c	557 c	530 c
T_2 (200 cm bed)	914 a	987 b	995 b	912 b	952 b
T_3 (150 cm bed)	1099 a	915 b	1055 ab	1058 a	1032 ab
T_4 (100 cm bed)	1105 a	1089 a	1128 a	1089 a	1103 a
F-test at (5%)					
Cultivars					
V_1 (Binatil-2)	935.98 a	819 b	848	823 b	857
V_2 (Binatil-3)	968.47 a	845 b	949	902 ab	916
V_3 (Binatil-4)	800.78 b	945 a	1025	987 a	939
F-test at (5%)			NS		NS

Note: Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 2.2. Interaction effects of drainage treatments and cultivars on grain yield of sesame.

Treatment	Grain yield (kg/ha)				
	Mymensingh	Magura	Iswardi	Sathia, Pabna	Average
T_1V_1	586	525 a	602	581	573
T_1V_2	445	505 a	632	600	546
T_1V_3	437	440 a	520	491	472
T_2V_1	1011	896 b	805	784	874
T_2V_2	1014	960 b	1082	928	996
T_2V_3	718	1104 a	1097	1022	985
T_3V_1	1152	929 a	946	920	987
T_3V_2	1165	893 a	1039	1068	1041
T_3V_3	979	922 a	1181	1187	1067
T_4V_1	995	928 b	1040	1007	992
T_4V_2	1250	1025 b	1042	1012	1082
T_4V_3	1070	1315 a	1301	1247	1233
F-test at (5%)	NS		NS	NS	NS

Note: Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

The highest yield was obtained in 100 cm wide beds accompanied by 30 cm drain between the beds, followed by 150 cm spacing accompanied by 30 cm drain between the beds.

Effect of different chemicals/hormones for reducing shattering of Binadhan-14

Binadhan-14 is a good short duration and late transplanting potential rice variety. But in the normal transplanting time of Boro (15th January), shattering of grain is a problem. To reduce shattering an initiative is taken and based on the information of the farmers, an experiment has settled on the field.

The objective of the study was to reduce/minimize the shattering of Binadhan-14.

The experiment was conducted in the field (unit plot size: 3 m x 3 m and total area 225 m^2) at BINA HQ, Mymensingh. The scheduled treatments were: T_1 = Control (farmer's practice/ No chemical or hormone) ; T_2= ACI Flora (Nitro benzene) foliar spray (@44 DAT); T_3= Mamun Agro Grow (α 1, Napthyl Acetic Acid); T_4= ACI Bioferty (Gibrellinecytokynine); T_5= ACI Flora (Nitro benzene @44 DAT) + MamunAgro Grow (α 1, Napthyl Acetic Acid @52 DAT); T_6= ACI Flora (Nitro benzene) + ACI Bioferty (Gibrellinecytokynine); T_7= Mamun Agro Grow (α 1, Napthyl Acetic Acid) + ACI Bioferty (Gibrellinecytokynine);.

The cultivar was Binadhan-14. Three replicates were used. The design was RCBD, with split-plot. The seedlings were transplanted on 23 February 2020, and harvested on 1 June 2020. Data on number of effective and non effective seeds/panicle, effective panicle/hill were taken. For find out the number of seed dropped, the panicles of three hills were collected by two method: using poly bag covered and uncovered. The statistical analysis was performed using statistical software Staistix10 (version 10.0).

The mean effects of different chemical treatments on yield and yield attributing characters and shattering (dropping out) are summarized in Table 3.1 and Table 3.2. The treatments showed insignificant difference in all parameters. The maximum percentage of seed dropped from control plot (15.4 %) and lowest percentage of seed dropped from the plot of applied treatment T_5 (6.2%).The highest number of effective seed/ panicle (93.2) was produced in treatment T_5 and the lowest number in T_4 (73.9). The lowest amount of grain yield was obtained in control plot (4.15 t/ha) and the highest amount in treatment T_5 (4.68 t/ha).

Table 3.1. Mean effects of treatments yield attributing characters of Binadhan-14.

Treatments	No. of Dropped Seed	Seed drop (%)	Effective panicle/hill	Panicle Length (cm)	Effective seed/ panicle	Non-effective seed/ panicle
T_1	143.4	15.4	11.2	21.1	81.6	23.1
T_2	85.9	11.3	10.8	21.3	78.1	16.5
T_3	63.5	7.9	11.9	21.9	79.9	19.
T_4	65.2	8	11.5	21.7	73.9	19.2
T_5	68.1	6.2	11.9	22.3	93.2	13.1
T_6	67.2	7.4	10.7	21.8	85.1	15.5
T_7	88.5	8.4	12.9	22.2	90.5	23.1
F-test (at 5%)	NS	NS	NS	NS	NS	NS

Data Collection process						
C1 (covered)	96.9	11.3	11.4	21.9	82.1	19.9
C2 (uncovered)	69.3	7.1	11.7	21.7	84.2	17.1
F-test (at 5%)	NS	S	NS	NS	NS	NS

Significantly different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 3.2. Mean of grain yield at various treatments

Treatments	Yield (t/ha)
T_1	4.15
T_2	4.84
T_3	4.65
T_4	4.62
T_5	4.68
T_6	4.20
T_7	4.54

In case of seed dropping rate treatment T_5 (application of Nitro benzene & "α 1, Napthyl Acetic Acid") shows better result among the treatments and which also produced highest number of effective seed/ penicle and maximum yield (2^{nd} highest) for Bina dhan-14. Experiment can be conducted again to confirm the result.

Development of sesame cultivar tolerant to water-logging

Performance evaluation of M5 and M6 population of sesame under natural rainfall condition

The objective was to develop water-logged tolerant sesame cultivar

The growing season was March, 2020 – June, 2020. The growing environments were artificial water-logging in Lysimeter and pot, and under natural rainfall conditionin the field. Rainfall distribution during the growing season is depicted in Fig. 4.1. Characteristics of some mutants that are survived under different conditions are given in Table 4.1.

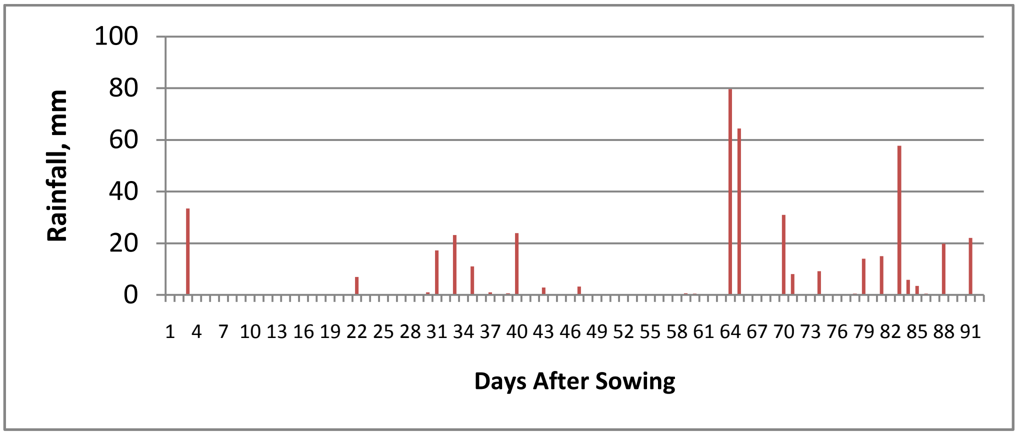


Fig. 4.1. Rainfall distribution during the growing season (March-May 2020)

Table 4.1. Main features of some harvested mutants under different conditions.

Mutant/Plant ID	Plant ht., cm	Branch/ plant	Days to maturity	Condition
K/C/450/P_1/M_5	**110-130**	**3-4**	**88-92**	Under natural rainfall with 200 cm bed and 30 cm drain between beds *[15nos under this category]*
K/C/450/P_2/M_5	110-130	2-3	90-95	
K/C/450/P_3/M_5	110-130	2-4	85-95	
K/C/600/P_1/M_5	110-130	2-4	85-92	
K/C/600/P_2/M_5	110-120	2-3	85-92	
K/C/600/P_3/M_5	**100-120**	**3-4**	**85-92**	
K/C/600/P_5/M_5	110-130	2-4	85-92	
K/C/700/P_1/M_5	90-100	2-4	85-90	
W/M/K/700/P_1/M_5	**90-100**	**3-4**	**85-90**	
W/M/K/700/P_2/M_5	**90-100**	**3-4**	**85-90**	
W/P/K/700/P_1/M_5	**80-100**	**3-4**	**85-90**	
D/K/S/450/P_1/M_5	100-130	4-5	100-110	
222M_2R_3/P_1	**90-100**	**2-4**	**85-90**	
Gopalganj-3	**90-100**	**4-5**	**82-90**	
Gopalganj (97)	**90-100**	**4-5**	**82-90**	
228M_2R_3/P_2	100-110	2-3	83-86	Under artificial water logging with control condition (pot) at flowering stage (about 48 hr) *[10 nos under this category]*
218M_2R_3/P_2	100-120	2-4	85-86	
239M_2R_3/P_3	**100-110**	**2-4**	**88**	
235M_2R_3/P_5	100-120	2-4	88	
234M_2R_3/P_2	100-110	2-3	88	
243M_2R_3/P_2	**100-120**	**2-3**	**88**	
221M_2R_3/P_2	100-120	2-3	88	
201M_2R_3/P_1	100-130	2-4	90-95	

$244M_2R_4/P_1$	100-130	2-4	90-95	
$W/M/K/700/P_2/M_5$	**80-90**	**2-3**	**85-88**	
$225M_2R_4/P_1$	**80-90**	**2-3**	**82-85**	Under natural rainfall and artificial water logging at field condition *[5 nos under this category]*
$243M_2R_4/P_4$	80-90	2-3	82-85	
$243M_2R_4/P_5$	**80-90**	**2-3**	**82-85**	
$242M_2R_3/P_1$	80-90	2-3	88-92	
$239M_2R_3/P_3$	**80-90**	**2-3**	**83-85**	

Note: Bold indicates more water-logged tolerant.

Fifteen 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.

Development of appropriate irrigation management strategy for increasing soybean yield in saline area

Irrigation management and chemical amendment for soybean cultivars under saline condition

The objectives of the study were to identify critical stage of soybean with respect to salinity and develop appropriate irrigation management practice for higher yield of soybean

The experiment was conducted in the farmer's field at Noakhali. The scheduled treatments were: T_1 = Control (farmer's practice/ no irrigation, no seed priming) ;T_2 = Sodium Silicate application (Si 10 kg/ha) as basal dose+ One irrigation at early(20-22 DAS) ; T_3 = One irrigation *at early stage* + one irrigation at *flowering stage;* T_4 = S*eed priming (12 hrs soaking in water, and then drying for 6 hrs)* + 30% excess Gypsum at basal dose + One irrigation *at vegetative stage*(45 DAS) + 30% excess Gypsum.; T_5 = One irrigation *at early stage* + 30% excess Gypsum+ one irrigation at *flowering stage* + Sodium Silicate application (Si 10 kg/ha).; T_6 = 30% excess Gypsum as basal dose + One irrigation *at early stage* + Sodium Silicate application (Si 10 kg/ha at 20-22 DAS)+ One irrigation at *flowering stage* + 30% excess Gypsum.The varieties were, V_1 = Binasoybean-3; V_2 = Binasoybean-4; V_3 = Binasoybean-5; V4 = BARI Soybean 6 (as Check). Three replicates were used. The main plot size was 8 m × 3 m. The design was RCBD, with split-plot. The seeds were sown on 30thJanuary 2020, and harvested on 12th May 2020. 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.The statistical analyses were performed using statistical software of "Statistix10" (version 10.0).

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 5.1.The treatments showed significant difference in all yield attributing characters except plant height, branch/ plant and grain yield. Cultivars showed insignificant difference for all cases.

Table 5.1. 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	Seed/pod	Grain yield (t/ha)
T_1	60.7	4.9	46.0 ab	2.7ab	2.66
T_2	68.4	5.6	58.2 ab	3.1 a	2.81
T_3	72.3	4.5	44.5 ab	2.9ab	2.76
T_4	71.3	4.9	70.4 a	2.6ab	2.86
T_5	68.9	4.1	54.2 ab	2.5b	2.79
T_6	70.9	4.1	40.3 b	2.7ab	2.70
F-test (at 5%)	NS	NS	S	**S**	NS
Cultivars					
V_1	74.0	5.2	50.1	2.7	2.62
V_2	68.3	5.3	64.2	2.8	2.81
V_3	62.6	4.2	51.7	2.7	2.76
V_4	70.2	4.1	43.1	2.7	2.69
F-test (at 5%)	NS	NS	NS	NS	NS

Note: Significantly different at 5% probability level by Tukey's Honest Significant Difference (THSD) test.

S*eed priming (12 hrs soaking in water, and then drying for 6 hrs)* + 30% excess Gypsum at basal dose (in addition to recommended dose) + One irrigation *at vegetative stage*(45 DAS) + 30% excess Gypsum (in addition to recommended dose) produced the highest seed yield under the prevailing climatic condition (having rainfall at vegetative). Application of Sodium Silicate (Si 10kg/ha at as basal dose) and one irrigation at early stage also found better yield. To confirm the result, the experiment will be repeated in the next year.

Development of appropriate irrigation management strategy for increasing rice yield in saline area

Effects of Irrigation Management and amendments in Boro rice under Saline condition (Field study, Satkhira)

The objective of the experiment was to identify appropriate irrigation and other management practices for higher yield in saline area

The experiment was carried out at farmer's field Asasuni and Haruddar. The test variety was Binadhan-10. Recommended dose of fertilizers 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 treatments were:T_1= 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)] [*Control-1, Agron. Div. Recommendation*]; T_2= Continuous saturation (0-3 cm) + 68 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering) + No Si + No ridge (normal/Recom. density) [*Control-2, AED Recom (earlier)*]; T_3= Continuous ponding (3-5 cm) +

150 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering) + 10 kg/ha Si (basal)+ addition of PK (25%) at booting + No ridge (high density, 10x10 cm)+ Washout (change standing water) at 20 days interval; and T_4= Continuous ponding (3-5 cm) + 99 kg/ha Gypsum (2/3rd basal, 1/3rd at booting/flowering) + 10 kg/ha Si (basal)+ addition of PK (25%) at booting+ Organic Matter + No ridge (high density, 10x10 cm)+ Washout (change standing water) at 20 days interval.

*Washout" of salt by irrigation at 20 days interval (or, when soil salinity exceeds 10 dS/m)

The seedlings were transplanted on 22Jan. 2020 at Asasuni and 23 Jan. 2020 at Haruddar. After establishment, treatments were followed.

Monthly averages of the daily weather parameters during the Boro rice-growing period (December to May) of 2019–20, were calculated and presented in **Table 6.1.**The monthly average maximum temperature during December 2019 to May 2020 varied from 21.67°C to 35.04°C and minimum temperature varied from 13.25°C to 24.89°C. The monthly average relative humidity during that period varied from 71.57% to 83.04% and monthly total rainfall varied from 6 mm to 320.2 mm during the rice-growing season.The monthly average highest temperature was 35.04°C in May and lowest temperature was 13.25°C in December.

Table 6.1: Monthly average daily weather parameters of Satkhiraduring *Boro* rice-growing period (December to May) during 2019–20

Year	Month	Monthly average maximum temperature (°C)	Monthly average minimum temperature (°C)	Monthly average temperature (°C)	Monthly Average relative humidity (%)	Monthly total rainfall (mm)
(2019–20)	December	21.67	13.25	16.96	83.04	6.00
	January	24.26	15.13	19.07	80.57	34.20
	February	27.15	16.93	21.53	72.21	0.40
	March	33.11	21.40	26.48	71.57	62.00
	April	34.72	24.10	28.59	78.90	24.40
	May	35.04	24.89	29.20	82.57	302.20

A: Asasuni, Satkhira

The mean effects of treatments on yield and yield attributing characters of Binadhan-10 at Asasuni are summarized in Table 6.2. The treatments showed insignificant difference in plant height, tiller per plant, panicle length and seed per panicle. On the other hand, the treatments showed significant difference on grain yield. The highest yield (6.13 t/ha) was obtained in treatment T4.

Table 6.2. Mean effects of Irrigation Management and amendments on yield and yield attributing characters at Asasuni, Satkhira

Treatment	Plant height (cm)	Tiller/ plant, (Nos.)	Panicle Length (cm)	seed/panicle (Filled grain) (Nos.)	Grain yield (t/ha)
T_1	106	9	25	133	5.80 ab
T_2	109	9	24	123	5.06 c
T_3	104	8	24	108	6.13 a
T_4	104	7	24	112	5.45 b
F-test at (5%)	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.

B: Haruddar, Satkhira

The mean effects of treatments on yield and yield attributing characters of Binadhan-10 (Boro rice) at Haruddar are summarized in Table 6.3. The treatments showed insignificant difference in all the parameter except tiller per plant. The highest yield (5.35 t/ha) was obtained in treatment T2.

Table 6.3. Mean effects of Irrigation Management and amendments on yield and yield attributing characters of Binadhan-10 under Saline condition at Haruddar, Satkhira.

Treatment	Plant height (cm)	Tiller/ plant, (Nos.)	Panicle Length (cm)	Seed/panicle (Filled grain) (Nos.)	Grain yield (t/ha)
T_1	93	9 ab	25	95	4.57
T_2	96	7 b	25	100	5.35
T_3	88	9 ab	25	102	5.05
T_4	96	10 a	24	96	4.66
F-test at (5%)	NS	S	NS	NS	NS

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.

From average grain yieldof two locations, it is found that treatment $T_3$was the best among the treatments.The experiment will be repeated in the coming year.

Evaluation of amendment practices to ameliorate saline water irrigation effect on salt tolerant *boro* rice cultivarin Lysimeter condition.

The experiment was conducted to evaluate effectiveness of some amendment practices for ameliorating salinity effect on salt-tolerant HYV rice cultivar **Binadhan-10**and to find out scope for using saline water for irrigation under amendment practices for *Boro* rice cultivationin Lysimeter condition.

The experiment was set at raised-bed Lysimeter containing 18 box of each 1.2 m^2 at Satkhira substation in RCBD design with three replications during the period from January 2020 to May 2020.The seedlings were transplanted on 22 January 2020 with recommended dose for Binadhan-10 is Urea, TSP, MoP, Gypsum, and Zinc @ 217, 110, 70, 45, and 4.5 $kgha^{-1}$. The treatments of the amendment were – T_1: Continuous ponding with 10 dS m^{-1}saline water, T_2: Irrigation with 10 dS m^{-1}saline water after 5 days interval (5cm to saturation) + Gypsum fertilizer @150 kg ha^{-1} as amendment (2/3rdat basal dose, 1/3rd at 30 – 45 DAT), T_3: Irrigation with 10 dS m^{-1} saline water + Gypsum fertilizer @150 kg ha^{-1}+ use of fresh water during the period of flowering stage (60 to 80) DAT, T_4: Irrigation with 10 dSm^{-1}saline water + organic fertilizer @ 750 kg ha^{-1}(2/3rd basal, 1/3rd at 30 – 45 DAT),T_5: Irrigation with 10 dS m^{-1} saline water + organic fertilizer @ 750 kg ha^{-1}+ use available fresh water during the period of flowering,T_6: Irrigation with 10 dS m^{-1}saline water + organic fertilizer @ 750 kg ha^{-1} + use of fresh water during the period of flowering+ Gypsum fertilizer @150 kg ha^{-1}. Fresh water irrigation was applied at most critical periods of rice seedlings to ensure good establishment of the crop: at transplanting period (0 - 10 DAT). Available Kaji organic fertilizer were tested as organic amendment. The weather data of the study periods were collected from the BINA substation satkhira“HOBO® U30-NRC Weather Station” beside the experimental premise**.**

Monthly averages of the daily weather parameters during the Boro rice-growing period (December to May) of 2019–20, were calculated and presented in **Table 7.1.**The monthly average maximum temperature during December 2019 to May 2020 varied from 21.67°C to 35.04°C and minimum temperature varied from 13.25°C to 24.89°C. The monthly average relative humidity during that period varied from 71.57% to 83.04% and monthly total rainfall varied from 6 mm to 320.2 mm during the rice-growing season.The monthly average highest temperature was 35.04°C in May and lowest temperature was 13.25°C in December.

Table 7.1.Monthly average weather parameters of Satkhiraduring *Boro* rice-growing period (December to May) during 2019–20

Year	Month	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Average relative humidity (%)	Monthly total rainfall (mm)
(2019–20)	December	21.67	13.25	16.96	83.04	6.00
	January	24.26	15.13	19.07	80.57	34.20
	February	27.15	16.93	21.53	72.21	0.40
	March	33.11	21.40	26.48	71.57	62.00
	April	34.72	24.10	28.59	78.90	24.40

May	35.04	24.89	29.20	82.57	302.20

The amendments exerted significant impacts on the growth and yield attributes, yields and harvest index of *boro* rice cultivars(**Table: 7.2**). The treatmentsT_3andT_6 reduced salinity stress and improved the growth and yield attributes and yield of rice. This treatment provided increased number of grains per panicle, total tillers per hill, and improved panicle length, 1000-grain weight, grain yield, straw yield androot-biomass yield. Treatment T_6 provided the largest straw yield per hill, longest panicle length, tallest plant and largest harvest index.The amendment treatments T_3 and T_6produced significantly ($p \leq 0.05$) higher total tillers and significantly improved the number of grains in the panicles than the treatments $T_{2,}$ $T_{4,}$ T_5 and T_1 under high salinity of irrigation water.The chemical fertilizer with amendment T_3 and combination of chemical and organic amendments (T_6) reduced harmful effects of salinity and improved grain yield significantly under saline condition compared to the other treatments.

Table 7.2. Growth and yield attributes, yield and harvest index of salt-tolerant *boro*ricecultivaras affected by amendment treatments

treatments	Plant height (cm)	Total tillers per hill (no)	Panicle length (cm)	Fill grains (no)	Thousand grain weight (g)	Grain yield per hill (g)	Straw yield per hill (g)	Harvest index (%)	Root-biomass yield (g)
T_1	104.3b	12.4d	23.0e	103.9d	26.2c	28.2d	30.1b	48.3c	28.9c
T_2	112.8a	14.5c	25.9bc	117.7c	26.9b	38.1c	32.9a	53.6b	34.4b
T_3	112.3a	16.9ab	26.5b	129.1ab	27.2b	49.4ab	33.5a	59.4a	34.7b
T_4	115.1a	15.1bc	25.3d	115.6c	26.9b	39.1c	33.3a	53.9b	34.9b
T_5	115.7a	16.7ab	25.5cd	120.1bc	27.0b	45.3bc	33.4a	57.5ab	34.9b
T_6	116.4a	18.1a	27.1a	134.4a	27.7a	55.9a	34.9a	61.6a	36.6a
$HSD_{0.05}$	4.585	2.001	0.476	9.817	0.37	7.578	2.077	4.628	1.434

Note: Common letter(s) analyzed by Statix-10 within the same column do not differ significantly at 5% level of significance ($p \leq 0.05$).

All the treatments in most cases, significantly improved straw yield compared to T_1. Treatments T_1 (control) produced lower root-biomass, but T_6produced significantly higher quantity of root-biomassunder saline-water irrigation. Among the amendment treatments, the treatments T_3 and T_6gave the highest harvest index but they did not vary significantly which was also followed by treatment $T_{5.}$

Amendment with chemical fertilizer or combination of chemicalfertilizerand organic amendments minimized the detrimental effects of irrigation–water salinity and improved grain yield of*boro* rice.Use of fresh water at critical growth stages and saline water at all other growth stages with effective amendment practice can maximize production of *boro* rice Binadhan-10upto 35%.

Groundwater resources management for sustainable crop production in northwest hydrological region of bangladesh (natp-2 funded project)

Determination of aquifer hydraulic properties (by pumping test)

The objective was to generate information on aquifer hydraulic properties for safe groundwater withdrawal rate.

Pumping test was done at NacholUpazila of Chapai Nawabganj district following standard procedure e.g. time-drawdown, distance- drawdown, recovery data.
Two observation wells were installed in line at about 300 ft and 470 ftfrom 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 water flow-meter installed at about 3.5 m from the source.

Distance-drawdown
The water level, and hence drawdown at both pumping well and observation wells (1^{st}& 2^{nd}) was measured at fixed scheduled times.

Time- drawdown
The water level at the observation wells were monitored at different scheduled time intervals.

Recovery data recording
Once the pumping had stopped(after steady-state condition had been reached), 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

Fig.8.1. Pictorial view of installing observation well

Fig. 8.2. Pictorial view of setting water flow meter for discharge measurement

The pictorial views are presented in Fig. 8.1 and Fig. 8.2. The static water level in the observation well was found as 32.46 m (106.5 ft).The time-drawdown and recover graph are presented in Fig. 8.3and Fig. 8.4.

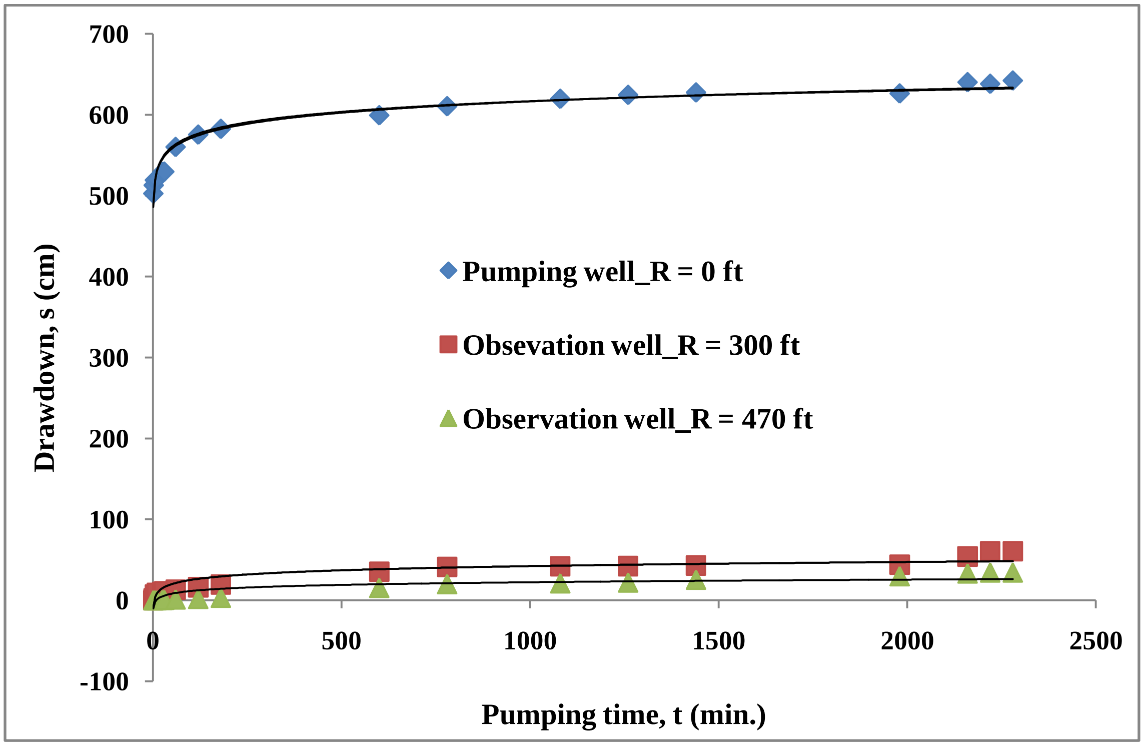


Fig. 8.3. Pattern of drawdown during the course of pumping

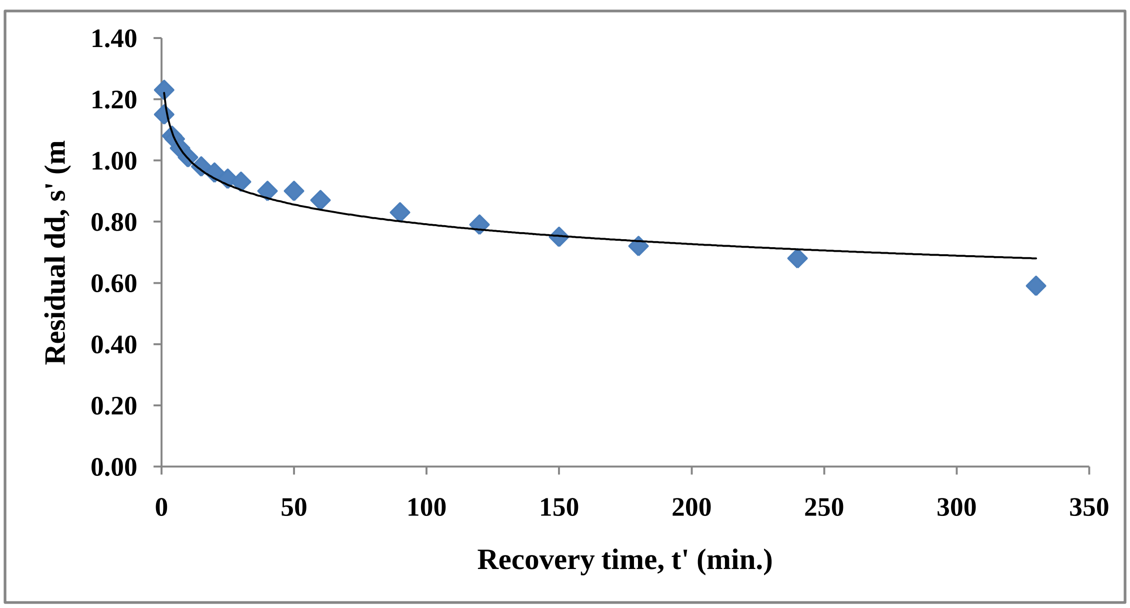


Fig. 8.4. Pattern of residual drawdown during recovery period

Table 8.1.Fineness Modulus (F.M.), Effective size (D_{10}& D_{60}) and Uniformity Coefficient (C_u) of aquifer materials of different depth.

Depth (ft)	Fineness Modulus (FM)	Effective Size (mm)		Uniformity Coefficient (C_u)	Remarks
		D_{10}	D_{60}		
0-80	-	-	-	-	Clay loam soil
90	2.93	0.24	0.45	1.88	Uniform materials/poor grading
100	2.83	0.24	0.47	1.96	Uniform materials/poor grading
110	2.68	0.21	0.43	2.05	Well graded materials
120	2.82	0.18	0.46	2.56	Well graded materials
130	2.63	0.22	0.47	2.14	Well graded materials
140	2.55	0.22	0.46	2.09	Well graded materials
150	2.54	0.21	0.42	2.00	Well graded materials
160	2.99	0.22	0.58	2.64	Well graded materials
170	2.43	0.23	0.42	1.83	Uniform materials/poor grading
180	2.61	0.27	0.45	1.67	Uniform materials/poor grading
190	-	-	-	-	Clay layer

Table 8.2. Different method-wise hydraulic conductivity (K), Transmissibility (T) and Specific Yield (S_y) of aquifer.

SI. No.	Method/Procedure	Hydraulic conductivity, K (m/day)	Transmissibility, T (m^2/day)	Specific Yield, S_y
1	Dupit's Steady State Radial Flow (Dupit 1863, later modified by Thiem 1906)	21.18	529.38	-
2	From Jacob's method (Distance dd) using following formula: T = 2.3*Q/(2*π*Δs') and then K = T/H ; Sy = 2.25*T*t/Ro	12.78	319.57	0.03
3	From Jacob's method (Time - dd) using following formula: T = 2.3*Q/(2*π*Δs') and then K = T/H ; Sy = 2.25*T*t/r2	25.83	645.72	0.0004
Average value (arithmetic)		19.93	498.22	0.016
Geometric mean		19.10	478.00	0.004

Fineness Modulus, Effective size (D_{10} & D_{60}) and Uniformity Coefficient (C_u) of aquifer materials of different depth are presented in Table 8.1. Fineness Modulus of aquifer materials (depth wise) ranged from 2.43 to 2.93. Coefficient of Uniformity (C_u) is greater than two (110 ft to 160 ft), which indicate well graded materials. Different method-wise hydraulic conductivity (K), Transmissibility (T) and Specific Yield (S_y) of the aquifer are presented in Table 8.2. Arithmetic mean of hydraulic conductivity (K) and Transmissibility (T) of aquifer were found 19.93 m/day and 498.22 m^2/day, respectively. The Specific Yield (S_y) of aquifer ranges from 0.03 to 0.0004.

Fineness Modulus of aquifer materials (depth wise) ranged from 2.43 to 2.93.Coefficient of Uniformity (C_u) is greater than two (110 ft to 160 ft), which indicate well graded materials. Arithmetic mean of hydraulic conductivity (K) and Transmissibility (T) of aquifer were found respectively, 19.93 m/day and 498.22 m^2/day. The Specific Yield (S_y) of the aquifer material ranges from 0.0004 to 0.03.

Studies on water quality for assessing irrigation and drinking suitability

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). Samples were collected from 50 DTWs covering the major irrigated area of Nachol and NiamatpurUpazila (Figure 9.1). Analyses were performed by Multi-parameter Photometer for anions and cations. Interpretation was made comparing with national (DPHE) /WHO/FAO guidelines.

Figure 9.1. 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 9.1. All parameters are within acceptable limit for drinking according to Bangladesh standards & WHO Guide Lines. Parameters are also within acceptabale limit for irrigation according to the Envornmental Studies Board,Water Quality Crieteria 1972, FAO.

The groundwater at the study areas are safe for drinking and irrigation according to national and FAO/WHO standards.

Table 9.1. Quality parameters of water collected from different DTWs.

Sample no.	pH	Ec ds/m	Fe (ug/L)	Total Cl(mg/L)	Mg (mg/L)	NO3 (mg/L)	TDS(ppm)	PO4 (mg/L)	Zn (mg/L)	SO4 (mg/L)	Na (ppm)	Cr (ug/L)	Mn (ug/L)	Ca(mg/L)	Ag (mg/L)	Al (mg/L)	K (mg/L)	Ni (mg/L)	Cu (mg/L)	Mo (mg/L)	Br(mg/L)
1	7.2	0.735	61	0.09	20	1.3	367	0.46	0	20	32.64	0	0	0	0	0	42	0	0	0.2	0.23
2	7.1	0.467	47	0.12	10	5.7	240	0	0	3	17.85	4	0	0	0	0	20	0	0.02	0	0.1
3	7.1	0.387	91	0	10	3.2	195	0.28	0.08	0	13.26	0	0	0	0	0	30	0	0	0.2	0.06
4	7.0	0.458	81	0.06	15	1.5	231	0.34	0	10	17.6	0	0	0	0	0	34	0	0	0.2	0.18
5	7.0	0.448	97	0.01	20	3.8	224	0.24	0	5		0	0	0	0	0	20	0	3	0.1	0.05
6	7.2	0.644	120	0	25	0.5	321	0.13	0.04	10		0	0	0	0	0	34	0	0	0	0.03
7	7.1	0.475	70	0	25	0.3	234	0.7	0	5		0	0	0	0	0	20	0	0.19	0.2	0
8	7.2	0.501	324	0.03	10	0	251	1.07	0	10		0	0	0	0	0	16	0	0	0	0
9	7.2	0.389	181	0.02	20	0.04	195	0.67	0	5		12	0	0	0	0	24	0	0	0	0.01
10	7.1	0.337	115	0	15	0	169	0.37	0.04	15	14.24	0	0	0	0	0	16	0	0.05	0	0
11	7.1	0.567	75	0.02	10	0.1	286	0.65	0.1	5		0	0	0	0	0	22	0	0.02	0	0
12	7.1	0.357	106	0.02	5	0	177	0.91	0.1	15	14.03	7	0	0	0	0	10	0	0.3	0	0.07
13	7.0	0.371	75	0.04	5	0.8	186	0.94	0.05	5		30	0	0	0	0	20	0	0.06	0.2	0.45
14	7.2	0.453	50	0.05	15	0	229	1	0	10		0	0	0	0	0	20	0	0.04	0.1	0.1
15	7.2	0.394	32	0	10	0	197	1.23	0.01	5		0	0	0	0	0	38	0	0	0.1	0
16	7.1	0.446	84	0.04	20	0	223	0.56	0.01	10	21.17	1	0	0	0	0	36	0	0	0	0
17	7.1	0.392	137	0.01	30	0.4	195	0.21	0.05	5	25.5	1	0	0	0	0	16	0	0.04	0	0.36
18	7.1	0.553	54	0.02	25	11.8	279	0.07	0.11	5		10	0	0	0	0	16	0	0.04	0.1	0.02
19	7.1	0.52	43	0.11	20	0	260	0.12	0.01	0		8	0	0	0	0	18	0	0	0.2	0

Sample no.	pH	Ec ds/m	Fe (ug/L)	Total Cl(mg/L)	Mg (mg/L)	NO3 (mg/L)	TDS(ppm)	PO4 (mg/L)	Zn (mg/L)	SO4 (mg/L)	Na (ppm)	Cr (ug/L)	Mn (ug/L)	Ca(mg/L)	Ag (mg/L)	Al (mg/L)	K (mg/L)	Ni (mg/L)	Cu (mg/L)	Mo (mg/L)	Br(mg/L)
20	7.1	0.441	10	0	30	0	220	0.13	0	5		0	0	0	0	0	14	0	0.02	0	0.01
21	7.2	0.529	56	0.03	20	0	263	0.12	0	5	15.3	0	0	0	0	0	24	0	0	0	0
22	7.2	0.428	44	0.05	15	0.3	201	0.36	0	10		0	0	0	0	0	16	0	0.09	0.1	0
23	7.1	0.495	30	0.08	35	0	250	0.14	0.04	5		0	0	0	0	0	18	0	0.1	0.2	0.18
24	0.0	0	69	0	15	1	0	0.46	0	20		22	0	0	0	0	42	0	0.01	0.2	0
25	7.1	0.528	46	0.02	15	0	265	0.39	0.06	15	20.91	0	0	0	0	0	20	0	0.03	0	0.01
26	7.0	0.266	227	0.08	35	0	195	0.3	0	10	15.56	0	0	0	0	0	18	0	0.05	0	0.01
27	7.2	0.464	107	0	35	1.3	545	0.08	0.07	5		8	0	0	.005	0	20	0	0.03	0	0
28	7.1	0.455	216	0	15	6.4	528	0.28	0.03	10		0	0	0	0.02	0	14	0	0.03	0.2	0.14
29	7.2	0.408	176	0	15	2	536	0.5	0.03	5	13.77	0	0	0	0	0	24	0	0	0.1	0.06
30	7.2	0.43	252	0.02	25	0	489	0.28	0.04	0		0	0	0	0	0	22	0	0.05	0.1	0
31	7.4	0.48	75	0	50	0	513	1.19	0.03	5		0	0	0	0	0	18	0	0	0	0.04
32	7.3	0.449	47	0.02	40	14.8	568	0.18	0.03	0	21.42	6	0	0	0	0	14	0	0.03	0.1	0
33	6.6	0.524	23	0.05	10	3.9	669	0.48	0.09	5		18	0	0	0	0	24	0	0	0.2	0.1
34	7.0	0.987	60	0	25	4.4	688	0.53	0	5		0	0	0	0	0	20	0	0	0.2	0.15
35	6.8	0.912	51	0	25	0	455	0.18	0	5	13.77	23	0	0	0	0	20	0	0	0	0.18
36	6.8	0.916	53	0	10	3.1	442	1.12	0	5		0	0	0	0	0	32	0	0.04	0.1	0
37	6.9	0.418	38	0.02	25	0	524	1.37	0	0		0	0	0	0	0	18	0	0.12	0	0.32
38	6.9	0.789	41	0	20	4.6	408	0.78	0.03	5	14.03	0	0	0	0	0	26	0	0.07	0.2	0.02
39	6.8	0.409	18	0	25	0	529	0.89	0	5		16	0	0	0	0	30	0	0.15	0.2	0

Sample no.	pH	Ec ds/m	Fe (ug/L)	Total Cl(mg/L)	Mg (mg/L)	NO3 (mg/L)	TDS(ppm)	PO4 (mg/L)	Zn (mg/L)	SO4 (mg/L)	Na (ppm)	Cr (ug/L)	Mn (ug/L)	Ca(mg/L)	Ag (mg/L)	Al (mg/L)	K (mg/L)	Ni (mg/L)	Cu (mg/L)	Mo (mg/L)	Br(mg/L)
40	6.9	0.9	138	0.08	5	0	461	0.89	0.01	10	15.3	0	0	0	0	0	26	0	0	0	0.09
41	6.8	0.398	31	0	10	0	481	1.19	0	0		2	0	0	0	0	18	0	0	0.1	0
42	6.8	0.414	97	0.05	25	3.9	524	0.83	0	5	15.3	0	0	0	0	0	20	0	0.09	0	0.06
43	7.1	0.909	49	0.05	20	0	437	0.53	0.08	0		0	0	0	0	0	22	0	0	0.1	0
44	6.9	0.398	38	0	5	0	503	1.31	0.08	10		8	0	0	0	0	20	0	0	0	0
45	6.9	0.32	85	0.02	10	30	482	1.02	0	25	16.83	10	0	0	0	0	20	0	0	0.1	0
46	7.0	0.392	156	0.07	30	0	470	1.15	0	0	10.46	51	0	0	0.0185	0	22	0	0	0	0.02
47	7.0	0.702	400	0.01	10	0.9	341	1.27	0	5		0	0	0	0	0	20	0	0.06	0.2	0
48	6.9	0.716	400	0	15	0	343	0.45	0	0	8.42	0	0	0	0	0	32	0	0.04	0	0
49	6.9	0.884	285	0	20	2.2	423	0.18	0.04	10		0	0	0	0.085	0	22	0	0.01	0	0
50	6.9	0.418	169	0.03	10	2.3	206	0.34	0.1	0		0	0	0	0	0	28	0	0	0.1	0
Envornmental Studies Board permis. Limit for irrigation	6.0-8.5	1.2	5					15	2			0.1	0.2			5		0.2	0.2		
GOB permis. Limit for drinking		0.6-1	300-1000	150-600	30-35	10	1000	6	5	400	200		0.1	75	.02	0.2	12	0.1	1		
WHO permis. Limit for drinking	6.5-8.5	-	-	-	-	50 as N	-		-	-	-		-	-	-	-	-	.02 (p)	2		

Cropping pattern study for identifying water-saving pattern

To identifying water-saving and economic cropping pattern

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 10.1.

Table 10.1. Description of the selected sites in location wise

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		
5	Nijampur	Nachol		

Existing major cropping patterns and new interventions

The existing cropping patterns of the sites are presented in Table 10.2. From the survey data, it is revealed that the major cropping patterns practiced by the farmers are: **T.Aman-Boro-Fallow(Pattern-5)**

Table 10.2 Major cropping patterns at the study sites

Sl No.	**Cropping Pattern**	**Percentage**
1	**T. Aman-Boro-Fallow**	**51**
2	T. Aman- Wheat-Fallow	19
3	T. Aman-Mustard-Boro	8
4	T. Aman-Lent-Fallow	8
5	T. Aman-Mustard-Fallow	8
6	T. Aman-Lent-Boro	3
7	T. Aman-pea-Fallow	2
8	T. 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 T. Aman varieties, drought tolerant broadcast Aus varieties) were included in the system to find out an economic and water-efficient cropping pattern based on the available resources. The following cropping patterns were selected for trial in the area (**Table10.2**).

Table 10.2 Details of cropping pattern selected for intervention

Major crops for pattern	Cropping sequence	Pattern No.
	Aus- T. Aman – Rabi (Mustard)	Pattern-1
Aus based	Aus - T. Aman – Rabi (Lentil)	Pattern-2
	Aus–T. Aman – Rabi (Wheat)	Pattern-3
Boro based	Boro - T. Aman – Rabi (Mustard)	Pattern-4
Boro based	Boro - T. Aman –Fallow	Pattern-5 *(control)*

Experimental details

The best treatment obtained in the first year for a particular crop, was used in the second year for that crop.

Field trial with new cropping pattern- Aus season

Varieties: (i) Binadhan-21 and (ii) BRRI dhan48 at Nachol and Binadhan-19 at Niamatpur

Irrigation management: 20 cm height levee around the plot, and supplemental irrigation if ASM drops below 85%

Aman season

Irrigation management: 20 cm height levee around the plot, and supplemental irrigation during booting to soft-dough, if ASM drops below 85%

Cultivars were:
At Nachol: (i) Binadhan-7, (ii) Binadhan-11 and (iii) Binadhan-22
At Niamatpur: (i) Binadhan-7, Binadhan-11, Binadhan-22 and (ii) BRRI dhan71 and BRRI Dhan75

Boro season

Irrigation management: 3 days AWD (5 cm ponding)

AWD = Alternate wetting and drying
“3 days AWD” means ‘drying of the land for 3 days after disappearance of ponded (5 cm) water’

Varieties were: (i) Binadhan-14 and (iii) Banglajira (Local)

Rabi Season - Mustard

Irrigation management: Irrigation at early (15-17 DAS) and vegetative stage (28-30 DAS)
The cultivars were Binasharisa-9 and Binasarisa-10.
Rabi Season - Lentil

Irrigation management: No irrigation (only the use of profile soil moisture)
Cultivar: Binamusor-8

Rabi Season- Wheat

Irrigation management: Three irrigations (at CRI, vegetative, booting-heading stage)
During second year, only 2 irrigations were required (due to rainfall).
Cultivar: BARI Gom 26

A: Benefit-Cost ratio Analysis (Nachol, Chapai Nawabganj)

Benefit-cost ratio was analyzed using full production cost. For each pattern, the crops other than rice were transformed to equivalent rice. The BCR was calculated for each pattern **(Table 10.3 and Table 10.4).**

Table 10.3. Cropping pattern wise rice-equivalent yield, no. of irrigation required, irrigation amount, irrigation saving, net income and BCR at Nachol, Chapai Nawabganj [Based on Control].

Cropping Pattern	Rice-equivalent yield (t/ha)	No. of irrigation required	Irri. Amount, cm (seasonal total)	Net Income (Tk/ha)	BCR	% Irrigation Saving	% Yield Increased
Pattern-1 (T.Aman-Mustard-T.Aus)	**15.27**	9.5	51	97163	**1.49**	**53**	**29**
Pattern-2 (T.Aman-Lentil-T.Aus)	14.18	8.5	46	85244	1.45	58	20
Pattern-3 (T.Aman-Wheat-T.Aus	13.22	11.5	61	75444	1.4	44	12
Pattern-4 (T.Aman-Mustard-Boro)	**16.43**	15.5	84	108521	**1.52**	**23**	**39**
Pattern-5 (T.Aman-Fallow-Boro) [Control]	11.8	20	109	63290	1.38	**-**	**-**

Table 10.4.Cropping pattern wise rice-equivalent yield, no. of irrigation required, irrigation amount, irrigation saving, net income and BCR at Nachol, Chapai Nawabganj [Based on Best one].

Cropping Pattern	Rice-equivalent yield (t/ha)	No. of irrigation required	Irri. Amount, cm (seasonal total)	Net Income (Tk/ha)	BCR	% Irrigation Saving	% Yield Reduction
Pattern-1 (T.Aman-Mustard-T.Aus)	**15.27**	9.5	51	97163	**1.49**	**39**	**7**
Pattern-2 (T.Aman-Lentil-T.Aus)	14.18	8.5	46	85244	1.45	45	14
Pattern-3 (T.Aman-Wheat-T.Aus	13.22	11.5	61	75444	1.4	27	20
Pattern-4 (T.Aman-Mustard-Boro)	**16.43**	15.5	84	108521	**1.52**	**-**	**-**
Pattern-5 (T.Aman-Fallow-Boro) [Control]	11.8	20	109	63290	1.38	30*	28

Note.
* indicate not savings because of locally cultivated long duration Aman and Boro Rice.

Cropping pattern wise rice-equivalent yield, no. of irrigation required, amount of irrigation, irrigation saving, net income and BCR are presented in **Table 10.4.**All the introduced cropping patterns yielded higher REY with reduced water compared to existing cropping pattern, P-5(T. Aman- Fallow-Boro). The higher cost benefit ratio (BCR) indicated the superiority of the proposed patterns over the existing pattern. The pattern P-4 (T. Aman-Mustard-Boro) with AWD in Boro, yielded the highest REY (as well as net profit) with 84 cm irrigation water in whole season. The pattern P-1 (T. Aman-Mustard-T.Aus) yielded the 2nd highest REY (as well as net profit) with 39% irrigation water savings compare to P-4 (T. Aman-Mustard-Boro); but sacrificing 7% yield.

B: Benefit-Cost ratio Analysis (Niamatpur, Noagoan)

Benefit-cost ratio was analyzed with whole production cost. For each pattern, the crops other than rice were transformed to equivalent rice. The BCR was calculated for each pattern **(Table 10.5 and Table 10.6)**

Table 10.5.Cropping pattern wise rice-equivalent yield, no. of irrigation required, irrigation amount, irrigation saving, net income and BCR at Niamatpur, Noagoan[Based on Control].

Cropping Pattern	Rice-equivalent yield (t/ha)	No. of irrigation required	Irri. Amount, cm (seasonal total)	Net Income (Tk/ha)	BCR	% Irrigation Saving	% Yield Increased
Pattern-1 (T.Aman-Mustard-T.Aus)	14.49	8.5	46	85135	1.43	**53**	**24**
Pattern-2 (T.Aman-Lentil-T.Aus)	**14.7**	7.5	41	96566	1.51	**58**	**26**
Pattern-3 (T.Aman-Wheat-T.Aus	13.34	10	53	79391	1.42	**46**	**14**
Pattern-4 (T.Aman-Mustard-Boro)	**16.14**	14.5	78	104472	**1.51**	**20**	**38**
Pattern-5 (T.Aman-Fallow-Boro) [Control]	11.67	18	98	63025	1.38	**-**	**-**

Table 10.6.Cropping pattern wise rice-equivalent yield, no. of irrigation required, irrigation amount, irrigation saving, net income and BCR at Niamatpur, Noagoan[Based on Best one].

Cropping Pattern	Rice-equivalent yield (t/ha)	No. of irrigation required	Irri. Amount, cm (seasonal total)	Net Income (Tk/ha)	BCR	% Irrigation Saving	% Yield Reduction
Pattern-1 (T.Aman-Mustard-T.Aus)	14.49	8.5	46	85135	1.43	42	10
Pattern-2 (T.Aman-Lentil-T.Aus)	**14.7**	7.5	41	96566	1.51	**48**	**9**
Pattern-3 (T.Aman-Wheat-T.Aus	13.34	10	53	79391	1.42	33	17
Pattern-4 (T.Aman-Mustard-Boro)	**16.14**	14.5	78	104472	**1.51**	-	-
Pattern-5 (T.Aman-Fallow-Boro) [Control]	11.67	18	98	63025	1.38	25*	28

Note.

* indicate not savings because of locally cultivated long duration Aman and Boro rice.

Cropping pattern wise rice-equivalent yield, no. of irrigation required, irrigation amount, irrigation saving, net income and BCR are presented in **Table 10.6**. 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 highest REY (as well as net profit) with 78 cm seasonal irrigation water. The pattern P-2 (T. Aman-Lentil-T.Aus) yielded the 2^{nd} highest REY (as well as net profit) with 48% irrigation water savings compare to P-4 (T. Aman-Mustard-Boro); but sacrificing 9% yield.

The pattern P-1 (T. Aman-Mustard-T.Aus) yielded the 2^{nd} highest REY (as well as net profit) with 39% irrigation water savings compare to P-4 (T. Aman-Mustard-Boro); but sacrificing 7% yield at Nachol. The pattern P-2 (T. Aman-Lentil-T.Aus) yielded the 2^{nd} highest REY (as well as net profit) with 48% irrigation water savings compare to P-4 (T. Aman-Mustard-Boro); but sacrificing 9% yield at Niamatpur.

Adaptive Research and Extension Division

Research Highlights

- During 2019-2020 a total of 344 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 Officer in Charge (OIC) of different BINA sub-stations.

- In adaptive trials, T.aman rice mutant, SSB-3 produced average grain yield of 4.85 t ha^{-1} almost same as check variety BRRI Dhan49 (4.77 t ha^{-1}). Average maturity period of mutant and check variety were 124 and 135 days, respectively indicating the mutant was moderately earlier than those of the check variety. Another T. aman rice mutant, Kasalat produced average grain yield of 4.09 t ha^{-1} which was lower than those of the check variety Binadhan-11 (4.68 t ha^{-1}) with almost same average maturity period of mutant line and check variety. Adaptive trials with newly released early T. aman, Binadhan-22 produced average grain yield of 4.53 which was lower than those of check variety, Binadhan-11 (4.97 t ha^{-1}) with almost same average maturity period. There was some BLB disease infestation was found in the experimental field of Binadhan-22. Therefore, to identify its suitability, need further trials in the upcoming years. In block farming, early T. aman rice varietiy, Binadhan-11 produced average grain yield of 5.47 t ha^{-1} with maturity period of 118 days. Binadhan-11 showed higher yield performance in normal condition because there was no flash flood in those areas in the reporting year. Higher yield, better cooking quality and suitable for both normal and flood prone areas farmers were found very much interested to cultivate this variety in the upcoming years. Binadhan-10 produced average grain yields of 5.57 t ha^{-1} with maturity period of 134. Farmers were found very much interested to cultivate Binadhan-10 due to its better performance in saline soils. Block farming with aus rice variety, Binadhan-19 produced average grain yields of 3.82 t ha^{-1} with maturity period of 99 days. The cultivated area of Binadhan-19 was gradually increased due to its better yield, shorter duration and fine grain quality.

- In adaptive trials, rapeseed/mustard mutants RM-10, RM-18 and RM-20 produced average yield of 1.77, 2.10 and 2.01 t ha^{-1} with average maturity period of 84, 82 and 83 days, respectively revealed that this three mutants performed better than those of other mutants and the check varieties. Adaptive trials, soybean mutants produced average seed yield of 2.16, 2.67 and 2.67 t ha^{-1}, with average maturity period of 120, 103 and 117, respectively. The results revealed that the check varieties performed better than those of the mutants. This year farmers have to face many challenges to cultivate soybean, COVIT-19 and early heavy rainfall in late April, during pod filling stage hamper soybean yield and quality of the seed. Block farming with Binasarisha-9 produced average yield of 1.59 t ha^{-1} with average maturity period of 84 days. Considering the higher yield and moderate duration of Binasarisha-9 indicated that farmers of all the locations easily include this variety as an extra crop between T. aman and boro rice for increasing cropping intensity. Binamasur-8 produced average yield of 1.65 t ha^{-1} with maturity period of 104 days. Farmers of Faridpur district was very much interested cultivate the variety in coming years.

- In order to establish BINA technology villages, a total of 112 block farming were conducted around BINA headquarter. Based on the BINA released technology adoption and overall activities in different locations established BINA technology villages are Ghara and Poranganj under Sadar Upazila of Mymensingh. However, establishment of BINA technology villages in other locations of Sadar, Mymensingh are now in progress.

- In order to promotion of BINA generated crop varieties, a total of five farmers training courses were organized during this period, and 175 male and female farmers were trained on cultivation of BINA developed improved crop varieties across the country. A total of ten 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, three TV programme were telecasted to popularize some BINA crop varieties.

On farm research and technology dissemination

Adaptive trial with T. aman rice mutant, SSB-3 at different locations

During aman season of 2019-2020, adaptive trials with T. aman rice mutant SSB-3 were conducted at farmers' plots in Mymensingh and Jamalpur districts. The objectives were to evaluate the performance of mutant line at two locations for providing the feedback information about the concerned line to the respective breeder. Unit plot size of individual plot was 5 × 4 m^2 at all the locations. Seed beds were prepared during end of June to mid of July and transplanting was completed within mid of July to mid of August 2019. 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 T. aman rice mutant, SSB-3 at different locations during 2019-2020

District	Upazila	No. of Expt.	Days to maturity		Yield (t ha^{-1})		Yield increased over control (%)
			SSB-3	BRRI dhan49	SSB-3	BRRI dhan49	
Mymensingh	Sadar	1	123	134	4.78	4.73	1.06
Jamalpur	Sadar	1	125	136	4.83	4.81	0.42
Total		**2**					
Mean			**124**	**135**	**4.85**	**4.77**	**0.74**

The results presented in Table 1 indicating that T. aman rice mutant SSB-3 produced average grain yield of 4.85 t ha^{-1} almost same as check variety BRRI Dhan49 (4.77 t ha^{-1}). Average maturity period of mutant line and check variety were 124 and 135 days, respectively revealed that the mutant line was moderately earlier than those of the check variety.

Adaptive trial with T. aman rice mutant, Kasalat at different locations

During aman season of 2019-2020, adaptive trials with T. aman rice mutant Kasalat were conducted at farmers' plots in Mymensingh, Magura and Cumilla districts. The objectives were to evaluate the performance of mutant line at those locations for providing the feedback information about the concerned line to the respective breeder. Unit plot size of individual plot was 5 × 4 m^2 at all the locations. Seed beds were prepared during end of June to mid of July and transplanting was completed with mid of July to mid of August 2019. 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 T. aman rice mutant, Kasalat at different locations during 2019-2020

District	Upazila	No. of Expt.	Days to maturity		Yield (t ha^{-1})		Yield increased over control (%)
			RM-Kas-18(c)1	Binadhan-11	RM-Kas-18(c)1	Binadhan-11	
Magura	Sadar	1	127	122	4.52	4.81	-6.03
Mymensingh	Sadar	1	119	134	3.64	4.11	-11.44
Cumilla	Sadar	1	114	114	4.12	5.11	-19.37
Total		**3**					
Mean			**120**	**123**	**4.09**	**4.68**	**-12.28**

The results presented in Table 2 indicating that T. aman rice mutant Kasalat produced average grain yield of 4.09 t ha^{-1} which was lower than those of the check variety Binadhan-11 (4.68 t ha^{-1}). The average maturity period of mutant line and check variety were 120 and 123 days, respectively revealed that the mutant line was slightly earlier than the check variety. In the experimental plots there were no incidence of disease infestation was found.

Adaptive trials with newly released early T. aman rice variety, Binadhan-22 compared to check variety

During aman season of 2019-2020, adaptive trials with early T. aman rice Binadhan-22 was conducted at different locations in collaboration with DAE. The main objectives were to evaluate the performance of the variety at different locations for the widening its adoption by the farmers. Area of each plot was 0.33 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, 2019 and age of seedlings were 20 to 25 days. Based on the available reports of adaptive trials are presented in Table 3.

Table 3. Performance of early T aman rice, Binadhan-22 compared to popular cultivar in different locations during 2019-2020

District	Upazila	No. of Expt.	Days to maturity		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-22	Binadhan-11	Binadhan-22	Binadhan-11	
Mymensingh	Sadar	3	115	121	5.12	4.80	6.67
Netrokona	Purbadhala	2	120	119	3.94	5.13	-23.20
Total		**5**					
Mean			**118**	**120**	**4.53**	**4.97**	**-8.27**

The results presented in Table 3 revealed that Binadhan-22 and check variety Binadhan-11 produced average grain yield of 4.53 and 4.97 t ha^{-1}, respectively. Average maturity period of both varieties were almost same. There were some infestations of BLB disease in the experimental field of Binadhan-22. It was a newly released variety, therefore, experimental plots were conducted for the first time this year to check its suitability. However, to identify its suitability, need further trials in the upcoming years.

Block farming with submergence tolerant T. aman rice variety, Binadhan-11 compared to check variety

During aman season of 2019-2020, block farming with submergence tolerant T. aman rice Binadhan-11 were conducted at the farmer's fields at different locations in collaboration with DAE. The main objectives were to evaluate the performance of this variety at different flood prone and normal areas for widening its adoption by the farmers. Area of each plot was 0.33 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, 2019 and age of seedlings were 20 to 25 days. Based on the 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 2019-2020

District	Upazilla	No. of Expt.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-11	BRRI dhan52	Binadhan-11	BRRI dhan52	
Mymensingh	Sadar	5	124	145	6.14	5.52	11.23
Netrokona	Purbadhala	5	115	-	4.94	-	-
Faridpur	Madhukhali	15	114	-	5.34	-	-
Total		**25**					**-**
Mean			**118**	**145**	**5.47**	**5.52**	**11.23**

The results presented in the Table 4 revealed that Binadhan-11 produced average grain yield of 5.47 t ha^{-1}, which was 11.23 percent higher compared to check variety, BRRI dhan52 at one location. Average maturity period of Binadhan-11 and BRRI dhan52 were 118 and 145 days, respectively. Binadhan-11 showed higher yield performance in normal condition because there was no flash flood in those locations in the reporting year. Higher yield, better cooking quality and suitable for both normal and flood prone areas farmers were found much keen to cultivate this variety 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 2019-2020, block farming with Binadhan-10 were conducted at the farmer's fields in different locations in collaboration with DAE. Area of each plot was 0.33 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 10 to 31 January 2020 and age of seedlings were 35 to 45 days. Based on the available reports, data of block farming plots are presented in Table 5.

Table 5. Performance of salt tolerant boro rice, Binadhan-10 compared to popular cultivar in different locations during 2019-2020

District	Upazila	No. of Expt.	Days to maturity		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-10	BRRI dhan67	Binadhan-10	BRRI dhan67	
Chattagram	Anwara	10	139	144	6.02	5.82	3.44
	Bashkhali	10	133	143	5.81	5.68	2.29
Cox's Bazar	Technaf	10	128	145	5.28	5.85	-9.74
Borguna	Amtoli	10	135	142	5.84	5.67	3.00
Potuakhali	Kolapara	10	134	141	5.89	5.69	3.51
Total		**50**					
Mean			**134**	**143**	**5.77**	**5.74**	**0.50**

The results presented in the Table 5 revealed that Binadhan-10 and check variety, BRRI dhan67 were produced almost same average grain yields of 5.77 and 5.74 t ha^{-1} respectively. Maturity period of Binadhan-10 and BRRI dhan67 were 134 and 143 days, respectively. Farmers were found very much interested to cultivate Binadhan-10 due to its better performance in saline soils. Farmers of above all districts were found keen to cultivate Binadhan-10 in the upcoming years.

Block farming with drought tolerant aus rice variety, Binadhan-19 compared to popular cultivar in different locations

During aus season of 2019-2020, block farming with drought tolerant aus rice Binadhan-19 were conducted at the farmer's fields in different locations in collaboration with DAE. Area of each plot was 0.33 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 2020 and age of seedlings were 15 to 25 days. Data of block farming plots are presented in Table 6.

Table 6. Performance of drought tolerant aus rice, Binadhan-19 compared to popular cultivar in different locations during 2019-2020

District	Upazila	No. of Expt.	Duration (days) Binadhan-19	Duration (days) BRRI dhan48	Yield (t ha^{-1}) Binadhan-19	Yield (t ha^{-1}) BRRI dhan48	Yield increased over control (%)
Mymensingh	Sadar	5	98	107	3.83	3.71	3.23
	Trishal	5	101	108	3.65	3.68	-0.82
	Bhaluka	5	100	108	3.75	3.68	1.90
	Tarakanda	5	99	106	3.92	3.87	1.29
Faridpur	Madhukhali	15	97	108	3.94	3.92	0.51
Total		**35**					
Mean			**99**	**107**	**3.82**	**3.77**	**1.22**

The results presented in the Table 6 indicated that Binadhan-19 and check variety, BRRI dhan48 were produced almost same average grain yields of 3.82 and 3.77 t ha^{-1} respectively. Maturity period of Binadhan-19 and BRRI dhan48 were 99 and 107 days, respectively indicating that Binadhan-19 was about 8 days earlier than those of BRRI dhan48. Due to its early maturity and fine grain quality farmers of all the locations were found interested to cultivate Binadhan-19 in the upcoming years.

Adaptive trial with rapeseed/mustard mutants at different locations during 2019-2020

During rabi season of 2019-2020, adaptive trials with rapeseed/mustard mutants were conducted at farmers' plots in different locations. The objectives were to evaluate the performance of mutants at different locations and to provide the feedback information about the concerned mutants to the respective breeder. Unit plot size of individual plot was 5 × 4 m^2 at all the locations. Seeds were sown during 1-15 November 2019. Fertilizers were applied as per recommendation. Data were recorded on crop duration and seed yield. The results are presented in Table 7.

Table 7. Performance of rapeseed/mustard mutants at different locations during 2019-2020

Location	No. of Expt	Parameters	RM-7	RM-10	RM-18	RM-20	BARI Sarisha-15	BARI Sarisha-17
Shibchar, Madaripur	2	Days to maturity	81	87	80	84	87	84
		Yield (t ha^{-1})	1.72	2.10	1.76	1.51	1.36	1.82
Sadar, Mymensingh	2	Days to maturity	82	81	82	82	80	80
		Yield (t ha^{-1})	1.67	1.77	1.72	1.71	1.60	1.63
Ghior, Manikganj	1	Days to maturity	82	81	82	82	80	80
		Yield (t ha^{-1})	1.94	1.80	2.15	2.13	1.43	1.73
Dawlatpur,	1	Days to maturity	85	86	83	84	83	82

Manikganj		Yield (t ha^{-1})	1.43	1.41	2.75	2.69	1.63	1.59
Total	**6**							
Mean (Days to maturity)			**83**	**84**	**82**	**83**	**83**	**82**
Mean (Yield t ha^{-1})			**1.69**	**1.77**	**2.10**	**2.01**	**1.51**	**1.69**

The results presented in Table 7 indicating that rapeseed/mustard mutants RM-07, RM-10, RM-18, RM-20, BARI Sarisha-15 and BARI Sarisha-17 produced average seed yield of 1.69, 1.77, 2.10, 2.01, 1.51 and 1.69 t ha^{-1}, respectively with average maturity period of mutants/varieties 82-84 days revealed that most of the mutants performed better than those of the check varieties.

Adaptive trial with soybean mutants at different locations during 2019-2020

During rabi season of 2019-2020, adaptive trials with soybean mutants were conducted at farmers' plots in different locations. The objectives were to evaluate the performance of mutants at different locations and to provide the feedback information about the concerned mutants to the respective breeder. Unit plot size of individual plot was 5 × 4 m^2 at all the locations. Seeds were sown during end of November to mid of December 2019. Fertilizers were applied as per recommendation. Data were recorded on crop duration and seed yield. The results are presented in Table 8.

Table 8. Performance of soybean mutants at different locations during 2019-2020

Location	**No. of Expt**	**Parameters**	**Name of Line/Variety**				
			SB-02	**SB-05**	**SB-07**	**Binasoyabean-6**	**BARI Soyabean-6**
Noakhali	1	Days to maturity	120	103	117	106	103
		Yield (t ha^{-1})	2.15	2.67	2.67	2.81	2.89
Chandpur	1	Days to maturity	119	103	117	104	102
		Yield (t ha^{-1})	2.17	2.67	2.67	2.83	2.95
Laxmipur	1	Days to maturity	121	104	116	105	104
		Yield (t ha^{-1})	2.16	2.67	2.67	2.82	2.92
Total	**3**						
Mean (Days to maturity)			**120**	**103**	**117**	**105**	**103**
Mean (Yield t ha^{-1})			**2.16**	**2.67**	**2.67**	**2.82**	**2.92**

The results presented in Table 8 indicating that soybean mutants SB-02, SB-05, SB-07, Binasoybean-6 and BARI Soybean-6 produced average seed yield of 2.16, 2.67, 2.67, 2.82 and 2.92 t ha^{-1}, respectively with average maturity period of mutants/varieties 120, 103, 117, 105 and 103, respectively. The results revealed that the check varieties performed better than those of the mutants. This year farmers have to face many challenges to cultivate soybean, COVID-19 and early heavy rainfall in late April, during pod filling stage hampers soybean yield and quality of the seed.

Block farming with mustard variety, Binasarisha-9 compared to popular cultivar at different locations

During the rabi season of 2019-2020, block farming were conducted with Binasarisha-9 at different districts in collaboration with DAE. The main objectives were to demonstrate the performance of

Binasarisha-9 to evaluate their location specific suitability and widen its adoption by the farmers. Unit plot size of block farming was 0.33 acre at all the locations. Seeds were sown during 1-15 November 2019 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 experimental plots. Data were recorded on crop duration and seed yield. The results are presented in Table 9.

Table 9. Performance of Binasharisa-9 compared to popular cultivar in different locations during 2019-2020

District	Upazila	No. of Expt.	Days to maturity		Yield (t ha^{-1})		Yield increased over control (%)
			Bina sarisha-9	BARI Sarisha-14	Bina sarisha-9	BARI Sarisha-14	
Mymensingh	Sadar	20	83	79	1.58	1.61	-1.86
	Gouripur	5	84	80	1.52	1.56	-2.56
Manikganj	Daulatpur	30	85	83	1.65	1.58	4.43
	Shibaloy	30	84	81	1.62	1.64	-1.22
Total		**85**					
Mean			**84**	**81**	**1.59**	**1.60**	**-0.30**

The results presented in Table 9 indicated that Binasarisha-9 and BARI Sarisha-14 produced almost same average seed yield of 1.59 and 1.60 t ha^{-1} with duration of 84 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 for purpose of attaining self sufficiency in the production of oilseeds.

Block farming with lentil variety, Binamasur-8 in collaboration with DAE

During the rabi season of 2019-2020, block farming were conducted with Binamasur-8 at Madhukhali, Faridpur in collaboration with DAE. The main objectives were to demonstrate the performance of Binamasur-8 to evaluate its location specific suitability and widen the adoption by the farmers. Unit plot size of block farming was 0.33 acre. Seeds were sown during November 2019 at the rate of 25 kg ha^{-1}. The check variety was BARI Masur-6. All fertilizers were applied as per recommendation. Data were recorded on crop duration and seed yield. The results are presented in Table 10.

Table 10. Performance of Binamasur-8 compared to BARI Masur-6 during 2019-2020

District	Upazilla	No. of Expt.	Days to maturity		Yield (t ha^{-1})		Yield increased over control (%)
			Bina masur-8	BARI Masur-6	Bina masur-8	BARI Masur-6	
Faridpur	Madhukhali	18	104	107	1.65	1.57	5.10

Total	**18**					
Mean		**104**	**107**	**1.65**	**1.57**	**5.10**

The results presented in Table 10 revealed that Binamasur-8 and BARI Masur-6 produced average yield of 1.65 and 1.57 t ha^{-1} with duration of 104 and 107, respectively. The results indicated that there was almost no difference in respect of duration and yield of tested varieties. However, Faridpur was a popular lentil growing area and farmers of this district were very much interested to cultivate Binamasur-8 in the coming years.

Establishment of BINA-Technology Pilot Area (BINA-Village)

In order to establish BINA-Technology Village, block farming were conducted at farmers fields in surrounding areas of BINA head quarter. Results of overall promotional activities to BINA village establishment at different locations are presented below:

Block farming with BINA developed different crop varieties in surrounding areas of BINA Headquarter, Mymensingh

During 2019-2020, block farming were conducted with BINA developed to crop varieties at Ghagra, Boyra, Chargobodia, Porangonj and Begunbari villages under Sadar Upazila of Mymensingh district. Results of block farming are presented in Table-11.

Table 11. Performance of BINA varieties in some locations of Sadar, Mymensingh during 2019-2020

Variety	No. of Expt.	Days to maturity	Yield (t ha^{-1})
Rice			
T. aman			
Binadhan-7	22	110	4.85
Binadhan-11	19	115	5.65
Boro			
Binadhan-14	6	120	5.60
Binadhan-10	11	142	6.92
Aus			
Binadhan-19	18	106	4.42
Oilseeds			
Binasharisha-7	1	108	1.45
Binasharisha-9	35	84	1.61
Total	**112**		

Mymensingh district is mostly suitable for rice growing and that of partly for mustard cultivation Results in Table 11 depicted that rice varieties of Binadhan-7, Binadhan-11, Binadhan-10, Binadhan-14 and Binadhan-19 produced average grain yield of 4.85, 5.65, 5.60, 6.92 and 4.42 t ha^{-1}, respectively. Binsarisha-7 and Binasarisha-9 produced average seed yield of 1.45 and 1.61 t ha^{-1}, respectively. An extra rabi crop could easily be cultivated adopting early T. aman Binadhan-7 and Binadhan-11 in aman season having higher yield of aman rice. A cropping pattern of "Binadhan-7/Binadhan-11-Binasarisha-9-Binadhan-14/Binadhan-10" has demonstrated very suitable and highly profitable in Ghagra and Poranganj of Sadar Upazila. These varieties following above cropping pattern are disseminating spontaneously among the farmers.

Training on the use of BINA developed technologies

In order to technology promotion, five training courses were organized during the period of 2019-2020. A total of 175 female and male farmers were trained on establishment of demonstration and seed preservation method of BINA developed promising varieties. Details of the training are presented in Table 12.

Table 12. Farmers and SAAO Training on the use of BINA developed technologies during 2019-2020

Sl No	Title	Place of Training	Date	No. of participants	Source of fund
1	Farmers training on "Cultivation method and dissemination techniques of BINA developed transferable technologies"	Tarakanda, Mymensingh	7.12.2019	35	Haor, char..
2	Farmers training on "Cultivation method and dissemination techniques of BINA developed transferable technologies"	Sadar, Mymensingh	11.2.2020	35	Haor, char....
3	Farmers training on "Cultivation method and dissemination techniques of BINA developed transferable technologies"	Muktagacha, Mymensingh	14.2.2020	35	Haor, char....
4	Farmers training on "Cultivation method and dissemination techniques of BINA developed transferable technologies"	Sadar, Mymensingh	29.2.2020	35	Haor, char....
5	Farmers training on "Cultivation method and dissemination techniques of BINA developed transferable technologies"	BINA Office, Mymensingh	14.6.2020	35	Haor, char....

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 13.

Table 13. Field days organized at the farmer's fields on different crop varieties during 2019-2020

Sl. No.	Crops	Varieties	Date	Locations	Participants
1.	Rice	Binadhan-11	19.11.2019	Sadar, Mymensingh	135
			21.11.2019	Sadar, Mymensingh	126
			27.11.2019	Sadar, Mymensingh	100
		Binadhan-22	22.11.2019	Sadar, Mymensingh	120
		Binadhan-10	22.5.2020	Sadar, Mymensingh	40
2.	Mustard	Binasharisha-9	18.2.2020	Dawlatpur, Manikganj	125
			18.2.2020	Shibaloy, Manikganj	105
			30.1.2020	Gouripur, Mymensingh	150
			11.2.2020	Sadar, Mymensingh	40
			15.2.2020	Sadar, Manikgonj	114

Print and electronic media exposure

For technology dissemination through print and electronic media, three programs were telecasted to popularize some BINA crop varieties. Details of the dissemination activities in electronics media are presented in Table 14.

Table 14. Electronic media exposure on different crop varieties during 2019-2020

Sl. No.	Name of crops/ varieties	Name of the channel	Location	Remarks
1.	Binadhan-11	MY TV	Sadar, Mymensingh	It was very effective for awareness creation
2.	Binadhan-10	Channel I	Sadar, Mymensingh	
3.	Binasarisha-9	Bangla Vision	Sadar, Mymensingh	

Agricultural Economics Division

Research Highlights (2019-20)

Yield gap of Binachinabadam-4 study was conducted in five major Binachinabadam-4 growing areas in Bangladesh namely Faridpur, Jhenaidah, Kishoreganj, Panchagarh and Bhola. 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. 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 results showed that the farmers level highest yield was obtained from Panchagarh (2.21 t ha^{-1}) followed by Bhola (2.11 t ha^{-1}), Kishoreganj (1.99 t ha^{-1}), Faridpur(1.92 t ha^{-1}) and Jhenaidah (1.81 t ha^{-1}) district. The average yield of Binachinabadam-4 was 2.01 t ha^{-1}. The estimated average yield gap I was 0.11 t ha^{-1} (4.84 %.) and average yield gap II was 0.19 t ha^{-1} (8.45 %.). The lowest total yield gap was 0.23 t ha^{-1} (10.36%) observed in Kishoreganj district and it was the highest 0.38 t ha^{-1} (17.35 %) in Jhenaidah district. Considering all, the average yield gap was 0.30 t ha^{-1} (12.85 %) and much scope for yield enhancement in the variety. 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 124.20Kg ha^{-1}, Urea 50.25 Kg ha^{-1}, MoP 140.14 Kg ha^{-1}, TSP 175.13 Kg h^{-1}, Zypsum 123.39 Kg ha^{-1} respectively, indicating that they are either below or above the range the recommendation. Other factors which were also responsible in the yield of Binachinabadam-4. In average 47.4 % used power tiller three times or more than three times, 65.3% weeded their lands 2 times and 61.3 % spray pesticide and insecticide to control disease and insect. From the regression equation, the coefficients for no. of 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 Binachinabadam-4 production could increase the yield to some extent. In order to decrease the yield gap of Binachinabadam-4 at farm level, the Government should ensure timely adequate supply of quality or adulteration free inputs (seed, fertilizer, pesticides, etc.). Ensuring labour facilities during harvesting time influence groundnut farmers to a greater extent to reduce yield gap. The study found that in Bangladesh, we are losing 0.30 $t{\cdot}ha^{-1}$(12.85%) yield of Binachinabadam-4. If we could reduce these gaps, our total production per year will be increased which will support in achieving food security.

Profitability study of Binadhan-17 was conducted in five major Binadhan-17 growing areas of Bangladesh, namely Sunamganj, Rangpur, Gopalganj, Pabna and Magura district. A total of 200 farmers were randomly selected as sample size in the study areas, 40 from each District. Data were collected from Binadhan-17 growers through interview schedule. costs and return analysis were done on both cash cost and full cost basis. The average costs of Binadhan-17 cultivation were Tk. 72557.75 and Tk. 49678.95 per hectare on full cost and cash cost basis, respectively. The highest production cost was for human labour (57.2%), followed by power tiller (9.2%), land use (8.6%) and irrigation (6.6%). The cost of Binadhan-17 cultivation was found highest in Pabna (Tk. 74276.05 ha^{-1}) followed by that in Magura (Tk. 73923.56 ha^{-1}), Gopalganj (Tk. 71929.00 ha^{-1}), Rangpur (Tk. 70898.73 ha^{-1}) and Sunamganj (Tk.69766.87 ha^{-1}), respectively. The average return from Binadhan-17 production in different locations is shown in Table 3. The average yield of Binadhan-17 was 5789.83 kg ha^{-1}. The yield was highest at Rangpur (5976.32 kg ha^{-1}) followed by Gopalganj (5894.41 kg ha^{-1}), Magura (5802.80 kg ha^{-1}), Pabna (5692.62 kg ha^{-1}) and Sunamganj

(5583.01 kg ha^{-1}). Most of the farmers in the study areas sold their paddy just after harvest. The total return from Binadhan-17 production consists of the values of Binadhan-17 and straw. The average gross margin was found Tk. 57343.56 ha^{-1} on variable cost basis. Gross margin was highest in Rangpur (Tk. 60820.88 ha^{-1}) followed by Gopalganj (Tk. 59205.18 ha^{-1}), Magura (Tk. 58227.84 ha^{-1}), Pabna (Tk. 55883.11 ha^{-1}) and Sunamganj (Tk. 52580.80 ha^{-1}), respectively. The average net return per hectare was Tk. 34207.56. The net return was highest in Rangpur (Tk. 38536.88 ha^{-1}) followed by Magura (Tk. 36091.84 ha^{-1}), Gopalganj (Tk. 35783.18 ha^{-1}), Pabna (Tk. 32345.11 ha^{-1}) and Sunamganj (Tk. 28280.80 ha^{-1}), respectively. Benefit cost ratio was estimated at 1.47 and 2.17 on full cost and variable cost basis implying that the Binadhan-17 cultivation at farm level was profitable. All of the explanatory variables namely, human labour cost (significant at 5 % level), power tiller cost (significant at 5 % level), seed cost (significant at 10 % level), fertilizer cost (significant at 10 % level) and insecticides cost (significant at 5 % level) are positively significant at Binadhan-17 cultivation, implying that the 1 percent increases in the variable cost increase the gross return from rice by 0.287, 0.257, 0.184, 0.410, 0.331 percent, respectively. The farmers in the study areas encountered some constraints to Binadhan-17 production. The first ranked constraint was unavailability of Binadhan-17 varieties' seeds in all areas. Other constraints were lack of training (64%), lack of technical know-how (38%), lack of capital (30%), lack of storage facility (17%), natural calamities (14%) and low education level of farmers (10%). The yield performance and economic return of Binadhan-17 production encouraging to the farmer’s for more cultivation.

Profitability and productivity of drought tolerant rice variety Binadhan-19 study was conducted in five districts namely Mymensingh, Ranpur, Pabna, Rajshahi and Chapainwabganj in Bangladesh. A total of 200 farmers were randomly selected (40 from each locations) to collect the data with a pre-designed questionnaire. Tabular, descriptive statistics and Probit model were used to fulfill objectives. Total cost of production included variable costs and fixed costs incurred for Binadhan-19 cultivation. On an average, the total cost of production was Tk. 66087.00 ha^{-1} where 40% was fixed costs and 60% was variable cost. The highest cost was found in Rajshahi (Tk. 75432 ha^{-1}) and the lowest in Pabna (Tk. 56833 ha^{-1}). Per hectare average yield of rice was 4.71 ton and per kg average price was about Tk. 17. The average gross return and gross margin of rice cultivation were found Tk. 90679 ha^{-1} and Tk. 51290 ha^{-1} respectively. Per hectare average net return was Tk. 24591which was found to be highest in Chapainwabgonj (Tk. 29739) followed by Mymensingh (Tk. 29216), Pabna (Tk. 27538), Rajshahi (Tk. 22680) and Rangpur (Tk. 12692). BCR on total cost basis was found 1.37 which was the highest in Mymensingh 1.49 and less in Rangpur districts 1.19. It was estimated that, to produce one kilogram of rice, total cost incurred Tk. 14. The estimated log likelihood value-gender, farm size, yield, agricultural extension services have statistically and positive significantly effect of adoption of the variety. The household characteristic related variables such as age, experience, annual income, human labor, duration of the variety have no statistically significant effect on the adoption of the variety. Marginal coefficients indicate that if male farmers increased by 100%, the probability of adopting Binadhan-19 varieties would increase at 38 times more likely to adopt of the variety. If farm size increased by 100%, the probability of adopting the variety would be increased at 0.07%. A farmer who has access to agricultural extension service is about 39 times more likely to adopt the variety. Again, if the yield increased by 100% the probability of adopting the varieties would increase by 0.08%. The marginal coefficients of district and soil fertility are negatively significant. If those variables increased by 100% the probability of adopting the varieties would decreased by 0.06% and 30%, respectively. Among the list the highest preferences was for neat rice 98% and it was the lowest for easy to harvest i.e 82%. Among the constraints the highest constrain said by the farmer was crop destroy by animal & bird of paddy and it was 81% and the lowest was disease and pest infestation i.e. 54% in Binadhan-19 cultivation.

Area coverage position of BINA developed rice, pulse and oilseed varieties was investigated in collaboration with DAE and Sub-stations of BINA in 64 districts of Bangladesh. In this study, the result was found that the overall area coverage of BINA developed rice varieties were 6.45%. Among the three season; Aus, Aman and Boro the highest area coverage was found in Aman season i. e. 10.45% followed by Boro 2.46% and Aus 1.26%, respectively, The overall area coverage of BINA developed pulse and oilseed varieties were 2.03% and 1.73%., respectively.

Yield gap of potential oil seed variety Binachinabadam-4 in some selected areas of Bangladesh

Groundnut (*Arachishypogaea L.*) is an annual legume which bears variety of names, such as peanut, earthnut and goobers. The study was conducted in five major Binachinabadam-4 growing areas in Bangladesh namely Faridpur, Jhenaidah, Kishoreganj, Panchagarh and Bhola. The objectives of the study were i) to estimate the yield gap of Binachinabadam-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 used. 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 = the yield of research stations,

Y_D = the yield of demonstration plots, and

Y_F = the yield of actual farm.

The production of Binachinabadam-4 is likely to be influenced by different factors, such as, seed, chemical 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:

$$Y = AX_1^{b1} X_2^{b2} \ldots\ldots\ldots\ldots\ldots\ldots X_n^{bn} e^{ui}$$

The production function was converted to logarithmic form so that it could be solved by least square method i.e.

$$\text{Log } Y = \text{Log } a + b_1 \log X_1 + \ldots\ldots\ldots\ldots\ldots\ldots + b_n \text{Log } X_n + e^{ui}$$

The empirical production function was the following:

$$\text{Log}Y = \text{Log}a + b_1 \text{Log}X_1 + b_2 \text{Log}X_2 + b_3 \text{Log}X_3 + b_4 \text{Log}X_4 + b_5 \text{Log}X_5 + b_6 \text{Log}X_6 + b_7 \text{Log}X_7 + b_8 \text{Log}X_8 + b_9 \text{Log}X_9 + Ui$$

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= Soil fertility
X_8= Farm size
X_9= 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 Panchagarh (2.21 t ha^{-1}) followed by Bhola (2.11 t ha^{-1}), Kishoreganj (1.99 t ha^{-1}), Faridpur (1.92 t ha^{-1})and Jhenaidah (1.81 t ha^{-1}) district. The average yield of Binachinabadam-4 was 2.01 t ha^{-1} (Table 1).As seen from Table 1, the estimated average yield gap I was 0.11 t ha^{-1} (4.84 %.) and average yield gap II was 0.19 t ha^{-1} (8.45 %.). The lowest total yield gap was 0.23 t ha^{-1} (10.36%) observed in Kishoreganj district and it was the highest 0.38 t ha^{-1} (17.35 %) in Jhenaidah district. Considering all, the average yield gap was 0.30 t ha^{-1} (12.85 %) and much scope for yield enhancement in the variety.

Table 1. Estimated yield gap of Binachinabadam-4 in different locations

Particular	Faridpur	Jhenaidah	Kishoreganj	Panchagrh	Bhola	Averag
Average yield of research station (Y_{R}), t ha^{-1}	2.19*	2.19*	2.22*	2.50*	2.42*	2.30
Average yield of demonstration plots (Y_D), t ha^{-1}	2.08*	1.97*	2.18	2.41	2.33	2.19
Average yield of actual farm(Y_F), t ha^{-1}	1.92	1.81	1.99	2.21	2.11	2.01
Yield gap I (%)	0.11 (5.02)	0.22 (10.05)	0.04 (1.80)	0.09 (3.60)	0.09 (3.72)	0.11 (4.84)
Yield gap II (%)	0.16 (7.69)	0.16 (8.12)	0.19 (8.72)	0.20 (8.30)	0.22 (9.44)	0.19 (8.45)
Total yield gap (%)	0.27 (12.33)	0.38 (17.35)	0.23 (10.36)	0.29 (11.60)	0.31 (12.81)	0.30 (12.85)

*Indicates the value of nearest sub-stations

Major factors that influencing the yield of Binachinabadam-4

In Table 2, the district wise farmers have to maintain according to recommended dose in some extent 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 124.20Kg ha^{-1}, Urea 50.25 Kg ha^{-1}, MoP 140.14 Kg ha^{-1}, TSP 175.13 Kg h^{-1}, Zypsum 123.39 Kg ha^{-1} respectively, indicating that they are either below or above the range the recommendation.

Table 2. Input–use pattern of Binachinabadam-4 growing farmers

Factors	Seed Kg ha^{-1}	Urea Kg ha^{-1}	MoP Kg ha^{-1}	TSP Kg ha^{-1}	Zypsum Kg ha^{-1}
Recommendation	125-130	40-50	130-140	165-175	110-120
Faridpur	119.67	43.99	137.75	175.75	118.13
Jhenaidah	115.84	46.46	133.91	163.82	100.00
Kishoreganj	128.34	54.11	145.44	174.96	141.56
Panchagarh	125.55	51.35	139.75	181.69	130.22
Bhola	131.61	55.33	143.86	179.45	127.05
Average	124.20	50.25	140.14	175.13	123.39

Other factors which were also responsible for the yield of Binachinabadam-4 are described in Table 3. In average 47.4 % used power tiller three times or more than three times, 65.3% weeded their lands 2 times and 61.3 % spray pesticide and insecticide to control disease and insect.

Table 3. Input–use patternof Binachinabadam-4 growing area

Factors	Faridpur	Jhenaidah	Kishoreganj	Panchagarh	Bhola	Average
Power Tiller (%)						
Two times	12.0	7.0	5.0	2.0	-	6.5
Three times	61.0	69.0	47.0	35.0	25.0	47.4
More than 3	27.0	24.0	48.0	63.0	75.0	47.4
Weeding (%)						
No Weeding	5.0	2.8	-	-	-	3.9
Weeding (1)	49.0	40.0	34.0	28.0	14.8	33.2
Weeding (2)	46.0	57.8	66.0	72.0	85.2	65.3
Pesticide and insecticide (%)	42.0	51.5	66.5	70.3	76.0	61.3

Table 4. Factors affecting the production for Binachinabadam-4 cultivation in the study areas

Item	Co-efficient	t-value	P>t-value
Intercept	4.794***	8.95	0.000
Power tiller (X_1)	0.029***	6.15	0.000
Seed (X_2)	0.151***	0.027	0.000
Urea (X_3)	0.123***	2.80	0.000
TSP (X_4)	0.258***	4.03	0.000
MoP (X_5)	0.088**	0.97	0.375
Gypsum (X_6)	0.005*	1.77	0.093
Soil fertility (X_7)	0.064*	1.00	0.302
Farm size (X_8)	-0.214 **	2.55	0.014
Experience (X_9)	0.111 **	1.24	0.022

Note: '*' '**' and '***' indicate significant at 10%, 5% and 1% level.

In Table 4, the contribution of specified factors affecting production of Binachinabadam-4 could be seen from the estimation of regression equation. Very few farmers used manure, so this was not included in the equation. The result showed that few coefficients do not have the expected sign. However, the coefficients for no. of power tiller, seed, Urea, TSP, MoP, Gypsum, soil fertility and experience were found to be positively significant at 1%, 5% and 10% level, respectively. The positive sign indicated that using more of these inputs in Binachinabadam-4 production could increased the yield to some extent. The negative sign of farm size indicate that yield was not achieved according to the farm size.

Constraints of Binachinabadam-4 cultivation

Farmers of Binachinabadam-4 growing areas were facing some problems in cultivating this variety by which yield. Major constraints that mentioned by the farmers and limit the yields of Binachinabadam-4 below the potential yield are described in Table 5.

Table 5. Major Constraints of Binachinabadam-4 cultivation

Sl. No	Particulars	Faridpur	Jhenaidah	Kishoreganj	Panchagarh	Bhola	Average
1.	Timely non-availability of good seed	58.56	46.67	40.11	39.55	43.92	45.76
2.	Lack of knowledge about recommended groundnut production technology	49.12	51.82	38.33	30.01	33.33	40.52
3.	Non-availability of sufficient labour in time	55.77	29.45	42.89	28.64	39.67	39.28
4.	Others*	50.04	38.88	25.65	45.21	30.22	38.00

*Drainage system, Infestation of insects, imbalanced and adulterated use of fertilizer, natural calamities, etc.

Some policy guidelines to reduce the Yield Gap

The majority of the respondent farmers wanted to provide Binachinabadam-4 varieties for the next year due to higher yield and higher profit. In order to decrease the yield gap of Binachinabadam-4 at farm level, the Government should ensure timely adequate supply of quality or adulteration free inputs (seed, fertilizer, pesticides, etc.). Frequent interaction was needed among farmers, extension personnel and Binachinabadam-4 growers. Hand-on training on improved groundnut cultivation and crop management practices for the groundnut growing farmers is also an important and government should take care of it. Ensuring labour facilities during harvesting time influence groundnut farmers to a greater extent to reduce yield gap. Drainage system should be developed to reduce loss during harvesting time. Results of the farmer’s 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 groundnut cultivation.

Conclusion

Reducing yield gap or increasing yield of Binachinabadam-4 as well as agricultural productivity is urgent for economic growth and development for any country in the world. The study found that in Bangladesh, we are losing 0.30 $t{\cdot}ha^{-1}$(12.85%) yield of Binachinabadam-4. If we could reduce these gaps, our total production per year will be increased which will support in achieving food security as well as Sustainable Development Goals (SDGs).

Profitability of Binadhan-17 production in some selected areas of Bangladesh

The study was conducted in five major Binadhan-17 growing areas of Bangladesh, namely Sunamganj, Rangpur, Gopalganj, Pabna and Magura district. The objectives were **(i)** to determine the profitability of Binadhan-17 growers; **(ii)** to assess the factors affecting production of Binadhan-17; and **(iii)** to identify the major constraints to Binadhan-17 production. Simple random sampling technique was followed for this study. A total of 200 farmers were randomly selected as sample size in the study areas, 40 from each District. Data were collected from Binadhan-17 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.

Result and Discussion

Socio-economic profile of the Binadhan-17 farmers

Age is an important factor that influences farmers decision to adopt improved technologies. The average age of the Binadhan-17 farmers was 44.5 years with minimum age of 17 years and the maximum of 71 years. About 89.2 percent of farmers occupation was agriculture. The sample farmers were grouped into five categories based on their level of education. Majority of the Binadhan-17 farmers (74.2% of the total farmers) had primary and secondary levels of education. Only 5.8 percent Binadhan-17 farmers were found to have completed their higher level of education. Twenty 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 Binadhan-17 farmers was 22.1 years. The average farm size per household was estimated at 1.4 ha. The highest farm size was found in Rangpur (1.77 ha.) followed by Magura (1.54 ha.), Gopalganj (1.45 ha.), Pabna (1.24 ha.) and Sunamganj (0.87 ha.), respectively. The average yearly household income was Tk. 193561.00. The highest household income was found in Rangpur (Tk. 210843.00) followed by Magura (Tk. 201542.00), Pabna (Tk. 189204.00), Sunamganj (Tk. 183564.00) and Gopalganj (Tk. 182652.00), respectively (Table 1).

Table 1. Socio-economic profile of Binadhan-17 producers in the study areas

Items	**Sunamganj**	**Rangpur**	**Gopalganj**	**Pabna**	**Magura**	**All areas**
Sample size	40	40	40	40	40	200
1. Farmer’s age (year)	40.20	46.50	44.80	42.90	48.10	**44.50**
2. Occupation (%)						
Agriculture	92	88	90	87	89	**89.20**
Business	5	5	6	7	6	5.80
Service	2	3	2	4	3	2.80
*Others	1	4	2	2	2	2.20
3. Level of education (%)						
Illiterate	22	19	20	18	21	**20.00**
Primary	43	44	40	42	43	42.40
Secondary	30	30	35	33	31	31.80
Higher Secondary	4	5	3	5	4	4.20
Degree & above	1	2	2	2	1	1.60
4. Farming experience (year)	20.30	22.50	22.80	21.80	23.30	**22.10**
5. Farm size (ha)	0.87	1.77	1.45	1.24	1.54	**1.40**
6. Household income (Tk/yr)	183564.00	210843.00	182652.00	189204.00	201542.00	**193561.00**

*Others: Rickshaw and van puller, day laborer, student etc.

Profitability level of Binadhan-17 production

Profitability is one of the major criteria for determination of acceptance of a crop. The cost of Binadhan-17 production, gross return, gross margin, net return and the benefit cost ratio (BCR) for Binadhan-17 cultivation are being discussed in the following sections.

Cost of Binadhan-17 cultivation

The cost of human labour, power tiller, seed, fertilizers, pesticides, and irrigation were taken into consideration, while calculating cost of Binadhan-17 production. Beside this, interest on operating capital was also considered as the cost of Binadhan-17 production. Total cost consists of variable cost and fixed cost that covered 68.5% and 31.5% of total cost for Binadhan-17 production.
From Table 2, the average costs of Binadhan-17 cultivation were Tk. 72557.75 and Tk. 49678.95 per hectare on full cost and cash cost basis, respectively. The highest production cost was for human labour (57.2%), followed by power tiller (9.2%), land use (8.6%) and irrigation (6.6%). The cost of Binadhan-17 cultivation was found highest in Pabna (Tk. 74276.05/ha) followed by that in Magura (Tk. 73923.56/ha), Gopalganj (Tk. 71929.00/ha), Rangpur (Tk. 70898.73/ha) and Sunamganj (Tk.69766.87/ha), respectively.

Table 2. Per hectare cost of Binadhan-17 production in different locations

Cost Component	Cost of production (Tk/hectare)					All areas	% of total cost
	Sunamganj	**Rangpur**	**Gopalganj**	**Pabna**	**Magura**		
(A) Variable Cost	**45466.87**	**48614.73**	**48507.00**	**50738.05**	**51787.56**	**49678.95**	**68.5**
Hired labour (Man days)	24404.49	24732.00	26543.00	26021.00	27859.00	**26175.10**	**36.10**
Power tiller	6410.00	6298.00	6534.00	7040.00	6817.00	**6676.40**	**9.20**
Seed	1037.40	907.73	824.00	778.05	972.56	**933.66**	**1.30**
Fertilizers:							
Urea	2519.40	2267.00	2413.00	2141.00	2393.00	**2342.68**	**3.20**
TSP	2778.75	2408.00	2552.00	2594.00	2864.00	**2701.75**	**3.70**
MoP	629.85	703.00	698.00	667.00	652.00	**660.77**	**0.90**
Gypsum	355.68	385.00	424.00	445.00	402.00	**397.94**	**0.50**
Zinc	440.00	550.00	610.00	660.00	418.00	**497.20**	**0.70**
Cow dung	2223.00	3705.00	2456.00	3129.00	3479.00	**3203.00**	**4.40**
Pesticides	1111.50	1324.00	1365.00	1409.00	1267.00	**1275.70**	**1.80**
Irrigation	3556.80	5335.00	4088.00	5854.00	4664.00	**4814.76**	**6.60**
(B) Fixed Cost	**24300.00**	**22284.00**	**23422.00**	**23538.00**	**22136.00**	**22878.80**	**31.50**
Family labour	16269.00	15158.00	15831.00	15281.00	15001.00	**15342.00**	**21.10**
Int. on operating capital	1430.00	1325.00	1289.00	1529.00	1184.00	**1330.40**	**1.80**
Land use cost	6601.00	5801.00	6302.00	6728.00	5951.00	**6206.40**	**8.60**
Total Cost (A+B)	**69766.87**	**70898.73**	**71929.00**	**74276.05**	**73923.56**	**72557.75**	**100**

Return from Binadhan-17 production

The average return from Binadhan-17 production in different locations is shown in Table 3. The average yield of Binadhan-17 was 5789.83 kg ha^{-1}. The yield was highest at Rangpur (5976.32 kg ha^{-1}) followed by Gopalganj (5894.41 kg ha^{-1}), Magura (5802.80 kg ha^{-1}), Pabna (5692.62 kg ha^{-1}) and Sunamganj (5583.01 kg ha^{-1}). Most of the farmers in the study areas sold their paddy just after harvest. The total return from Binadhan-17 production consists of the values of Binadhan-17 and straw.

The average gross margin was found Tk. 57343.56 ha^{-1} on variable cost basis. Gross margin was highest in Rangpur (Tk. 60820.88 ha^{-1}) followed by Gopalganj (Tk. 59205.18 ha^{-1}), Magura (Tk. 58227.84 ha^{-1}), Pabna (Tk. 55883.11 ha^{-1}) and Sunamganj (Tk. 52580.80 ha^{-1}), respectively. The average net return per hectare was Tk. 34207.56. The net return was highest in Rangpur (Tk. 38536.88/ha) followed by Magura (Tk. 36091.84 ha^{-1}), Gopalganj (Tk. 35783.18 ha^{-1}), Pabna (Tk. 32345.11 ha^{-1}) and Sunamganj (Tk. 28280.80 ha^{-1}), respectively. Benefit cost ratio was estimated at

1.47 and 2.17 on full cost and variable cost basis implying that the Binadhan-17 cultivation at farm level was profitable.

Table 3. Profitability of Binadhan-17 cultivation in different locations

Type	Study areas					All areas
	Sunamganj	Rangpur	Gopalganj	Pabna	Magura	
Yield from Binadhan-17 (Kg ha^{-1}.)	5583.01	5976.32	5894.41	5692.62	5802.80	**5789.83**
Return from Binadhan-17 (Tk. ha^{-1})	92119.67	104585.60	103152.18	102467.16	104450.40	101355.00
Return from straw (Tk. ha^{-1})	5928.00	4850.00	4560.00	4154.00	5565.00	5011.40
Total return (Tk. ha^{-1})	98047.67	109435.60	107712.18	106621.16	110015.40	106366.40
Total variable cost (Tk. ha^{-1})	45466.87	48614.73	48507.00	50738.05	51787.56	49022.84
Total Cost (Tk. ha^{-1})	69766.87	70898.73	71929.00	74276.05	73923.56	72158.84
Gross margin (Tk. ha^{-1})	52580.80	60820.88	59205.18	55883.11	58227.84	57343.56
Net return (Tk. ha^{-1})	28280.80	38536.88	35783.18	32345.11	36091.84	34207.56
Rate of return (BCR)						
BCR on full cost	1.41	1.54	1.50	1.44	1.49	1.47
BCR on variable cost	2.16	2.25	2.22	2.10	2.12	2.17

Factors affecting gross return of Binadhan-17 production

To determine the effects of the explanatory variables, linear and Cobb-Douglas model were initially estimated for Binadhan-17 rice production. Some of the key variables are explained below.

Human labour cost (X_I)

In table 4 most of the parameters are statistically significant and positive. The regression coefficients of human labour cost for Binadhan-17 under all areas were positive and significant at 5 % level implying that the 1 percent increases in the labour use cost increase the gross return from rice by 0.287 percent.

The regression coefficients of Sunamganj, Rangpur, Gopalganj, Pabna and Magura districts were positive and significant. The coefficient of Sunamganj, Gopalganj and Pabna districts were significant at 5% level implying that the 1 percent increases in the labour use cost increase the gross return from rice by 0.099, 0.259 and 0.391 percent, respectively. The coefficient of Rangpur and Magura district was significant at 1% level and it was 0.234 and 0.224 percent, respectively. This indicated that 1 percent increase in human labour cost keeping other factors constant, would increase the gross returns by 0.234 and 0.224 percent, respectively (Table 4).

Power tiller (X_2)

The regression coefficients of power tiller cost for Binadhan-17 under all areas were positive and significant at 5 % level implying that the 1 percent increases in the labour use cost increase the gross return from rice by 0.257 percent.

In table 4 showed that the coefficient of power tiller cost in Rangpur and Magura district was 0.234 and 0.010, which was found to be significant at 5 percent level. It indicates that an 1 percent increase in power tiller cost keeping other factors constant would be able increase the gross returns by 0.234 and 0.010 percent, respectively. The coefficient of power tiller cost under Sunamganj, Gopalganj and Pabna districts were positive but not significant.

Seed cost (X_3)

The regression coefficients of seed use cost for Binadhan-17 under all areas were positive and significant at 10 % level implying that the 1 percent increases in the labour use cost increase the gross return from rice by 0.184 percent. The coefficient of seedling cost of the Binadhan-17 production was statistically significant at 5 percent level of significance for Gopalganj and Magura district. The result implies that 1 percent increase in the seedling cost for Gopalganj and Magura district, keeping other factors constant, would result in an increase in gross return from rice by 0.150 and 0.702 percent.

The coefficient of seedling cost of the rice production was statistically significant at 10 percent level of significance for Sunamganj, Rangpur and Pabna districts were 0.620, 0.301 and 0.230. The result implies that 1 percent increase in the seedling cost for Sunamganj, Rangpur and Pabna districts farming systems, keeping other factors constant, would result increase in gross return from rice by 0.620, 0.301 and 0.230 percent, respectively (Table 4).

Fertilizer cost (X_4)

The regression coefficients of fertilizer cost for Binadhan-17 under all areas were positive and significant at 10 % level implying that the 1 percent increases in the labour use cost increase the gross return from rice by 0.410 percent.

The coefficient of fertilizer cost was statistically significant at 10 percent level of significance for Sunamganj and Pabna district. The result implies that 1 percent increase in the fertilizer cost for Sunamganj and Pabna district, keeping other factors constant, would result in an increase in gross return from rice by 0.257 and 0.280 percent. The coefficient of fertilizer cost under Rangpur, Gopalganj and Magura districts were positive but not significant (Table 4).

Irrigation cost (X_5)

The regression coefficients of irrigation cost for Binadhan-17 under all areas were positive but not significant.

In table 4 showed that the coefficient of irrigation cost in Rangpur and Pabna district was 0.050 and 0.079, which was found to be significant at 10 percent level. It indicates that an 1 percent increase in irrigation cost keeping other factors constant would be able increase the gross returns by 0.050 and 0.079 percent, respectively. The coefficient of irrigation cost under Sunamganj, Gopalganj and Magura was positive but not significant.

Insecticides cost (X_6)

The regression coefficients of insecticides cost for Binadhan-17 under all areas were positive and significant at 5 % level implying that the 1 percent increases in the labour use cost increase the gross return from rice by 0.331 percent. The coefficient of insecticides cost in Sunamganj, Gopalganj and Pabna districts were 0.258 0.184 and 0.221, which was found to be significant at 5 percent level. It indicates that an 1 percent increase in insecticides cost keeping other factors constant would be able increase the gross returns by 0.258 0.184 and 0.221 percent, respectively.

The coefficient of insecticides cost was statistically significant at 10 percent level of significance for Rangpur and Magura district was 0.181 and 0.480. The result implies that 1 percent increase in the insecticides cost for Rangpur and Magura districts, keeping other factors constant, would result increase in gross return from rice by 0.184 and 0.480 percent, respectively (Table 4).

Coefficient of multiple determination (R^2)

The coefficient of multiple determination (R^2) tells how well the sample regression line fits the data (Gujarati, 1995). It is evident from Table 4 that the values of R^2 were 0.738, 0.790, 0.770, 0.820 and 0.835 for Sunamganj, Rangpur, Gopalganj, Pabna and Magura districts, respectively. This means that around 74, 79, 77, 82 and 84 percent of the variations in gross return for Binadhan–17 rice, respectively were explained by the independent variables included in the model.

F-value

The F-values of Sunamganj, Rangpur, Gopalganj, Pabna and Magura districts were 8.950, 9.267, 8.436, 10.114 and 11.238 which were highly significant at 1% level of probability implying that all the explanatory variables were important for explaining the variations in gross returns of the Binadhan–17 variety in the study area (Table 4).

Return to Scale

The summation of all the production coefficient indicates return to scale. The sum of elasticity coefficients were 1.015, 1.056, 1.020, 1.078 and 1.034 in case of Binadhan–17 meaning increasing returns to scale (Table 4). This means that, 1 percent increase in all inputs simultaneously would result on average 1.015, 1.056, 1.020, 1.078 and 1.034 percent increase in gross return of Binadhan–17. This value being greater than 1 means that the farmers are operating at the region of increasing return to scale. More clearly, the farmers still have the scope to allocate more inputs in their rice field as it will generate a higher return than production cost.

Table 4. Estimated values of regression co-efficient and related statistics of Cobb-Douglas revenue type production function for Binadhan–17 production

Explanatory variables	Study areas										All areas	
	Sunamganj		Rangpur		Gopalganj		Pabna		Magura			
	Estimated Co-efficient	T-values	Estimated Co-efficient	T-values	Estimated Co-efficient	T-values	Estimated Co-efficient	T-values	Estimated Co-efficient	T-values	Estimated Co-efficient	T-values
Intercept	2.524 (0.831)	4.030	3.780 (1.441)	5.420	4.850 (0.510)	9.680	4.150 (0.750)	4.690	5.037 (1.406)	8.690	3.890 (1.650)	4.851
Human labour cost (X_I)	0.099** (0.080)	1.720	0.234*** (0.110)	2.136	0.259** (0.090)	2.871	0.391** (0.181)	3.831	0.224*** (0.085)	4.813	0.287** (0.061)	4.420
Power tiller cost (X_2)	0.204 (0.010)	1.836	0.234** (0.075)	3.308	0.312 (0.084)	2.885	0.059 (0.526)	2.182	0.010** (0.010)	1.680	0.257** (0.078)	3.408
Seed cost (X_3)	0.620* (0.150)	8.410	0.301* (0.085)	3.462	0.150** (0.080)	2.010	0.230* (0.180)	2.169	0.702** (0.284)	4.279	0.184* (0.120)	1.440
Fertilizer cost (X_4)	0.257* (0.061)	4.713	0.233 (0.091)	2.541	0.225 (0.081)	2.830	0.280* (0.120)	4.420	0.054 (0.140)	2.282	0.410* (0.161)	3.412
Irrigation cost (X_5)	0.020 (0.300)	0.530	0.050* (0.040)	1.120	0.086 (0.076)	2.132	0.079* (0.122)	2.350	0.420 (0.418)	3.425	0.056 (0.510)	2.082
Insecticides cost (X_6)	0.258** (0.108)	3.129	0.181* (0.146)	1.556	0.184** (0.152)	1.221	0.221** (0.148)	2.881	0.480* (0.162)	4.876	0.331** (0.180)	3.241
Coefficient of multiple determination (R^2)	0.738		0.790		0.770		0.820		0.835		0.801	
F-value	8.950***		9.267***		8.436***		10.114***		11.238***		10.228***	
Returns to scale	1.015		1.056		1.020		1.078		1.034		1.051	

Note:

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level
(Figures in the parentheses indicates the standard errors)

Major constraints to Binadhan-17 cultivation

Binadhan-17 is a profitable rice variety in the study areas. The farmers in the study areas encountered some constraints to Binadhan-17 production. The first ranked constraint was unavailability of Binadhan-17 varieties' seeds in all areas. Other constraints were lack of training (64%), lack of technical know-how (38%), lack of capital (30%), lack of storage facility (17%), natural calamities (14%) and low education level of farmers (10%).

Table 5. Major constraints to Binadhan-17 cultivation in the study areas

List of constraints	% of farmers responded						Rank
	Sunamganj	Rangpur	Gopalganj	Pabna	Magura	All areas	
1. Unavailability of seed	88	85	82	89	76	84	1
2. Lack of training	56	82	88	67	28	64	2
3. Lack of technical know-how	30	25	65	53	15	38	3
4. Lack of capital	17	50	49	12	25	30	4
5. Lack of storage facility	12	15	24	16	19	17	5
6. Natural calamities	10	13	13	15	17	14	6
7. Low education level of farmers	10	12	11	8	9	10	7

Conclusion

Binadhan-17 production in the study areas is profitable. All of the factors namely, human labour cost, power tiller cost, seed cost, fertilizer cost and insecticides cost are very important for Binadhan-17 cultivation. The yield performance and economic return of Binadhan-17 production encouraging to the farmer’s for more cultivation. In the study areas cultivation of this variety increasing day by day. There is a need of proper guide to farmers about Binadhan-17 production management practices in the study areas.

Profitability and productivity of drought tolerant rice variety Binadhan-19 in some selected areas of Bangladesh

The present study was conducted in five districts namely Mymensingh, Ranpur, Pabna, Rajshahi and Chapainwabganj in Bangladesh. These locations represent as no drought, slight, moderate, severe and very severe locations, respectively, in Bangladesh. Besides, availability of Binadhan-19 cultivated farmers was also taken into consideration. The objectives of the study were i) to estimate profitability and productivity of Binadhan-19 in the study areas; ii) to determine factor affecting to adoption of the variety; iii) to identify constraints of the variety cultivation; and iv) to suggest some policy guidelines. A total of 200 farmers were randomly selected (40 from each locations) to collect the data with a pre-designed questionnaire. The primary data were collected on the respondents' socioeconomic characteristics such as age, education, family size, farm size, and literacy level as well as the rice farming practices. From each areas 20 farmers was adopters and 20 was non-adopters. In the sampled areas data were collected through pre-designed interview schedule. Tabular, descriptive statistics and Probit model were used to fulfill objectives. Profitability analysis of Binadhan-19 has been determined on the basis of net return analysis. To determine the net returns from Binadhan-19 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:

$$\pi = Pm^* \, Ym + Pb^* \, Yb - \Sigma(Pxi * Xi) - TFC$$

Where, π = Net return
Pm = Price of main product per units
Ym = Total quantity of main product
Pb = Price of by-product per unit
Yb = Quantity of by-product
Pxi = Price of ith input per unit used for Binadhan-19 production
Xi = Quantity of the ith input used for Binadhan-19 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 rice production (in month).

Land preparation: Land preparation included, ploughing, laddering, pit preparation and other activities needed to make the soil suitable for plantation of seedling. In the study areas, all the farmers ploughed their land with the help of power tiller and tractor and the number of ploughing varied from farm to farm i.e 2-4.

Human labour: Human labour is one of the most important components for crop cultivation. Machine power could not replace human labour fully for cultivation till now in our country. Farmers used both family supplied and hired labour. Family labour includes the operator himself and other working member of the family, while the hired labour includes permanent hired labour, labour employed on monthly contract basis, casual labour and labour employed on the other contract basis.

Seed: Most of the farmers collect seeds from research institutes and DAE. Only a few farmers purchase seeds from the local market or other organizations. The farmers of the study areas mainly used local, zira shail, Binadhan-19, BRRI dhan48, etc.

Fertilizer: Proper use of fertilizer can enhance agricultural production largely and help to retain or improve soil fertility. The sample farmers used four kinds of chemical fertilizers namely; Urea, TSP, MoP and Sulphur in the survey area.

Pesticide: Pesticide mainly insecticide and fungicide was used by most of the sample farmers and applied to survey plot with different rates. The cost of pesticide was computed based on the price that the farmers have actually paid.

Irrigation: Farmers in the study areas used irrigation water in their plot from shallow tube well (SRW). Very few farmers followed deep tube well (OTW) for irrigation purpose.

Land rent: Land rent is one of the biggest fixed cost items for the production process. Rental value of land was estimated for the cropping period at the rate prevailing in the study area. In this analysis, cropping period was considered as 4 months that varied from crop to crop.

Probit and Logit models have been used extensively by agricultural production and farming systems economists for studying and analyzing farmers' adoption and diffusion of agricultural interventions. In Pakistan, Malik et al., 1991 and Heisey et al., 1990 used Probit model to examine the role of credit in agricultural development and to identify the determinants of adoption of wheat varieties. Traxler and Byerlee (1992) also used this analysis to identify the characteristics of insecticide farmers. In the present study, Probit regression model was used to find out the factors of adoption and non-adoption of the variety. The probit model is a statistical probability model with two categories in the dependent variable (Liao). Probit analysis is based on the cumulative normal probability distribution. The binary dependent variable, y takes on the values of zero and one. The outcomes of y are mutually exclusive and exhaustive. The dependent variable, y, depends on k observable variables xk where k=1,…,K (Aldrich and Nelson). While the values of zero and one were observed for the dependent variable in the probit model, there was a latent, unobserved continuous variable, y*.

$$y^*=\sum_{k=1}^{k} \beta_k x_k + \varepsilon \qquad (1)$$

ε is IN $(0,\sigma 2)$

The dummy variable, y, was observed and was determined by y* as follows.

$$y = \{ 1 \text{ if } y^* > 0, 0 \text{ otherwise} \qquad (2)$$

The point of interest relates to the probability that y equals one. From the above equations,

$$\text{Prob } (y=1) = \text{Prob } \sum_{k=1}^{k} \beta_k x_k + \varepsilon >$$
$$= \text{Prob } (\varepsilon > - \sum_{k=1}^{k} \beta_k x_k)$$
$$= 1 - \Phi (- \sum_{k=1}^{k} \beta_k x_k) \quad (3)$$

Where Φ was the cumulative distribution function of ε (Liao).

The Maximum Likelihood Estimation (MLE) technique was used to estimate probit model parameters. MLE focused on choosing parameter estimates that gave the highest probability or likelihood of obtaining the observed sample y. The main principle of MLE was to choose as an estimate of β the set of K numbers that would maximize the likelihood of having observed this particular y (Aldrich and Nelson, 1984).

The specification of the probit model was as follows.

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11+} \beta_{12} X_{12+} \beta_{13} X_{13+} U_i$$

Where,

Yi = Farmers adopting Binadhan-19 variety (If adopted = 1; Otherwise= 0), α = Intercept, Xi = Explanatory variables, βi = Coefficients of respective variables, and Ui = Error term

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 = Family size
X_6 =Annual income
X_7 = Farm size (hectare)
X_8 = Yield
X_9 =Duration (days)
X_{10}=Ext. contact
X_{11}=Soil fertility
X_{12}=Human labour
X_{13}= Districts

Table1. 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 = Family size	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 Binadhan-19 cultivation (ha)
X_8 =Yield	Continuous	Yield obtained by farmers in kg
X_9 =Duration (Days)	Continuous	No of days required for harvest
X_{10}=Ext. Contact	Dummy	if favorable=1; otherwise=0
X_{11}=Soil fertility	Continuous	High=1, Medium=2
X_{12}=Human labour	Continuous	No. of labour/ha
X_{13}=District	Continuous	Score

Results and Discussion

Demographic characteristics of the Binadhan-19 cultivated farmers.

The demographic characteristics of the rice farmers were presented and discussed according to their age, sex, education, marital status, household size, years of farming experience and farm size. The distribution of the farmers by age showed that the mean age for Binadhan-19 cultivated farmers was 43 years. This implies that the rice farming populations were still within their productive age and can still engage efficiently in rice production. Rice farming is a labour intensive occupation and exerts energy for land preparation, nursery, planting, weeding and harvesting. The findings are similar to those of Nwaobiala and Adesope (2015) who found out that the mean age of upland rice farmers and swamp rice farmers in Ebonyi State were 37.3 years and 39.2 years respectively. This is encouraging as an active age implies increased productivity and enables the farmers engage in other value adding activities like rice processing. Among the farmer 86% was educated which was categories as illiterate, Primary, Secondary, Higher secondary and above. In the study areas farmer's average experience was 20 year and income was tk. 235066 per year. The average family size was 6 where 50 % was male and 50% was female (Table 2).

Table 2. Socio-demographic profile of the selected rice farmer's during 2019

Variables	Meanvalues
Age (years)	43
Educational Status (%)	86
No education	20
Illiterate	20
Primary	17
Secondary	20
Higher Secondary	21
Above	2
Family size (no.)	6
Male	3
Female	3
Income (Tk/year)	235066
Total land size (hectare)	99
Land under Binadhan-19 cultivation	25
Farming experience (years)	20
Farming as a single occupation	99
Farming+ business	27
Farming+ job	11
Farming+others	24
Training or extension services (%)	20
Received	20
Did not receive	80

2. Pattern of Input Use

2.1 Pattern of input use for Binadhan-19 cultivation

Farmers in the study areas used various inputs for Binadhan-19 cultivation. Farmers used on an average 126 man-days per hectare of total human labour for Binadhan -19 cultivation where family labour was 57 man-days and hired labour was 69 man-days. On an average, they sowed 37 kg seed per hectare of land. They applied Urea at the rate of 111 kg ha^{-1}, TSP 119 kg ha^{-1}, and MoP 86 kg ha^{-1}. It was observed that among the chemical fertilizer, farmers used highest amount of TSP for the studied districts (Table 3).

Table-3. Level of major input use pattern of Binadhan-19 cultivation in the study areas.

Particulars	**Districts**					
	Mymensingh	**Ranpur**	**Pabna**	**Rajshahi**	**Chapainwabganj**	All
Human labour (man-days)	127	131	133	121	121	126
Hired	59	75	85	75	52	69
Family	68	56	48	46	69	57
Seed (kg/ha)	36	34	40	37	38	37
Urea	126	122	99	114	96	111
TSP	106	123	99	151	118	119
MoP	84	83	57	113	94	86

3. Cost of Cultivation

3.1 Total cost of production

Variable cost: The cost of production included all kinds of variable costs such as hired labour, land preparation, seed, manure, fertilizers, irrigation, pesticides, etc. used for the production of rice. Both cash expenses and imputed value of family supplied inputs were included in the variable cost. The study revealed that total variable cost of rice cultivation was Tk. 39389 per hectare which was 60% of total cost of production (Table 4.). The highest cost item was human labour which accounted for about 49 % of the total cost. Cost of land preparation and land use cost accounted for about 11% of total cost and ranked second cost item

Fixed cost*:* Family labour and rental value of land was considered as fixed cost of production. The family labour and land use cost were Tk. 19161 and Tk. 7536 per hectare which was accounted for about 29% and 11 % of total cost respectively (Table 4).

Total cost: Total cost of production included variable costs and fixed costs incurred for Binadhan-19 cultivation. On an average, the total cost of production was Tk. 66087 per hectare where 40% was fixed costs and 60% was variable cost (Table 4). The highest cost was found in Rajshahi (Tk. 75432 ha^{-1}) and the lowest in Pabna (Tk. 56833 ha^{-1}).

Table-4 Per hectare cost of Binadhan-19 in the study areas.

(Tk ha^{-1})

Particulars	District						
	Mymensingh	**Ranpur**	**Pabna**	**Rajshahi**	**Chapainwabganj**	**All**	**%**
Variable Cost							
Cost of and preparation	6213	6503	6974	8067	8150.63	7181	11
Hired labor	10490	13322	15564	16554	10272	13240	20
Seed	1794	1513	2612	1946	2141	2001	3
Cowdung	2582	2468	1500	5824	3569	1188	6
Urea	2248	1970	1750	1839	1591	1879	3
TSP	3118	3092	2841	4038	3207.34	3259	5
MoP	1384	2220	1239	2018	1154.17	1603	2
Sulphar	111	212	446	636	506	382	1
Cost of irrigation	4019	4604	2186	1190	1033	2606	4
Cost of insecticide	2062	2608	1500	3621	2215	2401	4
Sub-total	34021	38512	36612	45733	33839.14	38743	59
Interest on operating capital	567	642	610	762	564	646	10
Total variable cost	34588	39154	37222	46495	34403	39389	60
Fixed Cost							
Family labor	18461	17684	12931	19024	27708	19161	29
Land use cost	6955	8778	6680	7879	7392	7536	11
Total fixed cost	25416	26462	19611	26903	35100	26698	40
Total cost	60004	65616	56833	75432	72553	66087	100

4. Financial Profitability of Binadhan-19 in the study areas

Financial profitability (FP) is based on calculation of market prices of inputs and outputs that farmers actually pay or receive for producing a crop, along with the quantities used of each. Farmers allocate land and other resources in the production of different crops on the basis of relative financial profitability.

Table-5. Per hectare return of Binadhan-19 in the study areas

(Tk ha^{-1})

Particulars	Districts					
	Mymensingh	**Ranpur**	**Pabna**	**Rajshahi**	**Chapainwabganj**	**All**
Yield (kg ha^{-1})	4506	5050	4445	4652	4902	4711
Price (Tk. kg^{-1})	17	13	17	19	19	17
Return from Binadhan-19	76602	65650	75565	88388	93138	80087
Return from by-product	12618	12658	8806	9724	9154	10592
Gross Return	89220	78308	84371	98112	102292	90679
Total variable cost (TVC)	34588.02	39154	37222	48529	37453	39389
Total cost (TC)	60004	65616	56833	75432	72553	66088
Gross Margin	54631.98	39154	47149	49583	64839	51290
Net Return	29216	12692	27538	22680	29739	24591
BCR over total cost (undiscounted)	1.49	1.19	1.48	1.31	1.41	1.37
Cost of production (Tk. kg^{-1})	13	13	13	16	14	14

Per hectare average yield of rice was 4.71 ton and per kg average price was about Tk. 17. The average gross return and gross margin of rice cultivation were found Tk. 90679 ha^{-1} and Tk. 51290 ha^{-1} respectively. Per hectare average net return was Tk. 24591which was found to be highest in Chapainwabgonj (Tk. 29739) followed by Mymensingh (Tk. 29216), Pabna (Tk. 27538), Rajshahi (Tk. 22680) and Rangpur (Tk. 12692). BCR on total cost basis was found 1.37 which was the highest in Mymensingh 1.49 and less in Rangpur districts 1.19. It was estimated that, to produce one kilogram of rice, total cost incurred Tk. 14 (Table 5).

Determination of factor affecting to adoption of the variety

The estimated log likelihood value is highly significant indicating that the model with predictors is to be preferred over a model without predictors. Gender, farm size, yield, agricultural extension services have statistically and positive significantly effect of adoption of the variety. The household characteristic related variables such as age, experience, annual income, human labor, duration of the variety have no statistically significant effect on the adoption of the variety. The study areas and soil fertility are negatively significant for the adoption of the variety (Table 6)..

Table 6: Maximum likelihood estimates of variable determining adoption of the variety among respondent farmers

Variable	Co-efficient	Std. Err	Z statistic	Probability
X_1 =Age	-.0000819	.0101874	0.01	0.994
X_2 =Gender	1.17387*	.7144071	1.64	0.100
X_3 = Education	.0944802	.0621191	1.52	0.128
X_4 = Experience in farming	.0028103	.0103253	0.27	. 0.785
X_5 = Family size	-.0719539	.0603571	1.19	0.233
X_6 =Annual income	2.58e-07	5.06e-07	0.51	0.610
X_7 = Farm size	.0022593**	.00078	2.90	0.004
X_8 =Yield	.003857 **	.001837	2.10	0.036
X_9 =Duration (Days)	.0001081	.0153831	0.01	0.994
X_{10}=Ext. Contact	.3857288 **	.1960491	1.97	0.049
X_{11}=Soil fertility	-.9313744***	.2483106	3.75	0.000
X_{12}=Human labour	-.0015828	.0054463	-0.29	0.771
X_{13}=District	-.0018017**	.0009324	1.93	0.053
Number of observations	199			
LR chi^2 (12)	45.52			
Prob > chi2	0.000***			
Pseudo R^2	0.1650			
Log likelihood	-121.51639			

*.**, *** represent statistically significance at 10%, 5% and 1%, respectively

Marginal coefficients indicate that if male farmers increased by 100%, the probability of adopting Binadhan-19 varieties would increase at 38 times more likely to adopt of the variety. If farm size increased by 100%, the probability of adopting the variety would be increase at 0.07%. A farmer who has access to agricultural extension service is about 39 times more likely to adopt the variety. Again, if the yield increased by 100% the probability of adopting the varieties would increase by 0.08%. The marginal coefficients of district and soil fertility are negatively significant. If those variables increase by 100% the probability of adopting the varieties would decreased by 0.06% and 30%, respectively (Table 7).

Table7: Marginal Effect Estimates of the Probit Model

Variable	dy/dx	Std. Err	Z	Probability
X_1 =Age	-.000027	.0033589	0.01	0.994
X_2 =Gender	.3870364 *	.2306375	1.68	0.093
X_3 = Education	.0311511	.0201507	1.55	. 0.122
X_4 = Experience in farming	.0009266	.0034029	0.27	0.785
X_5 = Family size	.0719539	.0603571	1.19	0.233
X_6 =Annual income	8.51e.08	1.66e-07	0.51	0.609
X_7 = Farm size	.0007449 **	.0002441	3.05	0.002
X_8 =Yield	.000855**	.000631	1.36	0.032
X_9 =Duration (Days)	0000356	.0050719	0.01	0.994
X_{10}=Ext. Contact	.0850021**	0.067438	1.26	0.028
X_{11}=Soil fertility	-.3070833 ***	.0728358	4.22	0.000
X_{12}=Human labour	0005219	. .0017946	0.29	0.771
X_{13}=District**	-.0005941	.0002999	1.98	0.048

*.**, *** represent statistically significance at 10%, 5% and 1%, respectively

Preferences and major constraints to Binadhan-19 Cultivation

Binadhan-19 is a profitable crop in the study areas. Farmers prefered this variety for various reasons. Major of these are shown in the Table 5. Among the list the highest preferences was for neat rice 98% and it was the lowest for easy to harvest i.e 82%. Among the constraints the highest constrain said by the farmer was crop destroy by animal & bird of paddy and it was 81% and the lowest was disease and pest infestation i.e. 54% in Binadhan-19 cultivation (Table 8).

8. Table: Major Preferences and constrains of Binadhan-19 under different districts

Particulars	Districts					
	Mymensing h	Ranpur	Pabna	Rajsah i	Chapainwabganj	Average (%)
Preferences						
Palatability	18	17	15	16	18	84
Fine rice	18	19	18	19	19	93
Neat rice	19	19	20	20	20	98
High yield	17	18	17	17	18	87
Short duration	17	19	17	18	17	88
Less water, urea & pesticide require	19	18	17	16	17	87
Not Shattering	17	19	17	17	17	87
Easy to harvest	17	18	17	15	15	82
Constrains						

Disease and pest infestation	10	5	7	17	15	54
Scarcity of farm labour and high wage rate	16	13	15	14	14	72
Low price	13	18	13	14	14	72
Destroy by animal & bird	15	17	16	16	17	81

Conclusion:

Binadhan-19 production is profitable in the study area. The average yield was 4.71 ton per hector in Aus season and undiscounted BCR was 1.37. Therefore, Binadhan-19 farmers received high return on its investment. Econometrics analysis showed that gender, farm size, yield, extension contact are statistically significant of the adoption of the variety. Farmer's of the study areas mention about positive traits of the variety like palatability, fine rice, easy to harvest, less water and urea requirement etc. Some constraints faced by rice farmers in the study areas like low price, high labor price, crop field destroy by bird etc.

Area coverage of BINA developed rice, pulse and oilseed varieties in collaboration with DAE and Sub-stations of BINA.

The study was conducted in 64 district of Bangladesh to examine the area coverage of BINA developed rice, pulse and oilseed varieties at 2019-20 and suggest some policy guidelines. Field survey data were used for this study and those were collected from 64 districts through DAE office and substations of BINA. Both tabular and descriptive statistical analysis was used to fulfill the objectives. Finally, data were classified into 14 agricultural regions to identify the area coverage of BINA developed rice, pulses & oilseed varieties and partially results were obtained in the study.

Results and Discussion

From Table-1, it was seen that the overall area coverage of BINA developed rice varieties were 6.45%. Among the three seasons; Aus, Aman and Boro the highest area coverage was found in Aman season that was 10.45% followed by Boro 2.46% and Aus 1.26%, respectively. In Aman season, the highest coverage was 9.54% for Binadhan-7 and the lowest was 0.00016 % for Binadhan-22 as a newly developed variety. In Boro season, the highest coverage was 1.58% for Binadhan-10 and the lowest was 0.038 % for Binadhan-6. In Aus season, the highest coverage was 0.69% for Binadhan-19 and the lowest was 0.002 % for Binadhan-21.

Table 1: Variety wise area coverage of BINA developed rice varieties in 2019-20 (in ha)

Rice	Varieties	Cultivated Area (%)	Area Coverage (%)
Boro 3224627.00 **(2.46 %)**	Binadhan-5	5502.25 (1.00)	0.1706
	Binadhan-6	1195 (0.22)	0.0371
	Binadhan-8	11195 (2.03)	0.3472
	Binadhan-10	50853.6 (9.2)	1.577
	Binadhan-14	8965.19 (1.62)	0.278
	Binadhan-18	1650.00 (0.3)	0.0512
Aus 929824.00 **(1.26 %)**	Iratom	5273 (0.95)	0.5671
	Binadhan-19	6444(1.17)	0.693
	Binadhan-21	20.00 (0.001)	0.0022
Aman 4411036.00 **(10.45 %)**	Binashail	1204.00 (0.22)	0.0273
	Binadhan-7	421080 (76.22)	9.5461
	Binadhan-9	30.00 (0.01)	.0007
	Binadhan-11	11697 (2.29)	0.2652
	Binadhan-12	2193.00 (0.43)	0.050
	Binadhan-13	45.00 (0.01)	.0010
	Binadhan-15	49.00 (0.01)	.0011
	Binadhan-16	1870 (0.3)	.0420
	Binadhan-17	22305 (4.04)	0.5056
	Binadhan-20	906.00 (0.16)	0.0205
	Binadhan-22	6.00 (0.001)	0.00016
Total 6.45 %		552483.04 (100%)	

Source: DAE data, 2020

From Table 2, it was found that among the three seasons, area coverage was the highest for Aman that was 83.51% followed by Boro 14.36 % and it was the lowest for Aus i.e. 2.12 %. Among the 14 agricultural regions the highest area coverage was found 22.59 % in Jessore region (Reg-13) and the lowest found 0.67% in Rangamati region (Reg- 04).

Table: 2 Region wise area coverage of BINA developed rice varieties during 2019-20

(in ha)

Rice	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-10	Reg-11	Reg-12	Reg-13	Reg-14	All
Boro	5797.5 (7.31)	9482.8 (11.95)	5428.5 (6.84)	1008.5 (1.27)	7622 (9.60)	21422.2 (26.99)	1435.5 (1.81)	2466 (3.11)	6231 (7.85)	234 (0.29)	423.1 (0.53)	11043 (13.92)	2829 (3.56)	3937 (4.96)	79360.1 (14.36)
Aus	49.5 (0.42)	2639.5 (22.49)	280.5 (2.39)	127.5 (1.09)	3609 (30.75)	3306 (28.17)	468 (3.99)	465 (3.96)	405 (3.45)	0 (0.00)	55 (0.47)	37.5 (0.32)	184 (1.57)	111 0.95	11737.5 (2.12)
Aman	9373.5 (2.03)	29313.5 (6.35)	17229.5 (3.73)	2550.5 (0.55)	39742 (8.61)	9242.5 (2.00)	58049.2 (12.58)	65708.5 (14.24)	21350 (4.63)	21519 (94.66)	3293.4 (0.71)	8841.5 (1.92)	121811 (25.59)	53361 (11.57)	461385.1 (83.51)
Total	15220.5 (2.75)	41435.8 (7.50)	22938.5 (4.15)	3686.5 (0.67)	50973 (9.23)	33970.7 (6.15)	59952.7 (10.85)	68639.5 (12.42)	27986 (5.07)	21753 (3.94)	3771.5 (0.68)	19922 (3.61)	124824 (22.59)	57409 (10.39)	552482.7 (100.00)

Source: DAE data, 2020

Note: Reg-1**:** Cumilla region, Reg-2: Mymensingh region, Reg-3: Sylhet region, Reg-4: Rangamati (Hilly) Reg-5: Khulna region, Reg-6 Barishal, Reg-7: Rajsahi region, Reg-8 Ranpur Region, Reg-9 Dinajpur region, Reg10: Bogura region, Reg-11: Dhaka region, Reg-12: Chattagram region, Reg-13: Jashore region, Reg-14: Faridpur region.

From Table 3, the overall area coverage of BINA developed pulse varieties were 2.03%. The highest area as well as coverage was found 0.73 % for Binamoog-5, respectively and lowest was seen 0.00016 % in case of Binachola- 6.

Table 3: Variety wise area coverage of BINA developed Pulse varieties in 2019-20 in ha

Pulse	Varieties	Cultivated area (ha) (%)	Coverage (%)
1861298 (2.03 %)	Binamasur-5	3304.50 (8.73)	0.17754
	Binamasur-6	937.50 (2.48)	0.05037
	Binamasur-7	156.00 (0.41)	0.00838
	Binamasur-8	1412.25 (3.73)	0.07587
	Binamasur-9	120.00 (0.32)	0.00645
	Binamoog-4	97.50 (0.26)	0.00524
	Binamoog--5	13569.00 (35.84)	0.72901
	Binamoog--6	9620.25 (25.41)	0.51686
	Binamoog-7	1401.00 (3.70)	0.07527
	Binamoog-8	6373.50 (16.83)	0.34242
	Binamoog-9	9.00 (0.02)	0.00048
	Binachola-6	3.00 (0.01)	0.00016
	Binakhesari-1	624.00 (1.65)	0.03352
	Binakhesari-3	100.50 (0.27)	0.00540
	Binamas	135.00 (0.36)	0.00725
	Total	37863.00 (100.00)	

Source: DAE data, 2020

It was observed from Table 4, among the 14 regions the highest area coverage for pulses was found Barishal region 67.05% (Reg- 6) and the lowest was found Sylhet & Chittagong region 0.00% (Reg-3) & (Reg-12) respectively.

Tabe 4: Region wise adoption of BINA developed Pulse and Other varieties in 2019-20

(in ha)

Pulses	**Reg-1**	**Reg-2**	**Reg-3**	**Reg-4**	**Reg-5**	**Reg-6**	**Reg-7**	**Reg-8**	**Reg-9**	**Reg-10**	**Reg-11**	**Reg-12**	**Reg-13**	**Reg-14**	**All (%)**
Binamasur	0.00	0.00	0.00	24.8 (.42)	227.25 (3.83)	1.14 (0.02)	1231.1 (20.76)	12.5 (.21)	0.00	0.00	0.00	0.00	1348 (22.73)	3085.5 (52.03)	5930.29 (15.66)
Binamoog	244.5 (0.79)	67.5 (0.22)	0.00	11.96 (.04)	153.25 (.49)	24945.5 (80.30)	2238.26 (7.21)	114.88 (0.37)	1296.25 (4.17)	9 (0.02)	0.00	0.00	1408.5 (4.53)	580.65 (1.87)	31064.50 (82.04)
Binachola	0.00	0.00	0.00	0.00	0.00	0.00	3 (100)	0.00	0.00	0.00	0	0.00	0.00	0.00	3 (0.01)
Binakhesari	0.00	0.00	0.00	0.00	0.00	439 (60.59)	216 (29.81)	0.00	0.00	0.00	69.5 (9.59)	0.00	0.00	0.00	724.5 (1.91)
Binamas	0.00	0.00	0.00	0.00	0.00	0.00	135 (100)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	135 (0.36)
Sub total	**244.5 (0.65)**	**67.5 (.18)**	**0.00**	**36.76 (.10)**	**380.5 (1.00)**	**25385.64 (67.05)**	**3829.36 (10.11)**	**127.38 (0.34)**	**1296.25 (3.42)**	**3 (0.01)**	**69.5 (0.18)**	**0.00**	**2756.5 (7.23)**	**3666.15 (9.68)**	**37863.04 (100)**
Binarasun	0	0	117	0	0	0	153	0	0	0	0	0	0	0	270
Binagom	0	0	0	0	0	0	0	0	0	0	0	0	0	319.5	319.5

Source: DAE data, 2020

Note: Reg-1**:** Cumilla region, Reg-2: Mymensingh region, Reg-3: Sylhet region, Reg-4: Rangamati (Hilly) Reg-5: Khulna region, Reg-6 Barishal, Reg-7: Rajsahi region, Reg-8 Ranpur Region, Reg-9 Dinajpur region, Reg10: Bogura region, Reg-11: Dhaka region, Reg-12: Chattagram region, Reg-13: Jashore region, Reg-14: Faridpur region.

From Table 5, it was found that, the overall area coverage of BINA developed oilseed varieties were 1.73%. The highest area coverage was found 0.391 % for Binasarisha-4 and the lowest 0.002 %.was seen in case of Binachinabadam-5,

Table 5: Variety wise area coverage of BINA developed oil seed varieties during 2019-20 in ha

Oil Seed	Varieties	Cultivated Area (%)	Coverage (%)
2248344 (1.73 %)	Binasoybean-3	280.75 (0.72)	0.012487
	Binasoybean-5	4268.75 (10.95)	0.189862
	Binachinabadam-2	191.25 (0.49)	0.008506
	Binachinabadam-3	90.56 (0.23)	0.004028
	Binachinabadam-4	5606.03 (14.38)	0.24934
	Binachinabadam-5	4.46 (0.01)	0.000198
	Binachinabadam-6	424.84 (1.09)	0.018896
	Binachinabadam-7	306.00 (0.78)	0.01361
	Binachinabadam-8	884.48 (2.27)	0.039339
	Binachinabadam-9	21.73 (0.06)	0.000966
	Binachinabadam-10	12.32 (0.03)	0.000548
	Binatil-1	1060.34 (2.72)	0.047161
	Binatil-2	1815.50 (4.66)	0.080748
	Binatil-3	1150.00 (2.95)	0.051149
	Binatil-4	1108.00 (2.84)	0.049281
	Binasarisha-4	8786.92 (22.54)	0.390817
	Binasarisha-5	350.10 (0.90)	0.015571
	Binasarisha-7	1045.50 (2.68)	0.046501
	Binasrisha-8	2706.15 (6.94)	0.120362
	Binasarisha-9	7468.91 (19.16)	0.332196
	Binasrisha-10	1399.00 (3.59)	0.062224
Total		38981.59 (100.00)	

Source: DAE data, 2020

From Table 6 it was revealed that, among the 14 regions the highest area coverage was found 9562.80 (24.53 %) ha in Region 13 and the lowest was found 0.00 ha in region 3.

Table 6: Region wise adoption of BINA developed Oilseed varieties during 2019-20

(in ha)

Oil seeds	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-10	Reg-11	Reg-12	Reg-13	Reg-14	All %
Binasarisha	780 (3.59)	1578.66 (7.26)	0 (0.00)	820 (3.77)	47.55 (0.22)	2915.25 (13.40)	2245.5 (10.32)	450 (2.07)	529.01 (2.43)	701.25 (3.22)	998.86 (4.59)	130.5 (0.60)	6450 (29.65)	4110 (18.89)	21756.58 (55.81)
Binasoybean	360 (7.91)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	4177.5 (91.82)	0 (0.00)	0 (0.00)	0 (0.00)	0 0.00 ()	0 (0.00)	0 (0.00)	12 (0.26)	0 (0.00)	4549.5 (11.671
Bina Chinabadam	106.5 (1.41)	434.5 (5.76)	0 (0.00)	232.74 (3.09)	52.13 (0.69)	645 (8.55)	975 (12.93)	457.5 (6.07)	2505 (33.22)	0 (0.00)	3 (0.04)	486 (6.44)	738.3 (9.79)	906 (12.01)	7541.67 (19.35)
Binatil	3 (0.06)	38 (0.74)	0 (0.00)	30 (0.58)	0.3 (0.01)	57 (1.11)	687 (13.38)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2362.5 (46.02)	1956 (38.10)	5133.8 (13.17)
Total	1249.5 (3.21)	2051.16 (5.26)	0 (0.00)	1082.7 (2.78)	99.98 (0.26)	7794.75 (20.00)	3907.5 (10.02)	907.5 (2.33)	3034.01 (7.78)	701.25 (1.80)	1001.9 (2.57)	616.5 (1.58)	9562.8 (24.53)	6972 (17.89)	38981.55 (100.00)

Source: DAE data, 2020

Note: Reg-1**:** Cumilla region, Reg-2: Mymensingh region, Reg-3: Sylhet region, Reg-4: Rangamati (Hilly) Reg-5: Khulna region, Reg-6 Barishal, Reg-7: Rajsahi region, Reg-8 Ranpur Region, Reg-9 Dinajpur region, Reg10: Bogura region, Reg-11: Dhaka region, Reg-12: Chattagram region, Reg-13: Jashore region, Reg-14: Faridpur region.

In conclusion, the study identifies some problem and 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 etc (Table 7). For BINA variety cultivation the highest constraints and solutions was found about seed i.e. Non availability of seed and ensure adequate seed in every season as early as possible, respectively and it was as Rank I and lowest was for more location specific variety, Drop of paddy for Binadhan-14, 2/3 times pod collection of Binamoog-8 needed more labour cost, Contamination of seed for Binatil-2 were identified and Inter-Linkage is needed among DAE-BADC-BINA and the Farmers through project and storage capacity should be increased was Rank V.

Table 7: Constraints and suggestions by DAE personnel

Constraints	**No. of respondent**	**(%)**	Rank
• In General			
Non availability of seed	12	10.43	I
Lack of demonstration	9	7.83	II
Lack of Marketing facilities	6	5.22	IV
Lack of training facilities both in extension worker and farmers	8	6.96	III
Lack of proper planning between DAE and BINA	6	5.22	IV
More location –specific variety is needed	5	4.35	V
• **Variety specific**			
Drop of paddy for Binadhan-14	5	4.35	V
2/3 times pod collection of Binamoog-8 needed more labour cost	5	4.35	V
Contamination of seed for Binatil-2	5	4.35	V
Suggestions			
Ensure adequate seed in every season as early as possible	12	10.43	I
More Demonstration is needed to popularize these variety through DAE	8	6.96	III
Inter-Linkage is needed among DAE-BADC-BINA and the farmers through project	6	5.22	V
Arrangement of proper training for DAE officer, extension worker and farmer	10	8.70	II
Storage capacity should be increased	6	5.22	V
More distribution of Leaflet	7	6.09	IV

Source: DAE data, 2020

BINA Sub-stations

Sub-station, Ishurdi

Research Highlights

- Effect of seedling age on growth and yield of Binadhan-5 showed that, Days to maturity was found to be highest (166 days) when sown at 75 DAS and lowest 121days when sown at 30 DAS. Maximum (5.11 t/ha) and minimum grain yield (3.31 t/ha) was obtained 45 DAS and 75 DAS

- Effect of different fertilizer dose and planting method on the performance of Binadhan-19 under dibbling elucidated that, maximal (3.87 t/ha) and minimal (2.87 t/ha) grain yield was obtained from treatment combination T_2 (100% recommended dose of N, P, K, S and Zn)× S_0 (dry seeds/ no soaking) and T_1 (80% recommended dose of N, P, K, S and Zn)× S_0 (dry seeds/ no soaking). Maturity duration was more (104 days) in $T_2 \times S_{24}$ (Soaking for 24 hrs) and less in treatment $T_1 \times S_0$ (98 days).

- Different sources of N and P influence in growth and yield on relay crop with mustard in T. Aman rice concluded that, mustard is a fertilizer sensitive oil seed crop and for relay cropping with T. aman rice fertilizer application is must for gaining optimum seed yield.

- On farm observation trails with BINA developed aman rice varieties i.e. Binashail, Binadhan-7, Binadhan-11, Binadhan-12, Binadhan-13, Binadhan-17, Binadhan-20, Binadhan-22 and BRRI dhan49 (as check) revealed that, most farmers of Pabna region was interested to grow Binadhan-17 in *aman* season because of its higher yield, shorter duration and better market price due to grain quality.

Effect of seedling age on growth and yield of Binadhan-5

Binadhan-5 was evaluated with three sowing dates to investigate the influences of seedling age on yield and yield attributes. RCB design was followed for experiment setup with 4m × 3m unit plot size. Four different seedling ages (T_1= 30 days, T_2= 45 days, T_3= 60 days and T_4= 75 days) were used for transplantation. Days to maturity was found to be the highest (166 days) when sown at 75 DAS (T_4) and lowest (121 days) when sown at 30 DAS (T_1). Maximum grain yield was obtained from treatment T_2 (5.11 t/ha) and minimum was from treatment T_4 (3.31 t/ha). Delayed transplanting with older seedling required more time for vegetative growth and thereby lengthening life cycle which ultimately reduced the grain yield.

Table 1: Effect of seedling age on growth and yield of Boro rice

Treatment	Plant height (cm)	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	TGW (g)	Days to maturity	Grain yield (t/ha)
T_1	88.8 ab	8.33 b	22.9ns	108.6 a	11.60 d	32.20 a	121 d	3.99 c
T_2	92.3 a	10.3 a	24.2	85.7 ab	15.73 c	29.93 b	137 c	5.11 a
T_3	89.0 ab	11.0 a	22.1	80.5 b	21.13 a	32.57 a	152 b	4.82 b
T_4	80.9 b	8.67 ab	21.2	81.0 b	19.67 b	29.07 b	166 a	3.31 d
CV (%)	6.44	14.77	23.81	30.54	2.64	26.66	1.87	1.91

*Means bearing same letter(s) in a column do not differ significantly at 5% level of probability byLSD
T_1= 30 DAS; **T_2**= 45 DAS; **T_3**= 60 DAS; **T_4**= 75 DAS.

Effect of different fertilizer dose and planting method on the performance of Binadhan-19 under dibbling.

Performance of Binadhan-19 under dibbling method with variable fertilizer doses and soaking were observed to assess the yield. Experiment was laid out in a factorial RCB design with 4m ×2.5m unit plot size. Standard recommended fertilizer dose (Kg/ha) were: N= 96, P= 12, K= 60, S= 9 and Zn= 1.40. Three fertilizer doses T_1= 80% recommended dose of N, P, K, S and Zn; T_2= 100% recommended dose of N, P, K, S and Zn; T_3= 120% recommended dose of N, P, K, S and Zn were used as factor 'A'. Two types of soaking S_0= Dry seeds (without soaking), S_{24}= Soaking for 24 hrs were factor 'B'. It was noticed that, interaction effect of fertilizer dose and soaking type had significant influence on number of total spikelets/ panicle, grain yield (t/ha) and days to maturity of Binadhan-19. Maximal and minimal grain yield (Table 2) was observed in the treatment $T_2 \times S_0$ (3.87 t/ha) and treatment $T_1 \times S_0$ (2.87 t/ha). Maturity duration was more in $T_2 \times S_{24}$ (104 days) and less in treatment $T_1 \times S_0$ (98 days).

Table 2: Yield and yield attributes of Binadhan-19 with relation to various fertilizer dose and soaking

Treatments	Plant height (cm)	Total tillers plant^{-1} (no)	Panicle length (cm)	Total spikelets hill^{-1} (no)	Spikelet sterility hill^{-1} (%)	1000 seed weight (g)	Grain yield (t/ha)	Days to maturity
Fertilizer dose								
T_1	88.1 ns	11.91 ns	22.0 ns	1980 b	34.6	22.56	2.94 b	98.1 b
T_2	89.2	12.35	21.9	2586 a	36.3	23.40	3.66 a	102.3 a
T_3	91.0	12.44	22.6	2755 a	39.8	21.93	3.14 ab	102.3 a
Planting method								
S_0	88.3 ns	11.03 ns	22.3 ns	2183 b	36.7	22.43	3.37	100.0
S_{24}	90.5	13.44	22.0	2698 a	37.1	22.83	3.11	101.8
Fertilizer dose× Planting method								
$T_1 \times S_0$	86.7 ns	9.93 ns	21.7 ns	1193 b	34.9	22.32	2.87 b	98.0 b
$T_1 \times S_{24}$	89.4	13.89	22.3	2767 a	34.3	22.80	3.01 ab	98.3 b
$T_2 \times S_0$	87.5	10.93	22.1	2596 ab	37.3	23.07	3.87 a	100.6 ab
$T_2 \times S_{24}$	90.8	13.77	21.7	2577 ab	35.3	23.72	3.44 ab	104.0 a
$T_3 \times S_0$	90.6	12.22	23.1	2759 a	37.9	21.91	3.38 ab	101.3 ab
$T_3 \times S_{24}$	91.4	12.66	22.1	2752 a	41.6	21.96	2.88 b	103.3 ab
CV	3.80%	39.37%	3.96%	24.28%	21.88%	9.21%	15.80%	2.94%

Means bearing same letter(s) in a column do not differ significantly at 5% level of probability by LSD
Recommended fertilizer dose (Kg/ha): N= 96, P= 12, K= 60, S= 9 and Zn= 1.40.
T_1= 80% recommended dose of N, P, K, S and Zn; **T_2**= 100% recommended dose of N, P, K, S and Zn ; **T_3**= 120% recommended dose of N, P, K, S and Zn and **S_0**= Dry seeds (without soaking), **S_{24}**= Soaking for 24 hrs.

Different sources of N and P influence in growth and yield on relay crop with mustard in T. Aman rice

To investigate different sources of N and P influence the growth and yield on relay crop with mustard in T. Aman rice. A field experiment was undertaken to evaluate the seed yield and other yield contributing features of Binasarisha-9. RCB design with 4m × 3m unit plot size and four variable fertilizer treatments,T_1 = 100% N as Urea and 100% P as TSP with recommended dose of K S; T_2 = 100% P as DAP with recommended dose of KS; T_3 = 100% N as DAP with recommended dose of KS; T_4 = control (without fertilizer) was used for randomization. The highest plant height (93.00 cm), no. of siliqua/plant (47.6) and seed yield (1.70 t/ha) was found in T_3. On the other hand, control treatment gave the lowest plant height (71.00 cm), no. of siliqua/plant (31.33) and seed yield (0.62 t/ha) (Table 3). Resultsd indicating that mustard is fertilizer sensitive oil seed crop and in case of relay cultivation fertilizer application is must for optimum seed yield.

Table 3: Growth and yield attributes of mustard (Binasarisha-9) influenced by several sources of N and P under relay crop with T. Aman

Treatment	Plant height (cm)	Plant population/m^2	No. of siliqua plant^{-1}	Days to maturity	Seed yield (t/ha)	Straw yield (t/ha)
T_1	84.0 b	183.0	44.0 ab	84.0	1.61 a	3.14
T_2	74.3 c	202.3	30.3 b	84.3	1.07 b	3.13
T_3	93.0 a	170.3	47.6 a	85.6	1.70 a	4.02
T_4	71.0 c	196.3	31.3 b	86.0	0.62c	3.23
Level of Sig.	*	NS	*	NS	*	NS
CV	5.25%	20.23%	11.53%	3.87%	11.53%	21.88%

*Means bearing same letter(s) in a column do not differ significantly at 5% level of probability by LSD
T_1 = 100% N as Urea and 100% P as TSP with recommended dose of KS; **T_2**= 100% P as DAP with recommended dose of KS; **T_3** = 100% N as DAP with recommended dose of KS; **T_4** = Control

Observation trails with BINA developed Aman rice varieties in Pabna region

In *Aman* season of 2019, observation trials of Binashail, Binadhan-7, Binadhan-11, Binadhan-12, Binadhan-13, Binadhan-17, Binadhan-20, Binadhan-22 and BRRI dhan49 (as check) were conducted at the farmers field of Ishurdi. A RCB with dispersed location was used for experimentation and yield and yield contributing data were taken at final harvest. Objective of this observation was to demonstrate the relative field performances of different rice varieties so that farmers can choose their desired variety in terms of yield, quality and duration. Results presented in Table 4 indicated that among all the HYVs Binadhan-17 produced the highestgrain yield (6.58 t/ha) with minimum duration (115 days). Binashail and the check variety BRRI dhan49 had statistically identical and lengthy maturity duration (135 days and 135 days). Lowest yield was observed in Binashail (3.80 t/ha). Farmers of Pabna region were interested to grow Binadhan-17 in Aman season because of its higher yield, shorter duration and good market price due to grain quality.

Table 4: Performance of BINA developed Aman rice varieties in Pabna region during 2019-20

Variety	Plant height (cm)	Total tillers hill^{-1} (no)	Effective tillers hill^{-1} (no)	Filled grains panicle^{-1} (no)	Unfilled grains panicle^{-1} (no)	Days to maturity	Grain yield (t ha^{-1})
Binashail	126.6 b	15.43 a	14.37 a	115.87 d	30.47 a	135.33 a	3.80 e
Binadhan-7	91.4 e	14.20 ab	12.33 b	109.70 e	15.53 d	121.00 c	5.12 c
Binadhan-11	98.2 d	10.63 e	9.60 d	136.13 a	25.00 b	120.00 c	4.72 d
Binadhan-12	81.8 f	14.87 a	13.80 a	131.03 b	19.93 c	120.33 c	4.60 d
Binadhan-13	129.1 a	12.57 cd	12.30 b	73.47 h	10.93e	125.00 b	3.03 f
Binadhan-17	76.3 g	11.57 de	11.00 c	115.60 d	29.00 a	115.00 d	6.58 a
Binadhan-20	113.4 c	13.00 bc	12.27 b	102.00 f	16.00 d	125.00 b	5.08 c
Binadhan-22	91.2 e	11.43 de	10.30 cd	126.50 c	22.20bc	119.33 c	5.70 b
BRRI dhan49	83.0 f	13.00 bc	12.07 b	92.20 g	25.00 b	135.00 a	5.05 c

*Means bearing same letter(s) in a column do not differ significantly at 5% level of probability by LSD

Establishment of BINA Technology village through block demonstration in surrounding area of BINA Sub-station, Ishurdi

In order to establish BINA technology village, demonstrations were done in surrounding area ofBINA Sub-station, Ishurdi as well as at the farmer's field of greater Pabna region. Results ofoverall promotional activities related to BINATechnology village establishment are presented below-

Table5: Performance of BINA developed varieties during 2019-20

SL.	Crops	Variety Name	No. of demo	Avg. Duration (Days)	Avg. Yield (t/ha)
1.	Rice	Binadhan-11	11	118	4.21
		Binadhan-12	08	130	3.98
		Binadhan-17	25	116	5.15
		Binadhan-20	13	127	4.25
		Binadhan-14	10	131	4.70
		Binadhan-19	70	106	4.29
2.	Mustard	Binasarisha-4	10	83	1.50
		Binasarisha-9	36	85	1.54
		Binasarisha-10	02	82	1.40
3.	Lentil	Binamasur-5	26	102	1.64
		Binamasur-8	17	100	1.78
4.	Mungbean	Binamoog-5	03	60	0.74
		Binamoog-8	32	62	0.75
		Binamoog-9	01	60	0.74
5.	Sesame	Binatil-1	09	73	0.29
		Binatil-2	19	78	0.35
6.	Grasspea	Binakhesari-1	08	113	1.40

A total no. of 57 demonstrations was conducted of Binadhan-11, Binadhan-12. Binadhan-17 and Binadhan-20 in T. Aman season. Outcomes showed that farmers of greater Pabna region widely cultivated Binadhan-17 (avg. yield 5.15 t/ha and duration 116 days) because of its higher yield, shorter duration and grain quality. In *Aus* season, total 70 demonstrations were conducted with Binadhan-19 which yielded 4.29 t/ha^{-1} and maturity period 106 days. Farmers preferred this variety due to its slender and long fine grain. A total 48 numbers of demonstrations of Binasarisha-4, Binasarisha-9 and Binasarisha-10 were conducted in Pabna region. Binasarisha-9 produced higher seed yield (1.54t/ha) at 85 days maturity duration. Forty three demonstrations of Binamasur-5 and Binamasur-8 were carried out where Binamasur-8 produced higher yield (1.78 t/ha) with short duration (100 days). In Pabna region, farmers are interested to grow Binamoog-8 because 80% pods are matured at the same time which helps them to pick at a time and thereby reducing labor cost. Average yield of Binamoog-8 was found 0.75 t/ha at 62 days duration. Twenty eight demonstrations of sesames namely, Binatil-1 and Binatil-2 were conducted. Mean yield of Binatil-2 was 0.35 t/ha with 78 days duration. Reason of lower sesame yield was due to plenty of rainfall and adverse weather during maturity and harvesting time. Total 08 demonstrations of grass pea cv. Binakhesari-1 were implemented. Mean seed yield was 1.40 t/ha yield at 113 days duration

In order to technology transfer and rapid extension, 5 training programs were organized during the period of 2019-20 where, a total of 20 DAE personnel (Sub-Assistant Agriculture Officer, SAAO) and 320 female and male farmers were trained on cultivation of BINA developed improved rice, pulse and oil seed-based crop varieties.

For field motivation of the farmers and technology adoption, Farmers Field Day (FFD) on BINA developed varieties/technologies were carried out. A total of eight (8) field days on different crop varieties were organized in Pabna and Natore region.

Sub-station, Rangpur

Research Highlights

- A total of 64 demonstrations with all Aman varieties where 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 44 demonstrations with Binadhan-19 revealed that Binadhan-19 produced lower yield (2.6 % yield decreased) with less maturity period (6-8 days earlier) & fine grain than check varieties of BRRI dhan48

- A total of 32 groundnut demonstrations were performed and it was found that Binachhinabadam-8 produced 10 % higher seed yield than that of the local variety Nali badam.

- A total of 52 mustard demonstrations conducted in greater Rangpur and Dinajpur Region where Binaasarisha-9 performed better in respect of yield and earliness even though the mega variety BARI Sarisha-14.

- Cropping patterns (Ongoing till now): 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 2019-20, eighteen 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. Seeds were sown during mid July to mid August 2018 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 1.

Table 1: Mean performance of Binadhan-20 in Rangpur region during 2019-20

Locations (Upazilas)	No. of demos.	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-20	BRRI dhan72 (check)	Binadhan-20	BRRI dhan72 (check)	
Rangpur Sadar	22	127	135	5.8	4.8	34.48
Pirgacha, Rangpur	11	130	132	5.0	4.6	12.0
Pirganj, Rangpur	14	129	129	5.5	5.6	1.8
Mithapukur, Rangpur	17	130	132	5.3	5.0	5.6
Total	64					
Mean		129	132	5.4	5.0	7.4

Data in Table 1 revealed that Binadhan-20 produced average seed yields of 5.4 t ha^{-1} which higher 7.4 percent compared to check variety BRRI dhan 72. 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 average 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 2019-20, 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 demos.	Duration (days)		Yield (t ha^{-1})		Yield decresaed over check (%)
		Binadhan-19	BRRI dhan48	Binadhan-19	BRRI dhan48	
Mithapukur, Rangpur	10	100	112	5.4	5.6	(-) 3.7
Sundarganj, Gaibandha	05	103	110	5.2	5.4	(-) 3.8
Lalmonirhat sadar,Lalmonirhat	05	99	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		97	112	5.38	5.52	(-) 2.6

Data in Table 2 revealed that Binadhan-19 produced average seed yields of 5.38 t ha^{-1}, in which the lower 2.6 percent compared to check variety BRRI dhan48. Average maturity period of Binadhan-19 was 97 days. The check variety BRRI dhan48 produced average gain yield of 5.52 t ha^{-1} with average maturity period of 112 days. Another beneficial consideration of Binadhan-19 is fine grain than BRRI dhan48. Therefore, the Binadhan-19 has a great market value than that of BRRI dhan48. The farmers were found interested to cultivate this variety in Rangpur region during Aus growing season. It would be recommended for the next year for more dissemination.

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, 2019 - Kharif,2020

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 in greater area/region to get the more accuracy in case of above statement.

Table 1a: Yield attributes and profitability of Binadhan-17 in improved cropping Pattern

Locations	Bd-17	Plant height (cm)	No. of Effective tiller	No. of Filled grain/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Sadar ,	**Mean**	109.3	13.4	65.69	24.02	112	688	5.16	1.27
Mithapukur,	**Max.**	112	16	72					
Rangpur	**Min.**	107	10	61					

Note: Bd= Binadhan

Table 1b: Yield attributes and profitability of Binasarisha-9 in improved cropping pattern

Locations	BS-9	Plant height (cm)	No. of siliqua/ plant	No. of seeds/ siliqua	1000 seed wt. (g.)	Crop duration (days)	Yield /*bigha* (Kg)	Yield (t/ha)	BCR
Sadar ,	**Mean**	95.4	83.4	18.2	3.22	97	214	1.6	**1.56**
Mithapukur,	**Max.**	98	90	20					
Rangpur	**Min.**	94	76	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	No. of seeds/ pod	100 seed wt. (g.)	Crop duration (days)	Yield /*bigha* (Kg)	Yield (t/ha)	BCR
Sadar ,	**Mean**	35	83.4	4	3.22	68	214	1.6	**1.56**
Mithapukur,	**Max.**	42	90	6					
Rangpur	**Min.**	32	76	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/hill	No. of filled grain/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Sadar , Mithapukur, Rangpur	Mean	99.4	10.8	119.6	24.33	102	754	5.5	1.19
	Max.	102	13	130					
	Min.	96	10	110					

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	No. of filled grain/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Sadar , Mithapukur, Rangpur	**Mean**	110	7	124.6	24.7	150	550	3.9	0.80
	Max.	117	10	138					
	Min.	105	5	112					

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 , Mithapukur, Rangpur	**Mean**	44	5	99	85	1.5	11.1	**1.43**
	Max.	53	7					
	Min.	40	3					

Note: Diam. = Diamant

Table 1g: Yield attributes and profitability of BRRI dhan28 in existing cropping pattern

Locations	BRD-28	Plant height (cm)	No. of effective tillers/hill	No. of filled grain/ panicle	1000 seed wt. (g.)	Crop duration (days)	Yield /bigha (Kg)	Yield (t/ha)	BCR
Sadar , Mithapukur, Rangpur	Mean	99.4	10.8	119.6					
	Max.	102	13	130	24.33	152	612	4.5	1.11
	Min.	96	10	110					

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 2019-2020

Crops	Varity Name	No of Demonstration	Average Duration	Average Yield (t/ha)
Rice	Binadhan-19	7	102	5.1
	Binadhan-10	5	142	6.5
	Binadhan-20	2	128	5.5
	Binadhan-14	5	105	5.0
	Binadhan-17	8	118	6.3
Mustard	Binasarisha-4	3	87	1.7
	Binasarisha-9	6	83	1.6
	Binasarisha-10	1	78	1.3

Results indicated that Binadhan-14 produced higher grain yield with moderate crop duration (Table 3). But, Binadhan-14 had a greater tendency to shattering during it maturity period. Transplanted Aman, Boro & Aus varieties Binadhan-10, Binadhan-17, Binadhan-20, Binadhan-16 & Binadhan-19 produced desirable grain yield. Farmers had been interested to cultivate BINA developed Aman rice varieties in Aman season for their high yield, short crop duration. 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 and it needs to more emphasize regarding this issue.

Production of quality seed of BINA released crop varieties popular in Rangpur & Dinajpur region.

Seeds of BINA released crop varieties popular in Rangpur & Dinajpur region were produced at the sub-station farms and also in the farmer's fields of different locations and part of those seeds were purchased during 2019-2020. During the reporting period a total of 35.25 tons seeds of different crop varieties of BINA were produced and procured. Among them rice were about 18.25 tons, mustard 3.6 tons, Groundnut 13.0 ton & til 0.15 ton.

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies four training of one day was arranged at BINA Substation, Rangpur. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer.

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 22 field days on different crop varieties were organized in Rangpur & Dinajpur region.

Sub-station, Magura

Research Highlights

On Farm trail of Binadhan-17 along with different planting time in Magura showed that varieties Binadhan-17 and BRRI dhan58 had the maximum grain yield transplanted at January 10 in Boro season.

In validation trial of Binadhan-19, Binatil-3, Binasarisha-9 & Binamasur-8 which were gave the maximum yield 5.0 t/ha (100 days), 1.2 t/ha (89 days),1.5 t/ha (94 days) and 2.2 t/ha (101days) respectively than check variety of BRRI dhan-82, BARI Til-4, BARI sarisha-14 &BARI masur-8 which were gave yield 4.7 t/ha (106 days), 1.05 t/ha (96 days), 1.4 t/ha (86 days) & 2.0 t/ha (110 days) in Magura region.

Exp.1: **Determination of optimum planting time of Binadhan-17 in Boro season at Magura**

The experiment was conducted during 27 November to 2019 to 23 May 2019 at the BINA substation Magura farm and farmers field sottopur,sadar,Magura. The experiment was laid out in a randomized complete block design with three replications. The experiment comprised of three sowing dates viz. 27 November, 10 December, 20 December along with two varieties viz . Binadhan -17, BRRIdhan-58 and transplanting was done on 02 Jan. ; 10 Jan. ; 03 Feb.. Recommendated cultural practices were followed. Five hills were randomly selected from each unit plot prior to harvest for recording data. The recorded data were analyzed statistically. The results from both locations showed that the highest grain yield (7.36 t/ha) was obtained in 10 January transplanting (Table-1). Among the varieties, Binadhan-17 produced highest grain yield (6.7t/ha) and BRRIdhan-58 produced the second highest yield (6.3 t/ha). Interaction between variety and transplanting date showed that the highest grain yield (7.7 t/ha) was obtained by the variety Binadhan-17 when transplanted in 10 January and second highest by BRRIdhan-58 in same date. It concluded that Transplanting at January 10 would be the optimum time for Binadhan-17 in Magura region.

Table-1: Effect of planting time, variety and their interaction on the performance of Binadhan-17 and BRRI dhan58. [ON-FARM]

Treatment	Duration	PH	PL	NOP	NOFT	NOOFFS	NOOFUFS	TSW	GY	DYSTFPFW
Sowing Time										
T_1	157 a	84.6 b	22.46 ns	10.4 ns	8.83ns	151.8 a	20.0ns	24.5 a	5.93 b	125.6 a
T_2	154 ab	84.3 b	22.96	12.0	12.1	144.7 a	24.2	23.5 b	7.36 a	122.6 b
T_3	152 b	90.2 a	22.93	10.5	10.8	114.4 b	29.3	24.2 ab	6.37 b	118.6 c
Variety										
Binadhan-17	157 a	83.3 b	22.5ns	10.6 ns	10.7ns	148.0 a	31.9 a	24.2ns	6.77 a	123.3 a
BRRI dhan58	152 a	89.5 a	23.1	11.3	10.4	125.9 b	17.1 b	23.9	6.34 b	121.3 b
Sowing Time× Variety										
T_1× Binadhan-17	1593 a	83.2bc	23.1abc	10.9ns	11.0 ab	162.8 a	25.0 ab	24.9 a	6.12 cd	126.7 a
T_1× BRRI dhan58	155 bc	86.1 b	21.8 c	10.0	6.66 b	140.8 ab	15.0 b	24.1 ab	5.74 d	125.6 a
T_2 × Binadhan-17	157 ab	80.6 c	22.1bc	11.3	11.6 a	159.4 a	34.6 a	23.8 ab	7.70 a	124.8 a
T_2 × BRRIdhan58	152 cd	88.0 b	23.8 a	12.6	12.6 a	129.9bc	13.7 b	23.2 b	7.03 ab	120.6 b
T_3 × Binadhan-17	155 bc	86.1 b	22.3bc	9.67	9.66 ab	121.9bc	36.0 a	24.0 ab	6.50bc	119.6 b
T_3 × BRRIdhan58	150 d	94.3 a	23.6 ab	11.3	12.0 a	107.0 c	22.6 ab	24.5 a	6.24 cd	117.6 c
CV (%)	1.41	3.15	3.76	15.52	24.74	11.37	31.65	2.79	6.29	0.58

Means bearing same letter(s) in a column do not differ significantly at 5% level of probability by LSD; PH- Plant Height; PL-Panicle Length; NOP- No. of Panicle/hill; NOFT- No . of effective tiller/hill; NOOFFS- No of filled spikelets/panicle, NOOFFUS- No of unfilled spikelets/panicle; TSW- Thousand seed weight(g); GY- Grain yield(t/ha); DYSTFPFW- Days to 50% flowering.

Table-2 : Effect of planting time, variety and their interaction on the performance of Binadhan-17 and BRRI dhan58. [ON-STATION]

Treatment	Duration	PH	PL	NOP	NOFT	NOOFFS	NOOFUFS	TSW	GY	DYSTFPFW
Sowing Time										
T_1	154 a	83.6 c	21.7 c	11.6	12.0	122.3 b	31.4 b	24.0	6.27 b	126.5 a
T_2	150 b	91.1 b	23.1 b	12.6	12.6	150.4 a	39.2 a	23.6	7.30 a	122.6 b
T_3	147 c	94.2 a	24.0 a	12.1	12.1	140.7 a	45.6 a	23.7	6.95 a	118.6 c
Variety										
Binadhan-17	153 a	86.3 b	22.8	12.0	12.0	142.8	50.6 a	23.9	7.03 a	123.8 a
BRRI dhan58	148b	93.0 a	23.1	12.3	12.5	132.7	26.9 b	23.6	6.65 b	120.4 b
Sowing Time× Variety										
T_1× Binadhan-17	158 a	80.6 e	22.1 cd	11.6	11.6	120.8 b	41.0 b	24.6 a	6.61 c	127.3 a
T_1× BRRI dhan58	151bc	86.6 d	21.3 d	11.6	12.3	123.7 b	21.8 d	23.4 b	5.94 d	125.6 b
T_2 × Binadhan-17	154 b	88.2 d	22.6bc	12.3	12.3	149.6 a	53.5 a	23.9 ab	7.41 a	124.5 b
T_2 × BRRI dhan58	147 d	94.0 b	23.7 a	13.0	13.0	151.3 a	24.8 cd	23.3 b	7.20 ab	120.6 c
T_3 × Binadhan-17	148 cd	90.1 c	23.6 ab	12.0	12.0	158.1 a	57.2 a	23.4 b	7.07abc	119.6 c
T_3 × BRRI dhan58	145 d	98.3 a	24.4 a	12.3	12.3	123.2 b	34.0bc	24.0 ab	6.83bc	117.4 d
CV (%)	1.34	1.11	2.62	10.29	8.76	9.76	15.49	2.85	4.39	0.69

Means bearing same letter(s) in a column do not differ significantly at 5% level of probability by LSD; PH- Plant Height; PL- Panicle Length; NOP- No. of Panicle/hill; NOFT- No . of effective tiller/hill; NOOFFS- No of filled spikelets/panicle; NOOFFUS- No of unfilled spikelets/panicle; TSW- Thousand seed weight(g); GY- Grain yield(t/ha); DYSTFPFW- Days to 50% flowering.

Experiment 2: Validation of Binadhan-19 in Magura region.

During Kharif-1 of 2019-20, 02 trials were conducted with Binadhan-19 in Magura region. The check variety was BRRIdhan-82.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. Seedlings were transplanted during third week April to third week of May 2020. 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 3.

Table 3: Performance of Binadhan-19 in Magura region during 2019-20

Locations	No. of trials	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-19	BRRIdhan-82 (check)	Binadhan-19	BRRIdhan-82 (check)	
Alaipur	1	98	107	5.1	4.6	10.86
Ramnagar	1	102	105	4.9	4.8	2.08
Total	02					
Mean		100	106	5.0	4.7	6.38

Data in Table 3 reveal that Binadhan-19 produced average seed yields of 5.0 t ha^{-1} which higher 6.38 percent compared to check variety BRRIdhan-82. Average maturity period of Binadhan-19 was 100 days. The check variety BRRIdhan-82 produced average gain yield of 4.7 t ha^{-1} with average maturity period of 106 days. Therefore the variety of Binadhan-19 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-19in Magura region.

Experiment 3: Up-Scalingof Binatil-3 & BARI Til-4 in Magura region.

During Kharif-1 of 2019-20, 02 trials were conducted with Binatil-3 in Magura region. The check variety was BARITil-4. The main objectives were to demonstrate the performance of Binatil-3 and widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during First week of March 2020. 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 4

Table 4: Performance of Binatil-3 and BARI til-4 in Magura region during 2019-20

Locations	No. of trials	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binatil-3	BARITil-4 (check)	Binatil-3	BARITil-4 (check)	
Moghi	1	92	98	1.2	1.0	
Batiadangha	1	86	94	1.3	1.1	
Total	02					
Mean		89	96	1.2	1.05	14.28

Data in Table 4 revealed that Binatil-3 produced average seed yields of 1.2 t ha^{-1} which higher 14.28 percent compared to check variety BARITil-4. Average maturity period of Binatil-3 was 89 days. The check variety BARITil-4 produced average gain yield of 1.05 t ha^{-1} with average maturity period of 96 days. Therefore the variety of Binatil-3 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binatil-3 in Magura region.

Experiment 4: Observational trials with Binasarisha-9 & BARI Sarisha-14 in Magura region.

During Rabi of 2019-20, 02 trials were conducted with Binasarisha-9 in Magura region. The check variety was BARI Sarisha-14 .The main objectives were to demonstrate the performance of Binasarisha-9 and widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during first week of November 2019. 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 5.

Table 5: Performance Binasarisha-9 in Magura region during 2019-20

Locations	No. of trials	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisha-9	BARI Sarisha-14 (check)	Binasarisha-9	BARI Sarisha-14 (check)	
Alaipur	1	95	85	1.6	1.5	
Ramnagar	1	93	87	1.4	1.3	
Total	02					
Mean		94	86	1.5	1.4	6.66

Data in Table 5 revealed that Binasarisha-9 produced average seed yields of 1.5 tha^{-1} which higher 6.66 percent compared to check variety BARI Sarisha-14. Average maturity period of Binasarisha-9 was 94 days. The check variety BARI Sarisha-14 produced average gain yield of 1.4 tha^{-1} with average maturity period of 86 days. Therefore the variety of Binasarisha-9 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binasarisha-9 in Magura region.

Experiment 6: Observational trials with Binamasur-8 & BARI Masur-8 in Magura region.

During Rabi of 2019-20, 02 trials were conducted with Binamasur-8in Magura region. The check variety was BARI masur-8.The main objectives were to demonstrate the performance of Binamasur-8 and widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during First week of November 2019. 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 6.

Table 6: Performance Binamasur-8 in Magura region during 2019-20

Locations	No. of trials	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamasur-8	BARI masur-8 (check)	Binamasur-8	BARI masur-8 (check)	
Boroi	1	100	112	2.3	2.1	9.52
Ramnagar	1	102	108	2.1	1.9	10.52
Total	02					
Mean		101	110	2.2	2.0	10.00

Data in Table 6 revealed that Binamasur-8produced average seed yields of 2.2tha^{-1} which higher 9.52 percent compared to check variety BARI masur-8. Average maturity period of Binamasur-8 was 101 days. The check variety BARI masur-8 produced average gain yield of 2.0 tha^{-1} with average maturity period of 110 days. Therefore the variety ofBinamasur-8 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binamasur-8 in Magura 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 in Table 7.

Table 7. Performance of BINA developed varieties during 2019-20

Crops	Variety Name	No. of demo.	Avg. duration (days)	Av.yield (t ha^{-1})
Rice	Binadhan-7	05	117	4.91
	Binadhan-14	50	119	5.40
	Binadhan-16	10	103	4.58
	Binadhan-17	30	116	5.15
	Binadhan-19	82	104	4.90
	Binadhan-20	10	127	4.25
	Binadhan-21	03	104	4.23
	Binadhan-22	05	127	5.00
Mustard	Binasarisha-4	10	95	1.11
	Binasarisha-9	35	90	1.33
	Binasarisha-10	20	84	1.15
Lentil	Binamasur-5	05	104	1.91
	Binamasur-8	90	99	2.12
Chickpea	Binasola-4	05	128	1.09
Grasspea	Binakhesari-1	05	127	1.54
Groundnut(Rabi)	Binachinabadam-4	20	132	1.79
Mungbean	Binamoog-8	10	70	1.21
Sesame	Binatil-1	10	90	1.11
	Binatil-2	20	95	1.20
	Binatil-3	15	85	1.34

Results (Table 7) indicate that in Aus season, Binadhan-19 have higher grain yield with less duration. Farmers preferred this variety due its slender and long fine grain. In Aman season rice growers of Magura and 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 this variety. Transplanted Aman varieties Binadhan-16 and Binadhan-20 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. 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 an extensively cultivated mustard variety in this area. Farmers prefer this variety more than the BINA developed varieties due to its yield and quality. But in areas where early vegetables are grown Binasarisha-10 is cultivated there. 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.

Quality seed production of promising BINA released varieties for greater Jashore region

Seeds of some demanding and promising crop varieties of BINA were produced in sub-station and also in the farmer's fields at different locations. Seeds of different crop varieties which were produced and purchased from the farmer's field during 2019-20. For buying seeds from the farmer's government rate were followed. During the 2019-20 period a total of 21.36 tons seeds of different crop varieties of BINA were produced and procured. Among them rice were about 8.26 tons, groundnut 5.7 ton, mungbean 1.5 ton, mustard 1.5 ton, soybean 1.045 ton, sesame 1.1 ton, lentil 0.855 ton, chickpea 60 kg, grasspea 200 kg and turmeric 120 kg.

Training and workshop on BINA developed technologies

In order to transfer BINA developed technologies five training program and one regional workshop was arranged at BINA Substation, Magura. The participants were farmers (both male and female), Sub Assistant Agriculture Officers (SAAO) of DAE and officers of different government organizations under ministry of agriculture.

Field Days

In order to motivate farmers and to adopt BINA developed varieties/technologies 12 field days on different crops varieties were organized for rapid and mass dissemination.

Sub-station, Cumilla

Research Highlights

- The study on the determination of optimum spacing for yield of BINA developed Aus variety revealed that the yield of Binadhan-19 was the highest (4.25 t ha^{-1}) at 10 cm × 15 cm spacing at BINA Substation, Cumilla.
- Four Aus varieties (Binadhan-19, Binadhan-21, BRRI dhan48 and BRRI dhan85) were evaluated at BINA Substation, Cumilla. The highest grain yield was found in BRRI dhan85 (5.14 t ha^{-1}) followed by the BRRI dhan48 and Binadhan-19 (4.70 & 4.38 t ha^{-1}) respectively. Binadhan-21 required the least average duration of 104 days and second highest Binadhan-19 (107 days) respectively.
- The nine modern Aman rice varieties (Binadhan-7, Binadhan-11, Binadhan-16, Binadhan-17, BR 22, BRRIdhan71, BRRIdhan75, BRRIdhan80 and BRRIdhan87) were evaluated at the BINA Sub-station Farm, Cumilla. The mean grain yield was the highest (5.60 t ha^{-1}) in BRRI dhan87 followed by BR 22 (4.70 t ha^{-1}). On the other hand, Among the BINA Aman varieties the Binadhan-17 produced the highest grain yield (4.43 t ha^{-1}).
- Nine rice varieties were evaluated at the BINA Sub-station Farm at Cumilla during Boro season and Binadhan-17 and Binadhan-20 were found suitable to grow in Boro season. Four short duration mutant lines (EFSD-59, EFSD-66, EFSD-32 and EFSD-58) and one check variety (BRRIdhan28) was evaluated at the BINA Sub-station experimental farm at Cumilla during the Boro season and BRRI dhan28 performed the best.
- Four advanced soybean lines viz. SBM-02, SBM-07, SBM-08 and SBM-09 along with two check varieties, BARI soybean-6 and Binasoybean-2 were evaluated at the BINA Sub-station farm at Cumilla. Among the different advance lines/varieties, SBM-02 produced the highest seed yield (3.56 t ha^{-1}) followed by BARI soybean-6 (3.42 t ha^{-1}).
- Cropping pattern related experiment [T. Aman-Mustard-Boro] indicated that the Rice Equivalent Yield (REY) of proposed cropping pattern (11.25 t ha^{-1}) was lower than existing [Rice-fellow-rice] cropping pattern (11.81 t ha^{-1}) which is 4.74% lower than existing cropping pattern.
- Eight observation trials were conducted with Binadhan-20 in Aman season, 2019-20 at Sadar Dakshin, Burichang Upazilla of Cumilla district and Sadar Upazilla of Brahmanbaria district. The maximum yield was recorded (5.40 t ha^{-1}) at Sadar upazilla of Brahmanbaria district with the second highest duration (148 days).

Effect of different spacing on Binadhan-19

The experiment was conducted at BINA Substation, Cumilla during 2019-20 to select the appropriate spacing for Binadhan-19 on the growth and yield contributing characters. The experiment was laid out in RCB design with 3 replications. The unit plot size was 5 m × 4 m. The spacing was 10 cm × 15 cm, 15 cm × 15 cm, 15 cm × 20 cm and 20 cm × 20 cm. The recommended doses of fertilizers were applied. The data on yield and yield attributes were recorded from randomly selected 10 plants while the yield data were recorded from the harvest of whole plot. All the recorded data were statistically analyzed using MSTAT Statistical computer program according to the design used for the experiment. Mean effect of different spacing showed significant effect on yield. Among different spacing's, 10 cm × 15 cm showed highest seed yield (4.25 t ha^{-1}) and the second highest produced by 15 cm X 15 cm (4.04 t ha^{-1}).

Table 1. Yield and yield contributing characters of Binadhan-19 as affected by different spacing

Spacing (cm)	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.)	Total grains $panicle^{-1}$ (no.)	Yield (t ha^{-1})
10 × 15	84.7 b	7.87 c	7.20 c	21.4 b	66.5 c	22.8 a	89.3 c	4.25 a
15 × 15	92.5 a	9.87 b	9.50 b	21.5 b	68.9 c	21.3 a	90.2 c	4.04 ab
15 × 20	93.3 a	10.8 ab	10.2 ab	21.8 b	74.7 b	17.6 b	92.4 b	3.90 bc
20 × 20	94.6 a	11.9 a	11.6 a	22.7 a	80.2 a	16.3 b	96.5 a	3.60 c
CV (%)	3.81	9.62	9.79	1.92	1.84	4.17	1.06	3.80

Yield and yield contributing characters of four promising Aus rice varieties

Two newly released advanced BINA Aus rice varieties (Binadhan-19 & Binadhan-21) were compared to two check variety (BRRI dhan48 & BRRI dhan85) during 2019-2020 at BINA Substation, Cumilla. The objective was to select the most suitable variety for Aus season. The experiment was laid out as factorial randomized complete block design with three replications. The unit plot size was 5 m × 4 m. Data on yield and yield components were recorded at harvest and were statistically analyzed following the design used for the experiment and the means were compared with LSD. The results revealed that mean grain yield showed significant differences and their yields ranged from 3.8 t ha^{-1} to 5.14 t ha^{-1}. Among the varieties, BRRI dhan85 produced the highest grain yield of 5.14 t ha^{-1} and it was followed by BRRI dhan48 and Binadhan-19 (4.70 & 4.38 t ha^{-1}). The data recorded on crop duration from seedling to maturity revealed that the Binadhan-21 required the least average 104 days and second highest Binadhan-19 (107 days) (Table 2).

Table 2. Yield and yield contributing characters of four promising aus rice varieties in 2019-2020

Variety	Plant height (cm)	Total tillers hill^{-1}	Effective tillers hill^{-1} (no.)	Total grains panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Days to maturity	Grain yield (t ha^{-1})
Binadhan-19	83.8 b	13.5 c	13.1 bc	99.5 ab	88.1 a	14.4 b	107 3	4.38 bc
Binadhan-21	78.8 b	12.8 d	12.5 c	106.2 a	83.2 a	22.93 a	104 d	3.88 c
BRRIdhan48	93.6 a	14.4 b	13.9 ab	81.2 c	62.9 b	18.33 a	112 b	4.70 b
BRRIdhan85	95.5 a	15.3 a	14.8 a	85.0 bc	66.2 b	18.77 a	115 a	5.14 a
CV (%)	2.91	2.48	3.45	8.11	7.49	15.95	2.53	6.88

Comparative study of some modern Aman rice varieties

Nine Aman rice varieties (Binadhan-7, Binadhan-11, Binadhan-16, Binadhan-17, BR 22, BRRIdhan71, BRRIdhan75, BRRIdhan80 and BRRIdhan87) were evaluated at the BINA Sub-station Farm at Cumilla during Aman season in 2019. The objective was to select the most suitable variety for Aman season in Cumilla region. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 5 m × 3 m. Data on yield and yield components were recorded at harvest and were statistically analyzed following the design used for the experiment and the means were compared with LSD. The mean grain yield was the highest (5.60 t ha^{-1}) was obtained by BRRI dhan87 followed by BR 22 which produced second highest grain yield (4.70 t ha^{-1}) (Table 3). On the other hand, among the BINA Aman varieties, Binadhan-17 produced the highest grain yield (4.43 t ha^{-1}).

Table 3. Yield and yield contributing characters of some modern aman rice varieties in 2019-2020

Variety	Plant height (cm)	Total tiller hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Yield (t ha^{-1})	Duration (days)
Binadhan-11	94.3 c	8.00 b	7.53 bc	22.23 cd	91.2 a-c	26.17 ab	3.93 b-d	115.6 d
Binadhan-16	80.6 d	9.50 ab	8.73 a-c	21.23 d	65.1 c	5.60 c	3.33 d	98.0 e
Binadhan-17	84.6 d	9.47 ab	8.80 a-c	21.63 cd	101.8 ab	32.87 a	4.43 bc	118.3 cd
Bindhan-7	84.2 d	11.2 a	10.2 a	21.67 cd	71.7 bc	20.83 b	4.23 b-d	114.3 d
BR 22	106 ab	9.40 ab	9.00 ab	26.23 a	111.3 a	29.83 ab	4.70 ab	148.0 a
BRRI dhan71	97.9 bc	7.00 b	6.53 c	22.53 cd	93.0 a-c	29.00 ab	3.57 cd	124.0 bc
BRRI dhan75	94.4 c	9.13 ab	8.67 a-c	25.07 ab	102.8 ab	24.07 ab	4.57 b	115.0 d
BRRI dhan80	109 a	8.50 b	7.90 a-c	23.47 bc	99.1 a-c	22.17 ab	4.17 b-d	128.6 b
BRRI dhan87	112 a	8.37 b	8.07 a-c	26.27 a	121.3 a	32.00 ab	5.60 a	125.0 b
CV %	3.35	10.11	9.94	3.10	12.72	16.51	7.99	1.71

Feasibility of Binadhan-17 and Bindhan-20 growing in Boro season

The experiment was conducted at BINA sub-station, Cumilla during Boro season in 2019-2020 to recommend Binadhan-17 and Binadhan-20 for cultivation in Boro season. The rice varieties were Binadhan-17, Binadhan-20, BRRI dhan28, BRRI dhan29, BRRI dhan74, BRRI dhan84, BRRI dhan86, BRRI dhan88 and BRRI dhan89. The experiment was laid out in a RCB design with three replications. Data on yield and yield components were recorded at harvest and were statistically analyzed following the design used. The results showed that the highest grain yield (8.91 & 8.75 t ha^{-1}) was obtained by

BRRI dhan89 and Binadhan-17 followed by BRRI dhan29 which produced 8.65 t ha^{-1}(Table 4). The short duration varieties were recorded in BRRI dhan84 and BRRI dhan86.

Table 4. Yield and yield contributing characters of Binadhan-17 and Binadhan-20 along with some boro rice varieties in 2019-2020

Variety	Plant height (cm)	Total tiller plant^{-1} (no.)	Effective tiller hill^{-1} (no.)	Total grains panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Yield (t ha^{-1})	Duration (days)
Binadhan-17	93.2bcd	13.53 c	13.27 ab	189.9 a	137.2 a	52.73 b	8.75 a	157 a
Bina dhan-20	110.3 a	14.53 b	14.20 a	171.0 ab	99.07 ab	72.00 a	6.99abc	155 a
BRRIdhan28	92.1bcd	16.13 a	13.27 ab	113.1 ab	92.47 ab	20.67 cd	6.78a-d	140bc
BRRI dhan29	95.6 abc	13.93 c	14.20 a	152.1 ab	119.8 ab	32.30 c	8.65ab	160 a
BRRI dahn74	88.3 cd	15.33 ab	14.87 a	100.0 b	94.73 ab	5.27 e	6.46bcd	146 b
BRRI dhan84	98.9 abc	14.80 b	13.13 a	143.8 ab	113.8 ab	30.00 c	6.36 cd	137 c
BRRI dhan86	78.93 d	14.60 b	12.60 ab	101.5 b	82.60 b	18.93 d	4.64 d	139 c
BRRI dhan88	83.6 cd	14.00 bc	13.20 a	133.8 ab	94.53 ab	39.33 b	6.42 cd	141bc
BRRI dhan89	105.87 ab	12.33	11.67 b	163.6 ab	125.4 ab	38.27 b	8.91 a	159 a
CV %	5.64	11.63	9.72	20.73	15.61	70.95	12.95	1.35

On-station yield trial of some short duration lines in boro season

Four short duration mutants (EFSD-59, EFSD-66, EFSD-32 and EFSD-58) and one check variety (BRRIdhan28) was evaluated at the BINA Sub-station experimental Farm at Cumilla during Boro season in 2019-2020. The objective was to develop high yield short duration variety for Boro season. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 5 m × 4 m. Data on yield and yield components were recorded at harvest and were statistically analyzed following the design used for the experiment and the means were compared with LSD. The mean grain yield was the highest obtained by BRRI dhan28 (6.61 t ha^{-1}) (Table 5). Among the mutant lines, EFSD-66 produced the second highest grain yield (6.52 t ha^{-1}) followed by EFSD-59 (6.43 t ha^{-1}). The data recorded on crop duration from seedling to maturity revealed that the BRRI dhan28 required the least average 153 days and second highest EFSD-66 (154 days) (Table 5).

Table 5. Yield and yield contributing characters of some short duration rice lines in Boro season 2019-2020

Variety	Plant height (cm)	Total tiller hill^{-1} (no.)	Effective Tiller hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Duration (days)	Yield (t ha^{-1})
BRRI dhan28	90.7 a	12.20 ab	12.20 ab	138.3 a	11.93 ns	153.6 c	6.61 a
EFSD-59	84.9 b	12.27 ab	12.27 ab	142.0 a	13.70	165.3 a	6.43 a
EFSD-66	84.3 b	11.60 b	11.60 b	132.7 ab	11.83	154.6 c	6.52 a
EFSD-32	87.2 ab	12.53 a	12.53 ab	141.2 a	12.80	158.6 b	6.07 b
EFSD-58	85.8 b	14.40 a	14.40 a	122.3 b	11.50	164.3 a	5.77 b
CV%	**3.92**	**13.29**	**13.29**	**7.45**	**17.93**	**0.34**	**4.74**

Preliminary yield trial with three selected M_6 soybean mutants

The experiment was conducted at farmer's field of Haimchar Upazilla, Chandpur during 2019-2020 to select high yielding short duration line. Four advanced soybean lines viz. SBM-02, SBM-07, SBM-08 and SBM-09 along with two check varieties, BARI soybean-6 & Binasoybean-2. The experiment was laid out in RCB design with 3 replications. The unit plot size was 5m × 4 m. The recommended doses of fertilizers were applied. The experiment was harvested on different dates according to the maturity of the mutant lines/varieties. The data on yield and yield attributes were recorded from randomly selected 10 plants while the yield data were recorded from the harvest of whole plot. All the recorded data were statistically analyzed using MSTAT Statistical computer program. Among different advance lines/varieties, SBM-02 produced the highest seed yield (3.56 t ha^{-1}) followed by BARI soybean-6 (3.42 t ha^{-1}). Binasoybean-2 took the lowest duration (94 days).

Table 6. Yield and yield contributing characters of some short duration soybean mutants in 2019-2020

Varieties/lines	Plant height (cm)	Total branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Seeds pod^{-1} (no.)	Pod length (cm)	Duration (days)	Seed yield (t ha^{-1})
SBM-8	82.1 bc	3.20 ab	43.7 ab	2.07 ab	3.47 ab	95.6 b	1.92 c
BARI soybean-6	61.3 c	4.73 a	47.8 a	2.53 a	4.01 a	95.00 b	3.43 b
SBM-02	131 a	3.07 ab	34.4 b	2.33 ab	4.07 a	102.6 a	3.56 a
SBM-09	69.8 bc	4.27 ab	39.2 ab	2.13 ab	3.68 ab	96.3 ab	2.45 bc
SBM-07	86.0 b	2.87 b	49.5 a	1.87 b	3.81 ab	100.0 a	2.31 bc
BINA soybean-2	91.7 b	4.93 a	48.1 a	2.20 ab	3.36 b	93.6 b	2.41 bc
CV (%)	9.12	25.13	27.21	17.47	12.60	5.69	16.40

Boro (Binadhan-14) against T. Aman-Fallow-Boro in Cumilla region

A field experiment was conducted at Kasba upazilla of Brahmanbaria and Burichang upazilla of Cumilla during 2019-2020 to study an economically profitable three crops based cropping pattern in Cumilla region for increasing cropping intensity and productivity as well as to increase farmer's income. The proposed cropping pattern was T. Aman (Binadhan-17)-Mustard (Binasharisha-4)-Boro (Binadhan-14**)** and existing cropping pattern was T. Aman-Fallow-Boro. Results revealed that the rice equivalent yield (REY) of proposed cropping pattern (11.25 t ha^{-1}) is lower than existing cropping pattern (11.81 t ha^{-1}) which is 4.74% lower than existing cropping pattern. The proposed cropping pattern is not accepted farmers due long duration, high cost and low rice equivalent yield than the existing cropping pattern

Table 7. Average duration and yield of proposed and existing cropping pattern

Proposed cropping pattern					
Crops	Binadhan-17	Binasarisha-4	Binadhan-14	Total	
Duration (days)	123	94	126	Duration	343 days
Yield (t ha^{-1})	4.57	1.44	4.40	Rice equivalent yield	11.25 t ha^{-1}
Existing cropping pattern					
Crops	Binadhan-17	Fallow	BRRI dhan29	Total	
Duration (days)	123	-	154	Duration	277 days
Yield (t ha^{-1})	4.57	-	7.2 t ha^{-1}	Rice equivalent yield	11.81 t ha^{-1}

Observation trial with BINA released Binadhan-20 in Cumilla region

Eight observation trials were conducted with Binadhan-20 in previous Aman season in 2019-20 at Sadar Dakshin, Burichang of Cumilla district and Sadar upazilla of Brahmanbaria district in about 33 decimals per trial to demonstrate the performance of Binadhan-20 at the farmers field. The maximum yield was recorded (5.40 t ha^{-1}) at sadar upazilla of Brahmanbaria district with second highest duration (148 days). Though yield is satisfactory but farmers of these three upazilla are not highly interested to cultivate this variety due to long duration. Beside long duration this variety was highly affected by Cyclone Bulbul in previous year.

Table 8. Duration (DAS) and yield (t ha^{-1}) of Binadhan-20 in Cumilla region

Parameter of Binadhan-20	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Dauration (Days)	147.00	152.00	447.00	149.0000	1.52753	2.64575
Yield (t/ha)	3.87	5.40	13.36	4.4533	.47757	.82718

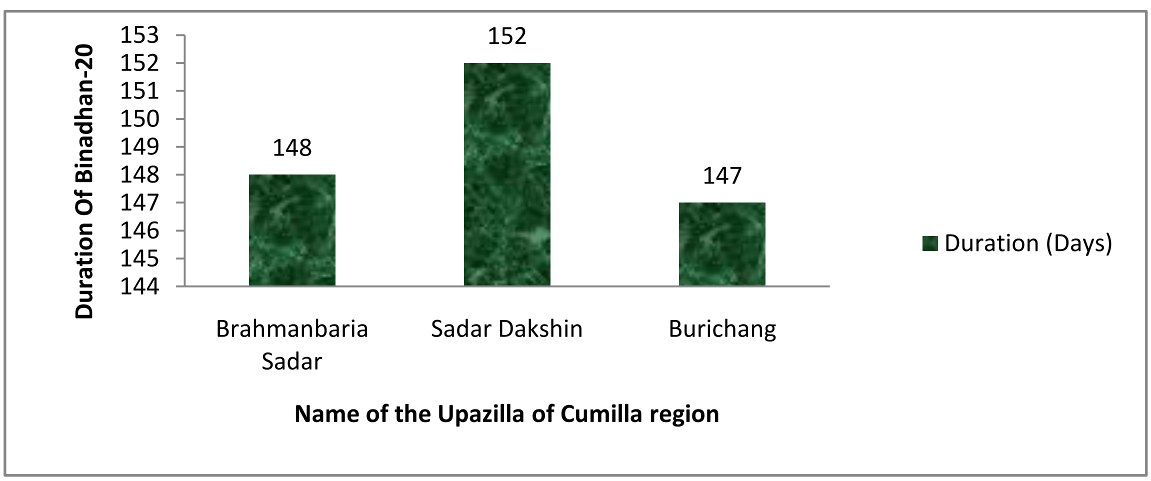


Figure 4. Duration of Binadhan-20 at Brahmanbaria Sadar, Sadar Dakshin and Burichang in Aman 2019-2020

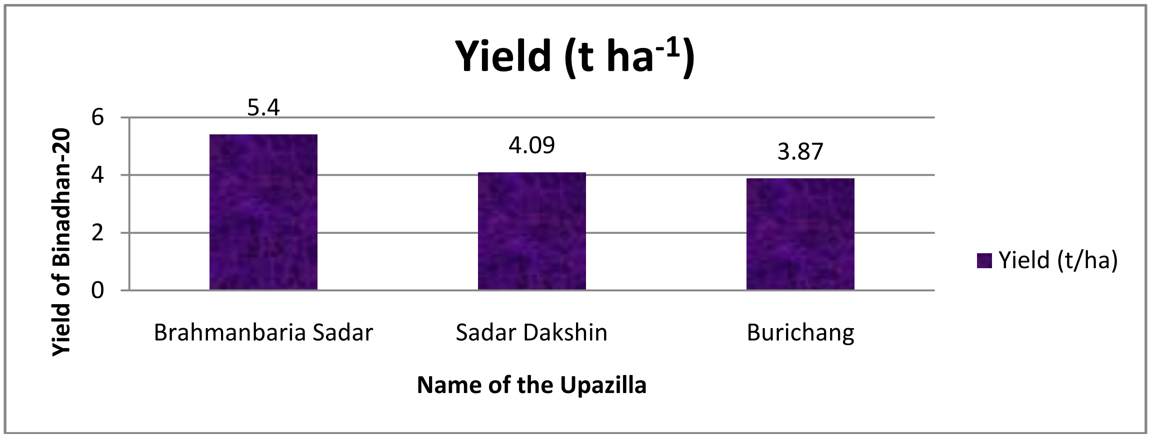


Fig. 5. Yield of Binadhan-20 at Brahmanbaria Sadar, Sadar Dakshin and Burichang in Aman 2019-2020

Seed multiplication and TLS/Breeder seed production of BINA developed varieties

Seeds of different popular varieties of BINA were produced at the BINA sub-station farm, Cumilla and also in the farmer's fields of different locations of Cumilla region and part of those seeds were purchased during 2019-2020. During the reporting period a total of 17.90 t seeds of different crop varieties of BINA were produced and procured. Among them rice were 14.35 t, mustard 3.38 t and sesame 0.164 ton.

Up-scaling of BINA developed different varieties in Cumilla region

For more dissemination and demonstrating of BINA developed varieties, 282 demonstrations were implemented during 2019-20. The average yield (t ha^{-1}) and duration of these demonstrations are given bellow-

Table 10. Performance of BINA developed different varieties in Cumilla region during 2019-20

Sl no.	**crops**	Variety Name	No. of Demo.	Average Duration (days)	Average yield (t ha^{-1})
	Rice	Binadhan-7	15	115	4.32
		Binadhan-11	15	119	4.78
		Binadhan-12	1	138	3.23
		Binadhan-13	1	137	2.7
		Binadhan-16	8	104	4.98
		Binadhan-17	34	124	5.87
		Binadhan-19	120	104	3.89
		Binadhan-20	12	138	4.68
		Binadhan-22	2	124	5.54
2	Mustard	Binasarisha-4	18	98	1.87
		Binasarisha-9	28	87	1.45
6	Til	Binatil-3	28	89	1.24

Among the BINA released high yielding rice varieties (Biandhan-7, Binadhan-11, Binadhan-12, Binadhan-16, Binadhan-17 and Biandhan-22), the yield of Bianadhan-17 is highest (5.87 t ha^{-1}) and Binadhan-22 is second highest (5.54 t ha^{-1}). These two varieties are promising and farmers are showing highly interest to cultivate. Most of the farmer likes Bianadhan-16 of its short duration and satisfactory yield. Some of the farmers like to cultivate Biandhan-12 due to its premium grain quality. Although Binadhan-13 produced high yield but due to its long duration and coarse grain, farmers are showing less interest to cultivate this variety. Due to high yielding quality of Binasarisha-4 and Binasarisha-9, these two varieties are getting popularity day by day in Cumilla region. Farmers interested growing Biantil-3 for short duration and high yielding but it's not getting popularity as desire due to its uncommon skin color of grain.

Training and workshop on the use of BINA developed technologies

In order to introduce and transfer to BINA developed technologies: one regional workshop and six training program was held at BINA Substation, Cumilla. The participants were (both male and female), Sub Assistant Agriculture Officers (SAAO) of DAE and officers of different government organization under the ministry of Agriculture.

Field Days

In order to motivate and introduce farmers BINA developed varieties/technologies 09 field days on different crops were held for rapid and mass dissemination and extensions of high yielding varieties.

Sub-station, Satkhira

Research Highlights

- A total of 118 demonstrations with short duration T. Aman rice BINAdhan-7, Binadhan-16, Binadhan-17 and Binadhan-20 produced average grain yields of 5.39, 5.21, 6.42 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. Some popular cultivars were used as check BRRI dhan49, BRRI dhan66, BRRI dhan67 & BRRI dhan75. In every cases the yield was comparatively higher and duration was short in BINA varieties compared to BRRI varieties. That's why farmers were found interested to cultivate Binadhan-7, Binadhan-16, Binadhan-17 & Binadhan-20.

- A total of 83 demonstrations with short durative high yielding Binasarisha-4 and Binasarisha-9 which produced better yield with less maturity period in most of the time than check variety of BARI sarisha-14.

- A total of 130 demonstrations with salt tolerant Boro rice Binadhan-10 which produced better yield (5.57 to 5.81 t ha^{-1}) with less maturity period than check varieties of BRRI dhan67.

- A total of 20 demonstrations with high yielding mung variety Binamoog-8 which produced better yield than check varieties of BARI mung-6 but need 5 to 7 days more than BARI mung-6.

- A total of 15 demonstrations with high yielding sesame variety Binatil-3 which produced better yield than check varieties of BARI til-3.

- Total 16 tons of TLS seeds of different crops were produced during 2019-20 at Satkhira sub-station

Up-scaling BINA developed high yielding and short durative T.Aman rice variety in Satkhira and Khulna region

During Aman season of 2019-20, 118 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 2019 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 1-4.

Table 1: Performance of Binadhan-7 in Satkhira and Khulna region during 2019-20

Upazila	No. of Trials	Duration (days)		Yield (t ha^{-1})	
		Binadhan-7	BRRI dhan49 (check)	Binadhan-7	BRRI dhan49 (check)
Sadar	5	117	133	5.40	5.10
Tala	4	118	135	5.30	5.08
Kolaroya	5	115	133	5.50	5.20
Koyra	5	117	134	5.30	5.15
Mean	19(Total)	117	134	5.39	5.13

Data in Table 1 revealed that Binadhan-7 produced average grain yield of 5.39 t ha^{-1} and average maturity period of Binadhan-7 was 117 days. Oon the other hand, BRRI dhan49 matuired 134 days with grain yield 5.13 t ha^{-1}. 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 2019-20

Upazila	No. of trials	Duration (days)		Yield (t ha^{-1})	
		Binadhan-16	BRRI dhan66 (check)	Binadhan-16	BRRI dhan66 (check)
Sakhira Sadar	05	101	118	5.15	4.65
Tala	03	105	119	5.17	4.65
Koyra	04	105	117	5.31	4.73
Mean	12 (Total)	104	118	5.21	4.64

Data in Table 2 revealed that Binadhan-16 produced average grain yield of 5.21 t ha^{-1} within 104 days and BRRI dhan66 produced 4.64 t ha$^{=1}$ within 118 days. 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 2019-20

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})	
		Binadhan-17	BRRI dhan75 (check)	Binadhan-17	BRRI dhan75 (check)
Satkhira sadar	15	117	119	6.55	5.65
Tala	10	117	119	6.30	5.45
Shyamnogor	10	117	118	6.35	5.61
Kolaroya	15	117	119	6.58	5.8
Dumuria	10	117	119	6.25	5.5
Koyra	10	116	120	6.46	5.58
Mean	70 (Total)	117	119	6.42	5.59

Data in Table 3 revealed that Binadhan-17 produced average grain yield of 6.42 t ha^{-1} with average maturity period of 117 days and BRRI dhan75 produced 5.59 tha^{-1} within 119 days. 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 2019-20

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})	
		Binadhan-20	BRRI dhan49 (check)	Binadhan-20	BRRI dhan66 (check)
Satkhira sadar	05	125	120	5.00	4.65
Tala	03	127	118	4.85	4.50
Shyamnogor	04	127	118	5.00	4.54
Koyra	05	126	120	5.10	4.58
Mean	17 (Total)	126	119	4.99	4.57

Data in Table 4 revealed that Binadhan-20 produced average grain yield of 4.99 t ha^{-1} with an average maturity period of 126 days and BRRI dhan66 produced 4.57 tha^{-1} with maturity period 119 days. 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 2019-20, total 83 demonstrations were conducted with Binasarisha-4 and Binasarisha-9 in satkhira region. The main objectives were to demonstrate the performance of Binasarisha-4 and Binasarisha-9 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during November 2019 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 and 6.

Table 5: Performance of Binasarisha-4 compared to popular cultivar in Satkhira region during 2019-20

Upazila	No. of Trials	Duration (days)		Yield (t ha^{-1})	
		BINAsarisha-4	BARI sarisha-14 (Check)	BINAsarisha-4	BARI sarisha-14 (Check)
Satkhira Sadar	10	86	78	2.1	1.65
Tala	05	85	78	1.8	1.58
Kolaroya	10	86	79	2.1	1.60
Shyamnogor	03	84	77	1.7	1.55
Mean	28 (Total)	85	78	1.9	1.6

Data in Table 5 revealed that Binasarisha-4 produced average seed yield of 1.9 t ha^{-1} with an average maturity period of 85 days. BARI sarisha-14 produced average gain yield of 1.6 t ha^{-1} with average maturity period of 78 days. Farmers were not found interested to cultivate Binasarisha-4.

Table 6: Performance of Binasarisha-9 compared to popular cultivar in Satkhira region during 2019-20

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})	
		Binasarisha-9	BARI sarisha14 (Check)	Binasarisha-9	BARI sarisha14 (Check)
Satkhira sodor	20	80	78	1.95	1.65
Tala	15	79	78	1.65	1.53
Kolaroya	20	81	78	1.75	1.56
Mean	55 (Total)	80	78	1.78	1.58

Data in Table 6 revealed that Binasarisha-9 produced average seed yield of 1.78 t ha^{-1} with an average maturity period of 80 days. BARI sarisha14 produced average seed yield of 1.57 t ha^{-1} with average maturity period of 78 days. Farmers were found interested to cultivate Binasarisha-9.

Up-scaling BINA developed salt tolerant variety Binadhan-10 in Satkhira and Khulna region

During Boro season of 2019-20, 130 demonstrations 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 2020 and age of seedlings was 35 to 40 days. The farmers managed all the production practices as per recommendation. Data of demonstration plots are presented in Table 7.

Table 7: Performance of Binadhan-10 in Satkhira and Khulna region during 2019-20

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})	
		Binadhan-10	BRRIdhan67 (check)	Binadhan-10	BRRIdhan67 (check)
Satkhira Sadar	20	127	141	5.59	5.25
Shyamnogor	30	127	141	5.57	5.30
Koyra	30	128	140	5.58	5.50
Asasuni	10	128	143	5.81	5.45
Tala	05	130	145	5.60	5.48
Dumuria	10	129	141	5.80	5.58
Debhata	05	131	143	5.57	5.49
Kaliganj	10	130	140	5.69	5.50
Mollahat	10	131	142	5.65	5.40
Mean	130 (Total)	129	142	5.65	5.44

Data in Table 7 revealed that BINAdhan-10 produced average yield of 5.65 t ha^{-1} and BRRI dhan-67 produced 5.44 t ha^{-1}. Average maturity period of BINAdhan-10 was 129 days and BRRI dhan-67 was 142 days. Therefore, the variety of 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 and short durative mungbean variety in Satkhira region

During the Rabi season of 2019-20, total 20 demonstrations were conducted with Binamoog-8 in Satkhira 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 2020 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 8.

Table 8: Performance of Binamoog-8 compared to popular cultivar in Satkhira region during 2019-20

Upazila	No. of demos	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamoog-8	BARI moog-6	Binamoog-8	BARI moog-6	
Satkhira sodor	10	67	60	1.6	1.5	6.67
Kolaroya	10	66	61	1.55	1.45	3.45
Mean	20 (Total)	67	61	1.58	1.48	5.06

Data in Table 8 revealed that Binamoog-8 produced average grain yield of 1.58 t ha^{-1} and crop duration was 67 days while BARImug-6 produced 1.48 t ha^{-1} with crop duration 61 days. 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 2019-20, total 15 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. Seeds were sown during mid February to mid March 2020 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 9.

Table 9: Performance of Binamoog-8 compared to popular cultivar in Satkhira region during 2019-20

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	10	87	95	1.45	1.38	5.07
Koalaroa	05	86	95	1.45	1.45	0.0
Mean	15 (Total)	86.5	95	1.45	1.40	-

Data in Table 9 revealed that Binatil-3 produced average grain yield of 1.45 t ha^{-1} and growth duration was 86.5 days which was better than check variety. 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, Satkhira at the farmer's fields. Results of overall promotional activities related to BINA-Technology village establishment at Surma Union are presented in Table 10.

Table 10: Performance of BINA developed varieties at Nogorghata union during 2019-20

Sl. No	Crops	Variety Name	Trial No.	Growth Duration (days)	Yield (t ha^{-1})
1.	Rice	Binadhan-10	6	132	5.75
		Binadhan-14	2	125	6.85
		Binadhan-7	3	115	4.60
		Binadhan-16	3	100	4.80
		Binadhan-17	5	113	6.20
2.	Mustard	Binasarisha-4	3	83	1.50
		Binasarisha-9	5	79	1.72
		Binasarisha-10	4	77	1.50
3.	Mungbean	Binamoog-8	2	65	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 (6.85 t ha^{-1}) with moderate crop duration (Table 10). Transplanted Aman varieties Binadhan-17, Binadhan-11, Binadhan-7 & Binadhan-16 produced desirable grain yield. Farmers had been interested to cultivate BINA developed Aman rice varieties in Aman season for their high yield and short crop duration. Mustard variety, (Binasarisha-4, Binasarisha-9 and Binasarisha-10) showed immense potentials in terms of yield and duration for cultivation in between Aman and Boro rice. Binamoog-8 also produced desirable seed yield. BINA technology village Establishment in Nogorghata union is in progress.

Production of quality seed of BINA released crop varieties at BINA Sub-station, Satkhira

Seeds of different popular varieties (Satkhira, Khulna and Bagerhat region) were produced at the sub-station farms and contract growing during 2019-20. During the reporting period a total 16 tons of TLS seeds of different crops were produced. Among them rice were about 14.13 tons, masue 0.300ton, mustard 1.39 tons, mung 0.25 ton and sesame 16 kg.

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies five training of one day was arranged at BINA Substation, Satkhira. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer.

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 8 field days on different crop varieties were organized in Satkhira region.

Sub-station, Jamalpur

Research highlights

- A field experiment was carried out at Jamalpur during 2019-20 to reveal the effects of different nitrogen management practices under different submergence situation on growth, N uptake and yield and irrigation on the growth. Result indicated that treatment T_3 (75 kg N ha^{-1}) produced highest yield (4.83 t ha^{-1}) and found best treatment for nitrogen after complete submergences.
- An experiment was conducted to evaluate the methods of zinc application on wheat to increase yield and Zn concentration of in grain. The grain yield of wheat greatly varied with genotypes which can be attributed to differences in genetic make-up. The different methods of Zn application varied significantly on the grain and straw yield of wheat. Result revealed that both soil and foliar application of Zn increase higher grain yield of wheat.
- An experiment was conducted at Jamalpur during 2019-20 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.
- Field experiments were conducted at farmer's field to observe the effect of the organic fertilizers on cabbage and tomato production during November 2019 to March 2020. The result indicated that application of organic fertilizer along with 85% recommended dose of chemical fertilizer is more profitable that application of chemical fertilizer only.
- A total of 195 demonstrations (33 decimal/demonstration) were conducted in Jamalpur during the year 2019-20.
- A total number of 23,725 kg seed including breeder and truthfully labeled seed (TLS) was produced during 2019-20.
- During the year 2019-20, three batch of farmer's training, one workshop and six field days were organized where 250 farmers and 20 Sub Assistant Agriculture Officers (SAAO) were trained.

Effect of n management practices under different submergence conditions on the growth, uptake and yield of rice

The experiment was conducted in the low land of BINA substation farm, Jamalpur and four treatment of nitrogen fertilizer was applied after 12 days of complete submergences. The control treatment received full dose of basal chemical fertilizer with a one third of N fertilizer before submergences but after the water removed no N fertilizer was added.

Table 1: Effect of different levels of nitrogen fertilizer after submergences on yield and yield contributing characters

Treatments	Plant height (cm)	Tiller hill^{-1} (no.)	Panicle length (cm)	1000 seed wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1 = Control	78.0c	8.03c	17.3b	24.98 ns	2.68c	4.04c
T_2 = 60 kg N ha^{-1}	85.8b	10.5b	22.7a	26.91	4.29b	5.27b
T_3 = 75 kg N ha^{-1}	91.3ab	12.6a	22.6a	26.84	4.83a	5.91ab
T_4 = 90 kg N ha^{-1}	89.9ab	12.8a	23.1a	26.04	4.80a	6.07a
T_5 = 105kg N ha^{-1}	92.0a	12.2a	23.2a	25.77	4.58ab	5.89ab
CV%	8.36	8.78	9.97	6.53	10.54	9.88

The yield and yield contributing characters of Binadhan-11 after submergences significantly differ due to the nitrogen treatments. Results indicated that application of different rate of N fertilizer increased grain and straw yield significantly over control treatment. The grain yield ranged from 2.68 to 4.83 t ha^{-1} of which the highest yield was obtained from treatment T_3 (75 kg N ha^{-1}) which was statistically similar with treatment T_4. Treatment T_1 which received no fertilizer after submergences produced lowest yields of 2.68 t ha^{-1}. The highest straw yield of 6.07 tha^{-1} was recorded in treatment T_4 (90 kg N ha^{-1}) and the lowest straw yields (4.04 t/ha) was recorded in control treatment. Result indicated that treatment T_3 (75 kg N ha^{-1}) produced highest yield after submergence.

Evaluation of the methods of fertilization (soil and foliar) for improvement of yield and Zn enrichment in wheat grains

The study was undertaken to evaluate the methods of zinc application on wheat to increase yield and Zn concentration of in grain. The grain yield of wheat greatly varied with genotypes which can be attributed to differences in genetic make-up. The different methods of Zn application varied significantly on the grain and straw yield of wheat.

The highest grain yield (3.74 t ha^{-1}) was obtained from BARI Gom26 and the lowest yield (3.49 t ha^{-1}) from BARI Gom25 (Table 2). Among the Zn treated genotype (both soil and foliar application) the grain yield ranged from 3.68 – 4.09 t ha^{-1} (Table 2). The highest grain yield (4.09 t ha^{-1}) was obtained from BARI Gom30 and the lowest yield (3.68 t ha^{-1}) from BARI Gom25.

The highest straw yield (4.71 t ha^{-1}) was obtained from BARI Gom29 and the lowest yield (4.32 t ha^{-1}) from Binagom-1. Addition of Zn increases the straw yield as well. Among the Zn treated genotype (both soil and foliar application) the straw yield ranged from 4.40 – 5.05 t ha^{-1} (Table 2). The highest grain yield (5.05 t ha^{-1}) was obtained from BARI Gom29 and the lowest yield (4.40 t ha^{-1}) from Binagom-1.

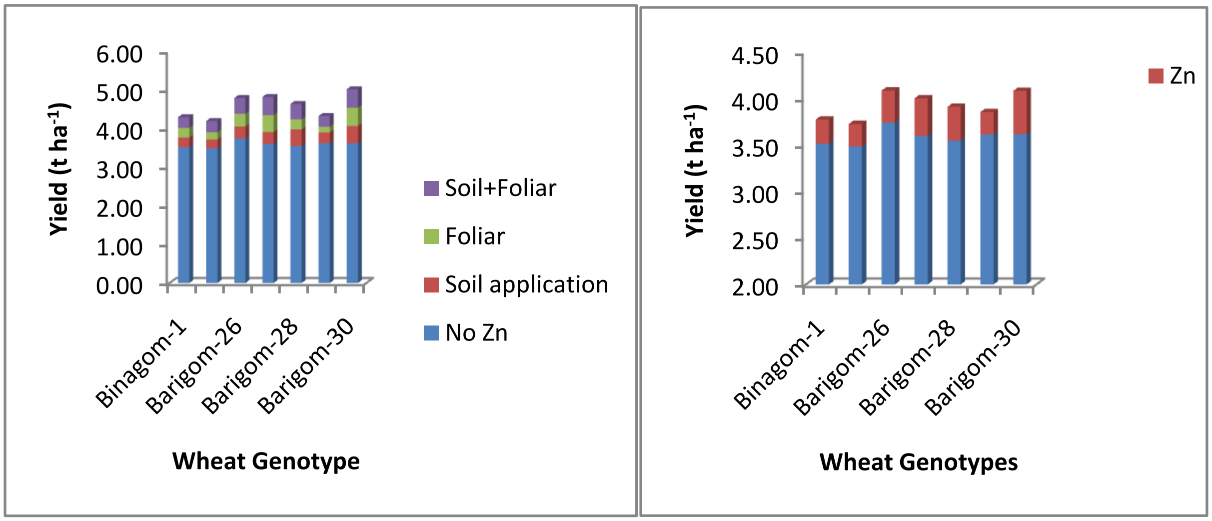


Fig 1. Effect of different methods of Zn application on wheat genotypes (mean increase of Zn both soil and foliar application)

Not all the genotypes were equally responsive to Zn fertilization. Based on the % Zn efficiency [(Control yield / Zn treatment) x 100], the five varieties were more Zn efficient (>90% Zn efficiency) than two genotypes moderately Zn efficient (80.1- 90.0 % Zn efficiency).

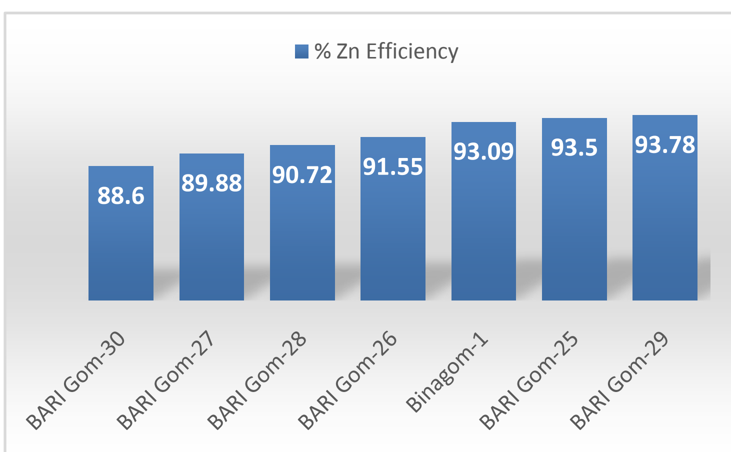


Fig 2. Per cent Zn efficiency of different varieties responds to application of wheat

Table 2: Effect of Zn application on grain and straw yield of different genotypes of wheat

Varieties	Grain yield (t ha^{-1})				Straw yield (t ha^{-1})			
	No Zn	Soil	Foliar	Soil+Foliar	No Zn	Soil	Foliar	Soil+Foliar
Binagom-1	3.52	3.77	3.77	3.80	4.32	4.40	4.55	4.65
BARI Gom-25	3.49	3.72	3.68	3.78	4.43	4.75	4.62	4.75
BARI Gom-26	3.74	4.05	4.07	4.15	4.45	4.76	4.58	4.80
BARI Gom-27	3.60	3.91	4.04	4.07	4.63	4.78	4.74	4.70
BARI Gom-28	3.55	3.98	3.81	3.95	4.64	4.77	4.80	4.80
BARI Gom-29	3.62	3.90	3.77	3.90	4.71	5.01	4.90	5.05
BARI Gom-30	3.62	4.07	4.09	4.10	4.67	4.80	4.83	5.03
Mean	3.59	3.91	3.89	3.96	4.55	4.75	4.71	4.82
Range	3.49-3.74	3.72-4.07	3.68-4.09	3.78-4.15	4.32-4.71	4.40-5.01	4.55-4.90	4.65-5.05

Determination of profitable cropping pattern with BINA developed crop varieties for Jamalpur

The experiment was conducted at three location of Jamalpur Sadar during 2019-20. 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 and
T_3: Boro – Fallow – T. Aman

Varieties developed by BINA were selected 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 3. 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 included. Total field duration of four crops pattern Mustard - Mungbean – Aus – T. Aman was 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 costs and returns of crops, per hectare yield, gross return, gross margin.

Table 3: 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 4). The yield of mungbean (Binamoog-8) and Aus (Binadhan-19) was recorded 1.5 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 4: Yield of 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	1.5	3.1	-	4.6
Mustard – Jute –T. Aman	-	1.6	-	-	2.5	4.6
Boro – Fallow – T. Aman	5.6	-	-	-	-	4.5

Evaluation of organic fertilizer for vegetable (Cabbage and Tomato) production at farmer's field

Field experiments were conducted at farmer's field to observe the effect of the organic fertilizers on cabbage and tomato production during November 2019 to March 2020. The initial soil status was pH 7.2, Om 1.24%, N 0.11%, P 15.3 ppm, K 0.22 me% and S 15.5 ppm. The treatment details are present in Table 5.

All the green organic fertilizer treated plots produced higher yield over chemical fertilizer treated plot (Table 5). The average yield ranged from 59.3 to 72.5t ha^{-1} and the highest yield of 72.5 t ha^{1} was recorded from treatment T_2 (85% RCF + 3 t ha^{-1} green OF) followed by treatment T_3 (85% RCF +1 t ha^{-1} green OF) which produced 65.3 t ha^{-1}. The lowest yield (59.3 t ha^{-1}) was obtained by the treatment T_1 (100% RCF). The highest percent increase in fresh yield over T_1, was 22.2. The highest MBCR 2.57 (average of two locations) was obtained from treatment T_2 and the result indicated that application of green organic fertilizer along with 85% recommended dose of chemical fertilizer is more profitable than application of chemical fertilizer only.

Table 5. Effect of green organic fertilizer on cabbage production (t ha^{-1}) at Jamalpur

Treatments	Cabbage yield (t ha^{-1})	Yield increase over control (T_1) (%)	MBCR
T_1 : RCF (N_{120} P_{35} K_{70} S_{16} Zn_2 $B_{0.5}$)	59.3c	-	-
T_2 : 85% RCF + 3 t ha^{-1} OF	72.5a	22.2	2.57
T_3: 85% RCF + 1 t ha^{-1} OF	65.3b	10.1	2.02
T_4: 70% RCF + 3 t ha^{-1} OF	64.2bc	8.26	0.74
T_5: 70% RCF + 1 t ha^{-1} OF	60.0c	1.18	0.24
CV (%)	11.96	-	

Figure in a column, having common letter (s) do not differ significantly at 5% level of probability.

The yield of tomato was increased significantly due to the treatments. All the organic fertilizer treated plots produced higher yield over chemical fertilizer treated plot. The highest yield of 70.4t ha^{-1} was recorded from treatment T_2 (85% RCF + 3 t ha^{-1} Sweet Gold OF) followed by treatment T_3 (85% RCF +1 t ha^{-1}Sweet Gold OF) which produced 62.1 t ha^{-1}. The lowest yield (58.3 t ha^{-1}) was obtained from the treatment T_1 (100% RCF). The percent increase in yield over T_1, was 20.5. From the different treatments of organic fertilizer with recommended chemical fertilizer packages, the results demonstrated that the highest tomato yield was obtained from the treatment T_2 (85% RCF + 3 t ha^{-1} OF).

Table 6. Effect of Sweet Gold organic fertilizer on tomato production at Jamalpur

Treatments	Tomato yield (t ha^{-1})	Yield increase over control (T_1) (%)	MBCR
T_1 : RCF (N_{120} P_{30} K_{80} S_{16} Zn_2 $B_{0.5}$)	58.4c	-	-
T_2 : 85% RCF + 3 t ha^{-1} OF	70.4a	20.5	2.34
T_3: 85% RCF + 1 t ha^{-1} OF	62.1ab	6.33	1.24
T_4: 70% RCF + 3 t ha^{-1} OF	60.3ab	3.25	-
T_5: 70% RCF + 1 t ha^{-1} OF	58.61b	-	-
CV (%)	9.68	-	

The highest MBCR (2.34) was obtained from treatment T_2 (85% RCF + 3 t ha^{-1} organic fertilizer) and second highest MBCR 1.24 was found from treatment T_3 (85% RCF + 1 t ha^{-1} OF). Result indicated that application of organic fertilizer along with 85% recommended dose of chemical fertilizer is more profitable than application of chemical fertilizers only.

Growing of M_1 generation for submergence tolerance and high yielding rice variety

Seeds of Binadhan-11 were irradiated with 200, 250, 300 and 350 Gy doses of gamma rays to create variability for submergence tolerance, select better plant type and higher yield in subsequent generations. After irradiation, the seeds were sown on 04 July and seedlings were transplanted on 28 July 2019 at BINA substation farm, Jamalpur with control Binadhan-11. Seedlings were transplanted at 15 cm distance within rows of 20 cm apart following 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. Intercultural operations were followed as and when necessitated. Finally, M_1 seeds were collected from the plants and kept separately according to dose to screen in the M_2 generation in the next T. Aman season.

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 district. Four varieties of rice (Binadhan-11, Binadhan-17, Binadhan-14 and Binadhan-19), 2 varieties of mustard (Binasarisha-4, Binasarisha-9) were considered to disseminate. For the demonstration program 33 decimal areas were taken for each demonstration. 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.

About 82 demonstrations of Amanrice varieties were distributed to the farmers of Jamalpur disstrict through DAE. The Aman rice varieties Binadhan-11 and Binadhan-17 were produced average yield of 4.3 and 5.1 t ha^{-1}, respectively. Data suggested that Binadhan-11 and Binadhan-17 will be a popular variety in Jamalpur region in the coming days.

About 35 demonstrations of mustard variety, Binasarisha-9 were distributed to the farmers of Jamalpur district through DAE. The mustard variety Binasarisha-9 was produced average yield 1.50 t ha^{-1}.

About 60 demonstrations of Aus rice varieties were distributed to the farmers of Jamalpur district through DAE. The Aus rice varieties Binadhan-14 and Binadhan-19 were produced average yield of 5.90 and 4.50 t ha^{-1}, respectively. Data suggested that Binadhan-14 and Binadhan-19 will be a popular variety in Jamalpur region in the coming days.

Breeder and TLS seed production

Breeder and truthfully labeled seed (TLS) was produced at the substation farm of Jamalpur according to the requisition from different division of BINA head quarters. Seeds of BINA released crop varieties popular in Jamalpur region were produced at the sub-station farms and also in the farmer's fields of different locations and part of those seeds were purchased during 2019-20. A total of 23,725 kg seed of which 3,620 kg breeder seed and 20,105 kg TLS was produced at BINA Substation, Jamalpur during 2019-20. Among them rice were about 21.38 tons, Patshak 70 kg and mustard 2.28 tons.

Training on BINA developed technologies

In order to transfer BINA developed technologies three training program was arranged at BINA Substation, Jamalpur. The participants were farmers (both male and female), Sub Assistant Agriculture Officers (SAAO) of DAE and officers of different government organizations under ministry of agriculture.

Field Days

In order to motivate farmers and to adopt BINA developed varieties/technologies 6 field days on different crops varieties were organized for rapid and mass dissemination.

Sub-station, Nalitabari

Research highlights

- A total of 290 demonstrations (33 decimal/demonstration) were conducted in Sherpur and Netrokona during the year 2019-20.
- A total number of 7000 kg seed including breeder and truthfully labeled seed (TLS) was produced during 2019-20.
- During the year 2019-20, two training and four field day programs were organized whereas 140 farmers and 8 Sub Assistant Agriculture Officers (SAAO) were trained.

Growing of M_1 population of local landrace Tulshimala rice

The experiment was conducted to create variability for shorter plant height, erect plant types, short duration with fine quality with aroma and higher grain yield. The experiment was conducted Aman season, 2019 at BINA Sub station Nalitabari farms Sherpur. The well dried 100g seed of ware taken to observed the effect of gamma irradiation on seeds which were irradiated with 150, 200, 250, 300 and 350 Gy of gamma rays. The germinated seed were observed daily after sowing. The results indicated differences for germination percentages to different ray different at different days interval. Seeds of local landrace Tulshimala rice M_2 seeds from each plant were collected and bulk them to grow M_2 population.

Demonstration with different Aman rice, mustard (Rabi) and groundnut varieties developed by BINA

The different varieties of rice, mustard and developed by BINA were demonstrated at different locations of Sherpur and Netrokona to show the performance of the varieties and to extend the varieties among the farmers. Varieties of rice (Binadhan-11, Binadhan-17, Binadhan-14, and Binadhan-19), mustard (Binasarisha-9) were considered to disseminate. For the demonstration program 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 and signboard per demonstration was provided to the farmers as partial cost of production of the crops.

About 80 demonstrations of Aman rice varieties were distributed to the farmers of Sherpur and Netrokona districts through DAE. The Aman rice varieties Binadhan-11 and Binadhan-17 were produced average yield 4.20 and 6.1 t ha^{-1}, respectively.

About 70 demonstrations of mustard variety were distributed to the farmers of Sherpur and Netrokona districts through DAE. The mustard variety Binasarisha-9 was produced average yield 1.55 t ha^{-1}.

About 70 demonstrations of Boro rice varieties were distributed to the farmers of Sherpur and Netrokona districts through DAE. The Boro rice varieties Binadhan-8, Binadhan-10 and Binadhan-14 were produced average yield of 6.10, 6.50 and 4.30 t ha^{-1}, respectively.
About 70 demonstrations of Aus rice varieties were distributed to the farmers of Sherpur and Netrokona districts through DAE. The Aus rice varieties Binadhan-19 and Binadhan-21 were produced average yield of 3.10 and 4.50 t ha^{-1}, respectively.

Table1: Demonstration (33 decimel) of different varieties and crops (rice, mustard) at different Upozilaof Sherpur and Netrokona district.

Sl. No.	Crops	District	Locations	Variety	No. of farmers	Yield (t/ha)
1.	Rice (Aman)	Sherpur	Sadar	Binadhan-17	10	6.2
			Nalitabari	Binadhan-11	10	4.2
				Binadhan-17	10	6.1
			Nakla	Binadhan-11	10	4.2
			Sribardi	Binadhan-11	10	4.3
			Jhinaigati	Binadhan-17	10	6.0
			Sadar	Binadhan-17	5	6.1
			Kendua	Binadhan-17	5	6.1
			Barhatta	Binadhan-11	5	4.1
			Mohongonj	Binadhan-11	5	4.2
2.	Mustard	Sherpur	Sadar	Binasharisha-9	10	1.6
			Nalitabari		10	1.5
			Nakla		10	1.6
			Sribardi		10	1.6
			Jhinaigati		10	1.5
		Netrokona	Sadar		5	1.5
			Kendua		5	1.6
			Barhatta		5	1.5
			Mohongonj		5	1.4
	Rice (Boro)	Sherpur	Sadar	Binadhan-10	5	6.7
				Binadhan-14	5	4.5
			Nalitabari	Binadhan-10	5	6.5
				Binadhan-14	5	4.3
			Nakla	Binadhan-8	5	6.1
				Binadhan-14	5	4.4
			Sribardi	Binadhan-8	5	6.1
				Binadhan-14	5	4.2
			Jhinaigati	Binadhan-10	5	6.4
				Binadhan-14	5	4.1
		Netrokona	Sadar	Binadhan-10	3	6.5
				Binadhan-14	2	4.3
			Kendua	Binadhan-8	3	6.0
				Binadhan-14	2	4.2
			Barhatta	Binadhan-8	2	5.9
				Binadhan-10	2	6.4
				Binadhan-14	1	4.1
			Mohongonj	Binadhan-8	2	6.1
				Binadhan-10	2	6.5
				Binadhan-14	1	4.2
	Rice (Aus)	Sherpur	Sadar	Binadhan-19	10	3.2

			Nalitabari	Binadhan-19	7	3.3
				Binadhan-21	3	4.5
			Nakla	Binadhan-19	10	3.1
			Sribardi	Binadhan-19	10	2.9
			Jhinaigati	Binadhan-19	10	2.9
		Netrokona	Sadar	Binadhan-19	5	2.9
			Kendua	Binadhan-19	5	3.1
			Barhatta	Binadhan-19	5	3.2
			Mohongonj	Binadhan-19	5	2.9

Quality seed production of promising BINA released varieties

Seeds of some demanding and promising crop varieties of BINA were produced in sub-station and also in the farmer's fields at different locations. Seeds of different crop varieties which were produced and purchased from the farmer's field during 2019-20. For buying seeds from the farmer's government rate were followed. During the 2019-20 period a total of 7.00 tons seeds of different crop varieties of BINA were produced and procured. Among them rice were about 5.9 tons, and mustard 1.1 tons.

Table 2: Total seed production, sell and distribution of BINA develop rice varieties of Aman season in 2019-20

SL. No.	Variety	Seed Production (kg)	Seed Purchase (kg)	Total sell (kg)	Total distribution (kg)	
					DAE	Farmer
1.	Binadhan-7	100	-	100	-	10
2.	Binadhan-11	100	-	100	400	100
3.	Binadhan-12	100	-	-	-	40
4.	Binadhan-15	50	-		-	20
5.	Binadhan-16	50	-		80	90
6.	Binadhan-17	300	1200	1000	1150	110
7.	Binadhan-20	100	-	50	350	10
8.	Binadhan-22	100	100	50	-	20
Total		900	2000	1100	4000	400

Table3: Total seed production, sell and distribution of BINA develop crop varieties of Rabi season in 2019-20

SL. No.	Crop	Variety	Total Seed Production (kg)	Total sell (kg)	Total distribution (kg)	
					DAE	Farmer
1.	Mustard	Binasharisha-9	1100	-	800	300
2.						
Total			1100	-	800	300

Table4: Total seed production, sell and distribution of BINA develop rice varieties of Aus season in 2019-20

SL. No.	Variety	Total Seed Production (kg)	Total sell (kg)	Total distribution (kg)	
				DAE	Farmer
1.	Binadhan-19	2000	-	1200	800
	Total	2000	-	1200	800

Table5: Total seed production, sell and distribution of BINA develop rice varieties of Boro season in 2019-20

SL. No.	Variety	Total Seed Production	Total sell (kg)	Total distribution (kg)		
				DAE	Farmer	BADC
1.	Binadhan-5	100		-	200	-
2.	Binadhan-8	300	-	150	-	-
3.	Binadhan-10	400	-	400	-	-
4.	Binadhan-14	200	-	300	100	-
	Total	1000		850	400	-

Training on BINA developed technologies

In order to transfer BINA developed technologies two training program was arranged at BINA Substation, Nalitabari. The participants were farmers (both male and female), Sub Assistant Agriculture Officers (SAAO) of DAE and officers of different government organizations under ministry of agriculture.

Field Days

In order to motivate farmers and to adopt BINA developed varieties/technologies 4 field days on different crops varieties were organized for rapid and mass dissemination.

Table6: Training organized by BINA Substation, Jamalpur

Sl. No.	Tittle	Date	Participants	Fund
1.	Training program on introduction of BINA developed varieties andcultivationprocedure at BINAsubstation, Nalitabari, Sherpur	19.01.2020	70	Revenue
2.	Training program on cultivation procedure of BINA developed Aman varieties and seed preservation at BINA substation, Nalitabari, Sherpur	12.06.2020	70	Revenue

Table 7: Number of trained farmers and extension personnel of Jamalpur and Tangile district

Sl. No	Field day	Date of Field day	No. of farmers	No. of SAAO	Source of fund
1.	Field day Binadhan-11	21.11.2019	120	02	Revenue
3.	Field day Binadhan-19	19.08.2019	120	02	Substation Strengthening...
4.	Field day Binasarisha-9	26.02.2020	100	02	Revenue
5.	Field day Binasarisha-9	15.03.2020	100	02	PBRG 089

Sub-station, Gopalganj

Research Highlights

- SRI (System of Rice Intensification) showed better performance in terms of yield contributing characters than conventional cultivation method. SRI(System of Rice Intensification) showed the highest yield (7 t/ha) than conventional (6.67 t/ha) cultivation method.

- BINA sub-station, Gopalganj suggested 4 crops and 3 crops cropping pattern model. Among the 3 and 4 crops cropping pattern red amaranth and T.Aman could not be cultivated due to flood. All crops performed better in terms of yield and yield contributing characters.

- A total of 283 demonstrations were conducted at the farmer's fields during 2019-20 inFaridpur-Gopalganj region using BINA developed different crop varieties to observe the yield performance and popularize its adoption by the farmers in Faridpur-Gopalganj region. Among the BINA developed crop varieties Binadhan-7, Binadhan-16, Binadhan-17, Binadhan-19, Binasarisha-4, Binasarisha-9, Binatil-2 and Binamug-8 produced higher yield in farmer's field and becoming popular in Faridpur-Gopalganj region.

Comparative performance of system of rice intensification (SRI) and conventional methods of rice Cultivation in southern part of Bangladesh

This experiment was carried out at BINA sub-station, Gopalganj during Aus season in 2019-20to compare the performance between System of rice intensification (SRI) and conventional rice cultivation methods. The rice variety was Binadhan-14. The experiment was laid out in a RCBD with three replications. The unit pot size was 60cm X 40cm. Two seedlings were transplanted in 15cm × 20cm spacing. The treatments were SRI and conventional methods of cultivation. In SRI method ($A_{10}S_2M$) seedling age (A) was 10 days, no. of seedlings/hill (S) was 2 and irrigated condition was moist (M). In conventional method ($A_{25}S_3F$) seedling age (A) was 25 days, no. of seedlings/hill (S) was 3 and irrigated condition was flooded (F). Application of fertilizer and intercultural operations were done as recommended. At 30, 60 and 90 days after sowing (DAS) data on different morphological characters were collected and data on yield and yield contributing characters were collected at harvest.

The morphological characters showed significant differences among the different seedling age of Binadhan-14 (Table 1). The tallest plants were recorded in SRI and shortest plant height found in conventional methods of cultivation. In both cultivation methods plant height increased up to 60 DAS and at 90 DAS both are decreased.

SRI showed the highest no. of tiller/hill throughout the growing season. In both SRI and conventional cultivation methods no. of tillers/hill showed the similar trends throughout the growing season. It was observed that leaf dry weight reached the highest plateau at 60 DAS in both the cultivation methods. SRI showed the highest leaf dry weight throughout the growing season than conventional cultivation method. Leaf sheath dry weight also showed the similar trends as leaf dry weight throughout the growing season. Dry matters partitioning were better at SRI than conventional cultivation method. It was might be due to efficient water use and no. of seedlings that lower the competition in SRI cultivation method. In SRI panicle dry weight decreased up to 90 DAS but conventional cultivation method showed the reverse trends. SRI showed the highest panicle dry weight than conventional cultivation method throughout the growing season.

Treatment	Plant height (cm)								
	40 DAS	60 DAS	90 DAS						
$A_{10}S_2M$	73.5a	107.0 a	110.4 a						
$A_{25}S_3F$	71.8a	98.33 b	101.6 b						

Table 1.Morphological characters and dry matter partitioning

Treatment/ DAS	PH (cm)		Tiller/hill		LDW		LSDW		PDW	
	$A_{10}S_2M$	$A_{25}S_3F$	$A_{10}S_2M$	$A_{25}S_3F$	$A_{10}S_2M$	$A_{25}S_3F$	$A_{10}S_2M$	$A_{25}S_3F$	$A_{10}S_2M$	$A_{25}S_3F$
40	73.5a	71.83a	40.33a	36.83a	11.85a	10.22a	10.30a	7.81b		
60	107.0 a	98.33b	42.00a	39.00a	32.07a	22.69b	32.04a	23.24b	40.47a	18.96b
90	110.4 a	101.6b	46.67a	40.50b	17.41a	14.25b	18.16a	15.91a	48.33a	28.74b

PH= Plant height, LDW= Leaf dry weight, LSDW= Leaf sheath dry weight, PDW= Panicle dry weight

All the yield contributing characters showed statistically similar except 1000 grains weight. SRI showed better performance in terms of yield contributing characters than conventional cultivation method. SRI showed the highest yield (7 t/ha) than conventional (6.67 t/ha) cultivation method (Table 2).

Table 2. Yield and yield contributing characters

Treatment	**Effective tiller hill^{-1}**	**Non - effective tiller hill^{-1}**	**Panicle length (cm)**	**spikelets panicle^{-1} (no.)**	**Filled grains panicle^{-1} (no.)**	**Unfilled grains panicle^{-1} (no.)**	**1000 grains weight (g)**	**Yield (t/ha)**
$A_{10}S_2M$	36.17ns	8.50a	24.6ns	124.9a	96.8 a	28.13a	23.57a	7.00 ns
$A_{25}S_3F$	32.83	4.83b	22.2	96.80b	77.87b	18.93b	21.29b	6.67
CV%	15.21	27.53	7.28	19.61	31.3	24.11	2.72	5.71

Development of a profitable cropping Pattern in Gopalganj region

An experiment was carried out in Gopalganj region to find out a profitable cropping pattern. This experiment was carried out throughout the year in different growing seasons with different crops at BINA sub-station, Gopalganj farm. BINA sub-station, Gopalganj suggested 4 crops and 3 crops cropping pattern model.

3 crops cropping pattern:	Lentil (Binamasur-8)	Mugbean (Binamug-8)	Fallow	T.Aman (Binadhan-22)

4 crops cropping pattern:	Mustard (Binasarisha-9)	Sesame (Binatil-2)	Red amaranth	T.Aman (Binadhan-16)

The experiment was carried out in RCBD design with three replications. Experimental plots size was 3m × 2m. 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}. All crops performed better in terms of yield and yield contributing characters. Among the 3 and 4 crops cropping pattern red amaranth and T.Aman could not be cultivated due to flood. So the experiment will be continued in next growing season.

Up-scaling of BINA developed crop varieties in Faridpur-Gopalganj region

A total of 283 demonstrations were conducted at the farmer's fields during 2019-20 in Faridpur-Gopalganj region using BINA developed different crop varieties. The main objective of these demonstrations was to observe the yield performance and widening its adoption by the farmers in Faridpur-Gopalganj region. The demonstration plot was 52 decimals with recommended spacing based on crop varieties. Application of fertilizer and intercultural operations were done following the BINA recommendation. Based on the collected reports from DAE and crop cutting data of demonstration plots are described below.

In kharif-1 season, there were 93 demonstrations were conducted at the farmer's field using Iratom-24, Binadhan-19 Binatil-2 and Binacinabadam-4, Binacinabadam-6 and Binacinabadam-8. The data on crop duration reveled that Iratom-24 and Binadhan-19 was harvested at 128 and 105 days where the average yield of Binadhan-14 and Binadhan-19 was recorded 3.48 and 3.64 t ha^{-1} respectively. Data suggested that Binadhan-19 will be a popular variety in Faridpur-Gopalganj region in the coming days.

About 92 demonstrations of Aman rice were distributed to the farmers of different districts through DAE in Faridpur-Gopalganj region. The Aman rice varieties Binadhan-7, Binadhan-11, Binadhan-13, Binadhan-15, Binadhan-16, Binadhan-17, Binadhan-20 and Binadhan-22 were harvested at 118, 113, 142, 116, 105, 114, 126 and 112 days and produced average yield 4.02, 4.1, 3.01, 3.85, 5.32, 4.69, 3.75 and 4.81 t ha^{-1} respectively. Among the cultivated Aman rice varieties Binadhan-16 is popular in Faridpur-Gopalganj region.

In Rabi season, there were 68 demonstrations using Binadhan-10, Binasarisha-4, Binasarisha-9, Binasarisha-10, Binachola-4, Binachola-6, Binamosur-5, Binamosur-8, Binamosur-9 and Binakhesari-1 were conducted throughout the Faridpur-Gopalganj region. All the varieties cultivated in Rabi season are popular and well accepted to the farmers of Faridpur-Gopalganj region. Binadhan-10 produced the average yield 4.68 t ha^{-1} within 128 days. In addition, Binasarisha-4 and Binasarisha-9 produced the average yield 1.38 and 1.40 t ha^{-1} and matured in 87 and 85 days of seeding, respectively.

In kharif-1 season, about 30 demonstrations were established in Faridpur-Gopalganj using Binamoog-8. Average yield of Binamoog-8 was recorded 1.41 t ha^{-1} and harvested in 68 days after sowing.

For transferring the BINA developed technology, two farmers training were performed to trained the 215 farmers (female and male) and 10 Sub-assistant Agriculture Officers (SAAO) on the cultivation procedure of BINA developed Aman rice varieties, and seed storage. Besides, there were 9 field days for different crops were organized to motivate the farmers in Faridpur-Gopalganj region.

Sub-station, Barishal

Research Highlights

- Four rice cultivars were evaluated for finding the morphological causes of rice grain yield production in Aus season. Results suggested that Binadhan-19 showed superiority in grain yield production mainly due to filled grain number per panicle with increased percentage of viable pollen.
- Binadhan-10 was assessed with different seedling age to observe the yield performance in Barishal region. The 45 days seedling displayed the longest panicle with highest number of filled grains and 1000 seed weight which finally contribute to highest grain production. Results suggested that seedling of Binadhan-10 should be transplanted at 45 days old for obtaining a maximum grain yield.
- For developing a tidal submergence tolerant rice line, the local cultivar Motamota, Lalmota and Mukta were irradiated with 250, 300, 350 and 400 Gy doses of gamma rays and planted in the sub-station farm, Barishal. The M_1 seeds were bulked from each treatment and stored for growing M_2 generation in the next Aman season.
- Morpho-molecular diversity of 24 cultivars using phenotypic traits and 24 molecular marker analysis were conducted. Based on the morphological observation a positive correlation was found between seed length and length/width ratio. Phenol reaction test on rice cultivars clearly distinguished eight cultivars belonged to the *japonica* and sixteen cultivars as *indica* types. Genetic diversity analysis found BRRI dhan77 had close genetic similarity with Gahinda; BRRI dhan76, Binadhan-17 were grouped in same sub cluster. Binadhan-20 is closely related with Kamina saru; BR-5 is closely related with Dudkalam; BRRI dhan34 has close genetic distance with Lalmota variety.
- A total of 618 demonstrations were conducted at the farmer's fields during 2019-20 in Barishal region using BINA developed different crop varieties to observe the yield performance and spreading its adoption by the farmers in Barishal region. Among the BINA developed crop varieties Binadhan-10, Binadhan-11, Binadhan-17, Binadhan-19, Binasarisha-4, Binasarisha-9, Binamoog-7 and Binamoog-8 produced higher yield in farmers field and becoming popular in Barishal region.

Morpho-physiological aspect of panicle development and spikelet sterility in rice

The experiment was conducted at BINA sub-station during Aus season in 2019-20 to find out the morphological causes in spikelet sterility in rice. Two BINA released rice varieties namely Binadhan-14 and Binadhan-19 along with two local cultivars collected at Barishal region were used as planting materials. The experiment was laid out in a RCBD with three replications. Unit plot size was 3 m × 3 m and spacing between hills and rows were 15 and 20 cm, respectively. The rice seedlings were transplanted at the age of 30 days on 19 May, 2019. Fertilizer was applied as recommended and intercultural operations were done when necessary. Phenotypic data was collected from five randomly selected plants from each plot.

The 1st internode was collected at the ripening stage and then transferred into the small bottle containing FAA solution and kept in the refrigerator at 4 ^{0}C. The peduncle samples were cut using a sharp blade and stained with 1% safranin for 30s, followed by two washes with distilled water, then placed on glass slides having glycerin. Finally, the cross sections of peduncle were observed by optical microscope at 100 magnifications.

For pollen viability study, the unopened spikelet was collected from the tip of the randomly selected rice panicle of each treatment and placed into FAA solution containing bottle. Then the pollen from each spikelet was stained on a glass slide by using 1% potassium iodide and fixed with a cover slip and were surveyed under optical microscope. Stained and well filled pollens were counted as fertile, while the unstained, half stained, shriveled and empty pollens were classified as sterile.

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjusted with Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C.

Considering the yield and yield contributing characters; it is observed that most of the studied traits showed significantly different among the four rice cultivars at harvest (Table 1). Where, the local cultivars China IRRI produced the tallest plants and Binadhan-14 & Binadhan-19 exhibited the shortest plant height (Fig. 1a&b and Table 1). Besides, Binadhan-19 produced the highest number of leaves per hill. Among the rice cultivars, China IRRI showed the longest panicle bearing maximum number of primary branches per panicle and Binadhan-14 & Binadhan-19 displayed the shortest panicle with lower number of primary branches per panicle. But the highest number of filled grains per panicle was recorded in Binadhan-14 & Binadhan-19 and the lowest number of filled grains per panicle was found in China IRRI and Kalihatta.

Figure 1: Phynotypic appearance; (A) flowering stage, (B) ripenning stage and (c) roots of four rice cultivars

Furthermore, the highest number of unfilled grains per panicle was noted in China IRRI followed by Binadhan-14, Binadhan-19 and Kalihatta (Table 1). Binadhan-19 exhibited the profuse root system that might help in nutrient uptake and survive drought condition (Fig. 1c). Finally, Binadhan-19 produced the highest grain yield comparing to other studied rice cultivars. These data postulated that variety has influence on grain yield and the yield can be increased with the increased grains per panicle.

Table 1. Yield and yield contributing characters of four rice cultivars

Variety	Plant height (cm)	Tiller hill^{-1}	No. of leaves hill^{-1}	Panicle length (cm)	Primary branches panicle^{-1} (Nos)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Yield/m^2 (g)
Binadhan-14	103.9 b	14.0^{ns}	65.3 b	22.1 c	8.7 ab	114.0 a	11.7 bc	472.5 a
Binadhan-19	103.4 b	14.3	76.3 a	22.8 c	8.3 b	112.7 a	15.0 b	510.3 a
China IRRI	177.5 a	13.6	66.3 b	27.5 a	10.0 a	87.7 b	34.0 a	318.7 b
Kalihatta	161.9 a	14.6	66.3 b	25.3 b	9.0 ab	79.0 b	8.0 c	298.8 b
CV%	18.42	6.41	22.93	2.04	1.59	22.01	6.62	8.94

The contribution of each internode to the culm length are schematically presented in Fig. 2A. All internodes were evenly shortened for all varieties that fit with dn-type of internode elongation pattern. Both the local cultivars China IRRI and Kalihatta produced the six internodes and BINA developed rice varieties namely Binadhan-14 and Binadhan-19 formed five internodes. Among them, 1st internode contributes more to all the cultivars and the 3rd and 4th internode of China IRRI and Kalihatta was mostly elongated (Fig. 2A & B) that may increase the culm length.

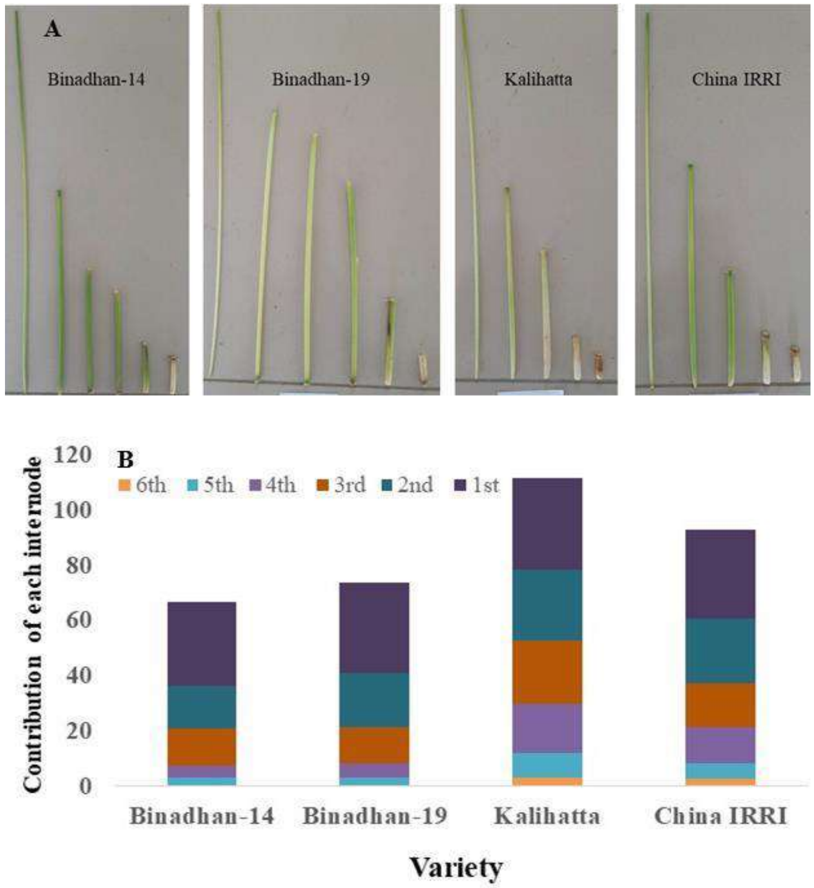


Figure 2: Internodes elongation pattern; (A) schematic (B) Contribution of each internode to culm length

The difference of vascular bundles in 1st internode and pith cavity size among different rice cultivars was examined. The number of vascular bundles was increased along with the increased cavity diameters of the 1st internodes. The highest number of large vascular bundle and bigger pith cavity was found in China IRRI followed by Binadhan-19, Binadhan-14 and Kalihatta (Fig. 3A & B). These results indicated that the meristematic activity and cell proliferation enhances plant growth for better dry matter accumulation.

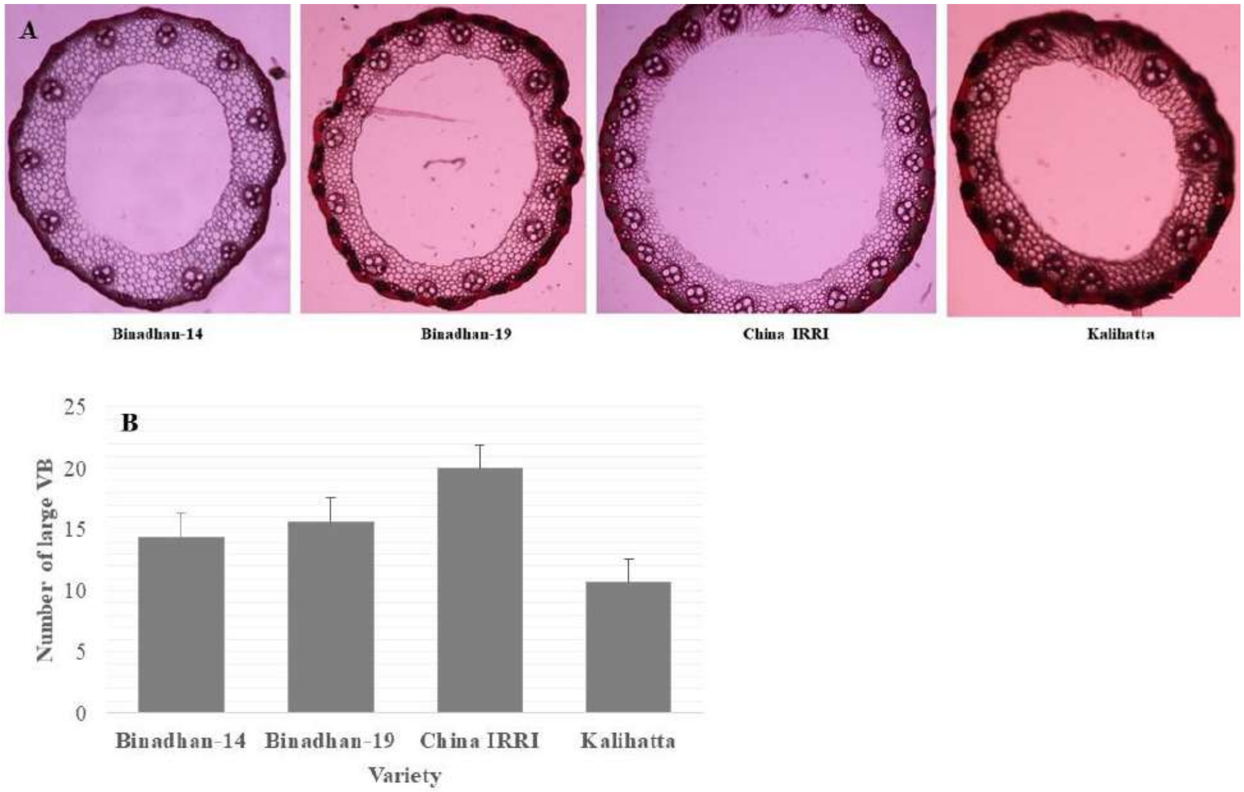


Figure 3: Anatomical observations; (A) Cross-section of the 1st internode (B) The number of large vascular bundles

An unopened spikelet was collected from the tip of each cultivar at flowering stage. Where, the maximum fertile pollen was recorded in Kalihatta which was almost similar with Binadhan14 and Binadhan-19 and the lowest was found in China IRRI. Contrasting with pollen fertility and the unfilled grain production (Table 1) of each cultivar suggested that pollen fertility is important for filled grain production in rice.

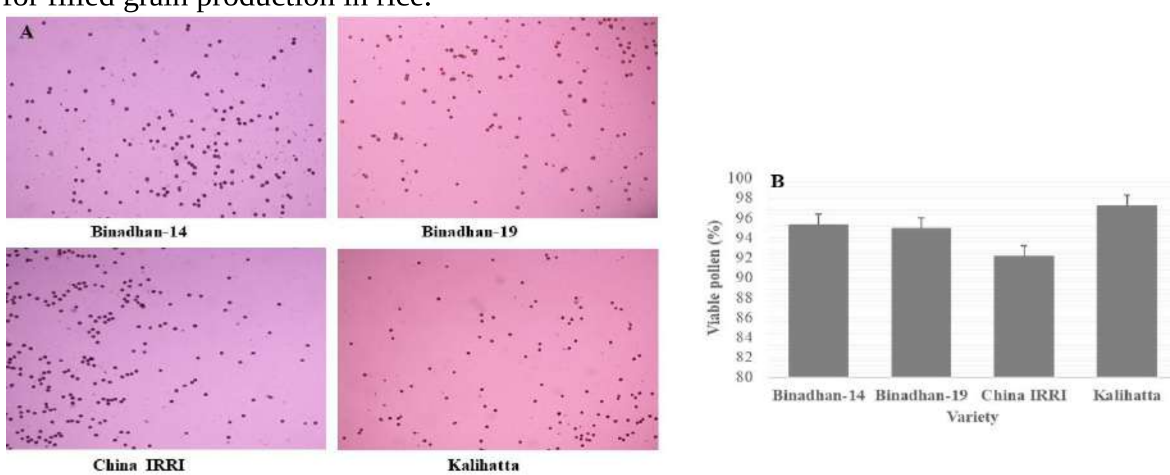


Figure 4: **Pollen viability of rice spikelets (A) stained and non-stained pollens (B) Percentage of viable pollen**

At early panicle initiation stage, all the studied rice cultivars showed the normal growth in panicle development (fig. 5A). China IRRI produced the longest panicle with more primary branches and Binadhan-19 had shorter panicles with higher number of grains per panicle (fig. 5 B&C and Table 1). Results suggested that the long panicle may not produce the highest grain number which ultimately contribute in grain yield production in rice.

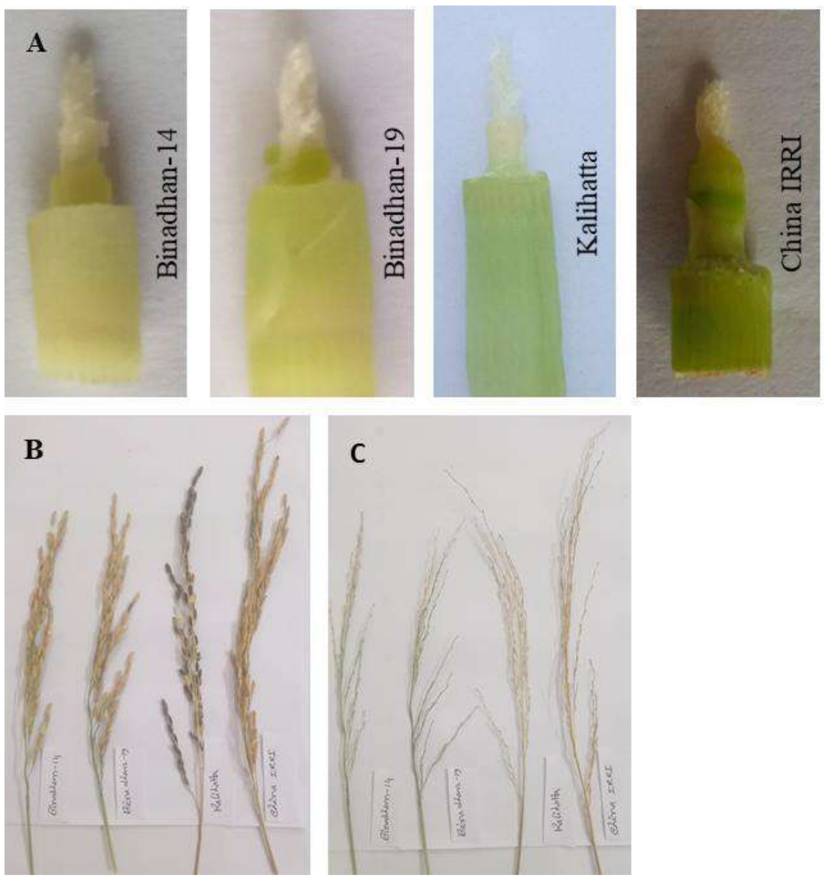


Figure 5: Panicle characterization; (A) Panicle initiation (B) Panicle at maturity stage (C) Schematic representation of rachis branches of four rice cultivars

Normally, dry weight and grain weight per plant showed the positive correlation. But here It is observed that the grain yield decreased with the increased of total dry matter production. Results indicated that negative correlation may found between grain yield and total dry mass production (Fig. 6). Based on the above discussion, Binadhan-19 showed superiority in grain yield production mainly due to filled grain number per panicle with increased percentage of viable pollen.

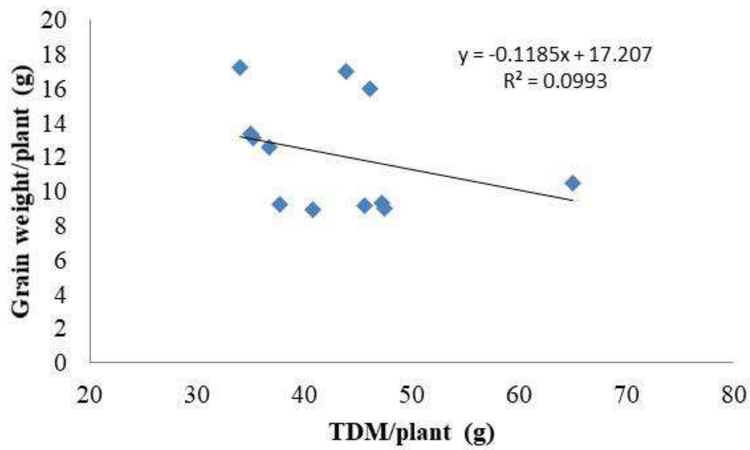


Figure 6: Relationship between total dry matter (TDM) production and grain weight per plant

Effect of seedling age on yield and yield contributing characters of Binadhan-10 cultivated in Barishal region

This experiment was carried out at BINA sub-station during Boro season in 2019-20 to assess the yield performance of Binadhan-10 with different seedling age. The experiment was laid out in a RCBD with three replications. The plot size was 3 m × 3 m and spacing between hills and rows were 15 and 20 cm, respectively. The rice seedlings were transplanted at the age of 30, 45 and 55 days respectively. Application of fertilizer and intercultural operations were done as recommended. At harvest, data on yield and yield contributing characters were collected from five plants randomly selected from each plot.

At harvest, most of the morphological characters showed insignificant differences among the different seedling age of Binadhan-10 (Table 1) except plant height. The tallest plants were recorded in 30 and shortest plant height found in the age of 45 days old seedling.

Table 2: Morphological characters of Binadhan-10 with different seedling age

Seedling age (days)	Plant height (cm)	Effective tiller hill^{-1}	Non-effective tiller hill^{-1}	Flag leaf length (cm)	Flag leaf width (cm)
30	110.5a	11.9	0.7	27.9	1.2
45	100.8b	12.7	1.1	28.1	1.2
55	104.5ab	12.9	0.7	26.8	1.2
CV%	7.25	4.05	1.22	4.08	0.029

In addition, Binadhan-10 exhibited significant variations among the yield contributing characters and yield with different seedling age except primary branches and unfilled grain production per panicle. The 45 days seedling produced the longest panicle with highest number of filled grains and 1000 seed weight (Table-2). Besides, it was formed the lowest number of unfilled grains per panicle that contribute to grain yield production. Finally, Binadhan-10 produced the highest grain yield with 45 days seedling among the different seedling age. Results suggested that seedling of Binadhan-10 should be transplanted at 45 days old for obtaining a maximum grain yield.

Table 3: Yield and yield contributing characters of Binadhan-10 with different seedling age

Seedling age (days)	Panicle length (cm)	Primary branches panicle^{-1}	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	1000 seed Weight (g)	Yield/m^2 (g)
30	27.9a	7.2	119.1a	20.1	26.5b	429.2b
45	26.6a	7.5	120.3a	16.1	28.1a	583.1a
55	24.5b	7.6	101.6 b	19.3	28.3a	413.0b
CV%	1.63	1.33	10.18	5.43	0.75	19.74

Improvement of tidal submergence rice variety for Barisal region through induced mutation and advanced breeding techniques

To create variability, seeds of local cultivar Motamota, Lalmota and Mukta were irradiated with 250, 300, 350 and 400 Gy doses of gamma rays and then the seeds were sown at BINA sub-station farm, Barishal during Aman season 2019. Thirty days old seedlings were transplanted in the main field maintain close spacing between hills and rows.

Results showed that survival rates and plant height decreased with the increased of radiation doses. Finally, the M_1 seeds were harvested from the survived plants of each treatment separately. Then the collected seeds were bulked and stored following the radiation dose and rice cultivars. To fulfil the target of this experiment, the M_2 generation will be grown in the next Aman season.

Genetic diversity study of some rice cultivars using morpho-molecular characters

The study was conducted at BINA sub-station with the collaboration of Plant Breeding and Biotechnology Division during Aman season in 2019-20 to characterize and identify the genetic variation amongst the rice cultivars. Here, eighteen local rice cultivars along with Binadha-17, Binadhan-20, BR5, BRRI dhan76 and Hwachungbyeo (Japonica type) were used.

In addition, 24 molecular markers consisted of eleven SSR and thirteen STS markers covering twelve rice chromosomes were applied for genetic characterization. Phenotypic data were gathered randomly from five grains of each cultivar. The length and width of rice grains were measured by digital slide calipers and mean value of each trait was calculated. 1000-grains weight was measured by digital weighing machine. Presence or absence of awn as a varietal character was measured by naked eye. Genomic DNA were extracted from fresh young leaves of twenty days old seedlings using modified CTAB method. The genomic DNA from samples were then subjected to PCR amplification of SSR and STS markers primers. Each PCR amplification was carried in 10 µl reaction mixture containing 1.0 µl 10x buffer, 0.5 µl dNTPs, 0.5 µl forward, 0.5 µl reverse primers, 0.1 µl *Taq* DNA polymerase, 6.4 µl ddH2O and 1.0 µl of template DNA. The amplified PCR products together with 100bp ladder (Thermo Scientific, USA) were separated in a non-denaturing 8% polyacrylamide gel in 1X TBE running buffer and then stained in 0.1 g/ml ethidium bromide containing water. Banding patterns were visualized with ultraviolet gel documentation system (Alphalmager HP Imaging System). The banding patterns of 24 genotypes were scored and analyzed for diversity study.

It is widely known that most of the wild varieties showed longer awn and domesticated varieties have short size of awn, but most of the HYV and modern varieties are lacking of awn. Presence or absence of awn is considered as very good character to differentiate japonica-indica type cultivars and indigenous cultivars. In our study, we found only two cultivars with short size of awn namely kachra and Tulsi Mala (Fig. 7).

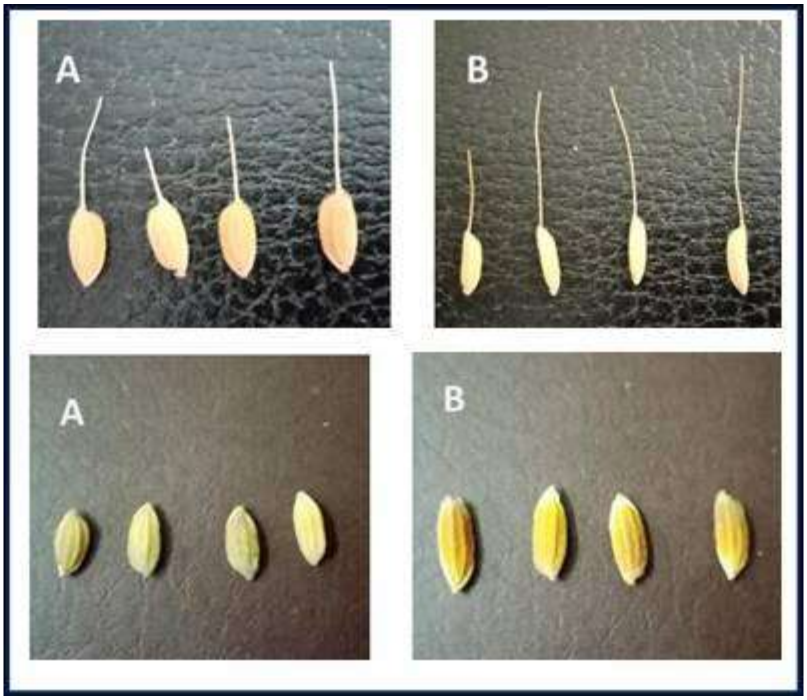


Figure 7: Presence and absence of awn; Kachra (A), Tulsi Mala (B), in Kalomota (C), Lalmota (D) rice cultivars.

The seed length and width showed significant difference in grain length and width (Table 4). The long grain length was found in those varieties similar to indica type. Amongst varieties, Binadhan-20 displayed the longest grain length followed by Tulsi Mala, Benapol andBinadhan-17 whereas Begun bichi showed the shortest grain length followed by BRRI dhan34.

Table 4: Phenotypic differences of seed in different rice cultivars

SL No.	Name of the variety	Length (mm)	Width (mm)	Ratio of length & width	1000 grain weight (g)
1	Kalo mota	8.45 e	3.12 bc	2.71 g	21. 11 f
2	Kacha mota	7.94 fg	3.58 a	2.22 j	26.65 b
3	BRRI dhan77	8.38 e	3.19 bc	2.62 hi	26.69 b
4	BRRI dhan76	7.97 fg	3.17 bc	2.52 hi	23.61de
5	BR5	6.09 i	2.28 g	2.68 hi	10.13 j
6	Katarivog	7.73 g	2.05 h	3.77 bcd	11.47 i
7	Dud kalam	7.26 h	3.07 cd	2.36 ij	24.10 d
8	Moulota	8.80 de	2.92 d	3.02 fg	24.62 c

9	Sada mota	8.61 e	3.43 ab	2.51 hij	23.53 cd
10	Lal mota	7.57 g	3.22 bc	2.35 ij	26.35 b
11	Benapol	9.39 bc	2.31 f	4.07 bc	24.11 cd
12	Kachra	8.16 e	3.18 bc	2.56 h	30.67 a
13	Jothui	8.31 f	3.12 bc	2.66 h	23.33de
14	Kamina Saru	7.47 gh	2.53 fg	2.99 fg	16.57g
15	Baila Amon	8.32 ef	2.96 de	2.81 fgh	23.46de
16	Gahinda	7.84 g	2.07 h	3.79 bcd	13.42 h
17	Saubail	8.33 e	2.43 f	3.42 e	13.37 h
18	Bashful	7.46 gh	2.84 de	2.62 h	16.60 g
19	Begun Bichi	5.83 i	2.24 g	2.60 h	11.13 i
20	Tulsi Mala	9.57 b	2.40 f	3.99 bcd	25.68 bc
21	Binadhan-17	9.39 b	2.25 g	4.17 b	21.28 f
22	Binadhan-20	10.37 a	2.26 g	4.59 a	25.82 bc
23	BRRI dhan34	6.25 c	1.97 h	3.17 ef	10.16 j
24	Japonica-1	9.218 bcd	2.66 ef	3.47 e	24.41 cd
	LSD value	0.45	0.18	0.20	0.95

The highest 1000 seed weight was found in Kachra (30.67 g), BRRI dhan77 (26.69 g), Kacha mota (26.65 g), Lalmota (26.35g), Binadhan-20. The lowest was recorded in BR5 (10.13 g), BRRI dhan34 (10.16 g), Begunbichi (11.13g), katarivog (11.47 g), Saubail (13.37 g), Gahinda (13.42 g) etc. (Table 4). All the measured traits among the cultivars were significantly different and had shown strong correlation among the traits. Seed length showed positive correlations with length/width ratio (r=0.59**) and 1000-grain weight (r=0.64**) and width also showed positive correlation with 1000-grain weight (r=0.69**). Negative correlations existed between seed width and length/width ratio (r=-0.74**) (Table 5).

Table 5: Correlation among length, width, length/width ratio and weight of grains

Correlations					
		Length	Width	Ratio	Weight
Length	Pearson Correlation	1	0.09	0.59**	0.64**
	Sig. (2-tailed)		0.65	0.00	0.00
Width	Pearson Correlation	0.09	1	-0.74**	0.69**
	Sig. (2-tailed)	0.65		0.00	0.00
Ratio	Pearson Correlation	0.59**	-0.74**	1	-0.12
	Sig. (2-tailed)	0.00	0.00		0.59
Weight	Pearson Correlation	0.64**	0.69**	-0.12	1
	Sig. (2-tailed)	0.00	0.00	0.59	

**. Correlation is significant at the 0.01 level (2-tailed).

The varieties showed no color changes after the test were declared as *japonica* type. On the other hand, the varieties change the seed coat color into light brown, brown, dark brown or dark in phenol reaction test were *indica* type. The phenol reaction test distinguished the cultivars BR5, BRRI dhan34, Gahinda, Japonica-1, Saubail, katarivog, Tulsimala, Begunbichi similar to *japonica* type. On the contrary, sixteen cultivars namely Baila Amon, Bashful, Sadamota, Binadhan-17, Binadhan-20, BRRI dhan76, BRRI dhan77, Dudkalam, Benapol, Jothui, Kachamota, Kachra, Kalomota, Kamina Saru, Lalmota, Moulota were similar to *indica* type rice (Fig. 8).

Figure 8: The phenol reaction rice hulls of different rice cultivars; (A) no color changed and (B) color changed

Here, eleven SSR and 13 STS markers were used to analyze the genetic diversity of 24 rice cultivars. A total of 60 alleles with a mean of 2.5 alleles derived from 24 rice varieties were detected (Table 6). The allele number per locus ranged from 2 to 4. The major allele frequency ranged from 0.33~0.83 and the gene diversity ranged from 0.25~0.73. Banding patterns of 24 rice cultivars at representative loci viz. S4097 and S5080 are shown in figures 9 and 10 respectively.

Table 6: Allele frequency, gene diversity and heterozygosity of 24 markers

Marker	Chr. No.	MAF	G No.	S. Size	B. observed	A. No.	Ge Diversity	Het.	PIC
RM167	11	0.71	3	24	24	3	0.45	0.00	0.41
RM337	08	0.69	5	24	24	4	0.49	0.04	0.45
RM407	08	0.53	3	24	16	2	0.50	0.19	0.37
RM434	09	0.5	3	24	24	2	0.50	0.08	0.38
RM1287	01	0.75	3	24	22	2	0.38	0.05	0.30
RM3825	01	0.52	3	24	23	3	0.59	0.00	0.51
RM5461	01	0.33	4	24	21	4	0.73	0.00	0.68
RM5639	03	0.43	5	24	21	4	0.66	0.05	0.59
RM5749	04	0.43	6	24	22	4	0.68	0.09	0.63
RM5806	10	0.43	4	24	23	3	0.63	0.09	0.55
RM10115	01	0.85	3	24	23	2	0.26	0.13	0.22
S1054	01	0.80	3	24	23	2	0.31	0.04	0.27
S1140	01	0.85	3	24	24	2	0.25	0.21	0.22
S3048	03	0.53	5	24	19	3	0.59	0.21	0.51
S4097	04	0.67	3	24	24	2	0.44	0.17	0.35
S5080	05	0.52	3	24	23	2	0.50	0.09	0.37
S7114	07	0.83	3	24	24	2	0.28	0.17	0.24
S8020	08	0.78	2	24	23	2	0.34	0.00	0.28
S9000	09	0.67	3	24	24	2	0.44	0.08	0.35
S9075	09	0.59	3	24	23	2	0.48	0.13	0.37
S10072	10	0.59	3	24	22	2	0.48	0.09	0.37
S11117	11	0.58	3	24	20	2	0.49	0.05	0.37
S12011B	12	0.58	3	24	24	2	0.49	0.17	0.37
S12091	12	0.63	3	24	20	2	0.47	0.25	0.36
Mean	-	0.62	3.42	24	22.3	2.5	0.48	0.10	0.40

The PIC value for each marker was used to assess the polymorphic level. The mean PIC value for all markers was 0.40 with the range of 0.22 (RM10115) to 0.68 (RM5461). 24 markers provided sufficient polymorphism to evaluate genetic diversity of these 24 varieties. Mean of heterozygosity of all markers were 0.10 with a range from from 0 to 0.25. Four markers (16.67%) such as RM167, RM3825, RM5461 and S8020 showed no heterozygosity. But the other twenty (83.33%) markers showed significant level of heterozygosity. Here the mean value of the gene diversity was 0.48, which ranged from 0.25 to 0.68. The highest gene diversity (0.68) was found in RM5749 and the lowest found in S1140 markers. Major allele frequency is the frequency at which the most common allele occurs in a given population and in the present study its mean value was 0.62 that ranged from 0.33 to 0.85.. The highest major allele frequency (0.85) was estimated in RM10115 and S1140, while the lowest (0.33) was found in R5461

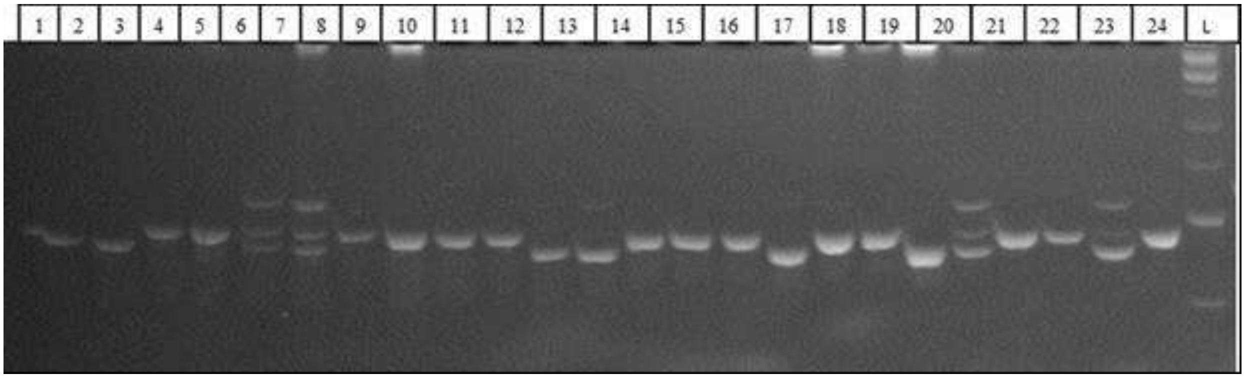


Figure 9: Banding profiles of 24 rice cultivars at locus S4097 and L=100 bp DNA ladder

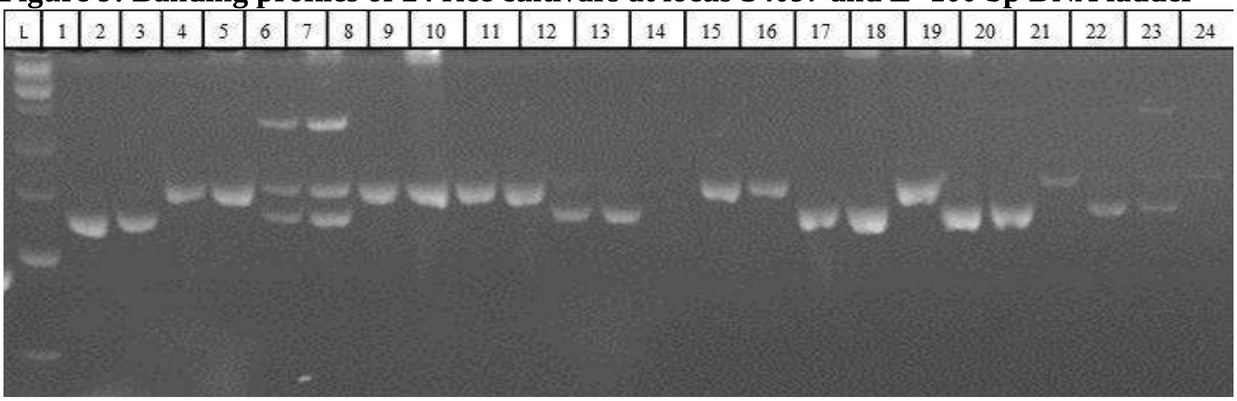


Figure 10: Banding profiles of 24 rice cultivars at locus S5080 and L=100 bp DNA ladder

An unrooted neighbor-joining tree was constructed to observe genetic relationships among 24 rice cultivars based on the alleles detected by 24 markers. As seen in Figure 11, the rice cultivars were grouped into four major cluster. The popular released Bangladeshi varieties, such as, BRRI dhan77 had shown close genetic relation with Gahinda; BRRI dhan76 and Binadhan-17 were in same sub cluster with Bashful variety; Binadhan-20 is closely related with Kamina saru; BR5 is closely related with Dudkalam; BRRI dhan34 showed close genetic distance with Lalmota variety. The released varieties those have same genetic relation with local cultivars may be derived from crosses of those varieties or those varieties whose have close genetic similarities with local varieties.

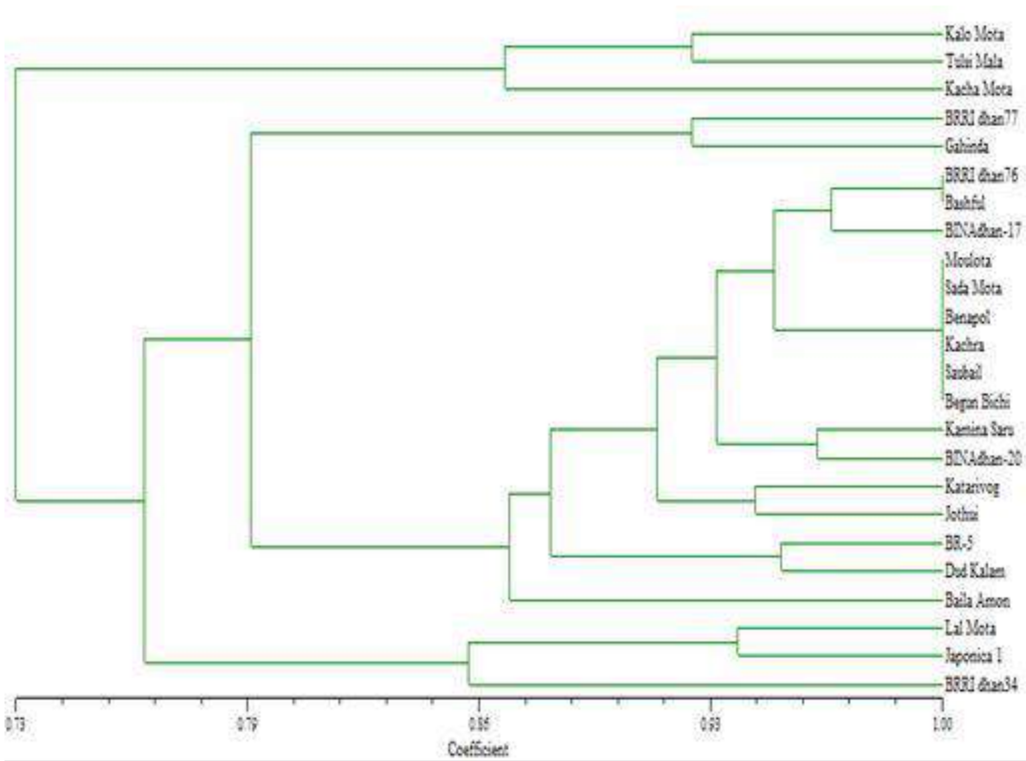


Figure 11: UPGMA dendrogram based on Nei's (1972) genetic distance summarizing the data on differentiation between 24 rice cultivars, using a combination of two different type molecular markers, SSR and STS.

Up-scaling of BINA developed crop varieties in Barishal region

A total of 618 demonstrations were conducted at the farmer's fields during 2019-20 in Barishal region using BINA developed different crop varieties. The main objective of these demonstrations was to observe the yield performance and widening its adoption by the farmers in Barishal region. The demonstration plot was 33 decimals with recommended spacing based on crop varieties. Application of fertilizer and intercultural operations were done following the BINA recommendation. Based on the collected reports from DAE and crop cutting data of demonstration plots are described below.

In kharif-2 season, there were 125 demonstrations were conducted at the farmer's field using Binadhan-14 and Binadhan-19. The data on crop duration revealed that Binadhan-14 and Binadhan-19 were harvested at 121 and 105 days where the average yield was recorded 3.42 and 3.64 t ha^{-1}, respectively. But the highest yield was found in Patuakhali district. Data suggested that Binadhan-19 will be a popular variety in Barishal region in the coming days.

About 262 demonstrations were distributed to the farmers of different districts through DAE in Barishal region. The Aman rice varieties Binadhan-7, Binadhan-11, Binadhan-13, Binadhan-17 and Binadhan-22 were harvested at 113, 119, 140, 121 and 116 days and produced average yield 3.21, 3.05, 2.66, 3.13 and 3.81 t ha^{-1}, respectively. Among the cultivated Aman rice varieties Binadhan-11 is popular in Barishal region.

In Rabi season, there were 90 demonstrations for Binadhan-10 and 89 demonstrations for Binasarisha-4 and Binasarisha-9 were conducted throughout the Barishal region. All the varieties cultivated in Rabi season are popular and well accepted to the farmers of Barishal region. Binadhan-10 produced the average yield 4.12 t ha^{-1} within 128 days. In addition, Binasarisha-4 and Binasarisha-9 produced the average yield 1.28 and 1.32 t ha^{-1} and matured in 87 and 85 days of seeding, respectively.

In kharif-1 season, about 50 demonstrations were established in Barishal, Patuakhali, Jhalkathi and Pirozpur district using Binamoog-7 and Binamoog-8. Average yield of Binamoog-7 and Binamoog-8 was recorded 1.20 and 1.41 t ha^{-1} and harvested in 65 and 68 days after seeding, respectively.

BINA sub-station is introduced some new crop varieties namely Binakhesari-1, Binamasur-8, Binatil-2, Binasoybean-3, Binachinabadam-4, Binatomato-10, Binatomato-11, Binatomato-12 and Binahalud-1 in Barishal though demonstration and seed subsidy and received good response from the farmers.

For transferring the BINA developed technology, two farmers training were performed to trained the 200 farmers (female and male) and 20 Sub-assistant Agriculture Officers (SAAO) on the cultivation procedure of BINA devel2oped Aman rice varieties and seed storage. Besides, there were six field days for Binadhan-10, Binadhan-11, Binadhan-17, Binadhan-19, Binasarisha-9 and Binamoog-8 were organized to motivate the farmers in Barishal region. In addition, BINA sub-station is trying develop a new cropping pattern Aman (Binadhan-11/Binadhan-1) - Binasarisha-9 - Aus (Binadhan-19) instead of (Aman- Shorisha – fellow) pattern using BINA released technology.

Sub-station, Noakhali

Research Highlights

- A total of 45 demonstrations with salt tolerant Boro rice Binadhan-10 produced better yield of 5.67 t ha^{-1}. Farmers demand is very high with better yield as well as salt tolerant and short duration.

- A total of 60 demonstrations with Binasoybean-1, Binasoybean-3 and Binasoybean-5 produced higher yield with less maturity period than check variety of Shohag.

- A total of 106 demonstrations with Binasarisha-4, Binasarisha-9 and Binasarisha-10 produced higher yield with short durations over the check variety BARI sarisha-16.

- A total of 33 demonstrations with Binadhan-19 were carried out during Aus 2020 season and produced average yield of 5.03 t ha^{-1} which is much more higher than the maximum yield potentials and becoming popular aus rice variety in the Noakhali region.

Up-scaling BINA developed Bindhan-10 in Noakhali, Chattogram and Cox'sbazar region

During 2019-20, 45 demonstrations were conducted with Binadhan-10 in Noakhali, Chattogram and Cox'sbazzar region. The check variety was BRRIdhan67.The main objectives were to demonstrate the performance of Binadhan-10 and widening their adaptability by the farmers. Area of demonstration plots was one acre. Seeds were sown during December 2019 and seedling was transplanted last week of January 2020. 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 Binadhan-10 with BRRI dhan67 in Noakhali, Chattogram and Cox'sbazar during 2019-20

Upazila	No. of demonstrations	Durations		Yield (t/ha)		% Yield increased over check
		Bina dhan-10	Check (BRRI dhan67)	Bina dhan-10	Check (BRRI dhan67)	
Chattogram	10	125	145	5.50	5.2	+5.77
Cox'sbazar	5	132	150	5.56	5.1	+9.02
Teknaf	5	128	147	5.34	5.0	+6.80
Anwara	10	135	143	5.43	5.2	+4.42
Bashkhali	5	133	151	5.64	5.3	+6.42
Subarnachar	10	126	146	6.47	5.2	+24.42
Total	**45**					
Mean±SE		129.83±1.4	147±1.04	5.66±0.14	5.17±0.03	+9.48

Data from table 1 shows the better performance of Binadhan-10 over the check variety (BRRI dhan67). The average duration of Binadhan-10 was recorded 129.83 days while in check it was 147 days indicating the early maturing trait of Binadhan-10 which is 18 days earlier than BRRI dhan67. In terms of yield; Binadhan-10 produced 5.66 t ha^{-1} while in check it was 5.17 t ha^{-1} indicating 9.48% increase in yield. Therefore, in the respective regions, Binadhan-10 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binasoybean-1, Binasoybean-3 and Binasoybean-5 in Noakhali and Laxmipur region

During 2019-20, 10 demonstrations with Binasoybean-1, 30 demonstration with Binasoybean-3 and 20 demonstrations with Binasoybean-5 were conducted in Noakhali and Laxmipur region. The check variety was Shohag. The main objectives were to demonstrate the performance of Bina developed soybean varieties and widening their adaptability by the farmers. Area of demonstration plots was one acre. Seeds were sown during last January 2020. 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 2, 3 and 4.

Table 2: Performance of Binasoybean-1 in Noakhali and Laxmipur region during 2019-20

Upazila	No. of demonstrations	Durations		Yield (t/ha)		% Yield increased over check
		Bina soybean-1	Check (Shohag)	Bina soybean-1	Check (Shohag)	
Subarnachar	5	111	117	2.45	2.0	22.5
Ramgoti	5	114	118	2.43	1.95	24.61
Total	**10**					
Mean±SE		112.5±1.06	117±0.35	2.44±0.01	1.97±0.01	23.54

Table 3: Performance of Binasoybean-3 in Noakhali and Laxmipur region during 2019-20

Upazila	No. of demonstrations	Durations		Yield (t/ha)		% Yield increased over check
		Binasoybean-3	Check (Shohag)	Binasoybean-3	Check (Shohag)	
Subarnachar	20	115	120	2.99	2.1	42.38
Ramgoti	10	113	116	2.68	2.2	21.81
Total	30					
Mean±SE		114±0.70	118±1.4	2.83±0.10	2.15±0.03	31.86

Table 4: Performance of Binasoybean-5 in Noakhali and Laxmipur region during 2019-20

Upazila	No. of demonstrations	Durations		Yield (t/ha)		% Yield increased over check
		Binasoybean-5	Check (Shohag)	Binasoybean-5	Check (Shohag)	
Subarnachar	10	110	115	2.23	1.92	+16.15
Ramgoti	10	112	117	2.12	1.90	+11.58
Total	**20**					
Mean±SE		111±0.70	116±0.70	2.17±0.04	1.91±0.78	+13.87

Table 2, 3 and 4 reveals that Binasoybean-1, 3 and 5 produced average seed yield of 2.44 t ha^{-1}, 2.83 t ha^{-1} and 2.17 t ha^{-1}, respectively which is 23.54, 31.86 and 13.84 percent higher than check variety Shohag, respectively. Average maturity period of Binasoybean-1, 3 and 5 was 112.5, 114 and 111 days respectively. The check variety Shohag produced average seed yield of 2.01 t ha-1 with average maturity period of 117 days. Comparing the above data it can concluded that the varieties of BINA (Binasoybean-1, 3 and 5) increased crop production as well as farmer's income. Farmers were found highly interested to cultivate soybean varieties developed by BINA in Noakhali and Laxmipur region.

Up-scaling of BINA developed Binasarisha-4, Binasarisha-9 and Binasarisha-10 in Feni region

During 2019-20, 50 demonstrations with Binasarisha-4, 50 demonstrations with Binasarisha-9 and 06 demonstrations with Binasarisha-10 were conducted in Feni region. The check variety was BARI Sarisha-16. 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 last December 2019 at the rate of 3kg/acre. All the 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 Tables 5, 6 and 7.

Table 5: Performance of Binasarisha-4 in Feni region during 2019-20

Upazila	No. of demon-strations	Durations		Yield (t/ha)		% Yield increased over check
		Binasarisha-4	Check (BARI sarisha-16)	Binasarisha-4	Check (BARI saarisha-16)	
Feni Sadar	10	80	110	1.43	1.21	+18.18
Porshuram	10	81	105	1.20	1.10	+9.09
Sonagazi	10	80	106	1.36	1.20	+13.33
Fullgazi	10	83	103	1.30	1.09	+19.27
Chagolnaiya	05	82	105	1.26	1.10	+14.55
Dhagonbhiya	05	84	108	1.36	1.13	+20.35
Total	**50**					
Mean±SE		81.67±0.57	106.17±0.90	1.32±0.03	1.14±0.02	+15.81

Table 6: Performance of Binasarisha-9 in Feni region during 2019-20

Upazila	No. of demonstrations	Durations		Yield (t/ha)		% Yield increased over check
		Bina sarisha-9	Check (BARI sarisha-16)	Bina sarisha-9	Check (BARI sarisha-16)	
Feni Sadar	10	85	110	1.40	1.21	15.70
Porshuram	10	87	105	1.10	1.10	0.00
Sonagazi	10	84	106	1.25	1.20	4.17
Fullgazi	10	88	103	1.30	1.09	19.27
Chagolnaiya	05	86	105	1.25	1.10	13.64
Dhagonbhiya	05	85	108	1.22	1.13	7.96
Total	**50**					
Mean±SE		85.83±0.55	106.17±0.93	1.25±0.04	1.14±0.02	+10.10

Table 7: Performance of Binasarisha-10 in Feni region during 2019-20

Upazila	No. of demonstrations	Durations		Yield (t/ha)		% Yield increased over check
		Bina sarisha-10	Check (BARI sarisha-16)	Bina sarisha-10	Check (BARI sarisha-16)	
Feni Sadar	01	82	110	1.35	1.20	+12.50
Porshuram	01	81	105	1.10	1.09	+0.92
Sonagazi	02	84	106	1.36	1.10	+23.64
Fullgazi	02	83	108	1.35	1.13	+19.47
Total	**06**					
Mean±SE		82.50±0.56	107.25±0.96	1.29±0.05	1.13±0.02	+14.16

Data in Tables 5, 6 and 7 reveals that Binasarisha-4, 9 and 10 produced average seed yields of 1.23, 1.25 and 1.29 t ha^{-1}, respectively which is 15.81, 101.0 and 14.16 percent higher than the check variety BARI sarisha-16. Average maturity period of Binasarisha-4, 9 and 10 was found 81, 86 and 82 days, respectively. The check variety BARI sarisha-16 produced average seed yield of 1.14 t ha^{-1} with average maturity period of 107 days. Therefore, the varieties of Bina Sarisha increased crop production with short duration as well as farmer's income. Farmers were found highly interested to cultivate Bina developed Sarisha varieties in Feni region.

Up-scaling of BINA developed Bindhan-19 in Noakhali region

During 2019-20, 33 demonstrations were conducted with Binadhan-19 in three locations of Subornachar, Noakhali region. The check variety was BRRI dhan26. The main objectives were to demonstrate the performance of Binadhan-19 and widening their adaptability by the farmers. Area of demonstration plots was one acre. Seeds were sown during mid March 2020 and seedling was transplanted first week of April 2020. 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 8.

Table 8: Performance of Binadhan-19 with BRRI dhan-26 in Subornachar, Noakhali during Aus 2020

Upzilla Subornachar	No. of demonstration	Durations		Yield (t/ha)		%Yield(±) over check
		Binadhan-19	Check (BR 26)	Binadhan-19	Check(BRRI dhan26)	
Keramotpur	30	105	117	5.63	4.10	+27.17
Center Bazar	2	103	118	4.37	3.52	+19.45
BADC Farm	1	106	116	5.29	3.74	+29.30
Total	**33**					
Mean±SE		104.7±0.41	117±0.27	5.09±0.17	3.78±0.07	+25.30

Data from table 8 shows the better performance of Binadhan-19 over the check variety (BRRI dhan26). The average duration of Binadhan-19 was recorded 104.7 days while in check variety it was 117 days indicating the early maturing trait of Binadhan-19 which is about 13 days earlier than BRRI dhan26. In terms of yield; Binadhan-19 produced 5.07 t ha^{-1} while in check it was 3.78 t ha^{-1} indicating 25.30% increase in yield. Therefore, in the respective regions Binadhan-19 is newly introduced popular Aus variety. Farmers are very excited to have such high yielding Aus variety in Subornachar area of Noakhali. For rapid dissemination more demonstration is required in the upcoming Aus season. Thus, Binadhan-19 is getting popular day by day among the farmers choices.

Sub-station, Chapainawabganj

Research Highlights

- A total of 92 demonstrations with short duration T. Aman rice varieties Binadhan-16 and Binadhan-17 were conducted and produced average grain yields of 4.48 t ha^{-1} and 5.90 t ha^{-1} respectively. Average maturity period of Binadhan-16 was 104 days and Binadhan-17 was 122 days. Check variety BRRI dhan 49 produced average gain yield of 5.28 t ha^{-1} with average maturity period of 139 days. Farmers were found interested to cultivate Binadhan-16 and Binadhan-17 because of short duration.
- A total of 70 demonstrations were conducted with short duration high yielding Binasarisha-4 and Binasarisha-9 which produced better yield than the check variety of BARI sarisha-14.
- A total of 65 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 a local cultivar.
- A total of 30 demonstrations were carried out with short duration high yielding Binachola-4 which produced better yield with less maturity period than the check variety of local cultivar.
- A total of 60 demonstrations were carried with high yielding moog variety Binamoog-8 which produced better yield than the check variety of BARI Mung-6.
- A total of 20 demonstrations were carried with high yielding sesame variety Binatil-3 which produced better yield than check varieties of local cultivars.
- A total of 34 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 20 demonstrations were carried with short duration high yielding Binadhan-14 which produced better yield with less maturity period than the check variety of local cultivars.

Block demonstrations with BINA developed high yielding and short duration T. Aman rice variety in Rajshahi region

During Aman season of 2019-20, 92 demonstrations with Binadhan-16 and Binadhan-17 were conducted at the farmer's fields in Rajshahi 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 2019, and age of seedlings was 20 to 25 days. The farmers managed all the production practices as per recommendation. Data of demonstration plots are presented in Tables 1 and 2.

Binadhan-16 produced average grain yield of 4.48 t ha^{-1}, which was 13 percent lower compared to check variety (Table-1). Average maturity period of Binadhan-16 was 104 days. Therefore farmers were found interested to cultivate Binadhan-16 as an Aman variety in Chapainawabganj region.

Table 1: Performance of Binadhan-16 in Rajshahi region during 2019-20

Upazila	No. of demos	Duration (days)		Yield (t ha^{-1})		Yield decreased over check (%)
		Binadhan-16	BRRI dhan49 (check)	Binadhan-16	BRRI dhan49 (check)	
Gomostapur	4	101	137	4.61	5.14	
Nachol	2	105	139	4.65	5.32	-13.00
Godagari	4	102	140	4.20	5.00	
Total	10					
Mean		104	139	4.48	5.15	

Table 2: Performance of Binadhan-17 in Rajshahi region during 2019-20

Upazila	No. of demos	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-17	BRRI dhan49 (check)	Binadhan-17	BRRI dhan49 (check)	
Chapai Sadar	8	127		5.75		
Nachol	20	120		6.15		
Gomostapur	42	125	139	5.50	5.40	9.25
Shibganj	2	126		5.90		
Godagari	10	122		6.01		
Tanore	10	124		6.12		
Total	82					
Mean		124		5.90		

Binadhan-17 produced average grain yield of 5.90 t ha^{-1}, which was 9.25% higher compared to check variety (Table-2). Average maturity period of Binadhan-17 was 124 days. Farmers are interested to cultivate Binadhan-17 during T. Aman season in Rajshahi region.

Block demonstrations with BINA developed high yielding and short duration mustard variety in Rajshahi region

During the Rabi season of 2019-20, total 70 demonstrations were conducted with Binasarisha-4 and Binasarisha-9 in Rajshahi 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 2019 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 grain yield.

Table 3: Performance of Binasarisha-4 compared to popular cultivar in Rajshahi region during 2019-20

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	3	90	82	1.60	1.52	
Nachol	5	85	81	1.69	1.75	
Gomostapur	10	87	83	1.77	1.60	
Shibganj	2	90	82	1.81	1.55	9.38
Tanore	2	89	80	1.73	1.45	
Godagari	8	88	81	1.92	1.65	
Total	30					
Mean		88	82	1.75	1.60	

Results reveal that Binasarisha-4 produced average seed yield of 1.75 t ha^{-1}, which was 9.38% percent higher than the cheek variety BARI sarisha-14 (Table-3). Average maturity period of Binasarisha-4 was 88 days. BARI sarisha-14 produced average gain yield of 1.60 t ha^{-1} with average maturity period of 82 days. Farmers were found interested to cultivate Binasarisha-4.
Binasarisha-9 produced average seed yield of 1.68 t ha^{-1} which was 7 percent higher than the check variety BARI sarisha-14 (Table-4). Average maturity period of Binasarisha-9 was 82 days. BARI sarisha-14 produced average gain yield of 1.57 t ha^{-1} with average maturity period of 83days. Farmers were found interested to cultivate Binasarisha-9.

Block demonstrations with BINA developed high yielding and short duration lentil variety in Rajshahi region

During the Rabi season of 2019-20, total 65 demonstrations were conducted with Binamasur-5 and Binamasur-8 in Rajshahi region. The main objectives were to demonstrate the performance as well as

Table 4: Performance of Binasarisha-9 compared to popular cultivar in Chapainawabganj region during 2019-20

Upazila	No. of demos	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisha-9	BARI sarisha-14 (Check)	Binasarisha-9	BARI sarisha-14 (Check)	
Sadar	05	82	83	1.65	1.52	
Nachol	05	79	82	1.50	1.57	
Gomostapur	15	79	83	1.76	1.50	
Shibganj	3	83	82	1.50	1.60	7.0
Tanore	2	84	85	1.75	1.55	
Godagari	10	86	80	1.95	1.67	
Total	40					
Mean		82	83	1.68	1.57	

Widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during October to November 2019 at the rate of 30 kg ha^{-1}. The check variety was a local cultivar. All fertilizers were applied as per recommendation and some of places one or two supplemental irrigation was applied in the demonstration plots where necessary. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and seed yield.

Table 5: Performance of Binamasur-5 compared to popular cultivar in Rajshahi region during 2019-20

Upazila	No. of demos	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamasur-5	Local cultivar (Check)	Binamasur-5	Local cultivar (Check)	
Sadar	10	100	114	1.65	1.45	
Nachol	10	102	113	1.60	1.35	
Gomostapur	40	99	112	1.53	1.40	12.9
Godagari	5	105	118	1.57	1.39	
Total	45					
Mean		101	114	1.58	1.40	

Binamasur-5 produced average seed yield of 1.58 t ha^{-1}, which was 12.9 percent higher than the check variety (Table-5). Average maturity period of Binamasur-5 was 101 days. Local variety produced average gain yield of 1.40 t ha^{-1} with average maturity period of 114 days. Farmers were found interested to cultivate Binamasur-5.

Table 6: Performance of Binamasur-8 compared to popular cultivar in Rajshahi region during 2019-20

Upazila	No. of demos	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamasur-8	Local cultivar (Check)	Binamasur-8	Local cultivar (Check)	
Sadar	4	101	114	1.50	1.40	
Nachol	4	99	113	1.60	1.38	
Gomostapur	5	100	112	1.33	1.30	
Volahat	2	100	118	1.48	1.52	7.0
Godagari	5	98		1.58	1.4	
Total	20					
Mean		100	114	1.50	1.40	

Binamasur-8 produced average seed yield of 1.50 t ha^{-1}, which was 7 percent higher than the check variety (Table-6). Average maturity period of Binamasur-8 was 100 days. Local variety produced average gain yield of 1.40 t ha^{-1} with average maturity period of 114 days. Farmers were found interested to cultivate Binamasur-8.

Block demonstrations with BINA developed high yielding and short duration Chickpea variety in Rajshahi region

During the Rabi season of 2019-20, total 30 demonstrations were conducted with Binachola-4 in Rajshahi 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 2019 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 pests. Data were recorded on crop duration and seed yield.

Table 7: Performance of Binachola-4 compared to popular cultivar in Rajshahi region during 2019-20

Upazila	No. of demos	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binachola-4	Local cultivar (Check)	Binachola-4	Local cultivar (Check)	
Chapai Sadar	15	125	140	1.19	1.05	18.44
Godagari	15	127	142	1.25	1.00	
Total	30					
Mean		126	141	1.22	1.03	

Results reveal that Binachola-4 produced average grain yield of 1.22 t ha^{-1}, which was 18.44% higher compared to check variety (Table-7). Average maturity period of Binachola-4 was 126 days. Farmers were found interested to cultivate Binachola-4 in Rajshahi region.

Block demonstrations with BINA developed high yielding and short duration Mungbean variety in Rajshahi region

During the Kharif-1 season of 2019-20, total 60 demonstrations were conducted with Binamoog-8 in Rajshahi 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 2020 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 pests. Data were recorded on crop duration and seed yield.

Table 8: Performance of Binamoog-8 compared to popular cultivar in Rajshahi district during 2019-20

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	10	68	63	1.23	1.11	
Shibganj	10	69	67	1.11	1.26	
Gomostapur	25	72	69	1.25	1.22	
Nachol	10	68	65	1.20	1.12	0.85
Godagari	5	69				
Total	60					
Mean		69	66	1.19	1.18	

Binamoog-8 produced average grain yield of 1.198 t ha^{-1}, which was 0.85% higher compared to check variety (Table-8). Average maturity period of Binamoog-8 was 69 days. Due to heavy rainfall, the yield of mungbean was lower than previous year.

Block demonstrations with BINA developed high yielding and short duration Sesame variety in Chapainawabganj region

During the Kharif-1 season of 2019-20, total 20 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 2020 at the rate of 7.5 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 pests. Data were recorded on crop duration and seed yield.

Table 9: Performance of Binatil-3 compared to popular cultivar in Chapainawabganj region during 2019-20

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binatil-3	Local cultivar	Binatil-3	Local cultivar	
Shibganj	10	93	102	1.00	0.95	5
Nachol	05	Damaged due to rainfall				
Gomostapur	05					
Total	20					
Mean		92	103	1.00	0.95	5

Binatil-3 produced average grain yield of 1.00 t ha^{-1}, which was 5% higher compared to check variety (Table-9). 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. Some demonstration plot were damaged due to heavy rainfall

Block demonstrations with BINA developed high yielding and short duration late Boro Rice variety in Rajshahi region

During the Kharif-1 season of 2019-20, total 20 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 2020. 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 pests. Data were recorded on crop duration and grain yield.

Table 10: Performance of Binadhan-14 compared to popular cultivar in Rajshahi region during 2019-20

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-14	Local Cultivar	Binadhan-14	Local Cultivar	
Shibganj	5	120	149	6.10	5.88	
Nachol	5	125	155	6.02	6.22	
Godagari	10	122	150	6.05	5.98	0.0
Total	20					
Mean		122	151	6.05	6.03	

Binadhan-14 produced average grain yield of 6.05 t ha^{-1}, which was insignificantly different with local cultivar (check variety). Average maturity period of Binadhan-14 was 122 days. Farmers were found interested to cultivate Binadhan-14 as a late Boro rice variety in Rajshahi region.

Block demonstrations with BINA developed high yielding and short duration Aus Rice variety in Rajshahi region

During the Kharif-1 season of 2019-20, total 34 demonstrations were conducted with Binadhan-19 in Rajshahi 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 April to the end, 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 pests. Data were recorded on crop duration and seed yield.

Table 11: Performance of Binadhan-19 compared to popular cultivar in Rajshahi region during 2019-20

Upazila	No. of demos	Duration (days)		Yield (t ha^{-1})		ased over check (%)
		Binadhan-19	BRRI Dhan-48	Binadhan-19	BRRI Dhan-48	
Chapai Sadar	5	105	131	5.05	4.85	
Gomostapur	10	111	130	5.10	4.93	
Nachol	5			4.50	4.00	3.78
Godagari	4	107	128	4.00	4.20	
Total	34					
Mean		107	130	4.66	4.49	

Results reveal that Binadhan-19 produced average grain yield of 4.66 t ha^{-1}, which was 3.78 percent higher compared to check variety (Table-11). Average maturity period of Binadhan-19 was 107 days. Because of excess rainfall during the vegetative growing stage was affected by stem borer in both varieties of Aus rice. Farmers were found interested to cultivate Binadhan-19 as an Aus variety in Rajshahij region.

Establishment of BINA Technology village, in surrounding area of BINA Sub-station, Chapainawabganj

In order to establish BINA-Technology village demonstrations and other extension work were done in surrounding area of BINA-substation, Chapainawabganj at the farmer's fields. Results of overall promotional activities related to BINA-Technology village establishment at Nizampur Union are presented in Table 12.

Production of quality seed of BINA released crop varieties in Rajshahi region

Seeds of BINA released crop varieties in Rajshahi region were produced at the sub-station farm of Chapainawabganj and also in the farmer's fields of different locations and part of those seeds were purchased during 2019-20. Seed production activities, locations, crop varieties and areas during the

Table 12: Performance of BINA developed varieties at Nizampur **union during 2019-20**

Sl. No	Crops	Variety Name	Demonstration No.	Average Duration in days	Average yield (t ha^{-1})
		Binadhan-17	10	123	6.17
1.	Rice	Binadhan-22	2	122	5.95
		Binadhan-19	10	105	5.00
2.	Mustard	Binasarisha-4	5	86	1.80
		Binasarisha-9	15	81	1.69
		Binasarisha-10	2	85	1.50
3.	Lentil	Binamosur-8	5	99	1.50

Reporting period were shown in (Table 13). In case of farmer's fields, partial input subsidies and free seeds or only free seeds were provided. During the reporting period a total of 7.87 ton seeds of different crop varieties of BINA were procured.

Table 13. Seeds produced/purchased, distributed/sold & stored during 2019-20

Varieties	Total seeds produced /purchased (ton)	Total distributed/sold (ton)	Seeds stored (ton)	Remarks
Binadhan-16	0.2	0.2	-	
Binadhan-17	2.5	2.50	-	
Binadhan-22	0.5	0.4	-	
Binadhan-14	1.0	-	1.00	
Binadhan-19	1.0	1.0	-	
Binasarihsa-4 & 9	1.5	-	1.5	
Binamosur-5 & 8	1.0	-	1.0	
Binachola-4	1.0	-	1.0	
Binamoog-8	0.53	-	0.53	

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies two training of one day were arranged at BINA Substation, Chapainawabganj. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer (SAAO).

Sub-station, Khagrachari

Research Highlights

- A total of 52 demonstrations with Aman rice Binadhan-11, a total of 15 demonstrations with Aman rice Binadhan-12, a total of 51 demonstrations with Aman rice Binadhan-17, 1 demonstration with Aman rice Binadhan-16 and a total of 52 demonstrations with Aman rice Binadhan-20 and 1 demonstration with Aman rice Binadhan-22 were set up in greater Hill tract region. All BINA developed Aman rice varieties produced better yield than check variety. Farmers demand is very high with better yield as well as short duration than the local check.
- A total of 5 demonstrations with Binachinabadam-4, 6, 8, 9 and 10 produced better yield of 2.24 t ha^{-1} than check variety. Farmers demand is very high with better yield as well as short duration.
- A total of 95 demonstrations with Binasharisha-4 and Binasarisha-9 produced better yield of 1.77 t ha^{-1} than check variety. Farmers demand is very high for better yield as well as short duration.
- A total of 35 demonstrations with Boro rice Binadhan-5, Binadhan-10 and Binadhan-14 produced better yield than check variety. Farmers demand is very high for better yield as well as short duration.
- A total of 10 demonstrations with Binamoog-8 produced better yield of 1.2 t ha^{-1} than check variety. Farmers demand is very high for better yield.
- A total of 105 demonstrations with Aus rice Binadhan-19 produced better yield of 5.48 t ha^{-1} than check variety. Farmers demand is very high with better yield as well as drought tolerant and short duration.

Up-scaling of BINA developed Binadhan-11 in Khagrachari, Rangamati and Bandarban region

During 2019-20, 52 demonstrations were conducted with Binadhan-11 in Khagrachari, Rangamati and Bandarban regions. The check was a local variety. The main objectives were to demonstrate the performance of Binadhan-11 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during July 2019, seedling was transplanted after 20-25 days after sowing and harvested at 118 days. 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 Binadhan-11 with local variety in Khagrachari, Rangamati and Bandarban region during 2019-20

Locations	No. of demonstration(s)	Durations		Yield (t/ha)		Yield increased over check (%)
		Bina dhan-11	Check (Local)	Bina dhan-11	Check (Local)	
Khagrachari	22	117	145	5.11	3.53	
Rangamati	15	118	150	5.07	3.89	
Bandarban	15	119	147	5.01	3.77	
Mean	52 (Total)	118	147	5.06	3.73	35.66

Table 1 shows the better performance of Binadhan-11 over the check variety. The average duration of Binadhan-11 was recorded 118 days while in check it was 147 days indicating the early maturing trait of Binadhan-11. In terms of yield, Binadhan-11 produced 5.06 t ha^{-1} while in check it was 3.73 t ha^{-1} indicating 35.66% increases in yield. Therefore, in the respective regions Binadhan-11 is getting popular day by day among the farmers choices.

Up-scaling of BINA developed Binadhan-12 in Khagrachari, Rangamati and Bandarban region

During 2019-20, 15 demonstrations were conducted with Binadhan-12 in Khagrachari, Rangamati and Bandarban region. The check was a local variety. The main objectives were to demonstrate the performance of Binadhan-12 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during July 2019, seedling was transplanted at 20-25 days after sowing and harvested in 132 days. 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 2.

Table 2: Performance of Binadhan-12 with local variety in Khagrachari, Rangamati and Bandarban region during 2019-20

Locations	No. of demonstration(s)	Durations		Yield (t/ha)		Yield increased over check (%)
		Binadhan-12	Check (Local)	Binadhan-12	Check (Local)	
Khagrachari	5	131	145	4.17	3.53	
Rangamati	5	133	150	4.07	3.89	
Bandarban	5	136	147	4.09	3.77	
Mean	15 (Total)	132	147	4.11	3.73	10.19

Data from Table 2 shows the better performance of Binadhan-12 over the check variety. The average duration of Binadhan-12 was recorded 132 days while the check was 147 days indicating the early maturing trait of Binadhan-12. In terms of yield, Binadhan-12 produced 4.11 t ha^{-1} while in check it was 3.73 t ha^{-1} indicating 10.19% increases in yield. Therefore, in the respective regions Binadhan-12 is getting popular day by day among the farmers choices.

Up-scaling of BINA developed Binadhan-16 in Panchari, Khagrachari region

During 2019-20, a demonstration was conducted with Binadhan-16 in Panchari, Khagrachari. The check was a local variety. The main objectives were to demonstrate the performance of Binadhan-16 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during July 2019, seedlings were transplanted at 25 days after sowing. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. At harvest, data were recorded on crop duration and grain yield. The results are presented in Table 3.

Table 3: Performance of Binadhan-16 with local variety in Panchari, Khagrachari region during 2019-20

Location	No. of demonstration(s)	Durations		Yield (t/ha)		%Yield increased over check
		Binadhan-16	Check (Local)	Binadhan-16	Check (Local)	
Panchari	1	93	147	4.52	3.73	21.18

Results indicated that Binadhan-16 performed better than the check variety regarding days to maturity and yield. The crop duration of Binadhan-16 was recorded 93 days while in check it was 147 days indicating the early maturing trait of Binadhan-16. Binadhan-16 produced 4.52 t ha^{-1} grain yield while in check it was 3.73 t ha^{-1} indicating 21.18% increaseed in yield. Therefore, in the respective regions Binadhan-16 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binadhan-17 in Khagrachari, Rangamati and Bandarban region

During 2019-20, 51 demonstrations were conducted with Binadhan-17 in Khagrachari, Rangamati and Bandarban regions. The check was a local variety. The main objectives were to demonstrate the performance of Binadhan-17 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during July 2019, seedlings were transplanted at 20-25 days after sowing. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. At harvest, data were recorded on crop duration and grain yield. The results are presented in Table 4.

Table 4: Performance of Binadhan-17 with local variety in Khagrachari, Rangamati and Bandarban regions during 2019-20

Locations	No. of demonstrations	Durations		Yield (t/ha)		%Yield increased over check
		Bina dhan-17	Check (Local)	Bina dhan-17	Check (Local)	
Khagrachari	21	110	145	6.33	3.53	
Rangamati	15	115	150	6.13	3.89	64.08
Bandarban	15	118	147	5.89	3.77	
Mean	51 (Total)	114	147	6.12	3.73	

Data from Table 4 shows the better performance of Binadhan-17 over the check variety regarding days to maturity and grain yield. The average duration of Binadhan-17 was recorded 114 days while in check it was 147 days indicating the early maturing trait of Binadhan-17. Regarding grain yield, Binadhan-17 produced 6.12 t ha^{-1} while in check it was 3.73 t ha^{-1} indicating 64.08% increases in yield. Therefore, in the respective regions Binadhan-17 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binadhan-20 in Khagrachari, Rangamati and Bandarban region

During 2019-20, 52 demonstrations were setup with Binadhan-20 in Khagrachari, Rangamati and Bandarban regions. The check was a local variety. The main objectives were to demonstrate the performance of Binadhan-20 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during July 2019, seedlings were transplanted at 20-25 days after sowing. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. At harvest, data were recorded on crop duration and grain yield. The results are presented in Table 5.

Data from Table 5 shows the better performance of Binadhan-20 over the check variety regarding crop duration and grain yield. The average duration of Binadhan-20 was recorded 129 days while

Table 5: Performance of Binadhan-20 with local variety in Khagrachari, Rangamati and Bandarban region during 2019-20

Locations	No. of demonstrations	Durations		Yield (t/ha)		%Yield increased over check
		Bina dhan-20	Check (Local)	Bina dhan-20	Check (Local)	
Khagrachari	22	126	145	4.02	3.53	
Rangamati	15	130	150	4.01	3.89	
Bandarban	15	132	147	3.89	3.77	
Mean	52 (Total)	129	147	3.97	3.73	6.43

in check it was 147 days indicating the early maturing trait of Binadhan-20. In terms of yield; Binadhan-20 produced 3.97 t ha^{-1} while in check it was 3.73 t ha^{-1} indicating 6.43% increases in yield. Therefore, in the respective regions Binadhan-20 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binadhan-22 in Panchari, Khagrachari region

During 2019-20, a demonstration was conducted with Binadhan-22 in Panchari, Khagrachari region. The check was a local variety. The main objectives were to demonstrate the performance of Binadhan-22 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during July 2019, seedlings were transplanted at 25 days after sowing.. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. At harvest, data were recorded on crop duration and grain yield. The results are presented in Table 6.

Table 6: Performance of Binadhan-22 with local variety in Panchari, Khagrachari region during 2019-20

Locations	No. of demonstration	Durations		Yield (t/ha)		%Yield increased over check
		Bina dhan-22	Check (Local)	Bina dhan-22	Check (Local)	
Panchari	1	112	147	5.01	3.73	34.32

Data from Table 6 shows the better performance of Binadhan-22 over the check variety regarding crop duration and grain yield. The average duration of Binadhan-22 was recorded 112 days while in check it was 147 days indicating the early maturing trait of Binadhan-22. In terms of yield; Binadhan-22 produced 5.01 t ha^{-1} while in check it was 3.73 t ha^{-1} indicating 34.32% increases in yield. Therefore, in the respective regions Binadhan-22 is getting popular day by day among the farmers choices.

Up-scaling of BINA developed Binachinabadam-4, 6, 8, 9 and 10 in Panchari, Khagrachari region

During 2019-20, 5 demonstrations were setup with Binachinabadam-4, 6, 8, 9 and 10 in Panchari, Khagrachari region. The check was a local variety. The main objectives were to demonstrate the performance of Binachinabadam-4, 6, 8, 9 & 10 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. At harvest, data were recorded on crop duration and grain yield. The results are presented in Table 7.

Table 7: Performance of Binachinabadam-4, 6, 8, 9 and 10 with local variety in Panchari, Khagrachari region during 2019-20

Location	No. of demonstrations	Durations		Yield (t/ha)		%Yield increased over check
		Binachinabadam-4, 6, 8, 9 and 10	Check (Local)	Binachinabadam-4, 6, 8, 9 and 10	Check (Local)	
Panchari	5	153	184	2.24	1.78	25.84

Data from Table 7 shows the better performance of Binachinabadam-4, 6, 8, 9 and 10 over the check variety regarding crop duration and pod yield. The average duration of Binachinabadam-4, 6, 8, 9 and 10 was recorded 153 days while in check it was 184 days indicating the early maturing trait of Binachinabadam-4, 6, 8, 9 and 10. In terms of yield; Binachinabadam-4, 6, 8, 9 and 10 produced 2.24t ha^{-1} while in check it was 1.78 t ha^{-1} indicating 25.84% increases in yield. Therefore, in the respective regions Binachinabadam-4, 6, 8, 9 and 10 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binasharisha-4 in Khagrachari, Rangamati and Bandarban region

During 2019-20, 25 demonstrations were conducted with Binasharisha-4 in Khagrachari, Rangamati and Bandarban regions. The check was a local variety. The main objectives were to demonstrate the performance of Binasharisha-4 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during November 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 8.

Table 8: Performance of Binasharisha-4 with local variety in Khagrachari, Rangamati and Bandarban region during 2019-20

Locations	No. of demonstrations	Durations		Yield (t/ha)		%Yield increased over check
		Bina sharisha-4	Check (Local)	Bina sharisha-4	Check (Local)	
Khagrachari	15	87	105	1.89	1.01	
Rangamati	5	89	101	1.77	0.98	
Bandarban	5	90	111	1.65	1.21	
Mean	25 (total)	89	106	1.77	1.07	65.42

Data from Table 8 shows the better performance of Binasharisha-4 over the check variety. The average duration of Binasharisha-4 was recorded 89 days while in check it was 106 days indicating the early maturing trait of Binasharisha-4. Regarding yield, Binasharisha-4 produced

1.77 t ha^{-1} while in check it was 1.07 t ha^{-1} indicating 65.42% increases in yield. Therefore, in the respective regions Binasharisha-4 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binasharisha-9 in Khagrachari, Rangamati and Bandarban region

During 2019-20, 70 demonstrations were conducted with Binasharisha-9 in Khagrachari, Rangamati and Bandarban region. The check was a local variety. The main objectives were to demonstrate the performance of Binasharisha-9 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during November 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 9.

Table 9: Performance of Binasharisha-9 with local variety in Khagrachari, Rangamati and Bandarban region during 2019-20

Locations	No. of demonstrations	Durations		Yield (t/ha)		%Yield increased over check
		Binasharisha-9	Check (Local)	Binasharisha-9	Check (Local)	
Khagrachari	50	80	105	1.65	1.01	
Rangamati	10	80	101	1.59	0.98	
Bandarban	10	83	111	1.57	1.21	
Mean	70 (Total)	81	106	1.60	1.07	49.53

Data from Table 9 shows the better performance of Binasharisha-9 over the check variety regarding crop duration and seed yield. The average duration of Binasharisha-9 was recorded 81 days while in check it was 106 days indicating the early maturing trait of Binasharisha-9. In terms of yield, Binasharisha-9 produced 1.60 t ha^{-1} while in check it was 1.07 t ha^{-1} indicating 49.53% increases in yield. Therefore, in the respective regions Binasharisha-9 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binasharisha-10 in Khagrachari, Rangamati and Bandarban region

During 2019-20, 25 demonstrations were conducted with Binasharisha-10 in Khagrachari, Rangamati and Bandarban region. The check was a local variety. The main objectives were to demonstrate the performance of Binasharisha-10 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during November 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 10.

Bionasharisha-10 showed apparently better performance in grain yield over control. The average duration of Binasharisha-10 was recorded 77 days while in check it was 106 days indicating the early maturing trait of Binasharisha-10. In terms of yield; Binasharisha-10 produced 1.09 t ha^{-1}

while in check it was 1.07 t ha^{-1} indicating 1.87% increases in yield. Therefore, as a short duration variety, Binasharisha-10 is getting popular day by day among the farmers.

Table 10: Performance of Binasharisha-10 with local variety in Khagrachari, Rangamati and Bandarban region during 2019-20

Locations	No. of demonstrations	Durations		Yield (t/ha)		%Yield increased over check
		Bina sharisha-10	Check (Local)	Bina sharisha-10	Check (Local)	
Khagrachari	15	75	105	1.12	1.01	
Rangamati	5	77	101	1.09	0.98	
Bandarban	5	79	111	1.07	1.21	
Mean	25 (Total)	77	106	1.09	1.07	1.87

Up-scaling of BINA developed Binadhan-5 in Sadar, Khagrachari region

During 2019-20, 10 demonstrations were conducted with Binadhan-5 in Sadar, Khagrachari region. The check was a local variety. The main objectives were to demonstrate the performance of Binadhan-5 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown in December 2019, seedlings were transplanted at 35-40 days after sowing. 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 11.

Table 11: Performance of Binadhan-5 with local variety in Sadar, Khagrachari region during 2019-20

Locations	No. of demonstrations	Durations		Yield (t/ha)		%Yield increased over check
		Binadhan-5	Check (Local)	Binadhan-5	Check (Local)	
Khagrasari Sadar	10	148	177	6.3	5.5	14.55

Data from Table 11 shows the better performance of Binadhan-5 over the check variety regarding crop duration and grain yield. The average crop duration of Binadhan-5 was recorded 148 days while in check it was 177 days indicating the early maturing trait of Binadhan-5. In terms of yield; Binadhan-5 produced 6.3 t ha^{-1} while in check it was 5.5 t ha^{-1} indicating 14.55% increases in yield. Therefore, in the respective regions Binadhan-5 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binadhan-10 in Sadar, Khagrachari region

During 2019-20, 10 demonstrations were conducted with Binadhan-10 in Sadar, Khagrachari region. The check was a local variety. The main objectives were to demonstrate the performance of Binadhan-10 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during December 2019, seedling was transplanted at 30-35 days after sowing. 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 12.

Table 12: Performance of Binadhan-10 with local variety in Sadar, Khagrachari region during 2019-20

Location	No. of demonstration(s)	Durations		Yield (t/ha)		%Yield increased over check
		Binadhan-10	Check (Local)	Binadhan-10	Check (Local)	
Khagrasari Sadar	10	139	177	6.7	5.5	21.18

Data from Table 12 shows the better performance of Binadhan-10 over the check variety regarding crop duration and grain yield. The average duration of Binadhan-10 was recorded 139 days while in check it was 177 days indicating the early maturing trait of Binadhan-10. In terms of yield; Binadhan-10 produced 6.3 t ha^{-1} while in check it was 5.5 t ha^{-1} indicating 21.18% increases in yield. Therefore, in the respective regions Binadhan-10 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binadhan-14 in Rangamati region

During 2019-20, 10 demonstrations were conducted with Binadhan-14 in Sadar, Rangamati region. The check was a local variety. The main objectives were to demonstrate the performance of Binadhan-14 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during February 2020, seedlings were transplanted at 20-25 days after sowing. 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 13.

Table 13: Performance of Binadhan-5 with local variety in Sadar, Khagrachari region during 2019-20

Location	No. of demonstrations	Durations		Yield (t/ha)		%Yield incre4ased over check
		Binadhan-14	Check (Local)	Binadhan-14	Check (Local)	
Sadar, Rangamati	10	113	177	6.49	5.5	18.0

Data from Table 13 shows the better performance of Binadhan-14 over the check variety in case of crop duration and grain yield. The average duration of Binadhan-14 was recorded 113 days while in check it was 177 days indicating the early maturing trait of Binadhan-14. In terms of yield, Binadhan-14 produced 6.49 t ha^{-1} while in check it was 5.5 t ha^{-1} indicating 18% increases in yield. Therefore, in the respective regions Binadhan-14 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binamoog-8 in Khagrachari region

During 2019-20, 10 demonstrations were conducted with Binamoog-8 in Sadar, Khagrachari region. The check was a local variety. The main objectives were to demonstrate the performance of Binamoog-8 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during January 2020. 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 14.

Table 14: Performance of Binamoog-8 with local variety in Sadar, Khagrachari region during 2019-20

Locations	No. of demonstrations	Durations		Yield (t/ha)		%Yield increased over check
		Binamoog-8	Check (Local)	Binamoog-8	Check (Local)	
Khagrasari Sadar	10	73	109	1.2	0.77	55.84

Data from Table 14 shows the better performance of Binamoog-8 over the check variety regarding crop duration and seed yield. The average duration of Binamoog-8 was recorded 73 days while in check it was 109 days indicating the early maturing trait of Binamoog-8. In terms of yield; Binamoog-8 produced 1.2 t ha^{-1} while in check it was 0.77 t ha^{-1} indicating 55.84% increases in yield. Therefore, in the respective regions Binamoog-8 is getting popular day by day among the farmers.

Up-scaling of BINA developed Binatomato-10 in Khagrachari region

During 2019-20, a demonstration was conducted with Binatomato-10 in Sadar, Khagrachari region. The check was a local variety. The main objectives were to demonstrate the performance of Binatomato-10 and widening their adaptability by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during November 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 15.

Table 15: Performance of Binatomato-10 with local variety in Sadar, Khagrachari region during 2019-20

Location	No. of demonstration	Durations		Yield (t/ha)		%Yield increased over check
		Binatomato-10	Check (Local)	Binatomato-10	Check (Local)	
Khagrasari Sadar	1	88	123	81.19	73.88	9.89

Data from Table 15 shows the better performance of Binatomato-10 over the check variety regarding crop duration and fruit yield. The average duration of Binatomato-10 was recorded 88 days while in check it was 123 days indicating the early maturing trait of Binatomato-10. In terms of yield; Binatomato-10 produced 81.19 t ha^{-1} while in check it was 73.88 t ha^{-1} indicating 9.89% increases in yield. Therefore, in the respective regions Binatomato-10 is getting popular day by day among the farmers.

Quality seed production of promising BINA released varieties for hill tracts

Seeds of some demanding and promising crop varieties of BINA were produced in sub-station and also in the farmer's fields at different locations. Seeds of different crop varieties which were produced and purchased from the farmer's field during 2019-20 are presented in Table 17. For purchase seeds from the farmer's government rate were followed. Farmers were provided with partial inputs, subsidies and free seeds or only with free seeds. During the 2019-20 period a total of 10 tons seeds of different crop varieties of BINA were produced and procured. Among them rice were about 9.47 tons, mustard 0.5 ton and patshak 0.03 tons.

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies four training program was arranged at BINA Substation, Khagrachari on set of respective season. The participants were farmers (both male and female) and Sub-assistant Agriculture Officers of DAE.

Field Days

In order to motivate farmers and adopt BINA developed varieties/technologies, 5 field days on rice and mustard were organized in Khagrachari.

Workshop

In order to transfer BINA developed technologies a workshop program was arranged at BINA Substation, Khagrachari onset of respective season. The participants were DD/UAO/AEO of DAE under Khagrachari district, DD of Horticulture Center under Khagrachari district and NARS Scientists of BARI/BINA/BSRI.

Sub-station, Sunamganj

Research Highlights

To get optimum yield of Binadhan-5 in the Sunamganj haor areas, 50-day old seedlings can be transplanted from the middle of December up to mid-January.

Effect of transplanting time and seedling age on growth and yield of boro rice in Sunamganj region

The experiment was carried out at BINA Sub-station farm, Sunamganj during 2019-20 to find out the optimum transplanting time and seedling age of Binadhan-5 at haor regions of Sunamganj. The experiment was laid out in split plot design assigning three date of transplanting (T1 = 15 December, T2 = 30 December and T3 = 14 January) in main plot and three age of seedlings (40, 50 and 60 days) in sub-plot making 9 treatment combinations replicated thrice. Unit plot size was 4×5 m. Seedlings were transplanted at 15 cm distance within rows of 20 cm apart. Fertilizer was applied according to the fertilizer recommendation guide. Proper cultural practices were implemented as when necessary. Five hills from each of the plot were (excluding border hills) selected at random to measure the yield contributing characters. One m^2 from each plot was harvested and the grains were adjusted to 14% moisture to determine the grain yield. Statistical analysis was done using GenStat software and least significant differences (LSD) was used to compare variations among treatments.

Yield and yield attributing characters of Binadhan-5 did not differed significantly at different transplanting time except the filled grains panicle^{-1} whereas seedling age had significant effect on the grain yield and some yield attributing characters. Fifty days old seedling produced highest yield (6.8 t/ha) which was contributed by highest number of filled grains panicle^{-1} and lowest number of unfilled grains panicle^{-1} (Table 1). To get optimum yield in the Sunamganj haor areas, 50-day old seedlings of Binadhan-5 can be transplanted from the middle of December up to mid-January.

Table 1 Yield and yield attributing characters of Binadhan-5 at different transplanting time and seedling age

Treatments	Plant height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 grain weight (g)	Days to 50 % flowering	Duration (days)	Yield (t/ha)
Transplanting Time									
15 Dec. (T1)	101.7	13.7	20.1	105.7	10	21.2	130	164	5.9

Treatments	Plant height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 grain weight (g)	Days to 50 % flowering	Duration (days)	Yield (t/ha)
30 Dec. (T2)	105.7	14.0	20.8	101	10.2	21.2	126	162	6.1
14 Jan. (T3)	102.8	13.5	20.2	106.3	11	21.2	126	163	6.0
$LSD_{0.05}$	NS	NS	NS	**	NS	NS	-	-	NS
Seedling Age									
40 days (A1)	106.0	15.3	20.7	103.7	7.3	21.63	121	157	5.7
50 days (A2)	101.8	12.8	20.6	117.0	8	21.63	127	165	6.8
60 days (A3)	102.3	13	19.9	92.3	15.8	21.63	134	168	5.6
$LSD_{0.05}$	NS	**	NS	**	**	NS	-	-	**
Transplanting time × seedling age									
T1A1	104	15	21.0	104	6	21.89	124	162	5.46
T1A2	101	13	20.3	116	10	20.7	120	159	**6.69**
T1A3	100	13	19.0	97	13	21	128	167	5.65
T2A1	108	16	20.7	102	5	21.5	120	169	5.87
T2A2	105	13	21.0	116	2	21.7	128	157	**6.9**
T2A3	104	13	20.7	85	16.5	20.85	120	157	5.85
T3A1	106	15	20.3	105	11	21.5	128	167	5.63
T3A2	99.5	12.5	20.3	119	12.67	20.9	120	167	**6.68**
T3A3	103	13	20.0	95	18	21.3	125	162	5.44
$LSD_{0.05}$	NS	NS	NS	**	**	NS	-	-	**

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 conducted at Sunamganj, Sylhet, Habiganj and Moulavibazar district. Results of overall promotional activities related to BINA-Technology village establishment are presented in Table 2.

Table 2. Performance of BINA developed varieties during 2019-20

SL.	Crops	Variety Name	No. of demo.	Avg. Duration (days)	Av.Yield (t ha^{-1})
1.	Rice	Binadhan-5	42	160	6.73
		Binadhan-8	4	136	6.14
		Binadhhan-10	6	134	6.31
		Binadhan-14	3	122	6.27
		Binadhan-7	11	122	4.91
		Binadhan-11	27	103	4.58
		Binadhan-12	1	116	5.15
		Binadhan-13	2	144	3.34
		Binadhan-17	40	116	6.43
		Binadhan-20	15	124	4.35
		Binadhan-22	1	117	5.92
		Binadhan-19	93	103	4.46
2.	Mustard	Binasarisha-4	60	90	1.11
		Binasarisha-9	15	90	1.33
		Binasarisha-10	15	84	1.15
3.	Groundnut	Binachinabadam-4	30	131.28	1.79
4.	Sesame	Binatil-1	21	90	1.11

Quality seed production of promising BINA released varieties for Sylhet region

Seeds of some demanding and promising crop varieties of BINA were produced in sub-station farm and also in the farmer's fields at different locations. Seeds of different crop varieties which were produced and purchased from the farmer's field during 2019-20 are presented in Table 3. For buying seeds from the farmer's government rate were followed. Farmers were provided with partial inputs, subsidies and free seeds or only with free seeds. During the 2019-20 period a total of 17.9 tons seeds of different crop varieties of BINA were produced and purchased. Among them rice were about 16.4 tons, groundnut 1.0 ton and mustard 0.5 ton.

Table 3. Seeds produced/purchased, distributed/sold and stored during 2019-20

Crop/variety	Produced/purchased (kg)	Distributed/sold (kg)	Comments
Binadhan-7	1,000	1,000	
Binadhan-11	2,000	2,000	
Binadhan-12	1,000	735	
Binadhan-13	100	100	
Binadhan-16	500	500	
Binadhan-17	2,800	2,800	
Binadhan-19	3,300	3,300	
Binadhan-20	2,000	2,000	

Crop/variety	Produced/purchased (kg)	Distributed/sold (kg)	Comments
Binadhan-22	500	500	
Binasail	200	100	
Binachinabadam-4	1,000	1,000	
Binadhan-5	500		Will be distributed in Boro/21 Season
Binadhan-10	2,000		
Binadhan-14	500		
Binasharisha-4	500		Will be distributed in Rabi/21 Season

Table 4. Number of Experiments completed during 2019-20 from BINA Sub-station, Sunamganj

Name of the Division	Name of the Crop	No. of Expt.
Plant Breeding	Rice (Aman)	3
	Rice (Boro)	5
BINA Sub-station, Sunamganj	Rice (Boro)	1
		Total = 9

Training and workshop on the use of BINA developed technologies

In order to transfer BINA developed technologies, six training programs was arranged at BINA Substation, Sunamganj. The participants were farmers (both male and female), Sub Assistant Agriculture Officers (SAAO) of DAE.

Field Days

In order to motivate farmers and to adopt BINA developed varieties/technologies, 05 field days on different crops varieties were organized for rapid and mass dissemination.